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Fanny Hermundsdottir

Sustainability innovations

The role of sustainability innovations in solving the sustainability challenges and increasing firm competitiveness

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of
Philosophiae Doctor
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Dept. of Industrial Economics and Technology
Management



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Summary

This dissertation seeks to explore how the implementation of sustainability innovations in firms can help us overcome the sustainability challenges and simultaneously increase firm competitiveness. This kind of research is important as the sustainability challenges are many, and firms are increasingly being pressured to help solving the many environmental and social issues we are facing. Thus, businesses are a key solution to solving the sustainability issues through the implementation of sustainability innovations. In addition to this, in the era of fast-changing markets, globalization and technology development, businesses are faced with increased competition and must continuously improve in order to survive. Hence, the overall research question of this thesis is:

How can businesses contribute to solving the sustainability challenges and simultaneously maintain their competitiveness?

In order to answer this research question, a mixed method research design is used with the development of four papers (appended as Paper 1-4). These four papers all investigate sustainability innovations and together they make important contributions to both theory and practice.

Paper 1 is a literature review of 100 peer-reviewed empirical articles, where the relationship between sustainability innovations and competitiveness is studied. It is found that a majority of articles show positive relationship between the two, however there are a range of moderating and mediating factors that influence the relationship that can be divided into national-, market-, industry- and firm-level factors. Paper 1 contributes to the sustainability literature by filling important gaps when it comes to what is known about the sustainability innovation-competitiveness relationship. In addition, it contributes to the literature by using a holistic definition of sustainability including the social pillar, by investigating how sustainability innovations and competitiveness is operationalized, by discovering several moderating and mediating factors that influence the relationship, and it comes with important avenues for further research.

Paper 2 is a quantitative study of Norwegian manufacturing firms that investigates how sustainability strategies affect the implementation of environmental and social innovation. In addition, the paper examines environmental and social innovations' effect on perceived

and objective firm performance. The findings show that having a sustainability strategy positively influences the implementation of environmental and social innovations. Further, environmental innovations are found to have a positive influence on both perceived and objective firm performance. Social innovations are found to have a positive influence on the perceived performance, and a negative effect on objective performance. This study makes important contributions to the field by showing how environmental innovations create competitive benefits for firms, illustrating the opportunities that come with the sustainability shift. In addition, it fills an important gap by studying social innovations' effect on firm performance, contributing to a more holistic view on sustainability.

Paper 3 is also a quantitative study of Norwegian manufacturing firms. In this paper it is investigated how the external shock of COVID-19 affects the implementation of environmental innovations. It is found that COVID-19 has a negative effect on the environmental innovations in the firms. Paper 3 thus illustrates the vulnerability of environmental innovations to external shocks, and the importance of stable market conditions in order for firms to work towards increased sustainability. In addition, for policy makers it demonstrates the importance of financial support and incentives for the sustainability transition to happen.

Paper 4 is a qualitative case-study of Norwegian oil and gas firms. Here, it is studied how the firms develop dynamic capabilities in order to innovate for sustainability and going into new markets as the renewable energy sector. Several microfoundations of dynamic capabilities are discovered, and it is clear that the firms can use a lot of their existing resources and capabilities, together with developing new ones, in order to accomplish this sustainability transition. Thus, paper 4 shows how there is potential for firms to use a lot of their existing resources and capabilities in new settings when contributing to solving the sustainability issues. In addition, the paper demonstrates the importance of developing dynamic capabilities in order to adapt to the fast changing environment and stay competitive in the more sustainability-focused future.

Together the four papers contribute in answering the research question of how businesses can help solving the sustainability challenges and simultaneously maintain their competitiveness. Based on the findings of the papers, it is found that firms can contribute to solving the sustainability challenges by implementing sustainability innovations that aim to

address environmental and social issues. Further, the papers find high empirical evidence in that sustainability innovations lead to increased competitiveness through increased value creation and non-financial assets, reduced cost and/or reduced risk. Thus, the findings contribute to the ongoing debate on sustainability implementation in firms, and show that firms can both contribute to solving the sustainability challenges, while simultaneously increase their competitiveness. By implementing the right types of innovations, firms can therefore create value both for the society and themselves. However, the relationship is not necessarily straightforward as there are a lot of factors that can influence the relationship related to national-, market-, industry- and firm factors. Overall, the findings contribute with important knowledge both to theory, practitioners and policy, and in the dissertation several implications of the findings are discussed.

Sammendrag

Formålet med denne avhandlingen er å undersøke hvordan implementering av bærekraftsinnovasjoner i bedrifter kan hjelpe oss med å løse bærekraftsutfordringene og samtidig øke bedriftens konkurransekraft. Denne typen forskning er viktig da bærekraftsutfordringene er mange, og bedrifter i økende grad blir presset til å bidra til å løse de mange miljømessige og sosiale problemene vi står overfor. Bedrifter er dermed en viktig brikke i å løse bærekraftsproblemene gjennom implementering av bærekraftsinnovasjoner. I tillegg til dette, i en tid med raskt skiftende markeder, globalisering og teknologiutvikling, står bedrifter overfor økt konkurranse og må kontinuerlig forbedre seg for å overleve. Det overordnede forskningsspørsmålet i denne avhandlingen er derfor:

Hvordan kan virksomheter bidra til å løse bærekraftsutfordringene og samtidig opprettholde sin konkurransekraft?

For å besvare dette forskningsspørsmålet brukes et mixed methods forskningsdesign med utvikling av fire artikler (vedlagt som Paper 1-4). Disse fire artiklene undersøker alle bærekraftsinnovasjoner og sammen gir de viktige bidrag til både teori og praksis.

Paper 1 er en litteraturgjennomgang av 100 fagfellevurderte empiriske artikler, der forholdet mellom bærekraftsinnovasjoner og konkurransekraft undersøkes. Det blir funnet at et flertall av artiklene viser positive sammenhenger mellom de to, men det er en rekke modererende og medierende faktorer som påvirker forholdet som kan deles inn i nasjonale-, markeds-, industri- og bedriftsnivå faktorer. Paper 1 gjør et viktig bidrag til bærekraftslitteraturen ved å fylle forskningsgapet som omhandler hva vi vet om forholdet mellom bærekraftsinnovasjon og konkurransekraft. I tillegg bidrar den til litteraturen ved å bruke en helhetlig definisjon av bærekraft som inkluderer den sosiale pillaren, undersøke hvordan bærekraftsinnovasjoner og konkurransekraft blir operasjonalisert, oppdage flere modererende og medierende faktorer som påvirker forholdet, og den presenterer viktige forslag for videre forskning.

Paper 2 er en kvantitativ studie av norske industribedrifter som undersøker hvordan bærekraftsstrategier påvirker implementeringen av miljø- og sosial innovasjon. I tillegg undersøker artikkelen miljø- og sosiale innovasjoners effekt på opplevd og objektiv bedrifts konkurransekraft. Funnene viser at det å ha en bærekraftsstrategi påvirker implementeringen av miljø- og sosiale innovasjoner positivt. Videre viser det seg at

miljøinnovasjoner har en positiv innflytelse på både bedriftenes opplevde og objektive konkurransekraft. Sosiale innovasjoner viser seg å ha en positiv innvirkning på den opplevde konkurransekraften, mens en negativ effekt på objektiv konkurransekraft. Denne studien gir viktige bidrag til feltet ved å vise hvordan miljøinnovasjoner skaper konkurransefordeler for bedrifter, og illustrerer mulighetene som følger med bærekraftskiftet. I tillegg fyller den et viktig forskningsgap ved å studere sosiale innovasjoners effekt på bedriftens konkurransekraft, og bidrar til et mer helhetlig syn på bærekraft.

Paper 3 er også en kvantitativ studie av norske industribedrifter. I denne artikkelen blir det undersøkt hvordan det eksterne sjokket av COVID-19 påvirker implementeringen av miljøinnovasjoner. Det er funnet at COVID-19 har en negativ effekt på miljøinnovasjonene i bedriftene. Paper 3 illustrerer dermed miljøinnovasjoners sårbarhet for eksterne sjokk, og viktigheten av stabile markedsforhold for at bedrifter skal kunne jobbe mot økt bærekraft. For beslutningstakere viser studien viktigheten av økonomisk støtte og insentiver for at bærekraftsomstillingen skal skje.

Paper 4 er en kvalitativ case-studie av norske olje- og gassbedrifter. Her studeres det hvordan bedriftene utvikler dynamiske kapabiliteter for å innovere for bærekraft og gå inn i nye markeder som den fornybare energisektoren. Flere mikroprosesser for dynamiske kapabiliteter blir oppdaget, og det viser seg at bedriftene kan bruke mye av sine eksisterende ressurser og kapabiliteter, i tillegg til å utvikle nye, for å gjennomføre denne bærekraftsomstillingen. Paper 4 viser derfor potensialet for bedrifter til å bruke mye av sine eksisterende ressurser og kapabiliteter i nye omgivelser når de skal bidra til å løse bærekraftsproblemene. I tillegg demonstrerer artikkelen viktigheten av å utvikle dynamiske kapabiliteter for å tilpasse seg det raskt skiftende miljøet og forbli konkurransedyktig i en mer bærekraftsfokusert fremtid.

Sammen bidrar de fire artiklene til å besvare forskningsspørsmålet om hvordan bedrifter kan bidra til å løse bærekraftsutfordringene og samtidig opprettholde sin konkurransekraft. Basert på resultatene i artiklene, er det funnet at bedrifter kan bidra til å løse bærekraftsutfordringene ved å implementere bærekraftsinnovasjoner som tar sikte på å adressere miljømessige og sosiale spørsmål. Videre finner artiklene sterke empiriske bevis på at bærekraftsinnovasjoner fører til økt konkurranseevne gjennom økt verdiskaping og ikke-finansielle eiendeler, reduserte kostnader og/eller redusert risiko. Det er imidlertid mange

faktorer som kompliserer dette forholdet knyttet til nasjonale-, markeds-, industri- og bedriftsfaktorer. Basert på funnene fra de fire artiklene diskuteres flere implikasjoner for teori, bedriftsledere og politikk.

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Fanny Hermundsdottir

Trondheim, June 2023

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Paper 2

Hermundsdottir, F., & Aspelund, A. (2022). Competitive sustainable manufacturing- Sustainability strategies, environmental and social innovations, and their effects on firm performance. *Journal of Cleaner Production*, 370, 133474.

Paper 3

Hermundsdottir, F., Haneberg, D.H., & Aspelund, A. (2022). Analyzing the impact of COVID-19 on environmental innovations in manufacturing firms. *Technology in Society*, 68, 101918.

Paper 4

Hermundsdottir, F., Eide, A.E., & Bjørgum, Ø. (2023). Transition from fossil fuels to renewable energy: Identifying the necessary dynamic capabilities for a transition in the petroleum-based service and supply industry. *In a review process in an international peer-reviewed journal*.

PART 1 – COVER ESSAY

1 INTRODUCTION

The sustainability challenges including environmental and social issues are putting pressure on humanity's wellbeing and economic prosperity (European commission, 2019). One of the main environmental issues concerns our current overuse and depletion of resources that threatens our ability to achieve sustainable development (European commission, 2019). The environmental degradation directly impacts social issues, threatening living conditions and human survival (Takalo et al., 2021). Today the economic growth is proportional with our resource use and emissions, causing a serious damage on the environment (Le and Ikram, 2022). In order to solve this, we need to decouple resource use and emissions from economic growth (UNEP, 2011). By doing this decoupling, we are one step closer to simultaneously achieve economic growth, sustainable development and improved living conditions for all (European commission, 2019).

As the sustainability issues are increasing, and business operations are associated with high amounts of resources use, emissions and waste (Tu and Wu, 2021), more and more pressure is put on firms to contribute to solving the sustainability challenges (Annunziata et al., 2018; Le and Ikram, 2022). In order to do this, firms need to take into account their environmental and social impact (Annunziata et al., 2018), by examining their strategies and operations and finding new ways of innovating (Hübel et al., 2022). Further, simultaneously as businesses are facing pressure to become more sustainability-oriented, they also face greater pressure on increasing their competitiveness due to fast-changing markets, globalization and technology development (Cheraffi et al., 2018; Le and Ikram, 2022). Thus, firms need to develop new innovations that simultaneously address important sustainability issues, meet stakeholder needs (Amui et al., 2017) and increase firm competitiveness (Arici and Uysal, 2022; Takalo et al., 2021).

These new ways of innovating can be done through sustainability innovations. Sustainability innovations are defined as innovations that simultaneously incorporate economic, social and environmental dimensions (Hübel et al., 2022). More specifically, sustainability innovations aim at providing environmental and social benefits, while increasing the competitive advantage of the firm (Cillo et al., 2019).

Hence, while it lies in the definition of sustainability innovations that they should be profitable and increase firm competitiveness, the question is if this is the case. Research on how sustainability innovations can lead to increased competitiveness has gotten increased attention the last years, however a lot of questions remain unclear (Cai and Li, 2018; Cillo et al., 2019; Pätäri et al., 2012). Even though a lot of research find that sustainability innovations positively impacts competitiveness, some studies find neutral or negative connections (e.g. Bermúdez-Edo et al., 2017; Cai and Li, 2018; Reyes-Santiago et al., 2019). Research also reveals that the relationship is complex, as the outcomes of sustainability innovations depends on each firm's context (Arfi et al, 2018; Lankoski, 2008). It is therefore important to further study the relationship between sustainability innovations and competitiveness, in addition to what kind of factors that affect this relationship (García-Sánchez et al., 2020; Grewatsch and Kleindienst, 2017; Hart and Dowell, 2011). There is also a need for more theoretical view on why sustainability implementations can contribute to increased competitiveness (Dentchev, 2004). Research within the sustainability innovation-competitiveness relationship is important, as in order to push firms towards increased sustainability implementation, sustainability must be a business opportunity with a potential for increasing the competitiveness of firms. Economic growth and sustainable development is in fact closely related, as economic growth is a key to reduce poverty and increase living conditions, especially in poor economies (FN, 2021; World Bank Group, 2015). Thus, firms must continue to grow, however the challenge is to create growth that simultaneously contribute to solving the sustainability challenges.

Another issue is how sustainability innovation can be implemented in practice. Many firms find it challenging to develop these kinds of innovations due to their complexity, the need to take environmental and social considerations, high-costs, associated risks, collaboration requirements, limited governmental support, and double externalities (Chen and Chang, 2013; Hübel et al., 2022; Neutzling et al., 2018; Rennings, 2000; Serrano-García et al., 2021, Takalo et al., 2021). One way firms can handle this problem and respond to the fast changing markets in a competitive way, is by building up key resources and developing dynamic capabilities by creating and reconfiguring their internal resources (Cillo et al, 2019; Hart and Dowell, 2011). In relation to this, there is a need for research studying what kind of proactive initiatives are necessary in order for firms to implement sustainability in their businesses and

improve their competitiveness (Annunziata et al., 2018). More specifically, it is called for research studying what kind of resources and dynamic capabilities must be developed in order to contribute to overcoming the sustainability challenges (Amui et al., 2017; Hart and Dowell, 2011; Khan et al., 2021). By studying the dynamic capabilities necessary for sustainability implementation, we can help firms with knowledge in what type of capabilities they need in order to help solving the sustainability issues (Amui et al., 2017). Researchers specifically call for the microfoundations, that is, the specific skills, processes and activities, associated with developing dynamic capabilities for sustainability (Buzzao and Rizzi, 2021).

Thus, the main RQ for this dissertation is: *How can businesses contribute to solving the sustainability challenges and simultaneously maintain their competitiveness?*

In order to answer this overarching research question we develop four papers, each with its own research question. The papers use different methods and theoretical perspectives, and each paper makes important contributions by filling specific gaps in the literature. Figure 1 shows an illustration of how the four papers in this dissertation are connected to each other. Below, the gap, research question and contribution of each paper will be elaborated on.

Paper 1

When examining the literature on sustainability innovations and competitiveness, it was observed that the literature was quite new, with many different definitions and contexts, ways of measuring, and mixed findings. It was also discovered that many of the previous literature reviews only examined the environmental pillar of sustainability, and did not include the social pillar. Paper 1 is therefore a result of this identified gap and is a literature review studying the state of art of what current research says about the relationship between sustainability innovations and competitiveness, with a focus on all three pillars of sustainability. Hence, the research question of paper 1 is:

RQ: What does current research say about the relationship between sustainability innovation and competitiveness, and what are the contextual factors that affect this relationship?

The literature review contribute to filling an important gap in what we know about the sustainability innovation-competitiveness relationship, and the contextual factors affecting it. In addition, it was logical to do a review as a first paper in this dissertation as it sat the stage for the rest of the dissertation by obtaining valuable insights about the research field.

In addition, it gave the opportunity to find avenues for further research which could be used in the subsequent papers.

Paper 2

Paper 2 is a result of the gaps that was identified in the literature review in paper 1. First, it was found that the social pillar and how it related to competitiveness was understudied. Second, as most studies use cross-sectional data in studying the sustainability innovation-competitiveness relationship, there was a need for more research using longitudinal data to be able to say something about causality. Third, there was a need for extending the different strategic management theories into the sustainability context to help explaining the phenomena. There was also a gap in the literature when it came to whether having sustainability strategies actually led to more sustainability innovations in firms.

Thus, there were several gaps that were identified in the literature that paper 2 could contribute to and it was natural to study the sustainability innovation-competitiveness relationship in an empirical setting. Paper 2 therefore uses quantitative data and examines how the sustainability innovation-competitiveness relationship plays out in the Norwegian manufacturing sector. Therefore, in paper 2 we answer the following research question:

RQ: Does the adoption of sustainability strategies lead to actual implementation of social and environmental innovations? What affect do environmental and social innovations have on firms' ability to create value, reducing costs and reducing market risk?

Hence, in paper 2 sustainability innovations is divided in environmental and social innovations.

Paper 3

When COVID-19 hit the world, there was a high interest and need for research studying how this kind of external disruption affected the sustainability work in firms. This kind of research is important in order to examine how robust the environmental innovations in firms actually are. It is not unlikely that there will be other external shocks in the future, and therefore it is important to study this issue to find solutions to how firms can continue to work towards increased sustainability despite of an external shock. Because, in order to solve the sustainability issues, environmental innovations could not just be a temporary thing that

fade away during an external shock. Thus, as the two first papers specifically examined how sustainability innovations relate to competitiveness, we saw the opportunity to study how an external shock affects the implementation of environmental innovations in firms by gathering quantitative data from the Norwegian manufacturing sector. Thus, the research question in paper 3 is:

RQ: How are efforts toward environmental innovations impacted by a sudden exogenous shock such as COVID-19?

Paper 3 therefore sheds light on how the external environment can influence the environmental innovations in firms. By doing a study on the robustness of environmental innovations during a crisis, paper 3 can say something about the relevance of the external environment when it comes to firms' ability to contribute to solving the sustainability challenges. This insight will be valuable for firms and policy makers in regard to external shocks that may occur in the future.

Paper 4

When the external environment changes, firms have to adapt in order to stay competitive. One way to adapt to these changes is by the development of dynamic capabilities. The increased pressure to become more sustainability-oriented is an external change that firms have to cope with and it is highlighted in the literature that there lacks research in *how* firms can become more sustainability-oriented. Thus, paper 4 study the transition to a more sustainability-oriented business in greater detail, and examines the role of dynamic capabilities in such a process. In the literature review it was found that there was a need to study other industries than the manufacturing industry, as this was the most studied one. Thus, in this paper it is gathered qualitative data in the Norwegian oil and gas industry¹. The research question is:

RQ: How can firms in the oil and gas industry transition into emerging renewable energy industries by using dynamic capabilities? More specifically, how can the firms use their

¹ In the cover thesis we call it oil and gas industry as this is the overarching industry the firms are in, while we in paper 4 call it petroleum-based service and supply industry

existing resources and knowledge in new, future-oriented industries by aligning and reconfiguring their existing resource base and by acquiring new resources?

This paper thus helps explaining how firms can contribute in solving the sustainability challenges, while they at the same time increase their competitiveness. Thus, together, these four papers contribute in answering the overarching research question.

The remainder of the cover essay is structured as follows: First, in chapter 2 I elaborate on important theories in the sustainability innovation literature. More specifically the role of business in society, and theories explaining how firms can achieve competitive benefits of implementing these types of innovations, and how this can be done. In chapter 3 I explain the methods used in the different papers and the methodological challenges associated with each paper, while I in chapter 4 present the findings of each paper. In chapter 5 I discuss the findings of the papers, while I additionally present various implications for both firms and policy, together with limitations and further research. Finally, chapter 6 presents the conclusion of this thesis.

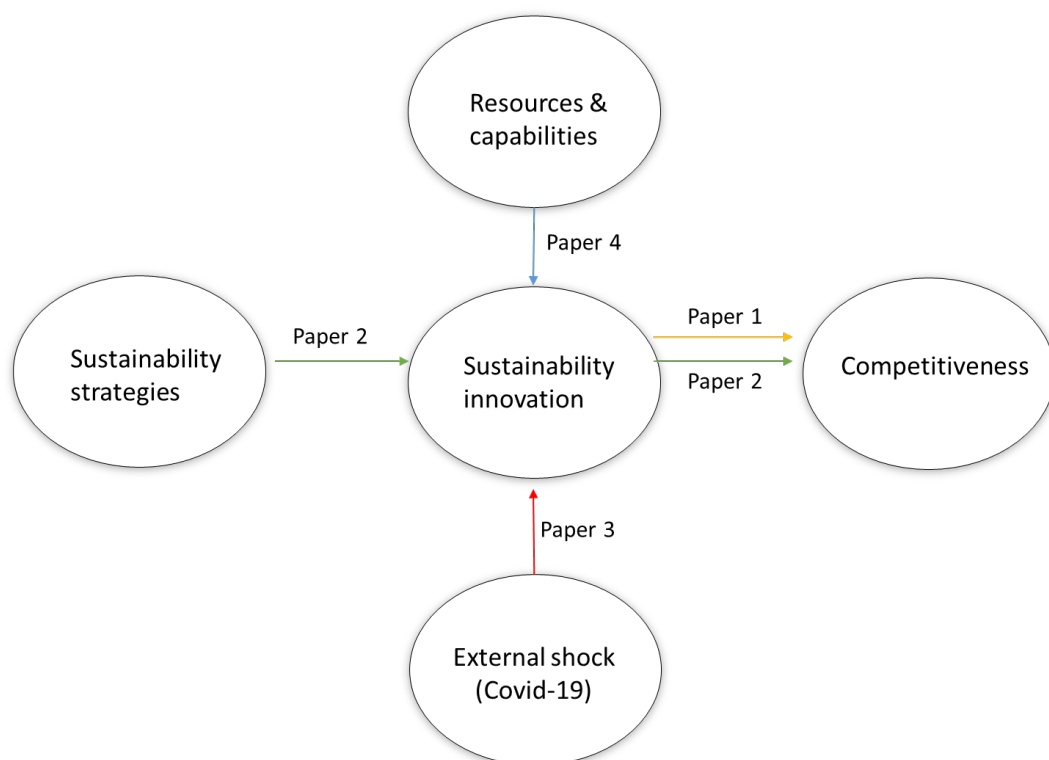


Figure 1: Relationship of papers in the dissertation

2 THEORY

2.1 Sustainability challenge

Our overuse and consumption of resources leads to degradation of the environment (European Commission, 2019). The global consumption of resources has increased fourteen-fold between 1900 and 2015, and is expected to double between 2015 and 2050 if the consumption continues in the same speed (European Commission, 2019). Further, climate change is another big sustainability challenge we are facing and is leading to increased global temperature, a rise in sea level, more extreme weather and ocean acidification among other things (FN, 2021; United Nations, 2015, p. 5). The undesired effects of climate change makes us more vulnerable to hunger and nature disasters, and has led to substantial and irreversible damages on ecosystems (FN, 2021; IPCC, 2023). Currently, about 3.3-3.6 billion people live in environments that are vulnerable to climate change, where poor countries are the most exposed (FN, 2021; IPCC, 2023). Further, the human activities and environmental degradation lead to undesired outcomes such as desertification, drought, land degradation, freshwater scarcity and loss of biodiversity (United Nations, 2015, p. 5). Thus, the current consumption of resources together with the climate change are not in accordance with sustainable development, and in order to achieve this we have to change the way of doing business, consumption patterns, and make appropriate regulations (UNEP, 2011).

2.2 Sustainability innovation

The Brundtland commission defined in 1988 the term sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations, 1987, p. 37). Dyllick and Hockerts (2002) apply this definition on businesses and define corporate sustainability as “meeting the needs of a firm’s direct and indirect stakeholders, without compromising its ability to meet the needs of future stakeholders as well” (p. 131).

A way of contributing to sustainable development is through sustainability innovation (Klewitz and Hansen, 2014), which is the core of this dissertation. In the literature, the definitions of sustainability innovations vary (Arfi et al., 2018; Boons and Lüdeke-Freund, 2013; Boons et al. 2013, Cillo et al., 2019). Boons et al. (2013) define sustainability innovations quite broadly as “innovations that improves sustainability performance” (p. 2), where sustainability consists of the three pillars environment, social and economic (Ranjbari

et al., 2021). In paper 1 we define sustainability innovations as “innovations wherein all sustainability dimensions, including environmental, social, and economic, are considered during the whole innovation process. Hence, the aim is to avoid or reduce negative impact on the environment while considering social aspects in all steps of the innovation process and to simultaneously do this profitably to sustain the business” (Hermundsdottir and Aspelund, 2021, p. 3). Thus, through sustainability innovations firms have the potential to both contribute to solving the sustainability challenges and at the same time increase their competitiveness (Hübel et al., 2022). The focus on profitability when it comes to sustainability is important as sustainability innovations should make a business case for the firms implementing them, instead of being solely charity or philanthropy. Thus, we acknowledge the importance of innovations being profitable, as the ultimate goal for firms is to create profit and grow (Schrettle et al. 2014).

What distinguishes sustainability innovations from environmental, eco or green innovations is that they include social objectives as well, making them more holistic (Boons et al., 2013). However, the terms environmental/green/eco and sustainability are used interchangeably in the literature (Arfi et al., 2018; Boons and Lüdeke-Freund, 2013; Klewitz and Hansen, 2014; Schrettle et al., 2014). A reason for this is that the sustainability pillars are highly interrelated. In fact, the environmental challenges impose great social risks and challenges because of biodiversity loss and environmental damages (IPCC, 2023), and improving the environmental pillar will therefore improve the social pillar (Klewitz and Hansen, 2014; Schrettle et al., 2014). For example, firms can reduce their resources and emissions by developing new technologies, produce new products that use less resources in the whole life cycle, or develop greener supply chains (Schrettle et al., 2014, p. 75). Even though these are environmental improvements, they will have a positive impact on the life quality of the population and improve social performance (Klewitz and Hansen, 2014; Schrettle et al., 2014; Zhang et al., 2021). In addition, the social pillar of sustainability is more relevant in emerging economies (Santos et al., 2019) as in developed economies many social considerations are well established in industry norms and regulations. For example, taking care of employees, engaging in the society and meeting the demand of the community (Klewitz and Hansen, 2014) are social considerations that are well integrated in Norwegian businesses. Therefore, because of the high interdependence of the sustainability pillars and

the social pillar being more covered in the Norwegian setting, the innovations studied in this dissertation fall under what I call sustainability innovations—even though we specifically study social and environmental innovations in paper 2, and environmental innovations in paper 3 and 4².

Further, sustainability innovations can take many forms such as new products, processes, services, organizational methods or business models (Charter and Clark, 2007, p. 9; Klewitz and Hansen, 2014; Neutzling et al., 2018). In addition, as other innovations, sustainability innovations can be divided into incremental and radical innovations (Klewitz and Hansen, 2014). While incremental innovations do relative improvements in sustainability performance compared to the prior state, it is the radical innovations that have the biggest potential in improving the sustainability challenges (Hart and Dowell, 2011; Klewitz and Hansen, 2014). However, in this dissertation we don't make a distinction of the different types of sustainability innovations, and we therefore address the innovation in general when talking about sustainability innovations.

2.3 Businesses and sustainability

Businesses' role in society has over time changed. Ever since the first businesses started, they have been there to solve a problem and create value. Traditionally, the view of businesses was that their purpose was to maximize shareholder value by supplying goods and services to the society at a profit, the so called neo-classical view (Bird et al., 2007; Scherer and Palazzo, 2011; Quazi and O'Brien, 2000). Businesses were not seen as a part of the society apart from meeting customer needs to maximize profitability (Quazi and O'Brien, 2000). It was the role of governments, not businesses, to take care of negative externalities, social and environmental challenges and the production of public goods (Scherer and Palazzo, 2011). Thus, social responsibility was seen as something that resulted in an additional cost, ultimately resulting in decreased competitiveness for firms. However, because of their size and influence, businesses are increasingly being blamed for the many economic, social and environmental problems and the expectation towards businesses has therefore over time changed (Porter and Kramer, 2011; Rasche et al., 2017). Corporations are now increasingly necessary for the society. They influence important aspects such as

² Note: In paper 4 we use the term green innovation, as I see environmental and green innovations as synonyms

employment, consumption, health care, education, social inequality and environmental issues, and are therefore important for the overall security and welfare of the society (Brammer et al., 2012, Rasche et al., 2017). This demonstrates that during the last decades firms have performed activities that earlier were performed by the government, and due to this some view businesses as important political actors (Scherer and Palazzo, 2011).

Sustainability issues started becoming a major concern in the 1990s when various stakeholders, including governments, started to give serious attention to the climate crisis and societal issues (Kolk and Pinkse, 2007). Along with the increasing challenges, researchers argued that to justify the existence of businesses that use and control a lot of the society's resources, businesses were obliged to widen their responsibility and include environmental and social consideration in their business (Quazi and O'Brien, 2000). In addition, since businesses are dependent of the society in terms of critical support structure and customers, it is of businesses long term interests to take care of their surroundings (Lee, 2008). Thus, to answer to the increasing call from stakeholders, including governments, companies worldwide have increased their attention towards sustainability the last decades (Kolk and Pinkse, 2007). The concept of corporate sustainability (CS) is therefore a quite modern concept (Lee, 2008), and what distinguishes it from the term corporate social responsibility (CSR) is that CSR has its main focus on social and ethical issues, while CS focus on social *and* environmental issues (Montiel, 2008). Nevertheless, today businesses are not only expected to maximize profit, they are also expected to consider how their operations influence the society and environment — and firms in polluting industries even more (George et al., 2016). It is now believed that to remain as a business, firms should consider not only the economic part of sustainability, but also the environmental and social parts as they are all interrelated and necessary to succeed in the long run (Dyllick and Hockerts, 2002).

Businesses undertake sustainability differently. As van Marrewijk (2003) argue: “simply stated: they either feel obliged to do it; are made to do it or they want to do it” (p. 99). Some firms do not do more than follow the regulations in their industry to avoid risk which is called compliance-oriented or risk-mitigation strategy (Baumgartner, 2014; Bos-Brouwers, 2010). Other firms take a more proactive approach and voluntarily introduce sustainability initiatives that go beyond what is legally necessary as they see these initiatives as strategic opportunities that could create competitive advantage (Da Giau et al., 2020; Kolk and Pinkse,

2007; Torugsa et al., 2013). For example, some firms have an eco-efficiency strategy where the focus lies in how sustainability can lead to more efficient processes, better utilization of resources and materials, and cleaner production (Baumgartner, 2014; Bos-Brouwers, 2010). One can therefore say that firms with a proactive sustainability strategy try to be one step ahead and anticipate future trends and requirements within sustainability (Kitsis and Chen, 2023). However, researchers argue that firms can go even further than this and be “truly sustainable”, indicating that environmental and social issues are taken into consideration in all business decisions and sustainability challenges are made into business opportunities, and the ultimate goal is to create value for the common good (Baumgartner, 2014; Bos-Brouwers, 2010; Dyllick and Muff, 2016). One explanation of why firms do different sustainability initiatives is that they are located at varying geographical locations which are prone to different regulations and communities (Kolk and Pinkse, 2007). Another reason could be the different industries the firms are in, as type of industry influences market factors and the type of activities they engage in (Grewatsch and Kleindienst, 2017; Kolk and Pinkse, 2007). Firms that are more influenced by the sustainability challenges in their operations also have a higher incentive to undertake sustainability strategies to reduce risk (Hart and Dowell, 2011).

Thus, it is therefore clear that businesses have an important role in society and are increasingly expected to take responsibility when it comes to sustainability issues. What type of sustainability initiatives firms do varies, but a key question for all is how they can undertake sustainability in a way that increases their competitiveness — or how can businesses create value both for the society and themselves simultaneously?

2.4 Shared value creation — creating value for both business and society

Broadly speaking, the view of the link between sustainability and competitiveness is twofold in the literature – the traditionalist view and the revisionist view (Cai and Li, 2018; Hussain et al., 2018; Quazi and O’Brien, 2000; Porter and van der Linde, 1995).

In the traditionalist view social responsibility is viewed as something that imposes extra costs on the businesses, resulting in reduced competitiveness (Porter and Kramer, 2011; Quazi and O’Brien, 2000). From a strategic point of view, starting new activities like sustainability initiatives require both financial and human resources (Schrettle et al., 2014) which leads to high expenditures. Therefore, according to this view sustainability and profitability cannot

align (Schaltegger and Burritt, 2018). In contrast however, Porter and Kramer (2011) argue how businesses are trapped in an old way of thinking of value creation where the focus lies in the short-term performance, and businesses forget to see the bigger picture in how larger influences as the environment surrounding the business, can determine their long-time success. A narrow view on capitalism prevents businesses to create value in a way that serves and meet the challenges of the society. Porter and van der Linde (1995) argue that instead of seeing environmental improvements as a cost or threat, businesses must change mindset and recognize the economic and competitive opportunities associated with environmental improvements.

The revisionist view argue how shared value creation (SVC) is a way of creating value in which business and society go hand in hand (Porter and Kramer, 2011). SVC “involves creating economic value in a way that also creates value for the society by addressing its needs and challenges” (Porter and Kramer, 2011, p. 4). Here, social challenges do not impose extra costs, instead they are opportunities for innovation that can increase productivity and expand markets. When creating shared value businesses contribute to further development of the society, while the business grows at the same time. “Shared value opens up many new needs to meet, new products to offer, new customers to serve, and new ways to configure the value chain” (Porter and Kramer, 2011, p. 16). Therefore, what distinguishes SVC from CSR, is that SVC is not about charity or philanthropy, it is about discovering new opportunities and innovating in ways that increases the competitiveness of the firms.

A lot of research is in line with Porter and Kramer’s (2011) argumentation about how sustainability can create shared value for both businesses and society, a so called business case for sustainability (e.g. Chan et al., 2016; Chu et al., 2019; Dey et al., 2020; Qiu et al. 2020). Not only researchers, but also business managers increasingly think that sustainability is necessary to implement in their firms to gain competitive advantage today, and even more in the future (Dyllick and Muff, 2016). Sustainability innovations can lead to resource productivity and increased efficiency through redesign of products, processes and methods of operation, which again lead to increased environmental performance and create competitive advantage (Porter and van der Linde, 1995). In fact, Porter and van der Linde (1995) discuss how pollution can be seen as resources that have been used inefficiently or incompletely, and therefore firms must think of environmental improvements as resource

productivity. In sum, increased productivity and efficiency will ultimately lead to reduced costs. Sustainability innovations can also lead to increased value creation through increased financial performance in response to new market needs and higher market shares by introducing new products and services (Tariq et al., 2019; Xie et al., 2019). Sustainability initiatives is also a strategy of reducing risk (Tariq et al., 2019). As emissions are costly and will be even more costly in the future due to regulations, taxes and penalties the society imposes on the businesses, businesses need to acknowledge and act towards improving their environmental performance in order to survive (Porter and Kramer, 2011; Porter and Reinhardt, 2007). In addition, increased environmental degradation also imposes risk on businesses as many of them are vulnerable to climate related effects such as energy and water availability, infrastructure and supply chain reliability, and global pandemics (Porter and Reinhardt, 2007). Environmental and social issues therefore have direct impact on the economic success of firms as they often influence both income and costs (Eweje, 2011). Investing in innovations that improves sustainability performance is therefore a way of securing future resilience (Schwartz, 2007). By innovating for sustainability through for example helping to protect the environment and mitigate risk in local communities, business also build goodwill and strengthen the firm image in the wider society in which they operate (Schwartz, 2007). In this way, introducing sustainability innovations can also lead to increased reputation and differentiation (Lam et al, 2005; Liao, 2016).

Thus, the revisionist view proposes that sustainability innovations can create shared value because of the many new business opportunities that derive from the sustainability issues. According to the literature the competitive outcomes of sustainability innovations can be categorized in increased value creation, productivity improvement or reduced costs, and risk reduction (Hermundsdottir and Aspelund, 2021 (Paper 1); Rasche et al., 2017).

2.5 A particular challenge for sustainability innovations: The double externality problem

A challenge when it comes to the competitiveness of sustainability innovations, is that they are subject to the double externality problem (Rennings, 1998). Similarly to traditional innovations, sustainability innovations produce spillover effects in the R&D process which means that the innovation creates benefits for others, for example for competing firms that can utilize the new generated knowledge resulting from the new innovation (Rennings, 1998). This means that the innovating firm cannot reap all the benefits of the innovation

themselves (Jaffe et al., 2005). A characteristic of sustainability innovations compared to traditional innovations is that they in addition produce positive externalities as they improve environmental quality. Externality is defined as a positive or negative significant effect of an activity imposed on a third party that is unrelated from the party that control the externality-producing activity (Jaffe et al., 2005, p. 165). For example, a polluting firm creates a negative externality for the society. Typically, it is the society that takes the costs of pollution, and therefore the polluting firm lacks incentive to reduce those imposed costs (Jaffe et al., 2005, Malen and Marcus, 2019). However, as sustainability innovations improve environmental quality they reduce external costs for the society compared to competing products or services (Rennings, 1998; Bernauer et al., 2007). While it is the innovating firms that create sustainability innovations that bear all the costs, it is the society that benefits the most of the innovation as it reduces negative impact on the environment (Beise and Rennings, 2005; Rennings, 2000). In other words, the innovating firms are not able to capture the social returns as private returns (Faber and Frenken, 2009). Thus, in sum, sustainability innovations create positive spillovers that competing firms can utilize and it is the society that reap the benefits of increased environmental quality – this is called the double externality problem and it reduces the incentives for firms to invest in sustainability innovations (Beise and Rennings, 2005; Jakobsen and Clausen, 2016).

Thus, the double externality problem demonstrates firms' challenge to capture value from their investments in sustainability innovations (Malen and Marcus, 2019). As long as firms cannot reap the full benefits of their investments in sustainability innovations, and competing products and services resulting in negative externalities do not internalize the costs, sustainability innovations can suffer from competitive disadvantages (Lüdeke-Freund, 2010; Qiu et al., 2020). Malen and Marcus (2019) also argue how the double externality problem will lead to firms investing more in incremental sustainability innovations instead of radical environmental innovations, to compensate for the value loss.

To increase the incentive for firms to invest in sustainability innovations, policy intervention has great importance (De Marchi, 2012). For example, policy can put limits on emission levels or internalize the costs of the negative externalities, which means that firms have to pay for environmental harm through for example taxes, to make incentives to develop environmentally friendly innovations (Jaffe et al., 2005; Malen and Marcus, 2019).

2.6 Stakeholder theory: stakeholders as a driver and a way of increasing firm competitiveness

The stakeholder theory is an important theory in order to understand firms' responses towards solving the sustainability issues (Kolk and Pinkse, 2007; Montiel and Delgado-Ceballos, 2014). The theory explains how a firm's success is dependent on how effectively it manages the relationship with its key stakeholders (Freeman and Phillips, 2002). Freeman (1984) defines stakeholders as "any group or individual who can affect or is affected by the achievement of the organization's objectives" (p. 46). Stakeholders that affect or is affected by firms can include governments, customers, employees, suppliers, non-governmental organizations, communities, investors or competitors (Freeman and Phillips, 2002; Kolk and Pinkse, 2007). In stakeholder theory the firm is seen as a part of a broad embeddedness of other firms and the societal environment that are interdependent on each other (Hörisch et al., 2014). Therefore, in order to survive businesses must not only satisfy its shareholders, but also its stakeholders such as employees, governments and customers (Lee, 2008).

Even though there are many different stakeholders influencing firms, the greatest attention will be put on the stakeholders that control the most crucial resources that the firms need to reach its objectives and ensure survival (Jawahar and McLaughlin, 2001; Kolk and Pinkse, 2007). For example, in most cases the government is the most influential stakeholder of firms, as governments have power to make regulations and restrict emissions for example through carbon taxes (Kolk and Pinkse, 2007). The stakeholders with the most power and legitimacy will therefore be the ones that the firm prioritize in its resource allocation to meet their demand (Ashrafi et al., 2020). Which stakeholders that are important however, may change over time and is relative to each firm's context (Buysse and Verbeke, 2003).

Stakeholder theory and corporate sustainability are closely related as they share the same understanding of what the purpose of business is, namely to create value for all stakeholders (Hörisch et al., 2014). In addition, both concepts see social and environmental responsibility not as separate from business, but instead they have to be a part of businesses' core strategy by reconceptualizing what value creation is about (Hörisch et al., 2014). In fact, stakeholders is in the core of the definition of corporate sustainability as it is defined as "meeting the needs of a firm's direct and indirect stakeholders, without compromising its ability to meet the needs of future stakeholders as well" (Dyllick and Hockerts, 2002, p. 131). Since businesses interact and have responsibility towards its stakeholders, stakeholder

theory can explain the behavior and action of firms when it comes to sustainability (Ashrafi et al., 2020). Research shows how stakeholder pressure has a positive effect on firms' sustainability initiatives (Guoyou et al., 2013; Yu et al., 2017). For example, stakeholders put pressure on businesses to set targets to limit their emissions and to disclose information about their operations (Kolk and Pinkse, 2007). Because of this, stakeholders, with their high potential influence, also have an important responsibility in keeping businesses accountable for their actions (Lee, 2008).

The stakeholder theory help explain how sustainability initiatives can positively impact the competitiveness of firms (Xie et al., 2019). By listening to the needs and expectations of its stakeholders, firms can find new ways of creating shared value through sustainability (Ashrafi et al., 2020; Xie et al., 2019). By meeting the needs of their stakeholders firms will get increased trust and support resulting in an enhanced corporate image (Quazi and O'Brien, 2000; Xie et al., 2019). The corporate image is an important determinant of customer satisfaction and a positive public image, which can lead to increased sales and stock prices (Xie et al., 2019). A unique corporate image is also a rare, non-substitutable and inimitable resource that can differentiate firms from its competitors and create competitive advantage (Quazi and O'Brien, 2000). Meeting the needs of its stakeholders also gives the firm "license to operate" which every firm is dependent upon as stakeholders give tacit or explicit consent or "permission" to operate as a business (Laudal, 2011). By undertaking sustainability initiatives businesses will build strong relationship with the society, which much likely will be rewarded by positive ratings and profit (Quazi and O'Brien, 2000). Thus, the stakeholder theory demonstrates that in order to survive, firms are not only accountable to its shareholders' interests, but to a range of stakeholders controlling important resources (van Marrewijk, 2003).

Thus, to sum up: stakeholder theory can both explain how stakeholders is an important driver when it comes to the implementation of sustainability innovations, but it can also explain why firms can gain increased competitiveness by implementing these innovations.

2.7 Resource based view: Creating competitive advantage through sustainability innovations

In order to integrate stakeholder demands in their sustainability innovations and create competitive advantage, firms must develop their resources (Hart, 1995). The resource-based view (RBV) argue that the differences in competitive advantage among firms can be explained by their resource heterogeneity (Barney, 1991; Christmann, 2000). More specifically, in order to obtain sustained competitive advantage firms must have resources that are a) valuable (V), in that sense that they enable firms to be more efficient or effective b) rare (R), in that sense that it is not simultaneously implemented by competitors, c) imperfectly imitable (I), by that firms that do not possess these types of resources cannot obtain them, and d) non-substitutable (N), which means that there can't be any equivalent resources competitors can obtain (Barney, 1991). In this context resources are defined as "all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness" (Barney, 1991, p. 101). The resources could be physical resources (e.g. technology, plant, and equipment), human resources (e.g. training and experience of employees) or organizational resources (e.g. reporting structure, planning and relations between groups within or outside the company) (Barney, 1991). Thus, in order to create competitive advantage the firm has to hold a bundle of unique resources that are valuable, rare, inimitable and non-substitutable such as specific management skills, physical assets, or efficient organizations processes and routines (Hang et al., 2019; Buysse and Verbeke, 2003).

RBV is an important theory in order to understand how firms can gain competitive advantages from sustainability innovations (Annunziata et al., 2018; Grewatsch and Kleindienst, 2017; Tu and Wu, 2021). By introducing sustainability innovations that are valuable, rare, inimitable and non-substitutable, firms can gain a competitive advantage (Tu and Wu, 2021). However, Hart (1995) argues how the RBV is constrained by the natural environment in order to build competitive advantage, and therefore introduces the term natural-resource based view (NRBV). The enormous sustainability challenges both constrain and influence business markets, and therefore firms must create environmentally oriented resources and capabilities in order to build competitive advantage in the future (Hart, 1995).

Hart (1995) explicitly introduces three different but interconnected strategies that could contribute to both increased sustainability and competitiveness; pollution prevention, product stewardship and sustainable development. Pollution prevention concerns reducing the firm's emissions and waste, leading to cost reductions through increased efficiency and reduces compliance and liability costs (Hart, 1995). Further, product stewardship includes going a step further than only operations and production, and concerns the ability to integrate key stakeholder demands into the development and design of products, and minimize environmental impact throughout the whole value chain (Hart, 1995). Here the goal is to make more environmentally friendly products, both in terms of environmental impact, resource use and ease of recycling and reuse, and competitive advantage can be achieved by preempting competitors both in terms of future regulations and access to important, limited resources (e.g. locations or customers). The last strategy, sustainable development, concerns continuous investments and long-term commitment towards solving the sustainability challenges, by for example investing in low-impact technologies, especially in the emerging economies. In this way, the firm invest in future competitive advantage (Hart, 1995). These three strategies are both path dependent with a sequential logic connected to them — that is, it is challenging to start product stewardship without first going through pollution prevention, but they are also embedded — it's easier to pursue one of the strategies, by the use of the others.

In order to build competitive advantage, it's not enough to have resources – the firm also need capabilities to utilize and manipulate them into value-creating strategies (Christmann, 2000; Eisenhardt and Martin, 2000; Piening and Salge, 2015; Wang and Ahmed, 2007). A capability is defined as “the ability of an organization to perform a coordinated set of tasks, utilizing organizational resources, for the purpose of achieving a particular end result” (Helfat and Peteraf, 2003, p. 999). In other words, capabilities is the ability of assembling, integrating and managing the bundle of different resources (Russo and Fouts, 1997, p. 537), or the capacity to perform a certain activity (Helfat and Peteraf, 2015). Due to the sustainability challenge, the development of sustainability oriented capabilities such as resource management, waste minimization, green product design, stakeholder integration and reduction of energy and waste, will be increasingly important in the future in order to build competitive advantage (Grewatch and Kleindienst, 2017; Hart, 1995).

2.8 Solving the sustainability challenges through the development of dynamic capabilities

The weakness with the RBV is the unilateral focus on internal resources in static environments, as in order to build competitive advantage the external environment also must be taken into consideration as the relevance of a firm's resources can change over time (Beske, 2012; Hart, 1995; Strauss et al., 2017). The dynamic capability theory is a spring off from the RBV, and acknowledges that a firm needs to change and adapt based on their external environment, and continuously build, integrate and reconfigure their resources and capabilities in order to stay competitive (Eisenhardt and Martin, 2000; Helfat and Peteraf, 2003; Teece et al., 1997). This means that the dynamic capabilities theory implies that firms not only compete on the utilization of current resources and capabilities (RBV), but also on their ability to create and reconfigure resources and capabilities to adapt to the changing environment (Chen and Chang, 2013; Hart and Dowell, 2011). Thus, dynamic capabilities enhances the RBV by "addressing the evolutionary nature of firm resources and capabilities in relation to environmental changes..." (Wang and Ahmed, 2007, p. 35).

Dynamic capabilities are defined as "the capacity of an organization to purposefully create, extend or modify its resource base" (Helfat et al., 2007, p.4). Thus, in increasingly unstable and complex environments, firms gain competitive advantage by creating and reconfiguring its resources in line with the external environment (Amui et al., 2017). Having a dynamic capability involves effectively managing a cluster of activities in order to achieve something that is strategically imperative (Feiler and Teece, 2014, p. 15). For example, during a hiring process the capability of best practice in recruitment is not sufficient to create value. Instead the firms needs to have the dynamic capability of "people strategy" that involves managing a cluster of activities such as recruitment, on-boarding learning, leadership and culture, to create value through the recruitment of the new employee (Feiler and Teece, 2014).

Dynamic capabilities are not something that solely emerge, instead firms must develop capabilities within sensing, seizing and reconfiguring though intentional efforts (Feiler and Teece, 2014). Sensing involves scanning the external and internal environment in order to find new strategic opportunities, and may involve talking to suppliers and customers, obtaining knowledge about competitors and what is happening in the business ecosystem, exploring technological opportunities or examining markets (Feiler and Teece, 2014; Teece, 2007). Seizing involves capabilities to capture the identified opportunity by developing new

products, processes or services (Teece, 2007). Seizing capabilities can include investments in R&D and commercialization, developing a business case, aligning stakeholders, raising capital and planning the implementation of the innovations (Feiler and Teece, 2014). Finally, reconfiguration involves the alignment and realignment of tangible and intangible assets to stay relevant and competitive as internal and external environment changes, and can include managing co-specialization, business model redesign and knowledge management (Feiler and Teece, 2014; Teece, 2007). Thus, dynamic capabilities can be described as “the capacity with which to identify the need or opportunity for change, formulate a response to such a need or opportunity, and implement a course of action” (Helfat et al., 2007, p. 2).

Firms’ ability to develop dynamic capabilities is crucial if we are to solve the sustainability challenges (Wu et al., 2013). Dynamic capabilities are important in the context of sustainability as firms continuously have to strengthen and renew their capabilities to be able to integrate sustainability challenges into the innovation development (Dangelico et al., 2017; Eikelenboom and de Jong, 2019; Mousavi et al., 2018). Firms that want to implement sustainability innovations face unpredictable changes both in terms of supply, market, competitors and stakeholders that influence the firms (Beske, 2012). Thus, in order to respond to the sustainability challenges firms must adapt, change and innovate to cope with the rapid changes in the environment (Amui et al., 2017). The implementation of sustainability innovations involves knowledge that goes beyond the firm’s existing knowledge base, which requires development of innovation capabilities to be able produce innovations that are both sustainable and competitive (Mousavi and Bossink, 2017).

Several studies find that firms with dynamic capabilities are better able to develop sustainability innovations due to their ability to orchestrate their existing knowledge and resources to create value for customers (e.g. Huang and Li, 2017; Khan et al., 2021; Mousavi et al., 2018; Singh et al., 2022; Yousaf, 2021). Many important dynamic capabilities for sustainability are identified in the literature. For example, capabilities such as collaboration experience, innovative capacity, eco-design, and market-orientation, are important for successful sustainability implementation (Amui et al., 2017; Chakrabarty and Wang, 2012; Dangelico et al., 2017). Thus, many firms struggle with implementing sustainability in their business because they lack the appropriate capabilities and resources to succeed (Da Giau et al., 2020).

Dynamic capabilities are connected with path dependency in that sense that firms that have already experience with sustainability implementation have gained important capabilities that increase their ability to engage in further sustainability implementation (Amui et al., 2017; Christmann, 2000; Schrettle et al., 2014). Thus, dynamic capabilities can be described as activities that are patterned and practiced (Helfat et al., 2007). In this way, sustainability-oriented dynamic capabilities over time become both increasingly non-imitable and non-substitutable. However, Eisenhardt and Martin (2000) argue that the competitive advantage from dynamic capabilities lies in using them “sooner, more astutely, or more fortuitously than the competition to create resource configurations that have that advantage” (p. 1117).

Microfoundations are often used as constructs or sub-dimensions of dynamic capabilities as dynamic capabilities can be seen as higher-order capabilities (Buzzao and Rizzi, 2021; Fallon-Byrne and Harney, 2017). As such, microfoundations are the distinct skills, processes, procedures, organizational structures, decisions rules, disciplines, or interactions that constitute dynamic capabilities (Strauss et al., 2017; Teece, 2007). Similarly, Eisenhardt et al. (2010) define microfoundations as the “the underlying individual-level and group-level actions that shape strategy, organization, and more broadly, dynamic capabilities” (p. 1263). Microfoundations are therefore important for understanding the underlying processes, activities and behaviors that constitute dynamic capabilities (Fallon-Byrne and Harney, 2017). In this way, they give enhanced understanding in where dynamic capabilities come from and how they develop (Fallon-Byrne and Harney, 2017).

3 METHODOLOGY

3.1 Philosophy of science and research approach

What assumptions we make, or what research philosophy we have, influences what we mean by our research questions, the methodology we use and how we understand our results (Saunders et al., 2012). Understanding and acknowledging the different views when it comes to ontology and epistemology is important in order to fully understand research including methods and methodological choices, theoretical debates and approaches to and views of social phenomena (Grix, 2002, p. 176). Grix (2002) explains: "If ontology is about what we may know, then epistemology is about how we come to know what we know" (p. 177). Before I dive further into the research approach of this dissertation, the terms ontology and epistemology need further explanations.

Ontology refers to the way we view the world and what the nature of reality is (Fleetwood, 2005; Saunders et al., 2012), or "what is out there to know about" (Grix, 2002, p. 175). When it comes to ontological positions, there are two main opposite views. Objectivism refers to a view where it is believed that the reality exists independent of one's knowledge of it (Fleetwood, 2005; van de Ven, 2007). "It implies that social phenomena and the categories that we use in everyday discourse have an existence that is independent or separate from actors" (Bryman, 2016, p. 29). In contrast, constructivism or subjective ontology refers to the view where one thinks that the reality is socially constructed (Fleetwood, 2005, van de Ven, 2007). "...social phenomena are created from the perceptions and consequent actions of social actors" (Saunders et al., 2012, p. 132). In research, ontology is the basis for one's epistemological and methodological view (Grix, 2002).

Epistemology refers to what we think can be known about reality and the question of what is acceptable knowledge (Fleetwood, 2005; Grix, 2002; Saunders et al., 2012). A lot of the debate concerns whether it is possible and suitable to use the same principles and procedures as the natural sciences when studying the social world (Bryman, 2016). In this regard, positivism refers to the position where it is believed that the methods of natural sciences can be used to study the social reality and that research can be conducted in an objective way (Bryman, 2016). Here, the use of hypotheses is common and one will often collect data where one can search for causal relationships and regularities (Saunders et al., 2012). It is believed that everything can be described, measured and compared

(Mehmetoglu and Jakobsen, 2017). A contrasting position is interpretivism, in which it is believed that since social sciences differ from natural sciences, the research logic must be different. The social world is too complex to be measured in the same way as the natural sciences, and we continuously interpret and interact with the social world surrounding us, resulting in a constant adjustment of our meanings and behavior (Saunders et al., 2012). Therefore, it is up to the social scientist to “grasp the subjective meaning of social action” (Bryman, 2016, p. 26). Thus, our view as researchers on ontology and epistemology have important implications for our research, both when it comes to methodological choices as data collection and our interpretations of the results.

When it comes to this thesis I first conducted a systematic literature review (paper 1), and then I conducted two quantitative studies (paper 2 and 3). The quantitative papers test several hypotheses and are thus associated with the positivist view, where it is believed that everything can be measured and described (Mehmetoglu and Jakobsen, 2017). I found the quantitative method really interesting and valuable to use in papers 2 and 3, as I got the opportunity to study many firms at the same time and see patterns and relationships across the firms. However, I felt that the quantitative method could not give me all the answers I was looking for, and I saw the need to talk to firms to get more information and insights about their sustainability implementation. Therefore, I found it appropriate in my final paper to do a qualitative case study (paper 4). The final paper is therefore associated with the interpretivism in that the reality is not that simple to measure (Saunders et al., 2012). In the last paper, I got the opportunity to get more details in important topics and also ask questions about things that were still unclear after the literature review and the two quantitative papers. Thus, I think that the different methods I have used in this dissertation complement each other and give a more comprehensive picture of the main research question.

Since I use both quantitative and qualitative methods in the papers, the overall methodology of the thesis is a mixed method research design. I argue that this is appropriate and helpful as I think that the different ontological and epistemological positions offer their own unique way of looking at the world, and a mixed method will therefore give me a rich, multifaceted view of the phenomena I am studying. Because of this, I place myself as a researcher within the pragmatism view, where it is believed that depending on the research question, one

research philosophy position may be more relevant and appropriate than others (Saunders et al., 2012). Thus, it is the research question that decides the method used (Fetters et al., 2013). Kelemen and Rumens (2008) argue: “As each lens offers a selective focus, researchers seek multiple perspectives of particularly complex and ambiguous phenomena” (p. 32). As such, each lens has focus on different representations, illustrating different dimensions of the phenomena that is being studied (Kelemen and Rumens, 2008). Hence, within pragmatism the researcher values different methodologies as each methodology has its pros and cons, which can help demonstrate the complexity of the organizational reality (Kelemen and Rumens, 2008). Using mixed methods is a way of triangulating findings which will lead to increased validity and the different methods can complement each other with different angles on the phenomena being studied, leading to a more comprehensive understanding (Bryman, 2006). By using both qualitative and quantitative methods the gaps from one method can be filled by the other, and vice versa (Bryman, 2016; Fetters et al., 2013). Thus, I therefore have a pragmatist view by that I’m open to several research methods, and I believe that the appropriate research method will depend on the research question. I also believe that the different research questions and methods in my papers each contribute in a unique way to answering the main research question, and that the use of different methods strengthen the findings of the dissertation.

Table 1: *The research papers’ RQ, research approach, data collection and observations*

	Paper 1	Paper 2	Paper 3	Paper 4
RQ	What does current research say about the relationship between sustainability innovation and competitiveness, and what are the contextual factors that affect this relationship?	Does the adoption of sustainability strategies lead to actual implementation of social and environmental innovations? What affect do environmental and social innovations have on firms’ ability to create value, reducing costs and reducing market risk?	How are efforts toward environmental innovations impacted by a sudden exogenous shock such as COVID-19?	How can firms in the oil and gas industry transition into emerging renewable energy industries by using dynamic capabilities? More specifically, how can the firms use their existing resources and knowledge in new, future-oriented industries by aligning and reconfiguring their existing resource base and by acquiring new resources?
Research approach	Systematic literature review	Quantitative	Quantitative	Qualitative
Data collection	Peer reviewed, empirical articles	Survey data and financial data	Survey data	Multiple-case study
Observations	100 articles	Responses from 682 managers	Responses from 526 managers	Six case companies

3.2 Main methodological issues in papers

As all research articles, the papers in this dissertation also have some methodological issues worth discussing. The methodological issues for each paper is discussed in the respective papers, however I will further elaborate on the main methodological issues below.

3.2.1 Methods - Paper 1

In the first paper we wanted to find out what the literature said about the relationship between sustainability innovations and competitiveness. Thus, a systematic literature review was seen as an appropriate methodology to answer the research question as literature reviews are typically used when one wants to get an overview of a certain topic (Snyder, 2019). What characterizes a *systematic* literature review is that the aim is to gather and assess all relevant research on the topic in order to answer the specific research question (Snyder, 2019). Snyder (2019) argues how a literature review with high quality must be replicable and demonstrate an appropriate search strategy and offer analysis and insights that offer valuable contributions to the research field.

As the aim of a systematic literature review is to include all relevant articles on the subject, the first main methodological issue is about the search strategy which influences what articles that were included in the review. In the literature review, four databases were used to the search for relevant articles: ABI/Inform Collection, Business Source Complete, Entrepreneurship Database, and Scopus. Even though these databases cover a lot of peer-reviewed research from thousands of publishers, there may have been some relevant articles that were not included in these databases and therefore have been omitted from the review. Another factor that may have influenced what articles were included is the search strings that were used to find relevant articles. One of the challenges with sustainability innovations is the many synonyms that are used in the literature (Arfi et al., 2018). Even though we included a range of keywords in our search strings (Sustainable/sustainability innovation – green innovation – eco-innovation – environmental innovation – social innovation – societal innovation) some relevant articles that have used other terms (for example resource efficient innovations, cleaner production-oriented innovations) might not have been included. The same issue is present regarding the key words used for competitiveness – some relevant articles might not have been discovered

due to other terms used in potentially relevant papers. In order to minimize this issue, we have a high focus in describing the process in how the literature review was conducted in the method section of the paper. This includes what databases and key words were used in the search for relevant articles. We also specifically list the inclusion and exclusion criteria in the selection of articles. In this way, the steps of the literature review are highly transparent, and other researchers that want to expand the findings of our paper, can learn from our paper to see what aspects they can build on.

Another methodological challenge when it comes to the literature review is the validity of measurement of both sustainability innovations and competitiveness in the included papers. The 100 included papers in the literature review measure sustainability innovations and competitiveness in different ways. It is obvious that the way both sustainability innovations and competitiveness is measured in the papers will influence the findings, and subsequently the findings of the literature review. However, in order to overcome this methodological challenge in the literature review we list the competitive outcomes of each paper accompanied with the reference to the paper (see Tables 4-6 in Paper 1). In this way, we make it clear what competitive outcome the papers found, and the readers that are further interested can read the specific paper to see what sustainability innovation variable they use.

3.2.2 Methods - Paper 2

In the second paper the aim was to find out whether firms that implement sustainability strategies actually implement more environmental and social innovation, in addition to what influence the implementation of environmental and social innovations have on firm performance. Because of this aim we found a quantitative methodology appropriate in the form of a survey. Here, I got the opportunity to use data that was already collected by my research group during the autumn 2015 and spring 2016. My research group had extracted around 4300 Norwegian manufacturing firms that belonged to NACE group C from the Brønnøysund Business register. Firms in the NACE group C are involved in industrial production which mainly deals with the physical or chemical transformations of materials, substances or parts into new products (SSB, n.d). This can for example be the production of food products, textiles, chemical products, metals or machinery (SSB, n.d). From the

extracted list, firms that lacked contact information and financial activity were removed, resulting in that the survey was sent out to approximately 2638 firms. The survey received 682 respondents, giving a response rate of 25.9% %. In addition to the survey data, we gathered financial data in the spring 2020 from all the firms that had participated in the survey. The financial data was gathered using Proff Forvalt, which is a provider of financial records from Norwegian firms. In order to get longitudinal data, we gathered financial data from the years 2015 to 2019. This let us measure competitiveness both in terms of perceived competitiveness (from the survey) and objective competitiveness (financial data from Proff Forvalt). Structured equation modelling was used to analyze the data.

The methodology of the paper has two main methodological challenges worth highlighting. The first issue is the operationalization of the constructs. Do we measure what we aim to measure? Looking at the literature one can see that environmental innovations, social innovations and competitiveness is measured in many different ways (Cillo et al., 2019; Hussain et al., 2018), and how the constructs are measured will affect the results. In order to cope with this issue, the constructs were made based on prior research. Prior to sending out the survey, it was also validated by several researchers. In this way, one could increase the validity of the measures used. In addition, in order to minimize the issue with operationalization in regards to the competitiveness construct, we also include the financial measures from Proff forvalt. In this way we have two measures of “competitiveness”, both self-reported and objective financial data, which contribute to increase the validity of the findings.

The second issue relates to the directionality of the sustainability innovation-competitiveness relationship. This is a big challenge in the sustainability-competitiveness literature, as most studies use cross-sectional data, making it challenging to say something about causality (Chu et al., 2019; Lin et al., 2019; Martínez-Ferrero and Frías-Aceituno, 2015). In order to cope with this issue, we use longitudinal financial data from the years 2015-2019. However, even though this reduces the uncertainty of the directionality of the sustainability innovation-competitiveness relationship substantially, we cannot say that this issue is completely solved. One way of solving this even more could have been to ask the respondents the point of time in which they implemented the sustainability innovations, and gather financial data from the years prior and after the implementation. Doing this we could

have had even stronger confidence in the causality of the relationship. However, conducting this kind of study is resource -and time consuming. When seeing the findings of the paper together with the findings of the literature review, we can have high confidence in that the findings are not prone to the issue of directionality in this case. In addition, since we use both subjective and objective firm performance data, the issue of directionality is reduced.

3.2.3 Methods - Paper 3

In February 2020 the COVID-19 pandemic entered the world and many businesses got severely affected. As researchers, we were interested in finding out if and how the pandemic influenced the sustainability implementation in firms. Thus, the aim of the third paper was to find out how COVID-19 affected the degree of environmental innovation in the firms. Here, like paper 2, we found a survey appropriate in order to answer the research question. Thus, my co-authors and I developed a survey that was sent out to around 8500 manufacturing firms in Norway belonging to NACE group C, extracted from the Brønnøysund register. After sending out the survey, it turned out that a lot of the respondents of the survey were not relevant due to non-financial activity of the firm, invalid email addresses, and their firm being out the scope (e.g. manufacturing jewelry as a hobby). Thus, the correct number of relevant firms were estimated to be somewhere between 3000-4500 firms. As we received 526 responses of the survey, the resulting response rate was between 11.7-17.5%. The data was gathered during December 2020 and January 2021. We used structured equation modelling to analyze the data.

An issue concerning the methodology of this study is that the data is cross-sectional, meaning that the “data is collected from a single respondent at a single point in time” (van der Stede, 2014, p. 569). In cross-sectional studies it is challenging to prove causality, as this requires a different research design such as panel data or longitudinal data and it can therefore not be known which way the relationship goes (Chu et al., 2019; Lin et al., 2019; Wijethilake et al., 2018; Wilderom et al., 2012). Therefore, in our study it is challenging to prove causality in that it was COVID-19 that led to a reduction of environmental innovations. However, we argue that since we asked the respondents of environmental innovation before COVID and environmental innovation during COVID, respectively, we know that the environmental innovations were reduced during COVID-19. We therefore argue that this

decrease in environmental innovation is most likely due to COVID-19. Further, the causality issue can be reduced as intuitively and theoretically the finding makes sense (van der Stede, 2014). The hypothesis was made based on existing theory, and it makes theoretically sense that firms reduce their environmental innovation efforts during a crisis such as COVID-19. In addition, we use several control variables (firm size, firm age, revenue and type of firm) to be more confident in the finding that COVID-19 could explain the variation in environmental innovation (van der Stede, 2014). Nevertheless, we urge future research to examine how the degree of environmental innovations has changes in the long term after COVID-19 by using longitudinal data.

Additionally, this paper shares the same methodological challenges as paper 2 when it comes to operationalization of constructs. Regarding the development of the environmental innovations construct we used a measure that have been validated by prior research several times. The impact-from-COVID-19 construct, was also made based on prior research. However, since COVID-19 was a new phenomenon, the measures associated with this is still quite new and not extensively used in research. However, also here, we tried to improve the validity of the measures by consulting with other researchers before the survey was sent out. We also include all the items in the paper, to be transparent and give other researchers the opportunity to validate them.

3.2.4 Methods - Paper 4

In paper 4 we wanted to study how firms can transition towards more sustainability-oriented industries by the use of dynamic capabilities. In this context, we found the oil and gas industry interesting to study as this is an industry with high emissions and pressure of becoming more sustainability oriented. There are also expectations that firms in the oil and gas industry phase out their current operations and have more and more sustainability focus in their operations. In addition to this, the industry has experienced high price volatility, making their business vulnerable to risks. As we wanted to study the process of how firms go into new markets, we found the case study methodology appropriate as case studies typically is preferred when answering a “how” question (Yin, 2018). In addition, case studies are appropriate when studying contemporary, or both past and present, events (Yin, 2018). The main source of data was semi structured interview data that were gathered based on

interviews with six oil and gas firms. The selection of firms was made by a purposive sampling, indicating that firms were selected based on their relevance to the research question (Bryman, 2016; Ishak and Bakar, 2014). In addition to the interview data, we also use secondary sources such as news, web-pages, and other relevant secondary documents. By this, we can triangulate the data and verify the findings.

As the other papers, paper 4 also has some methodological challenges. First, is the sample of the case companies. In the paper we included six case companies. If we have included more case companies or different case companies, the findings may have been different. What kind of case companies that are included will influence how generalizable the findings of the study are (Eisenhardt, 1989). However, when looking for appropriate case companies in the spring 2021, we found out that many of the sustainability innovation developments were not publicly available and therefore challenging for us to find. We therefore used some time to find appropriate case companies, and looked for potential companies in different web pages, offshore-wind databases, energy clusters and research projects. Not many case companies fitted the inclusion criteria. This is because we had to find firms that had actually started on their sustainability innovation development, and thus had gained some experience in going into the renewables energy sector. Thus, we had to find firms that had already done investments towards the sustainability innovation implementation and had employees that were working on this. In addition, we could only include companies that had a long-term focus on sustainability, and not just sustainability as a temporary project. In the end we contacted 7 firms, where one of them said no to participate in the study, whilst one recommended us another company they felt was more suitable. Therefore, even though the sample of cases could have been larger, given the challenge to find the appropriate case companies we argue that there were most likely not many other firms that were relevant to include. In addition, in relation to the knowledge and information we received from the six cases, we argue that the sample size reached saturation point after the six case companies, which means that additional cases would not necessarily lead to any new information (Ishak and Bakar, 2014).

The second point is about the issue of generalizations of the case study's findings, or its external validity (Yin, 2018). The findings of qualitative studies, including case studies, are often criticized for not being generalized to other settings as the interview data is based on a

small number of interviews that are not selected randomly from a specific setting (Bryman, 2016). Hence, as the context in this research is Norwegian oil and gas companies, it may be discussed how the findings apply to other countries and industries, facing different pressure, expectations, financial support and regulations (see chapter 3.3 for more elaboration on the context issue). However, even though the study is conducted in Norway we argue that that the findings most likely are transferable to other countries as well. Many oil and gas companies are international and are in markets around the world, and face the same kind of pressure to reduce their environmental and social impact. Thus, we argue that the Norwegian context in relation to this not necessarily is unique. Furthermore, we also argue that even though we specifically study oil and gas firms, the findings most likely are transferable to other industries also. There is high potential for other industries to also use their existing resources and capabilities and go into adjacent industries that are more sustainability-oriented like the renewables sector.

3.3 How the context of the empirical data gathering may influence the findings

In addition to the methodological issues associated with each paper, I want to briefly argue how the Norwegian context and industry context could influence the findings of the papers.

3.3.1 Norwegian context

The empirical data used in paper 2, 3 and 4 is gathered among Norwegian firms. First of all, as we are located in Norway which is a small country, there are good opportunities for gathering data as many firms are positive to participate and contributing to research. Norway has good opportunities for financial support towards sustainability through support schemes as The research council of Norway and Innovation Norway. In addition, between 2014 and 2020, Norwegian business received 16.2 billion NOK from the EU research and innovation funding program Horizon 2020, responding to 2,53% of the total funding from the program (Forskningsrådet, 2022). This indicate that there is a high focus of research and development in Norwegian businesses. Further, Norwegian firms have high focus on sustainability, and score high on innovation capacity, education level, and ethics and accountability (World economic forum, 2012). Hence, the Norwegian context makes a good opportunity to examine how firms work towards increased sustainability.

However, it is important to note that the results in this study may be affected by the Norwegian context, especially as Norway is one of the countries with most focus on corporate sustainability. Norwegian firms view sustainability as important and the national conditions give good opportunities for creating value from sustainability. Therefore, because of the Norwegian context it is important to have in mind that firms in other countries does not necessarily have the same foundation for both developing sustainability innovations and profiting on them. For example, Rezende et al. (2019) find that firms in different continents have differences in the green innovation-financial performance relationship - for example Europe has a positive relationship both in short and long term, while North America do not (Rezende et al., 2019). Thus, the findings in this dissertation must therefore be seen in light of that different national contexts may have different outcomes from the implementation of sustainability innovations (Chu et al., 2019), and different conditions when it comes to developing these innovations.

In addition, as briefly argued in chapter 2.2, Norway has a high focus on social sustainability. Norway is in fact one of the countries in the world that score the highest on social sustainability (World economic forum, 2012), and ranks nr. 1 of 169 countries on the Social Progress Index measuring social performance (Green et al., 2022; United Nations, 2023). Thus, social considerations are well established in Norwegian industries, and the context may therefore not be the best of studying social innovations. Therefore, in this dissertation the main focus lies on the environmental pillar of sustainability, as in Norway it is here the potential for improvement is highest. It is therefore only in paper 2 we specifically measure social innovation, while in paper 3 and paper 4 the focus lies on environmental innovations. However, as I argue in chapter 2.2 I still call all the innovations studied in this thesis sustainability innovations, as the majority of Norwegian firms have social considerations well implemented in their businesses, thus having the social pillar well covered.

3.3.2 Manufacturing industry and oil and gas industry

As the national context may influence the findings in this dissertation, so may the industry context in which the data is gathered. While paper 2 and 3 gather empirical data from the manufacturing industry, paper 4 gathers data from the oil and gas industry.

The manufacturing industry is an important industry for the production of products and services, and is a significant contributor to employment and value creation in Norway, where the industry's export represents 29% of Norway's total export income (NHO, n.d.; Sintef, 2019). However, as the manufacturing industry uses high amounts of energy and resources, the industry is viewed as one of the most polluting industries and subsequently have a lot of potential to become more sustainability oriented (Dey et al., 2020; Schrette et al., 2014).

Further, the oil and gas industry is an interesting industry to study as oil and gas traditionally has been a cornerstone in the global economy (Ahmad et al., 2017). In Norway the oil and gas industry is the industry with the highest value creation pr. employee (Sintef, 2019). The industry has a lot of attractive resources and capabilities that can be used in other sectors such as the renewables sector. However, due to the industry's negative environmental and social impact, the industry is pressured to lower their negative impact and become more sustainability-oriented (Ahmad et al., 2017; George et al., 2016). This especially applies to the Norwegian oil and gas companies, which face strict regulations and extreme pressure in becoming more sustainability-oriented in their business. Hence, also the oil and gas industry has high potential for increasing their sustainability performance, which again lead to opportunities for value creation.

Thus, the choice of industries could affect the findings in our papers. Different industries have different regulations, pressure, barriers and opportunities in implementing sustainability, which may also affect the competitive outcomes resulting from these innovations (Cherrafi et al., 2018; Chu et al., 2019). In an industry where there are many opportunities and potential for becoming more sustainable, like the manufacturing industry, it likely that this will affect the influence on firm performance (Burki et al., 2018). For example, Rezende et al. (2019) find a positive relationship between green innovation and financial performance among manufacturing firms, both in the short and long term, while non-manufacturing firms do not have this positive relationship. In highly polluting industries there may be easier to find opportunities for sustainability innovations by for example reducing waste, increasing the efficiency in production processes or creating more environmentally friendly products (Rezende et al., 2019). In addition, firms in highly polluting industries are more likely to implement these kinds of innovations as they face higher pressure from stakeholders to become more sustainability-oriented (Rezende et al., 2019).

Because of these reasons it is important to have in mind that the choice of industries also may have affected the results of the studies. Therefore, as we also mention in chapter 5.4, future studies should examine different types of industries to investigate how other industries work with sustainability innovations, and their effect of competitiveness.

4 FINDINGS

This chapter explains the background, research question, methodology, key findings and contribution of each paper in this dissertation.

4.1 Paper 1: Sustainability innovations and firm competitiveness: A review

Background

In order for firms to conduct sustainability innovations, they have to be profitable for the firm. Thus, for my first paper I saw the need for conducting a literature review on the relationship between sustainability innovations and competitiveness in order to get a better understanding of what current research actually says about this topic. The literature has for a long time been divided, where the traditionalist view sees sustainability innovations as cost drivers, while the revisionist view sees sustainability innovations as potential for increased value creation. In addition, the relationship is complex and there are various factors that can influence the outcomes of sustainability innovations. Thus, we saw the need for conducting a literature review in order to examine this relationship, and what factors that affect it.

Research question

What does current research say about the relationship between sustainability innovation and competitiveness, and what are the contextual factors that affect this relationship?

Method

This study uses a systematic literature review method in order to answer the research question. Here, 100 peer-reviewed articles are included in the review.

Key findings and contribution

In the literature review, it is found that 64 out of 100 studies find a positive relationship between sustainability innovations and competitiveness, 29 find a mixed relationship (positive, neutral and/or negative effects), 5 studies reported inconclusive findings, while 2 studies found negative effects. When it comes to the contextual factors that affect the relationship between sustainability innovations and competitiveness there are found several moderators and mediators. Regarding moderators the variables can be divided in national, market, industry and firm factors. The mediators are categorized within firm factors. Further,

it is found that sustainability innovations are mainly divided into product, process and managerial innovations, while firm competitive outcomes can be divided in increased value creation, reduced costs and non-financial assets (see Figure 2).

In this study we contribute to the research field by reviewing what current research actually says about the relationship between sustainability innovations and competitiveness. As the majority of studies find that sustainability innovations can lead to increased competitiveness, the findings of this study support the revisionist view in that sustainability innovations can create many new business opportunities for firms. Hence, the main finding of the review can give increased motivation and incentives for firms to implement sustainability innovations, and thus contributing to solving the sustainability challenges. In addition, the contextual factors we find that affect the sustainability-competitiveness relationship, also have important contributions to practitioners and gives a lot of opportunities for further research studying this in more depth.

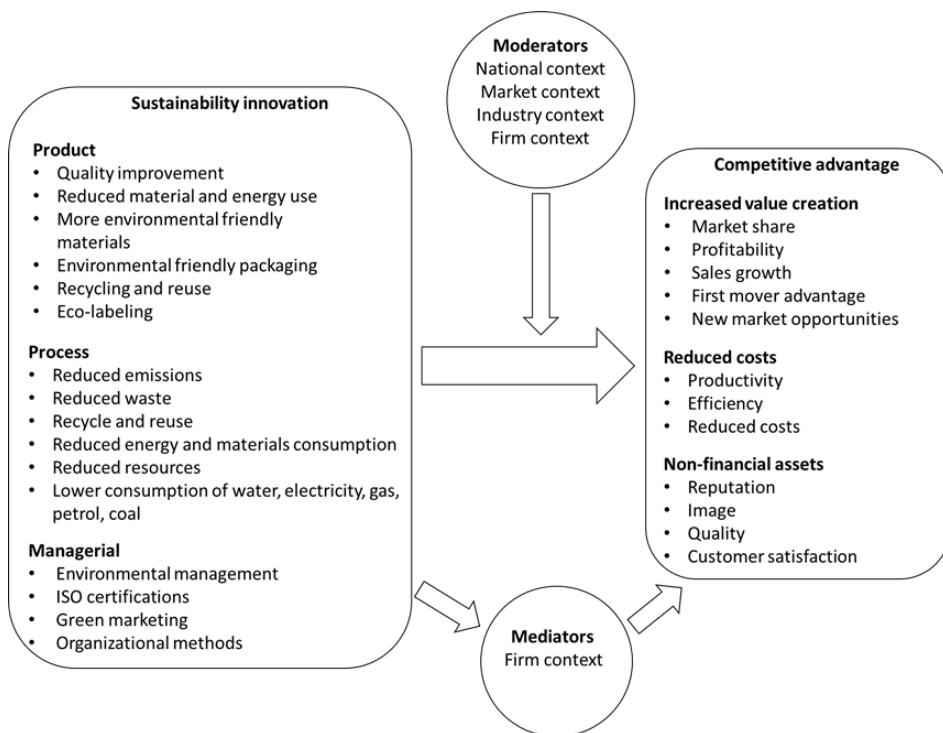


Figure 2: Sustainability innovations and competitiveness variables found in paper 1.

4.2 Paper 2: Competitive sustainable manufacturing - Sustainability strategies, environmental and social innovations, and their effects on firm performance

Background

After conducting the literature review, we wanted to empirically test how the implementation of sustainability innovations affect the competitiveness in the Norwegian manufacturing industry. In order to get a more nuanced picture, we found it interesting to divide sustainability innovations in environmental and social innovations. In addition, we wanted to see how having sustainability strategies actually affect the implementation of sustainability innovations. As a lot of the research studying the sustainability innovation-competitiveness relationship uses cross-sectional data, we found it important to test the relationship using longitudinal data as we then can say something about the causal effects of implementing these types of innovations.

Research question

This study investigates the question of whether the adoption of sustainability strategies leads to actual implementation of social and environmental innovations. Further, it investigates the question of whether different types of sustainability innovations – environmental and social – have different effects on firms' ability to create value, reduce costs or reduce market risk.

Method

This study is a quantitative study in which data from a survey and longitudinal financial data is used. The survey was sent out to CEOs of 2638 manufacturing firms in Norway between November 2015 and February 2016. It was received 682 responses, giving a response rate of 25.9 %. The survey included 110 questions about internationalization, growth strategies, sustainability strategies and innovation, managerial motivation and expected financial effects from sustainability innovations. The questions in the survey were answered by the use of a 7-point Likert scale ranging from 1- Not at all to 7- To a great extent. Further, the longitudinal financial data is collected from the online financial service provider Proff forvalt in which financial data of the firms from the years 2015-2019 is used. The rationale of using both survey and actual financial data is to provide a better picture of the directionality of sustainability innovation implementation – that is, is sustainability innovation related to

increased firm performance, or does high performing firms implement more sustainability innovations? In this way, we also aim to avoid common method bias as we measure firm performance both in terms of perceived performance (from the survey) and objective performance (from the financial data).

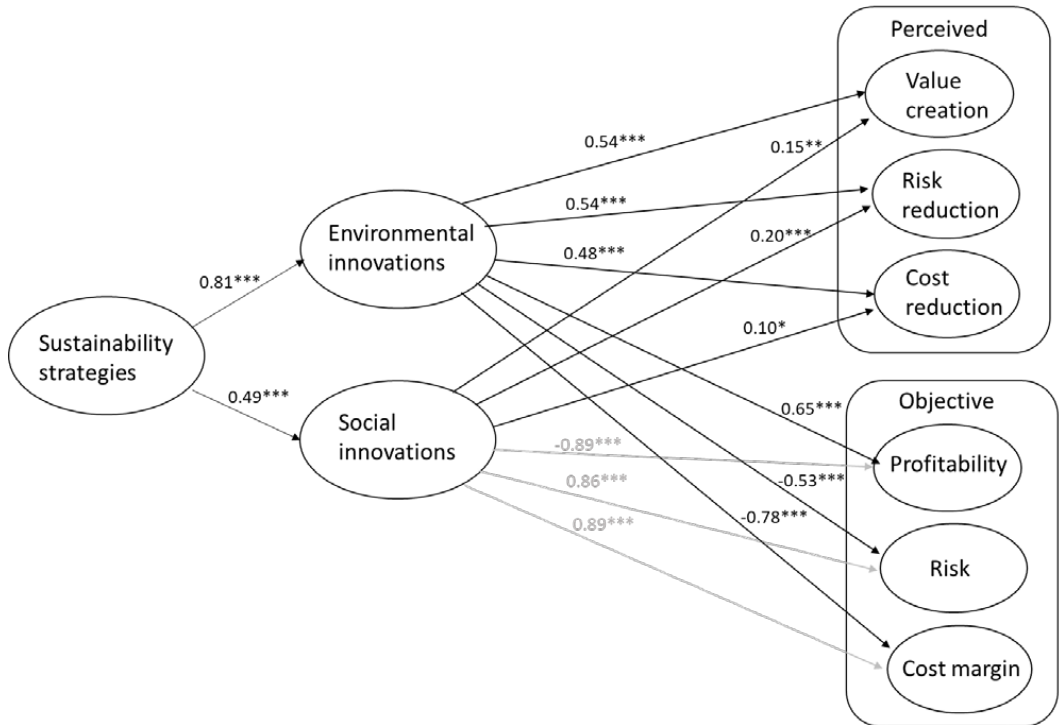
In order to analyze the data, we use structural equation modeling (SEM) in the software Stata/MP version 16. This is an appropriate method to use when the aim is to simultaneously estimate relationships between various independent variables and dependent variables (Hair et al., 2012). The SEM analysis was conducted by using latent path analysis (LPA) that consist of a measurement and a structural part. Both models showed acceptable model fits.

Key findings and contribution

We find that sustainability strategies have a significant positive effect on both environmental innovations and social innovations (see Figure 3). Further, it is found that environmental innovations have a significant positive effect on all perceived firm performance measures, including value creation, cost reduction, and risk reduction. When it comes to environmental innovation's effect on objective firm performance outcome, it is found to have a positive effect on profitability, and negative effect on cost and risk. Note that negative cost and risk mean that costs and risk are reduced which is positive for the firms. Further, social innovations are found to have positive effects on all perceived firm performance measures, including value creation, cost reduction, and risk reduction. However, when it comes to objective performance, social innovations have a negative effect on profitability, and lead to increased costs and risk.

This study has important theoretical and practical contributions. First, we contribute by showing the advantage of having sustainability strategies in order to implement sustainability innovations, which is an important implication for firms. We also contribute by studying the outcomes for both environmental and social innovations, showing how the outcomes between different innovations can differ. In this study, our findings show that firms have greater potential for increased competitiveness by implementing environmental innovations than social innovations, which can be explained by the Norwegian context in which social considerations are already implemented and a common-practice in regulations and industry norms. We also make an important contribution by using longitudinal data,

which is lacking in existing literature. Thus, we can be more confident in that the implementation of environmental innovations actually increases the competitiveness of firms over time, which again can increase firms' motivations of implementing this type of innovations.



***: $p < 0.001$; **: $p < 0.05$; *: $p < 0.1$; NS: non-significant.

Figure 3: The results from the research model. Black arrows represent supported hypotheses, while gray arrows represent unsupported hypotheses. Note: Due to the manner objective risk and cost margin are measured, negative values indicate reduced risk and cost margin.

4.3 Paper 3: Analyzing the impact of COVID-19 on environmental innovations in manufacturing firms.

Background

When the COVID-19 outbreak hit the world, businesses had to make big changes and adjustments because of lockdowns, declined demand and supply, and changes in consumption and investments. As researchers studying sustainability innovations, we found it really interesting to examine how this kind of external shock influenced the

implementation of environmental innovations in firms. In the literature there were two opposite views — COVID-19 could be an opportunity for firms to enhance their environmental innovation efforts, while on the other side researchers argued how COVID-19 would hamper the development of environmental innovations because of strict budgets and firms going into “survival” mode. We therefore wanted to see how this issue played out in the Norwegian manufacturing industry.

Research question

How are efforts toward environmental innovations impacted by a sudden exogenous shock such as COVID-19?

Method

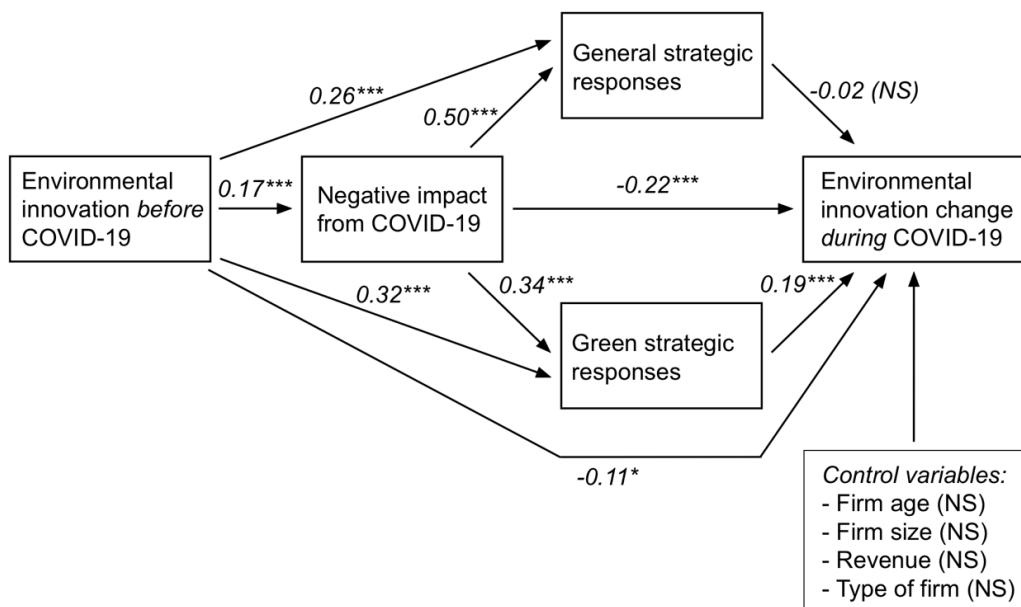
This study uses a quantitative research approach with the use of a survey. The survey was sent out to between 2000 and 4500 manufacturing firms in Norway in the time period December 2020 to January 2021. We received 526 answers on the survey, indicating a response rate of 11.7-17.5 %. In the survey it was asked about how the firms had been affected by COVID-19, type of changes the firms had done in response to COVID-19, in addition to the firms’ environmental innovation efforts, both before COVID-19 and after COVID-19. The questions in the survey were answered by the use of a 7-point Likert scale ranging from 1- Strongly disagree to 7- Strongly agree.

The data was analyzed by the use of the SEM method in the software Stata/MP version 16, in which both a measurement model and a structural model were tested. Both models showed acceptable model fits.

Key findings and contribution

The aim of the paper was to investigate how COVID-19 influenced the environmental innovation efforts in the manufacturing firms. The findings are illustrated in Figure 4. First, our findings show that firms with more environmental innovation efforts are more impacted by COVID-19. Further, our findings show that an external shock like COVID-19 in fact had a significant negative effect on the environmental innovation change. However, our findings also show that COVID-19 made firms conduct general strategic responses and green strategic responses to address the external shock.

The findings of this study have important contributions. The finding that COVID-19 has a negative effect on environmental innovations in firms, shows the importance of stable conditions for implementing these types of innovations. This can be explained by that during uncertainty, firms deprioritize environmental innovations due to financial instability and uncertainty of what the future brings. The deprioritizing of environmental innovations can imply that they are still quite new for many firms and not properly implemented as a core of firms' businesses strategies and operations. Hence, the findings imply the importance of having sustainability as a core of the business strategy in order to make it a key priority also under uncertain conditions. The finding also show the importance of governmental financial support and incentives for environmental innovations in order for firms to continue to pursue these types of innovations during times of crisis.



* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$, NS=non-significant

Figure 4: Results of SEM analysis.

4.4 Paper 4: Transition from fossil fuels to renewable energy: Identifying the necessary dynamic capabilities for a transition in the petroleum-based service and supply industry

Background

In the final paper in the dissertation I wanted to look closer at how firms actually work with implementation of sustainability innovations in practice. The oil and gas industry is an interesting industry in this setting. As the sustainability challenges are increasing, the oil and gas industry is experiencing high pressure to lower their emissions and find more environmentally-friendly methods of producing energy. The oil and gas industry also experience volatile prices that make them vulnerable to external shocks. Thus, oil and gas companies increasingly look for new green innovations in the renewables sector that can make them more competitive and prepared for the future. This sustainability transition requires reconfiguration and renewal of capabilities, resources and assets, and therefore we found dynamic capabilities as an interesting theoretical perspective to use.

Research question

How can petroleum-based service and supply industry firms transition into emerging renewable energy industries using dynamic capabilities? More specifically, we aim to examine how they can use their existing resources and knowledge in new, future-oriented industries by aligning and reconfiguring their existing resource base and by acquiring new resources.

Method

In this study we use a qualitative research method by the use of a multiple case study. The data sources used in this study comes from semi structured interviews and secondary data, where six firms from the petroleum-based service and supply industry are interviewed.

Key findings and contribution

Several microfoundations of dynamic capabilities are identified as important in order to transition towards a greener future in the renewables sector. First, when looking for new innovation opportunities within sustainability the firms show proactive behavior and extend their search window when looking for new opportunities. Next, we find that in order to address the identified opportunities the firms obtain new knowledge and resources in order

to be able develop sustainability innovations in a new marked. An important part of this was to initiate new and cross-sector collaborations to get access to the required knowledge and resources. Finally, the firms are able to use a lot of their existing resources and capabilities form the oil and gas industry in the innovation development. They also show ability of ambidexterity by that they still continue to operate in the oil and gas industry while they at the same time go into a new industry by developing more sustainability-oriented innovations.

This study has several contributions. We show how oil and gas companies can become more sustainability oriented and lower their negative impact on the environment by using a lot of their existing resources ad capabilities to go into more renewable industries. We also contribute by finding specific microfoundations necessary for this type of transition to happen. The study also illustrate how ambidexterity is an important skill in this initial transition phase, where the firms want to improve their sustainability, but still have to continue their current operations to have cash flow that finance their sustainability path.

5 DISCUSSION AND IMPLICATIONS

5.1 Key findings from papers and implications for theory

In this thesis the main research question is: How can businesses contribute to solving the sustainability challenges and simultaneously maintain their competitiveness? Seeing the four research papers together we find high empirical evidence in that sustainability innovations contribute to increased firm competitiveness - thus supporting the revisionist view and concept of shared value creation. Proactive firms can, by reconfiguring and developing their resources and capabilities, find new opportunities within the sustainability shift that increases their competitiveness. However, our findings also show that the implementation of these kinds of innovations are vulnerable to external shocks.

In this section I will discuss the findings of the articles in the light of the research question. The aim is to contribute with important knowledge in how businesses can help solving the sustainability challenges while they at the same time maintain and further increase their competitiveness. This type of knowledge is important if we are to reach the goals of reduced climate change and social differences. In this section I will start with discussing three main findings 1) The importance of sustainability strategies, proactivity, and sustainability innovations in solving the sustainability challenges, 2) How sustainability implementation relates to increased competitiveness, 3) What affect the transition towards more sustainability-oriented businesses. Next, I will discuss how stakeholder theory, RBV and DC are all related and important to understand sustainability implementation and their effect on competitiveness. Subsequently, I will discuss the dissertation's findings in terms of practical and political implications.

5.1.1 Sustainability strategies, proactivity and sustainability innovations

In order for businesses to really contribute towards increased sustainability, firms must start being proactive and view sustainability as a business opportunity (Porter and Kramer, 2011). Being proactive means that the firms believe that profitable opportunities can be found within sustainability as "managers do not find profitable opportunities where they do not look for them" (Hart and Dowell, 2011, p. 1468). Paper 2 in this dissertation directly illustrates how companies that have sustainability strategies, and thus being more proactive, actually implement more sustainability innovations. This makes sense as strategy ultimately

is about the choice of activities (Porter, 1996), and firms that have a sustainability strategy have a plan towards sustainability implementation. The finding that proactive sustainability strategy positively influences the adaptation of sustainability innovation is also found in other studies (Frare and Beuren, 2022; Kitsis and Chen, 2023). Paper 4 also supports this, where it is demonstrated that in order to find new business opportunities within sustainability, the companies must be proactive in their search and open to find new ways of doing business, even it means going into a completely new market. Thus, sustainability is not just another firm responsibility among many other things – instead firms must start viewing sustainability as an opportunity for value creation (Baumgartner, 2014). In sum, being proactive and going beyond compliance to laws is key in order to solve the sustainability challenges (Kitsis and Chen, 2023).

Sustainability strategies and proactivity have a positive influence on the implementation of sustainability innovations which are key to solve the sustainability challenges. By implementing innovations that reduce environmental harm and meet social needs, businesses contribute to solving environmental and social issues. Firms are crucial players towards achieving sustainable development because of their high influence and many resources (Baumgartner, 2014). Businesses have to start addressing their environmental and social impact by implementing sustainability in their decision making (Eweje, 2011). It is vital that firms find out how sustainability implementations can be aligned with the external environment and tailored to the specific firm, its surroundings and business context in order to be successful (Aragón-Correa and Rubio-López, 2007; Eweje, 2011). Not only will these actions contribute to sustainable development, but it is also a step towards remaining competitive in the future (Eweje, 2011).

Stakeholder theory is not only used to explain how sustainability innovations can lead to increased competitiveness (Lankoski, 2008), but it can also be used to explain why some firms are more proactive towards sustainability than others. The reason for this is that stakeholder pressure is an important driver for why firms implement sustainability innovations in the first place (Eweje, 2011). Some firms are more stakeholder oriented and thus more motivated to meet stakeholders' expectations and the overall increasing environmental awareness in the society, and are therefore more proactive and go beyond being compliance driven (Buisse and Verbeke, 2003; Hart, 1995). This coincides with the

study of Rennings and Rammer (2009) who find that firms that have implemented environmental innovations actually use their stakeholders more actively in their search for innovation ideas. Further, Torugsa et al. (2013) find that firms that are more stakeholder oriented are more proactive in all sustainability dimensions (economic, social and environmental). Paper 4 illustrates how the oil and gas companies felt the urge of becoming more sustainable because of the pressure they were facing from stakeholders.

Thus, sustainability strategies and proactivity are vital in order to develop sustainability innovations, which are crucial if we are to solve the sustainability challenges. Finally, stakeholder theory is an important theory in explaining why some firms are more proactive than others and implement these kinds of innovations.

5.1.2 How sustainability implementation relates to increased competitiveness

We can push firms towards implementing sustainability innovations by showing how the implementation of these types of innovations can increase their competitiveness. Sustainability innovations thus become a strategic choice, rather than just an act of “being good”. Because, as we live in a market-based economy firms must be economically successful in order to survive. Thus, finding a “business case” for sustainability is crucial. The majority of firms can find business cases for sustainability (Schaltegger and Burritt, 2018), where the opportunities with most potential are cases that are related to the firm’s business and its focus areas (Porter and Kramer, 2011). Firms also need to identify their unique opportunities and threats concerning sustainability to create competitive advantage (Aragón-Correa and Rubio-López, 2007; Baumgartner, 2014). Paper 1 and 2 in this dissertation clearly show how firms that implement sustainability innovations can increase their competitiveness by increased value creation and non-financial assets, reduced cost or reduced risk.

Paper 1 and 2 show that firms that implement sustainability innovations can increase their value creation by for example increased market shares, sales growth and profitability. Paper 4 also show how oil and gas firms find new business opportunities and thus new ways of gaining profits in renewable energy markets, by implementing sustainability innovations. Further, paper 1 show how implementing sustainability innovations also may lead to increased non-financial assets including improvement of image, reputation and customer

satisfaction. This outcome highly relates to the increased value creation outcome as an increase in non-financial assets will most likely result in, at least in the long run, factors such as increased market shares and sales growth. As we argue in paper 2, these outcomes can be explained by stakeholder theory. When firms meet the expectation of important stakeholders, they will ultimately satisfy a need and create value for potential customers. The implementation of sustainability innovation will lead to increased customer loyalty and strengthen the firm brand and reputation, which can increase market share and sales (Hang et al., 2019; Lankoski, 2008). Meeting the demand of environmental conscious customers can also open up new market segments and markets, and the firms can charge premium prices (Lankoski, 2008). All in all, one can say that by implementing sustainability innovation firms increase customer value (Lankoski, 2008), which ultimately lead to higher income for the firms. Therefore, papers 1, 2 and 4 contribute to stakeholder theory by illustrating how firms can, through implementing sustainability innovations, meet stakeholders' expectations and as a result increase their competitive advantage. Finally, these papers also contribute and support the concept of shared value creation (Porter and Kramer, 2011), by showing how sustainability innovations in fact can create business opportunities that simultaneously are good for society.

Further, paper 2 and paper 4 demonstrate how the implementation of sustainability innovations can help reduce risk. Paper 4 specifically shows how the main reason for the implementation of sustainability innovations is that it is a way of finding a new business opportunity that better fits the expectations of stakeholders, the expectations of downscaling non-renewable energy sources and the rising sustainability trend. The implementation of sustainability innovation was also a measure to create a more resilient business portfolio to avoid big losses due to the high volatility in the oil and gas market. Thus, for the oil and gas companies the implementation of sustainability innovation was ultimately an important measure of reducing business risk. Firms that are passive towards sustainability may face a competitive disadvantage if sustainability concerns become a common practice among their competitors (Buysse and Verbeke, 2003). Hence, it may become risky to not be sustainability-oriented. In contrast, firms that early on implement sustainability innovations in their markets may gain first mover advantages (Buysse and Verbeke, 2003). By being proactive towards sustainability, firms can also reduce risk by

preparing for future regulations (Christmann, 2000; Russo and Fouts, 1997). Proactive firms can avoid or reduce regulatory costs, plan the future with more flexibility and anticipation of what will come, and can instead be in the forefront of influencing and setting a benchmark for future regulations (Lankoski, 2008). Firms that innovate for sustainability may also obtain loans easier and cheaper (Lankoski, 2008), so-called green loans, which can influence the firm's financial risk in the future.

Stakeholder theory can also explain how sustainability innovations can lead to risk reduction. For example, firms that have insufficient sustainability performance, may suffer from bad reputation and relationship with its stakeholders which will have a negative effect on the firm (Buysse and Verbeke, 2003). By being in forefront of future regulations related to sustainability, firms reduce their risk of being outdated in the future. Ultimately, how well firms meet the expectations of their stakeholders can explain many of the positive outcomes of firms' sustainability innovations implementation (Giacomini et al., 2021).

Finally, paper 1 and paper 2 demonstrate how the implementation of sustainability innovations can lead to reduced costs. As one of the main goals of sustainability innovations is to create the same output of economic activity with less resources and/or materials, cost reductions may be achieved as a result of more efficient use of resources (Ghisetti and Rennings, 2014; Rennings and Rammer, 2009). By reducing energy and materials consumption, and lowering the consumption of water, electricity, gas etc., firms can save costs (Hojnik et al., 2017; Rennings and Rammer, 2009). Firms can also reduce their costs by recycling, reuse and reducing waste (Hojnik et al., 2017). Thus, cost savings can occur due to more efficient production processes and reduction of input on these processes (Christmann, 2000). In addition, by implementing sustainability innovations firms can obtain cost savings by avoiding environmental taxes and penalties, reducing insurance costs (Eweje, 2011), and potential liability costs (Christmann, 2000; Lankoski, 2008). In the development of sustainability innovations as for example pollution prevention technologies, firms may reduce their costs through the discovery of inefficiencies in their existing production or processes that they were not aware of earlier (Christmann, 2000). By introducing sustainability innovations early, firms may save costs in the long run by making innovations that comply with future regulations and thus avoid future disruptions in their innovation process (Christmann, 2000). In addition, as mentioned earlier in relation to risk, firms that

implement sustainability innovations and address the sustainability issues early, could influence the development of future regulations. In this scenario, proactive firms can gain a relative cost advantage compared to its competitors as the competitors must make investments to comply with the future regulations when they come (Christmann, 2000).

In paper 2 we argue how the RBV theory can explain how the implementation of sustainability innovations can lead to reduced costs. Here, I expand this view and argue that the RBV theory can explain how sustainability innovations can lead to competitive advantage in general. By developing their internal resources, firms can enhance their ability to develop sustainability innovations that can ultimately give them increased competitive advantage. For example, the RBV can explain why some types of sustainability innovations lead to competitive advantage, while some do not (Christmann, 2000; Russo and Fouts, 1997). For instance, end-of-pipe solutions can easily be obtained for all competitors in the market, and does not require redesign of processes and services (Christmann, 2000; Ghisetti and Rennings, 2014). The implementation of this type of technology is pretty straightforward and does not lead to a change in resources and capabilities in the firms, nor increased resource efficiency (Russo and Fouts, 1997). On other hand, more advanced technologies like pollution prevention technologies are more complex and specific to the firm's production process, and thus more challenging to copy (Christmann, 2000). This type of technology requires a redesign in the firm's production or service processes and is therefore more difficult to imitate for competitors, and have thus greater potential for cost advantage by resource efficiency and increased competitive advantage (Christmann, 2000; Russo and Fouts, 1997). Thus, a firm's resource base can explain whether competitive advantage can be obtained from sustainability innovations (Ghisetti and Rennings, 2014).

5.1.3 What affect the transition towards more sustainability-oriented businesses

In order to answer the RQ in how firms can contribute to solving the sustainability challenges and how sustainability can contribute to increased competitiveness, I have found through the four papers that some factors can speed up or sink the transition towards increased sustainability implementation in firms. Paper 1, paper 3 and paper 4 all can say something about what factors that affect the success of transition towards increased sustainability in firms.

First, in paper 3 we find that external shocks like COVID-19 can sink the contribution of businesses to solve the sustainability challenges. We found that among Norwegian manufacturing firms, COVID-19 had a negative effect on the degree of environmental innovations in the firms. This finding is also found in other studies studying firms in other countries (Barreiro-Gen et al., 2020; Zhang et al., 2020). The finding that COVID-19 negatively affected environmental innovation in firms has several implications. First, the finding illustrates the importance of stable conditions for a sustainability transition to happen. The reduction of environmental innovations during an external shock can be explained by that firms deprioritize the development of environmental innovations when a shock hits, due to disruptions in supply, reduction of demand, and generally more insecure financial situation. When a shock hits and available resources are reduced and financial situation is worsened, firms may lose their motivations and ability in investing in sustainability initiatives as short-term investments may get the priority (Giacomini et al., 2021; Lee et al., 2013). Thus, stable market conditions seem to be important for firms in order for them to contribute to the sustainability challenges. Second, is the importance of having sustainability in the core of a firm's strategy. The fact that the manufacturing firms reduced their environmental innovations efforts due to COVID-19 may indicate that sustainability is not a part of their core business, and that the investments in these innovations are not seen as a key strategic priority. Barreiro-Gen et al. (2020) found in their study that the longer the firms had worked with sustainability issues prior to COVID-19, the more they prioritized environmental and social issues during COVID-19. This implies that firms that have sustainability incorporated in their strategies and have gained sustainability capabilities also prioritize sustainability efforts during an external shock. Again, this shows the importance of firms incorporating sustainability in firm strategies, and making sustainability a core of the business and a key priority. In this way, it will be easier for firms to continue their efforts towards environmental innovations despite an external shock. Finally, the findings from this study show the importance of having incentives and funding to support sustainability innovations. Sustainability innovations often require big investments and have a long pay-back time (Hojnik and Ruzzier, 2016). During an external shock, firms will find it risky to continue investing in these types of innovations, and firms must therefore have the necessary resources to go through with it even when an external shock hits.

Further, how well firms manage to contribute to solving the sustainability challenges also depends on how they manage to utilize current resources and capabilities and develop new ones in order to keep up with the changes in the environment. The development of dynamic capabilities is in fact found to stimulate the introduction of sustainability innovations in several studies (Chen and Chang, 2013; Huang and Li, 2017; Khan et al., 2021; Mousavi et al., 2018; Singh et al., 2022). By developing dynamic capabilities firms create or reconfigure their resources to adapt to rapidly changing environments which is crucial in the context of sustainability (Huang and Lil, 2017). In other words, the development and use of dynamic capabilities influences in what degree firms manage to contribute to the sustainability challenges (Wu et al., 2013). We examine this in paper 4 where we studied firms in the oil and gas sector that were in a phase where they needed to renew themselves in order to stay competitive in the future. The oil and gas firms started to look for new business opportunities in more environmentally friendly sectors where they could to a large degree utilize their current resources. This makes sense, as there are lower barriers and costs to entry sectors where the firm can use some of its current knowledge and experience (Schrettle et al., 2014). To reconfigure assets and resources and use them in changed environments is in fact the core of dynamic capabilities (Helfat et al., 2007). However, even though the case companies could utilize some of their current resources and capabilities, going into new markets often require the development of new dynamic capabilities as different markets have a different logic (Hart and Dowell, 2011). In paper 3, we also found how COVID-19 influenced many of the firms to be proactive and undertake green strategic responses in order to cope with the new market situation. The companies that managed this, were in fact less affected by COVID-19. This aligns with the finding of Santa-Maria et al. (2022) that organizational flexibility, or the ability to quickly adjust to changes in the environment, is in fact an important microfoundation of dynamic capabilities. The findings from paper 3 and paper 4, thus tell us that dynamic capabilities can help firms in innovating for sustainability by reconfiguring their resources and capabilities to accomplish a strategic outcome (Mousavi and Bossink, 2017; Feiler and Teece, 2014). The questions that remains answering is how this can be done.

Paper 4 shows how the oil and gas firms by developing dynamic capabilities, through microfoundations of sensing, seizing and reconfiguring (Khan et al., 2021; Teece et al., 2007),

can innovate for sustainability. In the sensing phase we found that the oil and gas companies looked outside of the firm boundaries and knowledge to find new opportunities. In the paper we say that they “extended their search window” when broadly looking for opportunities across industries and markets. Our research thus supports the findings that firms innovating for sustainability more broadly search for innovation ideas and often relies more on external sources in the innovation idea phase compared to traditional innovations (De Marchi and Grandinetti, 2013; Horbach et al., 2013; Rennings and Rammer, 2009). As discussed under 5.1.1 the findings from paper 4 also showed how the oil and gas firms were proactive in order to find new business opportunities within sustainability. Similarly, in their case-study of manufacturing firms, Mousavi et al. (2019) found that the firms were proactive towards sustainability by having sustainability as a guiding principle and value proposition, and by implementing a sustainability innovation strategy. Khan et al. (2020) also find in their multiple-case study that in successful circular economy business cases, the companies showed proactive sensing activities such as active market monitoring and technology scanning, internal brainstorming sessions and experimental learning through participation in conferences, seminars and trade shows.

Regarding the seizing phase we found that the oil and gas firms heavily relied on external actors in the innovation development phase. This is explained by due to the sustainability innovations’ complexity and novelty, they involve more knowledge and competences than traditional innovations and therefore increasingly require cooperation with other actors outside of the firm in the innovation development (De Marchi and Grandinetti, 2013; Horbach et al., 2013; Mousavi and Bossink, 2017; del Río et al., 2015). This type of new knowledge and competence may be new production processes, inputs or materials (Horbach et al., 2013). Other studies also find that collaboration is an important microfoundation to obtain new knowledge, resources and skills important for the sustainability innovation development (Khan et al., 2020; Khan et al., 2021; Mousavi et al., 2018).

When it comes to reconfiguring, we find that all of the oil and gas firms redeploy their existing resources and capabilities in the sustainability innovation development. To utilize current knowledge and make new combinations of the knowledge is an important dynamic capability facilitating sustainability innovation development (Huang and Li, 2017). Similarly, Santa-Maria et al. (2022) identify co-specialization of assets, that is, prioritizing projects that

fit the firm in terms of existing capabilities, as an important reconfiguring microfoundation. In order to utilize current resources and capabilities well, firms must have high levels of internal resource integrations, that is, cross-functional and cross-employee exchange of knowledge, coordination and integration (Dangelico et al., 2017; Eikelenboom and de Jong, 2019).

5.1.4 The relationship between RBV, DC and stakeholder theory in the sustainability context

Even though RBV, dynamic capabilities and stakeholder theory are used as different theories in the sustainability literature, I argue that they are closely related and interdependent. I claim that it is important to understand all of these theories in order to understand firm behavior towards sustainability and competitiveness. Stakeholder pressure is one of key drivers of why firms start implementing sustainability innovations and develop sustainability-oriented capabilities and practices (El-Kassar and Singh, 2019). This was evident from paper 4, in which stakeholder pressure was one of the main reasons the case companies wanted to become more sustainability-oriented. Further, Sodhi (2015) connects all three theories by arguing how firms maximize their value creation by developing dynamic capabilities, resources and routines and simultaneously satisfying their stakeholders. Thus, the RBV and DC can be connected with stakeholder theory by that firms can develop unique capabilities within sustainability and creating competitive advantage by following stakeholder's demand (Singh et al., 2022). I argue that all these theories together can explain the findings in paper 1 and paper 2, in that sustainability innovations in many occasions lead to increased competitiveness. Specifically, in a country like Norway where the stakeholder pressure in terms of sustainability is high, firms that develop their resources and capabilities within sustainability are likely to achieve competitive outcomes. Therefore, all three theories can be used to explain that how a firm chooses to allocate its resources, and the competitive outcome is influenced by and influence its stakeholders (Grewatsch and Kleindienst, 2017). Hart (1995) also directly links the NRBV with stakeholder theory, as firms are not only dependent on the development of valuable internal resources in order to build competitive advantage, but also the relationship with external stakeholders in terms of image, legitimacy and reputation. In fact, incorporating external stakeholder demands in the firm's product design and development is an important capability to build competitive advantage (Hart, 1995).

I further argue how the RBV and dynamic capabilities are directly connected and together can explain the potential competitive advantage from sustainability innovations. Having the ability to innovate for sustainability is an important skill that requires different capabilities. Capabilities are important parts of a firm's resources (Barney, 1991; Schrettle et al., 2014) and therefore I argue how sustainability-related dynamic capabilities in fact are part of a firm's VRIN resources. In other words, by developing their sustainability-related dynamic capabilities firms strengthen their ability to innovate for sustainability, which ultimately can become a VRIN resource creating competitive advantage for the firm. Sustainability-oriented dynamic capabilities are capabilities that evolve over time as the firms gets more experience and are thus path-dependent (Amui et al., 2017), which make them increasingly VRIN (Barney, 1991; Schrettle et al., 2014). Hence, I see the RBV and dynamic capabilities as interdependent theories in explaining why sustainability innovations can lead to increased competitiveness.

In addition, the theory of dynamic capabilities complements the RBV in understanding the process of how firms implement sustainability, as sustainability is characterized by complex and ambiguous markets, which is the core assumption of dynamic capabilities (Hart and Dowell, 2011). Dynamic capabilities is in fact about integrating, reconfiguring, creating or discharging resources in order to respond to the external environment and create competitive advantage (Strauss et al., 2014), which directly relates it to the RBV. Or simply said "resources have to be changed using dynamic capabilities as the firm seeks competitive survival in a rapidly changing environment" (Sodhi, 2015, p. 1381). Therefore, dynamic capabilities is ultimately about the management of putting together the appropriate resources in respond to fast changing environments, and is therefore an important extension of the RBV when it comes to sustainability.

5.2 Practical implications

The findings of the papers in this dissertation have several practical implications for firms. The first and most important implication, it that this dissertation shows that businesses can obtain increased competitive advantage including increased value creation and non-financial assets, and reduced costs and risks by implementing sustainability innovations. Thus, firms can increase their competitiveness by introducing sustainability innovations through new products, processes or managerial methods. Therefore, I agree with several researchers that

instead of asking *whether* firms should implement sustainability innovations, we should ask *how* this can be done in the best possible way (Baumgartner, 2014; Eiadat et al., 2008; Lankoski, 2008; Schaltegger and Burritt, 2018).

Second, in order to solve the sustainability challenges the first step for businesses is to start integrating sustainability in their core strategies and everyday thinking, as we find that firms that have a sustainability strategy develop more sustainability innovations. Firms should rethink how they create value, by addressing the needs of the society and by developing more sustainability-oriented value propositions that take into account both environmental and social factors in addition to economic factors (Iles and Martin, 2013; Porter and Kramer, 2011). Firms that are able to renew themselves and address environmental change by incorporating it into their strategies have greater chances of success (Schrettle et al., 2014). However, being proactive and doing more than complying with regulations, requires the development of specific capabilities (Strauss et al., 2017) which brings us to the next implication.

Third, paper 4 shows how dynamic capabilities are important for the development of sustainability innovations. Thus, firms must spend both significant time and resources on developing their dynamic capabilities as they are found to positively affect the implementation of sustainability innovations and increase competitiveness (Singh et al., 2022). The microfoundations we find in paper 4 that I want to highlight for firm managers are proactivity, collaboration and reconfiguration of existing assets and resources. Proactivity is important in order to find new opportunities within the sustainability challenges. Further, to develop dynamic capabilities firms need the appropriate resources and often new knowledge (Schrettle et al., 2014). Due to the complexity of sustainability issues, firms cannot solve them alone. Thus, firms need to collaborate with various external actors to gain knowledge that is outside of the firm's core competences (Dangelico et al., 2017; Khan et al., 2020; Khan et al., 2021; Mousavi et al., 2018). Furthermore, reconfiguring of existing assets and resources is important in order to develop sustainability innovations. As a start, firms should ask themselves what type of sustainability innovations is most appropriate (Schrettle et al., 2014) in terms of where can they use some of existing resources and capabilities in new ways? Thus, the findings of paper 4 help firm managers to

understand what types of resources and capabilities that are important in order to develop sustainability innovations (Prieto-Sandoval et al., 2019).

The findings of this dissertation also have some implications for the financial industry. As sustainability innovations comes with risks and are connected to the double externality problem, banks have a responsibility of providing green loans with low interest rates to business that want to invest in sustainability (Dyllick and Muff, 2016; Li et al., 2018). In this way the risk and barriers towards sustainability innovation can be decreased.

The last practical implication is not only relevant for firms but also important stakeholders such as consumer markets and governments and relates to changing the rule of the game (Dyllick and Muff, 2016). Firms cannot solve the sustainability issues alone, and in order for it to happen systematic changes need to happen from developing standards for sustainability reporting, internalizing sustainability costs, increase knowledge about sustainability among consumers, and introducing taxes on resource consumption and emissions, among other things (Dyllick and Muff, 2016, p. 167). Another important step towards solving the sustainability issues is gaining critical mass in business markets (Laudal, 2011). This means that when sustainability becomes more wide-spread and a common practice in an industry, firms like SMEs may find it easier to invest in sustainability initiatives as they will be more confident of gaining returns of their investments and economies of scale can be obtained to a larger degree (Laudal, 2011). When critical mass is achieved in an industry, firms that have not implemented sustainability get punished by the market (Grewatsch and Kleindienst, 2017) and through regulations. When critical mass is obtained, important and required knowledge will be more available for all firms, making it easier for all types of firms to invest in sustainability innovations (Laudal, 2011). This actually is a paradox that relates to the double externality problem: firms are reluctant to invest in sustainability innovations because of innovation spillover effects and not being able to capture the whole investments due positive externality to the environment, but it is required to invest in sustainability innovations to gain critical mass. Thus, in order to solve the sustainability challenges a change in the rule of the game must happen, making sustainability a common practice in all industries. One way of doing this is through regulations, which leads us to implications for policy.

5.3 Implications for policy

The findings of this dissertation also have some implications for policy. First, in order for business to contribute in solving the sustainability issues, regulations are necessary to drive and motivate the implementation of sustainability innovations in firms (Chan et al., 2016; del Río et al., 2015; Horbach et al., 2013; Porter and van der Linde, 1995; Rennings and Rammer, 2009). In fact, institutional differences like regulations can explain why some firms are more sustainability-oriented than others and why outcomes from sustainability are different among firms (McWilliams and Siegel, 2011). Porter and van der Linde (1995) argue that regulations are necessary as it cannot be assumed that firms find profitable opportunities within sustainability without a push due to the complexity, incomplete information and limited time attention they face. Furthermore, due to the double externality problem, market forces alone are insufficient to drive sustainability innovations in firms, and therefore regulations are necessary (Rennings, 2000; Rennings and Rammer, 2009). In relation to the double externality problem, regulations can also force firms to internalize environmental costs (Aragón-Correa and Rubio-López, 2007), making it more expensive to be a polluter and more attractive to create positive externalities.

However, not all regulations are good regulations — they need to be thoroughly worked out in order to enhance firm competitiveness and value creation (Hörisch et al., 2014; Porter and van der Line, 1995). For example, setting the appropriate time period to let firms adjust to the regulations give industries the opportunity to innovate and finding out themselves how they can solve the sustainability issues in their industry (Porter and van der Line, 1995). By giving industries too little time to adjust can lead to disruption in production processes and implementation of innovations with lower environmental performance, as high environmental performance innovations take longer time to implement (Christmann, 2000). Instead, regulations should be made in a way that reduce the barriers of sustainability innovations by increasing transparency, help reducing firms' costs, and by including private firms in their design of public policies (Laudal, 2011). Appropriate policies should also take into account what factors need to be in place for firms to adopt sustainability innovations (El-Kassar and Singh, 2019), as the different microfoundations we find in paper 4, or the moderators and mediators we find in paper 1.

Regulations can also be complemented by other initiatives. For example, governments can stimulate sustainability innovation development by increasing awareness among firms, facilitating or financing collaborations among firms and various stakeholders such as universities to find mutual interest (Dangelico et al., 2017; del Río et al., 2015; Hörisch et al., 2014), or by introducing incentives like awards or reporting guidelines (Hörisch et al., 2014). Governments can also try to increase demand for sustainability products and services, through for example public procurement and the development of eco-labels (del Río et al., 2015).

Another key for sustainability implementation is financial support (del Río et al., 2015; IPCC, 2023). Financial support can accelerate firms' investment in sustainability and help mitigating the risks associated with these types of investments (IPCC, 2023). In this way, financial support can help increasing the incentive to invest in sustainability innovations, solving parts of the double externality problem. Financial support is not only important in the initial phases of sustainability innovations implementation but also in the longer term. When a firm gradually improves its environmental performance, it will get more and more challenging to further reduce its environmental emissions without bigger changes in underlying processes and production (Hart, 1995). Therefore, financial support is equally important in the longer term as reductions will be progressively more and more capital intensive as the firms must undertake bigger changes to keep reducing its environmental impact (Hart, 1995). Also, as firms are experiencing that financial markets are pushing for short-term performance, financial support in the longer term is important as sustainability strategies making a big impact takes time to develop and thus needs a longer time perspective (Dyllick and Muff, 2016). Financial support may also be important in the longer run as the more sustainability becomes a norm in industries, the less are the firms able to gain a competitive advantage by differentiation from competitors (Grewatsch and Kleindienst, 2017). Finally, paper 3 in this dissertation shows the need for stable conditions in order for firms to implement sustainability innovations. However, external shock may happen again in the future, and therefore it is important with financial support both during and after this type of shock, to prevent businesses from divesting in sustainability innovations.

5.4 Limitations and further research

Based on the limitations presented in part 3.2, I have several suggestions for further research.

First, I think it is crucial with more research in what factors need to be in place in order for sustainability innovations to lead to increased competitiveness for firms. Hence, I agree with researchers arguing that the question regarding sustainability innovations and competitiveness needs to shift focus from *whether* to *how*. Because, even though we find that sustainability innovations can lead to increased competitiveness in paper 1 and paper 2, we also find that the relationship is complex by having a range of moderators and mediators affecting the relationship. In paper 1 we find that the relationship depends on factors that are related to the national context (e.g. regulations), market context (e.g. market turbulence, market uncertainty), industry context (e.g. pollution intensity, innovation speed) and firm context (e.g. firm capabilities or type of innovations). Thus, the relationship will depend on the context of each situation, and therefore we cannot say that the relationship is universally positive (Lankoski, 2008). Because of the different factors that will influence whether sustainability innovations lead to increased competitiveness, further research should examine *how* this positive outcome can be created. For example, are strict regulations or “loose” regulations most effective for sustainability implementation making a radical impact on the sustainability issues? And how can the competitiveness of firms be enhanced under such regulations? More specifically, future research should study what factors need to be in place in order for sustainability implementation to create shared value in different types of situations (Dentchev, 2004; Lankoski, 2008).

The second point relates to the first point, and concerns how different national and industry contexts can affect the findings of this study. As discussed in chapter 3.3 will industries with higher environmental impact face more pressure from stakeholders, regulations and have a higher potential for improving their environmental performance (Grewatsch and Kleindienst, 2017). The sustainability innovations-competitiveness relationship will also depend on type of industry as different industries have varying concerns and impact on the sustainability pillars (Grewatsch and Kleindienst, 2017). Type of industry can also affect firms’ ability to develop different types of dynamic capabilities due to factors as R&D investments, industry ecosystems and stakeholder pressure (Dangelico et al., 2017). In addition, the Norwegian

context could influence the findings as different countries for example have different regulations and stakeholder pressure. The competitiveness of sustainability innovations will therefore depend on how well the different innovations meet stakeholder demands (Giacomini et al., 2021; Schrettle et al., 2014). Thus, I suggest that future research study how sustainability innovations can create shared value in different type of industries and national contexts.

The third suggestion for further research relates to paper 4 and the development of dynamic capabilities for sustainability. In a fast changing environment, it is crucial for businesses to be able to adapt and respond to changes as the sustainability challenge. How firms can gain competitive advantage from sustainability implementation is highly dynamic as stakeholder demands, technology and regulations evolve and change fast (Lankoski, 2008). Therefore, I believe that the businesses that are able to adapt, reconfigure and acquire new resources, and make business cases of sustainability, are the ones that will “win” in the future. Hence, I believe that it is crucial with research further studying the development of dynamic capabilities for sustainability. What kind of dynamic capabilities are important, and how do firms develop them? Here, longitudinal studies are especially interesting to see how dynamic capabilities develop over time in firms.

Finally, in this dissertation I have focused on sustainability innovations in general, and not on specific types of innovations as product, process and managerial innovations. However, research shows that different types of sustainability innovations can lead to different competitive outcomes (e.g. Arundel and Kemp, 2009; Burki et al., 2018; El-Kassar and Singh, 2019; Rexhäuser and Rammer, 2014; Tumelero et al., 2019). In addition, there are differences in sustainability innovations in terms of whether they are incremental or radical that influence how much they contribute to solving the sustainability challenges (Boons et al., 2013). In this dissertation I have not examined the degree of radicalness of the innovations. However, in paper 4, some of the oil and gas firms are developing sustainability innovations that are radical innovations as they require a lot of resources and time, and significantly reduces the firms’ environmental impact. I argue that the development of dynamic capabilities is necessary in order to be able to implement these kinds of innovations. I therefore propose that radical innovations, specifically, require the development of dynamic capabilities, and call for research studying this in more depth.

Further, I propose that future research make a distinction and study different types of sustainability innovations (e.g. product, process, managerial, and radical vs. incremental), what innovations have the highest potential for solving sustainability issues in different industries, and their outcomes in terms of competitiveness.

6 CONCLUSION

The research question in this dissertation is: *How can businesses contribute to solving the sustainability challenges and simultaneously maintain their competitiveness?* In order to answer this overarching research question, four papers are developed, each with their own sub-research question. In the literature review in paper 1 we show that the majority of articles find positive relationships between sustainability innovations and competitiveness. However, the relationship is complex, as there are many factors affecting the relationship connected to national-, market-, industry- and firm-level factors. Paper 2 study the same subject in the Norwegian manufacturing industry. Here, we find that environmental innovations have a positive effect on both perceived firm performance and objective firm performance. Social innovations however, only have a positive effect on perceived firm performance, while they have a negative effect on objective firm performance. In addition, we find that sustainability strategies have a positive effect on the implementation of both environmental and social innovations. In paper 3, we find that an external shock like COVID-19 has a negative effect on the environmental innovations in firms. Finally, paper 4 shows that a shift towards increased sustainability among firms requires the development of specific dynamic capabilities.

The dissertation reveals that how firms can contribute to solving the sustainability issues while maintaining their competitiveness, is a complex question. As the sustainability challenge is still a quite new phenomenon, sustainability will increasingly change markets and industry characteristics (Schrettle et al., 2014) in the years to come. Nevertheless, what is clear is that businesses don't survive without the society and the environment. Thus, we can't longer see business and society as two separate units —business and society go hand in hand and are dependent on each other to function and have a purpose. The current trend indicates that businesses that want to survive in the future, must implement sustainability in their business. A way of doing this is by developing sustainability innovations. However, in order to solve the sustainability challenges, it is not enough to implement incremental adjustments that only reduce the negative impact from firms' current operations — instead firms must implement radical innovations that aim to solve social and environmental problems (Boons et al., 2013; Hart and Dowell, 2011). Therefore, I urge firms to go together and develop radical sustainability innovations that can truly solve the sustainability issues.

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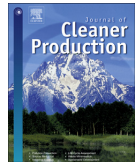
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PART 2 – RESEARCH PAPERS

PAPER 1



Review

Sustainability innovations and firm competitiveness: A review

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ABSTRACT

The purpose of this article is to map out the currently available research concerning the relationship between sustainability innovations and competitiveness and to identify the contextual factors that mediate and moderate this relationship. The present study is a systematic literature review that includes 100 relevant peer-reviewed publications. We examine the studies' methodology, industry, sustainability innovation terms, sustainability innovation variables, competitiveness variables, and findings to investigate if, and under what circumstances, there is a positive relationship between sustainability innovations and firm competitiveness. The study concludes that a vast majority of studies found positive relationships. Hence, the findings support the revisionist view that sustainability innovations can create win-win situations for a firm. However, the relationship is complex, and this study contributes with an overview of national-, market-, industry-, and firm-level factors that have a moderating or mediating effect on the relationship.

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1. Introduction

Resource use and emissions as a result of both population and economic growth have placed an amplified burden on the environment (UN, 2019). Mounting scientific evidence of the detrimental effects and the undesirable social and environmental consequences of this trend has increased the external pressure on firms to react to these challenges and to deal with issues related to climate change and social and environmental degradation (Cai and Li, 2018; El-Kassar and Singh, 2019; Lubberink et al., 2017). In addition to the external pressure of becoming more sustainable, businesses are facing growing competition due to globalization and new technologies (Aggarwal, 2011; Cherrafi et al., 2018). This combined pressure has increased the focus on green and sustainable value creation among businesses and led to focus on the question of whether sustainability innovations can solve both these problems—simultaneously increase both sustainability and competitiveness (Chu et al., 2018).

The relationship between corporate sustainability and competitiveness has gained much interest among scholars, but the findings have been fragmented and inconclusive (Cai and Li, 2018; Hussain et al., 2018; Rezende et al., 2019). For a long time, many firms viewed sustainability innovations predominantly as cost drivers (Dey et al., 2019). They were seen as innovations that required high initial investments, had long payback time, and produced only limited environmental benefits (Cai and Li, 2018; Hojnik and Ruzzier, 2016a). However, some recent research suggests a significant and positive relationship between sustainability innovations and a firm's competitiveness (Bacinello et al., 2019; Qiu et al., 2019; Suat and San, 2019). For example, it has been found that countries and businesses are showing an increasing tendency toward sustainability (Dey et al., 2019; Eurostat, 2020), and it is argued that this is happening because sustainability is associated with higher profitability, efficiency, and competitiveness (Cherrafi et al., 2018). These inconclusive and sometimes contradictory findings suggest that the relationship is complex and that more research is needed to establish how, and under what conditions, the relationship remains positive.

Some previous reviews have sought to clarify the research on the sustainability innovations—performance relationship. For example, Tariq et al. (2017) reviewed the drivers, consequences, moderators, and mediators of green innovations, but their study was inconclusive and called for more research on how organizational factors affect green innovations and their outcomes. More recently, Bitencourt et al. (2020) examined the drivers, consequences, and moderators of eco-innovation in a meta-study of quantitative studies in the field. They found a positive relationship, but the study lacked an investigation into the mediating and moderation effects. Further, review studies have been done on the success factors (De Medeiros et al., 2014) and drivers of environmental innovations (Hojnik and Ruzzier, 2016b). However, as Adams et al. (2016) note, theory development related to the topic in

the literature shows characteristics of immaturity and fails to provide an explanation of the mechanisms and conditions associated with different environmental innovations and their effect on business performance.

Common to all previous reviews is that they predominantly focus on environmental innovations and exclude the social issues that fall within the definition of sustainability (Elkington, 1997). Moreover, as they show that the literature still points in different directions, there is an urgent need to examine the state of the art of the relationship between sustainability innovation and firm competitiveness (Hussain et al., 2018; Lopes Santos et al., 2019). In particular, they call for more studies on how different conditions, such as internal and external factors, affect the outcome of sustainability innovations (García-Sánchez et al., 2019; Ghassim and Bogers, 2019; Hojnik and Ruzzier, 2017; Rezende et al., 2019).

The study of the relationship between sustainability innovation and competitiveness is not only necessary to fulfil our academic need for knowledge. It is also vital for managers who are seeking to leverage business strategies that are based on sustainability innovations (Bossle et al., 2016). In future decades, incorporating sustainability into businesses will likely be critical to preserve future businesses (Severo et al., 2017, p. 89). Moreover, more knowledge within this field is important for future policy making at the government level. Previous studies have suggested that stricter sustainability regulations can positively affect a firm's competitiveness and performance by driving innovation activities in firms (Porter and van der Linde, 1995; Zefeng et al., 2018). Hence, this understanding might give an idea of how regulations can stimulate sustainability innovation in firms (Hojnik and Ruzzier, 2016a) and how the private sector can contribute to solving sustainability challenges.

This study contributes by broadening the operational concept of sustainability innovations to include social innovations and reviews studies on the sustainability innovation—competitiveness relationship with special focus on determining the factors that mediate or moderate the relationship. Through this, we seek to contribute to clarifying and reducing the apparent complexity of the sustainability innovation—firm competitiveness relationship and to uncover the points of agreement in published studies, topics that remain disputed, and the most promising venues for further research.

2. Theoretical framework

Ever since the seminal work of Joseph Alois Schumpeter (in 1911/1934) firmly established innovation as the main engine for economic development, innovation has become the central economic term for what brings change to organizations, industries, and society as a whole. In Damanpour's words, "The adaption of innovations is conceived to encompass the generation, development, and implementation of new ideas or behaviors ... Innovation is a means of changing an organization, whether as a response to

changes in its internal or external environment or as a preemptive action taken to influence an environment" (Damanpour, 1991, p. 556). Hence, innovation can take many forms and can be related to new products, processes, services, management methods, or organizational structures (Baregheh et al., 2009; Nohria and Gulati, 1996). While it is demanding for firms to constantly innovate (Tushman and Nadler, 1986), it is also crucial in order for them to adapt to rapidly changing competition and market demands and to be able to create a sustained competitive advantage (Baregheh et al., 2009). For these reasons, innovation remains a key economic concept that the business sector needs to adopt in order to contribute to societal changes related to the sustainability challenge.

The term "sustainability" is diverse in its definitions. Originally, it was defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 37). Later, a common operationalization became the triple bottom line, consisting of the economic, environmental, and social dimensions (Elkington, 1997; Engert et al., 2016; Seuring and Müller, 2008). In the same manner, Dyllick and Hockerts (2002) describe sustainability in three aspects—the business case, the natural case, and the social case. These three dimensions are considered to influence and to be interrelated with each other (Dyllick and Hockerts, 2002). At the firm level, corporate sustainability has been defined as "meeting the needs of a firm's direct and indirect stakeholders (such as shareholders, employees, clients, pressure groups, communities etc.), without compromising its ability to meet the needs of future stakeholders as well" (Dyllick and Hockerts, 2002, p. 131). Furthermore, corporate sustainability concerns a firm's activities that are directed toward solving environmental and social issues in a strategic and profitable way (Salzmann et al., 2005, p. 27). Hence, corporate sustainability requires firms to incorporate all three dimensions of sustainability into their business decisions and activities (Dyllick and Hockerts, 2002; Schaltegger et al., 2012) while simultaneously ensuring their profitability.

2.1. Sustainability innovation

To conduct a literature review concerning sustainability innovations, a clear and well-framed understanding of the concept is important. The terms "green," "eco," "environmental," "social," and "sustainability innovation" reflect the terms described above and are commonly used in describing innovations that reduce a firm's negative impact on the environment and society (Díaz-García et al., 2015, p. 22). Boons et al. (2013) define sustainability innovation as "innovation that improves sustainability performance" (p. 2), where performance includes all three dimensions of sustainability—environmental, economic, and social. Similarly, another well-cited definition of sustainability innovation is "a process where sustainability considerations (environmental, social, and financial) are integrated into company systems from idea generation through to research and development (R&D) and commercialization. This applies to products, services and technologies, as well as to new business and organizational models" (Clark and Charter, 2007, p. 99). This latter definition includes managerial innovations in addition to innovations that are generally associated with sustainability, namely, those related to products, processes, services, and business models (Schiederig et al., 2012).

We identify two main issues in the literature concerning the term sustainability. First, as several researchers have pointed out, the main issue with the current sustainability innovation-related research is that the term is often reduced to environmental improvements, turning it into a one-dimensional concept (Klewitz and Hansen, 2014; Seuring and Müller, 2008). Sustainability is,

however, a broader concept as it includes the social aspect (Ben Arfi et al., 2018), and therefore researchers call for a more holistic approach, where the social dimension is taken into consideration (Adams et al., 2016; Engert et al., 2016). Hence, with this literature review, we aim to not only include the environmental pillar of sustainability but also the social pillar. The second issue with the sustainability–innovation definition is that the environmental pillar has a range of synonyms used in the literature (Bitencourt et al., 2020). In general, the terms "sustainable innovation," "environmental," "green," and "eco-innovation" are, to a large degree, used synonymously in the literature (Ben Arfi et al., 2018; Forsman, 2013; Hojnik and Ruzzier, 2016b; Karakaya et al., 2014). In recent literature reviews, it has been noted that there are only trivial differences between the terms and that they are often used interchangeably (Schiederig et al., 2012; Tariq et al., 2017). Because of the synonymous use of these concepts in the literature, we find it necessary to include all of them within our literature search, representing the environmental pillar of sustainability. Hence, for the purpose of this review, we have adopted the following broad definition: Sustainability innovations are innovations wherein all sustainability dimensions, including environmental, social, and economic, are considered during the whole innovation process. Hence, the aim is to avoid or reduce negative impact on the environment while considering social aspects in all steps of the innovation process and to simultaneously do this profitably to sustain the business. We argue that for all practical purposes, the innovations included in this study fall under this definition.

2.2. Sustainability innovation and competitiveness: why is this relationship reasonable to assume?

Previous research has identified a variety of drivers for the adoption of sustainability innovations. Díaz-García et al. (2015) argue that these drivers fall within two main categories: external pressure from governments and stakeholders (for example, in the form of regulations), and internal motivation to increase competitiveness (for example, through the reduction of operational costs). Several studies confirm that regulations are an important driver of sustainability innovation and that firms subjected to regulations are more likely to innovate for sustainability than firms that are not (Doran and Ryan, 2012; Horbach et al., 2012; Rennings and Rammer, 2009). Other studies have found drivers emerging from the motivation to increase competitiveness. For example, Clark and Charter (2007) found that market- and finance-related drivers, such as customer requirements, the brand and reputation of companies, and cost savings in terms of materials and energy, are important drivers for the adoption of sustainability innovations. Occasionally, regulations and the quest for competitiveness act together to drive sustainability innovations (Horbach et al., 2012). However, Yalabik and Fairchild (2011) find that competitive pressure from the market drives environmental innovation more than regulations and, hence, motivates more research on the role of sustainability innovations in increasing competitiveness.

To understand the sustainability innovation–competitiveness relationship, we need to understand how it is conceptualized in the academic and popular literature. From a broad perspective, there are two opposite views of how sustainability innovations and competitiveness are connected (Cai and Li, 2018; Hussain et al., 2018; Triebswetter and Wackerbauer, 2008). According to the traditionalist view, sustainability innovations are viewed as cost drivers (Cai and Li, 2018; Palmer et al., 1995; Walley and Whitehead, 1994). For example, Walley and Whitehead (1994) claim that the popular idea of environmental improvements creating win-win situations for firms is unrealistic due to the high costs and complicated solutions that are involved. The increasing costs, risks,

insufficient government support, and regulations associated with sustainability innovations may have a negative effect on competitiveness (García-Sánchez et al., 2019). Hence, according to this view, sustainability innovations are considered a zero-sum trade-off between the environment and the economy. On one hand, strict regulations lead to social benefits, while on the other, they lead to additional costs for firms, higher prices, and reduced competitiveness (Frondelet et al., 2007; Porter and van der Linde, 1995). In contrast to this view, the revisionist view dismisses the notion that it is a zero-sum game and argues that sustainability innovations can create win-win situations that create value for the environment and society while simultaneously increasing the competitiveness of firms (Porter and van der Linde, 1995). Porter and van der Linde (1995) argue that the traditionalist view is outdated and that the right environmental regulations make firms innovate for new solutions that increase value creation and operational efficiency. They further argue that firm managers should conceptualize the sustainability shift as a business opportunity rather than something that exclusively drives costs. This notion is supported by Boons et al. (2013), who debate that companies that invest early in sustainability innovations should be able to gain a competitive advantage—at least in the medium term. How these firms will fare in the long term is more difficult to predict because of fast-changing technologies, regulatory shifts, and path dependencies associated with the shift.

Associated with the revisionist view, there are several arguments as to why sustainability innovations can increase firm competitiveness. Firstly, sustainability innovations can lead to more efficient processes by reducing the use of raw materials as well as energy and resource consumption in terms of water, waste, soil, and oil (Chiou et al., 2011; Gürlek and Tuna, 2018). Secondly, they can improve product quality and efficiency through a reduction in material consumption, the use of less hazardous materials and less packaging, and an increase in the use of recyclable materials (Dey et al., 2019). Thirdly, they can improve managerial processes through the use of assessment methods such as environmental management systems that make it easier to identify and realize cost savings and productivity improvements (Hojnik and Ruzzier, 2017). Fourth, launching sustainability products is an efficient way of exploiting opportunities associated with the growing number of customers that are concerned for the environment and society. Hence, it may result in product differentiation, a growing customer base, and improved market and brand positioning (García-Sánchez et al., 2019; R. J. Lin et al., 2013).

Fig. 1 pulls together the theory section: external and internal drivers compel firms to conduct sustainability innovations. These

innovations incorporate the three dimensions of sustainability: environmental, social, and economic. The effects of sustainability innovations are disputed in the literature. According to the traditionalist view, sustainability innovations ultimately lead to reduced competitiveness, whereas the revisionist view proposes that they lead to increased competitiveness.

Based on the definitions and theories proposed in the literature, the present review seeks to answer the following research question: What does current research say about the relationship between sustainability innovation and competitiveness, and what are the contextual factors that affect this relationship?

3. Method

To investigate the current research question, a literature review is appropriate as it summarizes previous studies (Fink, 2019, p. 254) and presents what is known, what varies across studies, and what gaps exist in the field of research. In this way, reviews are important not only to interpret and assess the strength of earlier research but also to guide the direction of future research (Gough et al., 2017). Following the procedures of other systematic literature reviews (Bitencourt et al., 2020; Klewitz and Hansen, 2014), the steps that were conducted in the review are presented below.

3.1. Step 1: Systematic literature search

This study used the following four research databases in the field of economics and management for the literature search: ABI/Inform Collection, Business Source Complete, Entrepreneurship Database, and Scopus. Based on the definition of sustainability innovations presented in section 2.1, which encompasses both environmental and social dimensions, we found it relevant to include terms related to both environmental-related innovations and social innovations in our keyword search. In addition, as pointed out in section 2.1., because of the synonymous use of the words sustainability, environmental, green, and eco-innovations in the literature (Forsman, 2013; Schiederig et al., 2012; Tariq et al., 2017), we found it necessary to include all different terms related to these types of innovations to fully capture the environmental pillar of sustainability. Hence, in our keyword search, we use synonyms for environmental sustainability in addition to including the social aspect of sustainability. This approach is also used in prior literature reviews concerning sustainability (e.g., Bocken et al., 2014; Engert et al., 2016; Klewitz and Hansen, 2014; Seuring and Müller, 2008).

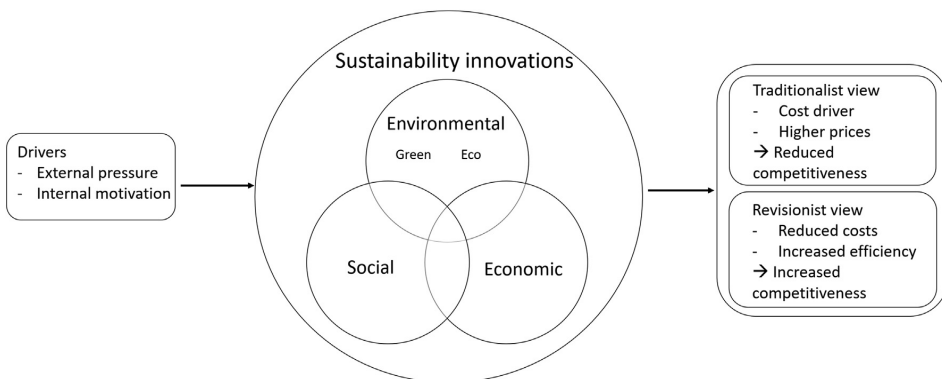


Fig. 1. Theoretical framework.

Following Pittaway et al. (2004), keywords and their synonyms were combined with "OR" and "AND" to create the following search algorithms:

- Sustainable/sustainability innovation – green innovation – eco-innovation – environmental innovation – social innovation – societal innovation
- Competitiveness – firm performance – organisational performance – organisational performance – corporate performance – financial performance – firm organisational performance – firm organisational performance – organisational results – organisational results – firm results – corporate results – company result – competitive advantage – economic performance

To avoid selection bias caused by the use of synonymous words, we also used the databases' thesaurus function to identify synonyms and common words used in the database. In addition, we used wildcards (i.e. *, ? N3, N/3) in the keyword search to find as many relevant articles as possible. The criteria for inclusion were the use of the keywords in the abstract, an empirical research design, and publication in peer-reviewed academic journals.

3.2. Step 2: Choice of relevant articles

In line with Pittaway et al. (2004), the relevant articles were chosen through two rounds of screening. First, the title and abstract of the articles were roughly scanned, and the articles that seemed relevant were saved. In the second round of screening, the papers were read more thoroughly, and the articles that were not relevant enough were removed based on the exclusion criteria—that is, duplicates, non-English articles, non-empirical research, and research that did not focus on the theme at the firm level were removed. In addition, articles that did not specifically focus on sustainability innovations and competitiveness were removed. This included articles that studied, for example, sustainability strategies, sustainability performance, environmental capabilities, or environmental disclosure instead of sustainability innovations. In other words, the studies had to specifically study innovation. This strict exclusion was necessary to keep the individual assessment of what were relevant articles to a minimum. This exclusion step was also necessary to sufficiently narrow the scope of the literature review to include only sustainability innovations. Finally, to ensure sufficient quality (Tariq et al., 2017), articles published in journals that did not appear in the Academic Journal Guide (AJG) or the Scimago Journal & Country Rank (SJR) were removed.

The final screening resulted in 100 articles in total (see Fig. 2 and Table 1), which were published between 2005 and 2020. The journal that included most of the selected articles was Journal of Cleaner Production (23 articles), while Business Strategy and the Environment, Journal of Business Ethics, Corporate Social Responsibility and Environmental Management, Technological Forecasting and Social Change, and European Journal of Innovation Management contributed three to six studies each. The rest of the sample came from a broad range of journals that spanned a variety of disciplines, but each journal contributed only with a few studies on the relevant topic.

3.3. Step 3: Analysis of articles

As the aim of this article is to investigate the relationship between sustainability innovations and competitiveness reported by studies, several aspects had to be analyzed. The analysis can be divided into descriptive and thematic analysis (Tranfield et al., 2003). The first step was a descriptive analysis, which includes reporting the content of the papers into several categories (Tranfield

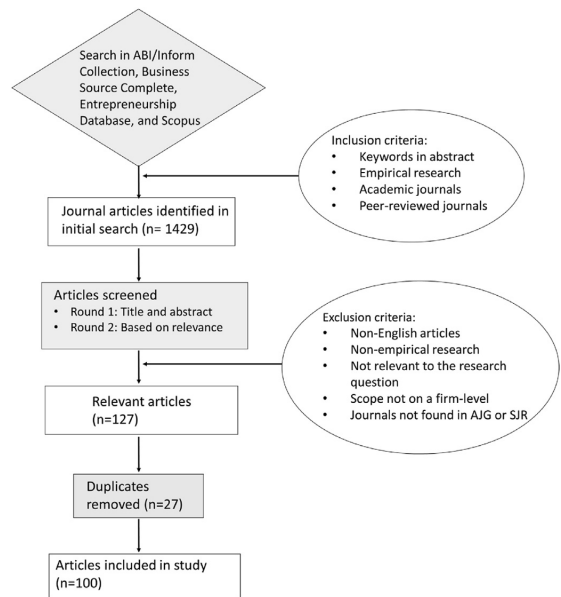


Fig. 2. Illustration of the literature review process.

et al., 2003). We found this necessary to better answer our research question and to be able to compare and assess the overall strength of the findings. In line with Seuring and Müller (2008), several descriptive dimensions were assessed, including the research methodology, publishing year, conceptualizations of sustainability innovation, and operationalization of *sustainability innovation* and *competitiveness*. In addition, to answer the second part of the research question, we included an analysis on the moderators and mediators of the sustainability innovation–competitiveness relationship. The descriptive data from the studies are presented in the results section below.

The thematic analysis includes identifying key findings, the consensus, and emerging themes from the data (Tranfield et al., 2003). More specifically: “the aim is to systematically categorize the content of the papers and identify relationships” (Klewitz and Hansen, 2014, p. 61). In line with Lane et al. (2006), our thematic analysis went through the initial steps of coding and grouping similar codes together to eventually distill several emerging themes from the articles. This led to the results shown in Fig. 3 and Tables 4–7 in the results section.

4. Results

The present study starts with a systematic analysis of the methodology, conceptualization, and operationalization of the key terms and conclusions related to the sustainability innovation–competitiveness relationship in each article. First, we present a description of the sample of studies, and following this, we move on to addressing specific findings related to the research question.

4.1. Description of the studies included in the review

Of the 100 studies that were finally included in the review, 64 reported a positive relationship between sustainability innovations

Table 1
Number of articles found in the included databases.

Database	ABI/Inform Collection	Business Source Complete	Entrepreneurship Database	Scopus
Number of articles in the initial search	412	230	143	644
Relevant articles	27	8	3	89
Duplicates		27		
Total		100		

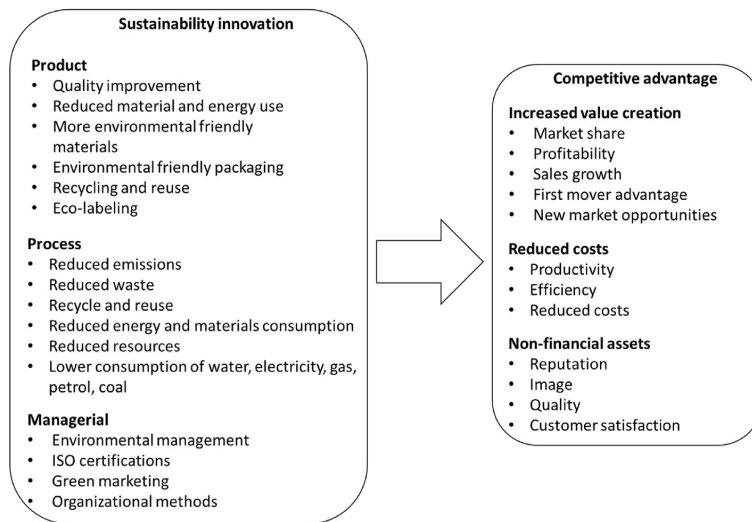


Fig. 3. Sustainability innovations and competitiveness variables.

Table 2
Methodology used in the selected articles.

Quantitative		Qualitative		Mixed methods
Survey 73	Secondary data 17	Single case 2	Multiple cases 6	2

Table 3
Year of publication of the articles.

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Number of articles	1	1	0	1	1	2	5	3	12	7	7	10	10	11	25	4

and firm competitiveness; 29 reported mixed results that included positive, neutral, and/or negative effects; 5 studies reported inconclusive findings; and 2 studies reported negative effects.

Table 2 presents an overview of the research approaches used in the studies. The table shows that a large majority of the studies used quantitative methods (90 out of 100), whereas only 10 studies used qualitative methods. Hence, there seems to be an overload of articles using quantitative methods compared to qualitative in this research field. On one hand, this is not surprising as the topic being studied is the relationship between two factors and is a variance question in nature (Van de Ven, 2007). However, on the other hand, the high number studies using quantitative methods is still intriguing as the study of the competitive outcome of sustainability innovations is a rather recent subject in the academic literature, with 80% of the articles published in 2013 and after (see Table 3). As the underlying mechanisms still need to be studied in more depth

(Tumelero et al., 2019), a case-study approach is in many ways more appropriate (Dionisio and de Vargas, 2020). Hence, we note that the sustainability innovation–competitiveness relationship is an understudied subject in qualitative method articles and propose this as a further research in section 5.3.

Table 3 shows that the number of studies in this domain is rapidly increasing, with the majority of studies published from 2013 onwards.

We also observed that while the studies came from a variety of industries, the manufacturing and high-tech industries were dominant (54% combined). Notably, the sample also includes 22 multi-industry studies (22% of the studies).

4.1.1. Sustainability innovation: terms

The reviewed studies use different terms to refer to sustainability innovations. Many of the studies (n = 38) use the term

Table 4
“Increased value creation” outcomes resulting from sustainability innovations.

Variable	Study	Result
Sales growth	Cortez and Cudia (2010)	Positive
	Forsman (2013)	Higher**
	Forsman (2013)	Higher*
Profitability	Cortez and Cudia (2011)	Positive (two)
	Cainelli et al. (2011)	Better*
	Antonioli et al. (2016)	Positive
Revenue	Lopes Santos et al. (2019)	Neutral (six)
	Tugores and García (2015)	Positive (two)
		Neutral (five)
Operating margin	Przychodzen et al. (2019)	Neutral (two)
	Ghissetti and Rennings (2014)	Positive (energy and resource-efficient innovations)*** Negative (externality-reducing innovations)***
Profit margin	Rennings and Rammer (2009)	No differences*
	Rennings and Rammer (2011)	Neutral (product), negative (process)
Return on employed capital	Przychodzen et al. (2019)	Positive (green patents) Negative (green patents/total patents)
		Neutral (two)
Market value/book value	Przychodzen et al. (2019)	Neutral (two)
	Antonioli et al. (2016)	Mixed, both negative and neutral
EBITDA	Cacciolatti et al. (2020)	Negative
	Cacciolatti et al. (2020)	Neutral
Credit rating	Cortez and Cudia (2011)	Neutral (two)
	Scarpellini et al. (2019)	Positive
Income	Aguado et al. (2013)	Positive
	Cortez and Cudia (2010)	Positive
Assets	Cortez and Cudia (2011)	Both positive and neutral
	Cortez and Cudia (2010)	Positive
Equity	Cortez and Cudia (2011)	Both positive and neutral
	Przychodzen and Przychodzen (2015)	Negative (however, this means more resources available for further growth)
Earnings retention ratio (dividends to shareholders)		Higher**
	Forsman (2013)	Lower**
Operating earnings	Forsman (2013)	Higher**
	Forsman (2013)	Lower*
Equity ratio	Forsman (2013)	Higher**
	Forsman (2013)	Lower*
Return on total assets	Forsman (2013)	Higher**
	Rennings and Rammer (2009)	No differences*
Success of innovation	Lin et al. (2014)	Positive (process and product)
	Bermúdez-Edo et al. (2017)	Neutral
Market share	García-Sánchez et al. (2019)	Positive
	Leyva-de la Hiz et al. (2019)	Positive
Tobin's Q	Sánchez-medina et al. (2015)	Positive
	Aguilera-Caracuel and Ortiz-de-Mandojana (2013)	Neutral*
ROA	Aguilera-Caracuel and Oriz-de-Mandojana (2013)	Positive
	García-Sánchez et al. (2019)	Negative
	Lopes Santos et al. (2019)	Neutral (six)
	Przychodzen and Przychodzen (2015)	Positive
	Xie et al. (2019)	Positive (two)
	Rezende et al. (2019)	Positive
	Przychodzen et al. (2019)	Neutral (two)
	Xie et al. (2016)	Positive (two)
ROE	Antonioli et al. (2016)	Neutral
	García-Sánchez et al. (2019)	Negative
ROS	Przychodzen and Przychodzen (2015)	Neutral
	Ghassim and Bogers (2019)	Positive
	Lopes Santos et al. (2019)	Mixed (five positive, one negative)
	Rexhäuser and Rammer (2014)	Positive: in general Positive: resource efficiency-innovations Negative: environmental impact-innovations
ROI	Courtney and Powell (2020)	Positive (two)
Firm performance constructs	Amores-Salvadó et al. (2014)	Neutral
	Lin et al. (2013)	Positive
	Hojnik and Ruzzier (2017)	Positive
	Hojnik et al. (2018)	Positive
	Juniati et al. (2019)	Positive
	Ma et al. (2018)	Positive
	Handayani et al. (2017)	Positive
	Tang et al. (2018)	Positive (two)
Financial performance constructs	Zhang et al. (2020)	Positive
	Tariq et al. (2019)	Positive
	Huang and Wu (2010)	Positive
	Cai and Li (2018)	Neutral
	Chan et al. (2016)	Positive
	Chu et al. (2019)	Positive
	Chu et al. (2018)	Positive

(continued on next page)

Table 4 (continued)

Variable	Study	Result
	Li (2014)	Neutral
	Dey et al. (2019)	Positive
	Zailani et al. (2015)	Positive
	Zhu et al. (2017)	Positive
	Severo et al. (2017)	Positive
	Liao (2018)	Positive (three)
	Hojnik and Ruzzier (2016a)	Positive
	Long et al. (2017)	Positive (total)
		Positive (product design and production processes)
		Neutral (raw materials and waste treatment)
		Positive (product, process)
	Suat and San (2019)	Positive
	Rotondo et al. (2019)	Positive
	Padgett and Moura-Leite (2012)	Negative
	Cavazos-Arroyo and Puente-Diaz (2019)	Neutral
Organizational performance constructs	Maletić et al. (2014)	Positive (two)
	Maletić et al. (2016)	Positive (two)
	Leal-Rodríguez et al. (2018)	Positive
	Wang et al. (2019)	Neutral
	Reyes-Santiago et al. (2019)	Negative
	Gupta (2017)	Positive (two)
	Huang and Li (2017)	Positive (product, process)
	El-Kassar and Singh (2019)	Positive (process) and neutral (product)
	Svensson et al. (2019)	Positive (two) and neutral (one)
Competitive advantage constructs	Chen et al. (2006)	Positive (two)
	Arenhardt et al. (2016)	Positive (two)
	Chen and Chang (2013)	Positive (two)****
	Gürlek and Tuna (2018)	Positive
	Chiou et al. (2011)	Positive (three)
	Dong et al. (2014)	Positive (four)
	Wong (2012)	Positive (process, product)
	Kamboj and Rahman (2017)	Positive (two)
	Qiu et al. (2019)	Positive
	Wang (2019)	Positive
	Ekawati et al. (2016)	Neutral
	Hojnik and Ruzzier (2017)	Positive
	Khaksar et al. (2016)	Positive
	Hojnik and Ruzzier (2016a)	Positive
	Chang (2018)	Positive (service, product)
	Chang (2011)	Positive (product)
		Neutral (process)
	Suat and San (2019)	Neutral (process)
		Positive (product)
		Neutral (product, process)
Company growth construct	El-Kassar and Singh (2019)	Neutral (product, process)
	Herrera (2015)	Positive
	Hojnik and Ruzzier (2016a)	Positive
	Osei and Zhuang (2020)	Positive
Business performance construct	Bacinello et al. (2019)	Positive (two)
	Leenders and Chandra (2013)	Mixed (two positive, two neutral)
Economic sustainability	Javed et al. (2019)	Positive
Financial and intangible value	Spitzeck et al. (2013)	Positive
Shared value	Li et al. (2018)	Positive
International performance construct	de Menezes et al. (2013)	Inconclusive
New green product success construct	Wong (2013)	Positive (product, process)
Socio-economic construct	Tumelero et al. (2019)	Positive (product, organizational)
		Neutral (process)

*On comparing firms with green innovations with other firms **On comparing successful green innovations with non-successful green innovations *** Only for highly green innovations ****Non-linear relationship for highly green innovations *****Numbers in parentheses indicate the number of relationships with that particular result.

“green innovation,” which is commonly defined as “a hardware or software innovation that is related to green products or processes, including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs or corporate environmental management” (Chen et al., 2006, p. 332). Next, 23 of the studies use the term “environmental innovation,” for which the common definition is “... new or modified processes, techniques, systems and products to avoid or reduce environmental harms” (Kemp and Arundel, 1998, p. 11). Further, 18 studies use the term “eco-innovation,” which is defined as “new ideas, behaviors, products and processes that reduces the environmental impact” (Rennings, 2000, p. 322). A total of 11 of the

studies use the term “social innovation,” defined as “... new technologies, strategies, ideas and/or organizations to meet social needs or solve social problems” (European Commission, 2013, p. 15). Social innovations aim at addressing the challenges that society faces and “contribute to important public values (e.g., health, education, safety, and life quality)” (Piccarozzi, 2017, p. 6). Finally, 10 studies use the term “sustainability innovation,” which is commonly defined as “a process where sustainability considerations (environmental, social and financial) are integrated into company systems from idea generations through to research and development (R&D) and commercialization. This applies to products, services and technologies, as well as new business and organization

Table 5
“Reduced costs” outcomes resulting from sustainability innovations.

Variable	Study	Result
Productivity	Cainelli et al. (2011)	Higher ^a
	Doran and Ryan (2012)	Higher ^a
	Rennings and Rammer (2009)	Higher ^a
Cost reductions	Chan et al. (2016)	Positive
	Aguado et al. (2013)	Positive
	Rennings and Rammer (2009)	Higher ^a
	Triebswetter and Wackerbauer (2008)	Positive
	Grekova et al. (2013)	Positive (process)
	Burki et al. (2018)	Positive (managerial) and neutral (process)
	Liao (2016)	Positive (process) and neutral (product)
Cost competitive advantage	Wang et al. (2019)	Positive
	Aguado et al. (2013)	Positive
Efficiency	Hojnik et al. (2017)	Positive (three), neutral (three)
	Doran and Ryan (2016)	Mixed (two positive, one negative, six neutral)
	Doran and Ryan (2012)	Positive
Turnover per employee	Antonioli et al. (2016)	Neutral

^a On comparing firms with green innovations with other firms **Numbers in parentheses indicate the number of relationships with that particular result.

Table 6
“Non-financial assets” outcomes resulting from sustainability innovations.

Variable	Study	Result
Quality	Rennings and Rammer (2009)	Higher ^a
	Lam et al. (2005)	Positive
Share of export	Rennings and Rammer (2009)	No differences ^a
	Triebswetter and Wackerbauer (2008)	Positive
New patents	Triebswetter and Wackerbauer (2008)	Positive
Increased skill levels	Cainelli et al. (2011)	Higher ^a
Employment	Horbach and Rennings (2013)	Positive (process) and neutral (product)
	Lam et al. (2005)	Positive
Reputation	Lin et al. (2014)	Positive (process) and negative (product)
	Lam et al. (2005)	Positive
Differentiation	Grekova et al. (2013)	Positive (product)
	Liao (2016)	Positive (product, process)
	Wang et al. (2019)	Positive
Brand value	Yao et al. (2019)	Positive (product, process)
Risk	Tariq et al. (2019)	Positive
Long-term debt	Cortez and Cudia (2011)	Positive and negative**
Access to new targets	Sanzo-Perez et al. (2015)	Positive (ten) and neutral (four)

^a On comparing firms with green innovations with other firms **On comparing industries.

models” (Clark and Charter, 2007, p. 99). Hence, 79% of the studies use terms related to the environmental pillar of sustainability, while only 11% of the studies use the term social innovations, confirming the notion of Klewitz and Hansen (2014) that the literature to a large degree is skewed toward innovations reducing the impact on the environment.

4.1.2. Operationalization of sustainability innovations

Based on our review of the studies, it appears that there is also great heterogeneity with regard to how sustainability innovations are operationalized. As the majority of the studies include only the environmental pillar of sustainability, they use environmental-related measures. Studies seem to distinguish between sustainability-related products, processes, and managerial innovations. Sustainability-related product innovations are most often measured in terms of reduction in energy consumption, materials, and other input factors and the use of materials with a lower footprint and higher recyclability, reusability, and durability. Sustainability-related process innovations are frequently measured in terms of reduction in the use of materials, waste, water, soil, electricity, gas, coal, or oil/petrol; reduction in emissions and air and noise pollution; and the adoption of cleaner technologies. Finally, sustainability-related managerial innovations are measured

in terms of redefining operation and production processes; redesigning and improving products or services; implementing environmental management systems, value chain management systems, and organizational methods; and implementing relevant international standards, such as ISO14001 (environment) or ISO9001 (quality).

The few studies including social innovation mainly measure the term by innovations that solve social problems, have social benefits, or address social needs.

4.1.3. Operationalization of firm competitiveness

As observed for sustainability innovations, the measures for firm competitiveness also differ between studies (see Tables 4–6), but they can be classified into increased value creation, reduced costs, and non-financial assets. Return on assets (ROA); growth in market share; growth in sales; growth in profits, income, or revenues; and improved productivity, efficiency, and quality are the most common operationalization measures.

Fig. 3 illustrates the most commonly used sustainability innovation and competitiveness variables, and the ways they can be related as sustainability innovations, such as product, process, or managerial, can result in competitive outcomes such as increased value creation, reduced costs, or non-financial assets.

Table 7
Moderators and mediators affecting the sustainability innovation–competitiveness relationship.

Moderators		Mediators
National	Firm	Firm
Stringency of environmental regulations (-)	<i>Sustainability performance</i>	<i>Sustainability performance</i>
Green subsidies (neutral for CT on FP, - EOP on FP)*	Green Image (+)	Environmental performance (+)
Green subsidies (neutral)	<i>Firm Characteristics</i>	Environmental performance (+)
Environmental normative levels (neutral)	Company size (+)	Social performance (+)
Market	Internationalization (neutral)	Sustainable consumption (+ for technical innovation, neutral for non-technical innovation)
Market resource intensity (+ for profitability, - for risk)	Environmental management system (+)	<i>Green innovation</i>
Market turbulence (+ for profitability, - for risk)	Channel structure management (+)	Competitive benefits (+)
Technological turbulence (+ for profitability, - for risk)	Low level of potential slack (+)	Green product competitive advantage (+)
Market uncertainty (+)	Resource commitment (+)	Cost competitive advantage (neutral)
Environmental dynamism (+ for both cost and profit)	Internal efficiency demand (+)	Differentiation competitive advantage (+)
Geographic scope of exploitation (+)	<i>Firm culture</i>	Green product innovation (+)
Geographic scope of knowledge sourcing (-)	Flexibility orientation (+)	<i>Firm capabilities</i>
Industry	Control orientation (-)	Resource integration capability (+)
Industry innovation speed (- for both process and product)	Managerial environmental concern (+ for process, neutral for product)	Resource reconfiguration capability (+)
Regulation intensity (+ for product, neutral for process)	Top management commitment (neutral)	Environmental insight capability (+)
Industry pollution intensity (+ for both process and product)	HR practices (neutral)	
Environmental dynamism/turbulent industry environment (- for product on cost, neutral for process on cost, - for product on differentiation, + for process on differentiation)	Training practices (+)	
Industry munificence (+ for Tobin's Q, - for ROA, - for ROE)	Customer relational governance: Relationship and trust (-)	
	Customer relational governance: Cooperation and reciprocity (+)	
	<i>Firm capabilities</i>	
	Absorptive capacity (+ for CT on FP, neutral for EOP on FP)*	

*CT (clean technologies), FP (financial performance), EOP (end-of-pipe technologies)

4.2. Empirical findings on the relationship between sustainability innovations and firm competitiveness

Tables 4–6 summarize the current literature on the direct relationship between sustainability innovations and firm competitiveness. The findings are presented according to the classification of firm competitiveness outcomes (shown in Fig. 3), namely, increased value creation, reduced cost, and non-financial assets. Even though there are some variations in the results, a significant majority of the studies conclude that there is a positive relationship between sustainability innovations and firm competitiveness, with the positive effects ranging from relatively weak to strong.

4.2.1. Increased value creation

Overall, the majority of the published studies examines whether sustainability innovations contribute to increased value creation. The studies investigated a total of 188 unique relations between sustainability innovations and increased value creation: 120 relations were found to be positive (64%), 54 were found to be neutral or inconclusive (29%), and 14 were found to be negative (7%). We also observed that the relationship was studied by means of a broad range of statistical methods and variables for competitiveness and that there was no obvious pattern indicating that the methodology used influenced the negative and positive findings. Hence, it seems reasonable to assume that the conclusion of a positive relationship is robust regardless of the statistical methods used and the operationalization of variables.

4.2.2. Reduced costs

There are fewer studies on the effect of sustainability innovations on reducing costs. Nonetheless, this review identified 15 studies that investigated a total of 31 different relationships. Of these reported relationships, 18 were positive (58%), 12 were neutral (39%), and 1 was negative (3%). As with the previous outcome, a broad range of statistical methods and

operationalizations are used in the different studies, and hence, one can assume that the findings are robust.

4.2.3. Non-financial assets

With regard to the last category, non-financial assets, this study also found predominantly positive conclusions. The 13 relevant studies investigated 35 relationships: 27 were positive (77%), 6 were neutral (17%), and 2 were negative (6%). Hence, the findings appear to be robust for this category, too, as the studies find similar results regardless of the methodologies and operationalizations used.

4.3. Moderating and mediating effects

The section above answers the first part of the research question. The second part, which focuses on the circumstances under which sustainability innovations positively influence firm competitiveness, revolves around the question of which context-related factors mediate or moderate this relationship. An analysis of the included studies indicates that based on the context, these factors can be categorized as national-, market-, industry-, and firm-level factors.

4.3.1. National context

Three studies investigated the moderating influence of the national context. The earliest study found that national environmental regulations have a negative moderating effect on the relationship between green innovation and firm performance, whereas environmental normative levels have no moderating effect (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013). Quite surprisingly, another study observed that green subsidies have a negative effect on end-of-pipe technologies and financial performance and a neutral effect on clean technologies and financial performance (Xie et al., 2016). This neutral effect of green subsidies was also reported in another study (Xie et al., 2019). Based on these findings, or rather, due to a lack of sufficient studies, it appears that

the effect of national-level factors is understudied and the findings are inconclusive.

4.3.2. Market context

Several studies have explored the moderating effects of market context. One study found that market uncertainty has a positive moderating effect on the green innovation–competitiveness relationship (Chu et al., 2018). Similarly, Chan et al. (2016) found that environmental dynamism, which implies high variations in customer preferences, demand, supply, and technology innovations, positively moderates the effect of green product innovations on cost efficiency and profitability. Another study investigated the moderating effects of market resource intensity, market turbulence, and technological turbulence and found that all three market-level factors amplify the effect of green innovation on financial performance (Tariq et al., 2019). Apart from these studies, which predominantly focus on various types of market turbulence, a recent study found that munificent environments positively moderate the effect of eco-innovations on market value; additionally, the negative effect of eco-innovations on profitability was found to be increased in munificent surroundings (García-Sánchez et al., 2019). Bermúdez-Edo et al. (2017) found that a low geographic scope of innovation knowledge sourcing positively moderates the relationship between environmental innovation and firm performance. Further, they found that a broad international scope of innovation exploitation positively moderates the effect of sustainability innovations on firm performance (Bermúdez-Edo et al., 2017). In conclusion, there is little research on how market factors influence sustainability innovations' effect on competitiveness; however, the existing studies indicate that turbulent markets with high uncertainty positively affect the relationship.

4.3.3. Industry context

Not only market-level factors but also industry-level factors are found to moderate the relationship between sustainability innovation and competitiveness. For example, Yao et al. (2019) found that high regulation intensity and pollution intensity in the industry positively moderate the effect of green innovation on brand value. However, with regard to industry innovation speed, it was found that a high industry innovation speed negatively affects this relationship (Yao et al., 2019). Further, another study on the moderating effect of environmental dynamism, referring to a turbulent industry environment, found that this positively moderates the effect of environmental process innovation on differentiation advantage (Liao, 2016). When it comes to environmental product innovation, however, a negative moderating effect is found. In addition, environmental dynamism has neutral and negative moderating effects of environmental process and product innovation on low-cost advantage, respectively (Liao, 2016).

Thus far, several market- and industry-level factors that moderate a firm's ability to benefit from sustainability innovations have been identified. However, in these areas, research is far from able to deliver a comprehensive framework of the industry and market factors that influence the sustainability innovation–firm competitiveness relationship.

4.3.4. Firm context

Firm-level factors are the most studied moderators and mediators in the literature to date. Relevant firm-level factors can be divided into the following five categories: sustainability performance, firm characteristics, firm culture, firm capabilities, and green innovation. Amores-Salvado et al. (2015) studied the moderating effect of environmental management systems on the relationship between environmental product innovation and firm market performance and found it to be positive. Another study

found that the absorptive capacities of the firm strengthens the relationship between green process innovation and financial performance (Xie et al., 2016). Similarly, Chu et al. (2019) show that organizational culture influences the effect of sustainability innovations on firm performance—that is, a flexibility-orientation enhances the relationship, whereas a control-orientation weakens it. Further, Leyva-de la Hiz et al. (2019) examined the slack of resources in firms, i.e. the amount of resources exceeding what is needed to produce the minimum levels of output, and found that low levels of slack positively affect the environmental innovation–firm performance relationship. Another study examined the moderating effect of managerial environmental concern and found that this positively moderates the effect green process innovations have on firm performance (Tang et al., 2018), whereas another study found that top management commitment had no such moderating effect (El-Kassar and Singh, 2019). Table 7 summarizes the moderating and mediating factors that have been identified at the national, market, industry, and firm levels. The effects are indicated in parentheses.

From the reviewed studies, we observe three interesting issues. First, moderating effects are far more studied than mediating effects (see Table 7). Secondly, the moderating variables that are studied include both external factors (i.e., national, market, and industry) and internal factors (i.e., firm context), whereas the mediating variables include only internal factors (i.e., firm context). Thirdly, seen as a whole, the moderating and mediating variables mostly study internal factors, whereas external factors are in comparison understudied.

5. Discussion

This review study sought to examine the currently available research findings on the relationship between sustainability innovation and competitiveness as well as the factors that influence this relationship. The findings of this systematic review of the direct effect of sustainability innovations on firm competitiveness strongly indicate that the relationship is generally positive in the sense that sustainability innovations, in general, increase a firm's value creation and its ability to attract non-financial assets and also reduce costs. This finding supports the revisionist view that new business opportunities accompanying the sustainability shift more than compensate for the associated liabilities. Consequently, these findings also indicate that the traditionalist view, which considers sustainability innovations as a financial burden for firms, lacks explanatory power.

If, as per the findings of most studies, the traditionalist view lacks explanatory power and sustainability innovations contribute to firm competitiveness, why are more firms not investing more in such innovations? The reason may lay lie in the somewhat complex and ambiguous relationship between sustainability innovations and competitiveness, which several of the studies in this review have illustrated. As Rosca et al. (2018) point out, "... sustainable development is a holistic, complex process which encompasses various dimensions and links between key stakeholder groups and issues" (p. 152). This complexity, in addition to the diversity associated with sustainability-related issues, which range from climate change to human rights, may be the reason why many firms lack sustainability strategies (Engert et al., 2016). Additionally, a common trait of sustainability innovations is the uncertainty of the outcome (Hojnik and Ruzzier, 2016a). Hence, strategic decisions related to sustainability innovations are associated with both complexity and uncertainty in regard to outcomes (Engert et al., 2016), and this reduces the attractiveness of these kinds of investments.

Even though the general positive nature of the relationship has been established in this review, there is still significant

heterogeneity in the findings across studies. Below, we will discuss two important sources of this heterogeneity, namely, the methods and contextual factors (that is, the mediation and moderation effects of these factors).

5.1. Method-related heterogeneity

One obvious reason for heterogeneity in the findings is the methodological approach and choice of method in each study. First, this study shows that the variables used to operationalize sustainability innovations and firm competitiveness vary extensively across studies (see Fig. 3 and Table 4–6). Not only are the conceptualizations of sustainability and firm competitiveness different, but they are also measured differently. For example, some studies use single-question variables, while others use more robust indexes of multiple variables. In fact, some researchers argue that the variations in the outcomes of studies is caused by the variance in measurement (Hussain et al., 2018). However, there are also other ways of interpreting these findings. One can argue that the heterogeneity of the methods is a strength of the field of research because it means that the findings are robust in the face of variance in measurement. Alternatively, one can argue that as we compare different variables and operationalizations, it is hard to really compare the results from the studies and accumulate knowledge.

Another reason for the heterogeneity in outcomes might be that different types of sustainability innovations influence competitiveness differently (Rexhäuser and Rammer, 2014). Different types of innovations, such as product, process, radical, and incremental, influence business activities differently with varying levels of impact on efficiency and risk and, hence, result in different outcomes (Forsman, 2013) and also influence the strength of the relationship differently (Dong et al., 2014). Further, some sustainability innovations simply aim to reduce unwanted externalities, such as pollution or emissions, and do not necessarily result in any payoff in monetary terms (Antonioli et al., 2016; Ghisetti and Rennings, 2014). Another example is research finding that environmental product and process innovations had a different impact on firm competitiveness, namely, differentiation advantage and cost efficiency advantage, respectively (Grekova et al., 2013). Schiederig et al. (2012) argue that the challenge in measuring and comparing the environmental benefits resulting from different innovations makes it difficult to accumulate knowledge in this research area. In summary, the heterogeneous findings on the relationship between sustainability innovation and competitiveness can partly be explained by the great variety of methodological approaches and operationalizations, underscoring the call for more typology studies in researching this relationship (Dong et al., 2014).

An additional methodological challenge is related to time lags and time of censoring. As with all innovations, there is a time lag between their implementation and their economic results (Hojnik and Ruzzier, 2016a; Rezende et al., 2019; Wong, 2012). Investment costs and temporary higher operational costs during the implementation and learning phases may lead to negative effects on firm profitability in the short term (Antonioli et al., 2016), and it might take years before positive economic effects are visible on the accounts (Hojnik and Ruzzier, 2016a). Consequently, the results of studies might vary according to the time span between the adoption of an innovation and the measurement of firm performance (Antonioli et al., 2016) and also according to whether the study uses cross-sectional or longitudinal data.

Another recurring issue regarding research methods is related to the directionality of the sustainability innovations–competitiveness relationship. In other words, do sustainability innovations provide increased competitiveness, or are highly competitive firms more likely to adopt sustainability innovations? Cross-sectional studies are

unable to establish the directionality (Pätäri et al., 2012), and in the literature, cross-sectional studies are quite common. Some argue that competitive advantages from sustainability innovations are a result of a cumulative process that starts prior to the development of the innovation because highly competitive firms already have both innovative capacity and competitiveness (Forsman, 2013; Forsman et al., 2013). For example, Forsman (2013) finds that in the period preceding the innovation process, successful green innovators show higher return on total assets than unsuccessful green innovators. In addition, during the development period, successful green innovators have higher market and financial advantages. In other words, a firm's competitive advantage as a result of green innovations may be influenced by the prior advantages they possess in terms of, for example, capabilities, financial resources or risk, and reputation among customers. In line with this, Martínez-Ferrero and Frías-Aceituno (2015) identified a positive two-sided relationship between sustainability initiatives and financial performance among firms. They argue that this is a virtuous circle, as good economy gives firms the opportunity to invest in sustainability activities, which in turn leads to positive firm outcomes that make it possible to invest new resources into sustainability activities. One can argue whether this means that financially stronger firms take more sustainability initiatives than other firms, or whether sustainability initiatives result in financially stronger firms, which in turn becomes a reinforcing factor. Hence, like many other researchers (Y. C. Huang and Wu, 2010; W. L. Lin et al., 2019), we see a strong need to investigate the sustainability innovation–competitiveness relationship based on longitudinal data in order to settle the debate on directionality.

5.2. Context-related heterogeneity

Given that the business environment is characterized by complexity and uncertainty, the relationship between managerial actions and their consequences is not necessarily straightforward (Chen and Chang, 2013). Sustainability innovations' effect on firm competitiveness is influenced by a variety of factors (Ben Arfi et al., 2018). As shown in the results section, contextual factors influence the relationship between sustainability innovations and competitiveness in a variety of ways. It is important to understand and take into account these contextual factors in order to gain a more precise understanding of this relationship (Bermúdez-Edo et al., 2017). As we see from the results section, national regulations, incentives, society's awareness of sustainability issues, market uncertainty, industry norms and regulations, type of industry, and firm factors all have an influence on the effect of sustainability innovations on competitiveness. Hence, Fig. 4 below extends our initial research framework to include these factors. This deduction is in alignment with earlier research findings that the effectiveness of green innovations depends on certain contextual and conditional factors (Chu et al., 2018). However, we have also contributed to the knowledge by specifying the most pertinent mediating and moderating factors identified in the literature so far. These factors are discussed in more detail below.

First, the national context seems to play an important role in the ability of firms to turn sustainability innovations into competitiveness (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013; Horváthová, 2010). Regulations, industrial agreements, and incentives from the government all influence the degree to which firms engage in green innovations (Doran and Ryan, 2012). Moreover, institutional contexts and corporate governance systems are found to moderate the relationship between sustainability initiatives and financial performance (Martínez-Ferrero and Frías-Aceituno, 2015). Findings in published studies also indicate that green innovative firms are more common in countries with stronger environmental regulations (Aguilera-Caracuel and Ortiz-de-

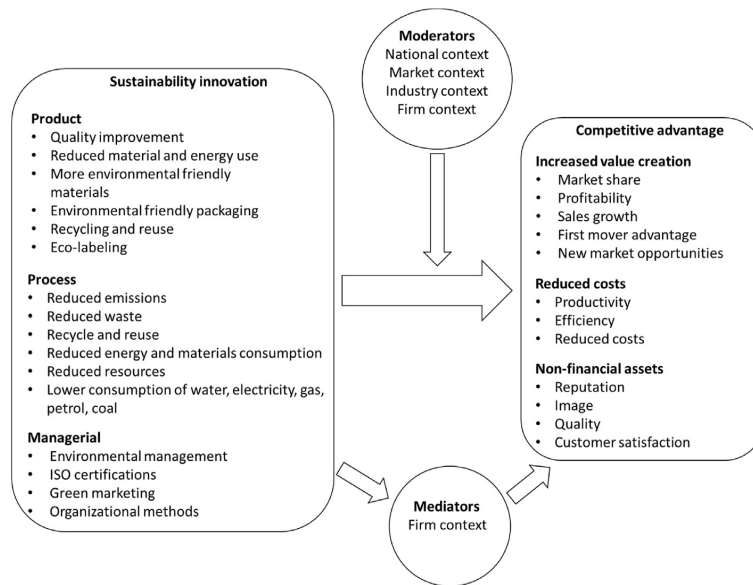


Fig. 4. Extended model depicting the relationship between sustainability innovation and competitiveness.

Mandojana, 2013). This is in agreement with the argument of Porter and van der Linde (1995) that environmental regulations drive innovation in firms. Additionally, compared to non-green innovative firms, green innovative firms are located in environments where the normative levels are higher (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013). This means that businesses situated in countries with high environmental consciousness and values will strive to improve environmental outputs and create awareness around their activities (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013). Similarly, Rezende et al. (2019) found that firms located in Europe benefit more from green innovations than firms located in North America and Asia, both in the short and long term, for the same reasons. Thus, societies with high awareness of environmental issues are more likely to foster more innovative green firms. This notion is in alignment with the meta-analysis conducted by Bitencourt et al. (2020), in which it was found that countries with high scores on the global sustainable competitiveness index, measured by, for example, natural capital, intellectual capital, and governance efficiency, have a stronger relationship between eco-innovations and firm performance.

With regard to the second context, market-related factors are also found to affect the relationship between sustainability innovations and competitiveness. More specifically, findings show that high environmental dynamism, which refers to high variations in customer preferences, demand, supply, and technology innovations, positively affects the relationship (Chan et al., 2016). In dynamic environments, existing products and services become quickly outdated in the face of new and improved offerings (Chan et al., 2016). Hence, there is more “room” for new sustainability innovations to succeed in the market. Chu et al. (2018) explain the positive moderating effect of uncertain markets as follows: in an uncertain business environment, few companies dare to take the risk associated with green innovations; however, those who do will gain more. Hence, a turbulent technological and market context enhances the effect of sustainability innovations on firm competitiveness (Tariq et al., 2019).

Third, we observe that industry characteristics can moderate the sustainability innovation–competitiveness relationship especially in terms of industrial institutional environments (Yao et al., 2019). For example, Rezende et al. (2019) found that manufacturing firms gain more from green innovations than non-manufacturing firms do. Their rationale is that the manufacturing sector includes more pollution and emissions, and hence, it is easier to identify business opportunities than, for example, in the service and information sectors. In another study, a comparison of the automotive and electronics industries showed that environmental innovations positively affect all performance measures (sales, income, assets, long-term debt, and equity) in the automotive industry, while in the electronics industry, it affects only sales (Cortez and Cudia, 2011). Similarly, Chen et al. (2006) found significant differences between industries with regard to the effects of green process and product innovations. Furthermore, the pressure for environmental practices varies between industries as there are different levels of self-regulation initiatives and codes of practice (Lenox and Nash, 2003). In industries with high energy use and emissions, the adoption of sustainability innovations is high and common (Cainelli et al., 2011). Hence, what drives sustainability innovations is industry specific, and the extent to which industries react to environmental challenges varies (Chu et al., 2018). For example, some process industries with high levels of pollution are found to face higher pressure and, hence, are more liable to develop sustainability innovations (Amores-Salvadó et al., 2015). Moreover, the specific industry a firm belongs to also predicts the ability to respond as industry factors influence the effect of resources, capabilities, and behaviors of the firm (Liao, 2016). Hence, type of industry can be a good predictor of a firm’s incentives for adopting environmental innovations both in terms of drivers, such as governmental regulations and market pressure, and goals, such as reduction in energy and material consumption or emissions (Cainelli et al., 2011). In addition, the specific industry plays an important role in the effects of sustainability innovations.

The national, market, and industry factors are central in institutional theory, which discusses how institutions such as governments, consumers, and competitors exert pressure and drive development and the adoption of sustainability innovations in firms (Tariq et al., 2017). Firms create social legitimacy among stakeholders by adjusting to the customers' values and social norms and incorporating the standards proposed by governmental institutions and industry regulatory bodies (Chu et al., 2019; Sarkis et al., 2010). Fulfilment of these criteria increases legitimacy and the likelihood of competitive survival (Tariq et al., 2017). Thus, institutional theory explains how external norms, values, and traditions can account for the actions of firms (Chu et al., 2018). In addition to institutional theory, stakeholder theory is commonly used to explain the development and adoption of sustainability innovations. This is because primary and secondary stakeholders are found to influence strategic decisions regarding sustainability innovations that, in turn, attract new customers and shareholders (Tariq et al., 2017). Hence, institutional and stakeholder theories are central in the research on how external factors influence firms and their tendency to develop and adopt sustainability innovations for competitive purposes. These factors can work as drivers, but they also help us explain under what circumstances sustainability innovations have a positive effect on competitiveness.

Fourth, this study has identified several firm-level factors that influence the sustainability innovation–competitiveness relationship. The complexity of sustainability innovation stipulates that firms need experience and skills exceeding the traditional industry experiences (Ben Arfi et al., 2018). It is argued that in order to create value from sustainability innovations, resources and capabilities must be used in a way that differentiates the firm from other companies (Forsman, 2013). As different sustainability innovations are found to have different competitive outcomes, managers' knowledge of the firm's competitive capabilities and the integration of sustainability innovations with the overall strategy becomes important (Wong, 2012). The moderating and mediating effects of different firm-level factors are also reported in the literature review by Tariq et al. (2017). They discuss the relationship in light of the resource-based theory and argue that resource commitment and the uniqueness of the firm's resource bundle contribute to the firm's ability to respond to external stakeholder demands and achieve results from green innovations. In addition, they argue that dynamic capabilities are understudied but constitute an important perspective as firms in a dynamic environment must constantly create, deploy, and protect their competitiveness.

5.3. Further research

Several gaps have been uncovered in the review, and hence we have numerous propositions for further research. With regard to the first part of our research question, we discover that the majority of the included studies finds that sustainability innovations have a positive effect on firm competitiveness. However, there are still studies that find neutral and negative effects. We therefore see this inconsistency in findings as proof that this still needs to be studied in greater depth in future research. We also observe that as many as 80% of the studies have researched the environmental part of sustainability in terms of environmental-, green-, or eco-innovation. Hence, the social part of sustainability is far understudied, which we see as an issue as social matters and environmental issues are interrelated and must be solved simultaneously to achieve sustainability (Engert et al., 2016). We hence propose further research to include social innovations when conducting these types of studies to obtain a more holistic understanding of sustainability.

With regard to the second part of the research question, this study concludes that current research has yet to provide a comprehensive answer to the question as to what factors positively moderate and mediate the relationship between sustainability innovations and firm competitiveness. Even though several factors have been identified, there are many factors that remain under-investigated and have yet to be identified. Hence, we see a strong need for future research to focus on the mediating and moderating variables affecting the sustainability innovation–competitiveness relationship. We propose that a reason for the variation in regard to sustainability innovations' effect is because of different national, market, industry, and firm factors. One can debate whether these factors can be generalized across studies as each firm has its own characteristics and operates in idiosyncratic contexts. We therefore propose to both study the already-investigated moderating and mediating effects presented in this study but also to investigate new factors that may influence this relationship. Specifically, we observe that mediating variables and variables concerning external factors (e.g., in the national, market, and industry contexts) are understudied.

In relation to moderating and mediating effects, we find the institutional and stakeholder theories, and strategic management theories, such as the resource-based and dynamic capabilities theories, to provide valuable insight into this subject. Therefore, we call for more research that employs and extends these theories to provide a fuller understanding of factors that influence the relationship between sustainability innovation and competitiveness.

Further, as noted earlier in the article, the manufacturing industry is the most studied industry on this research topic (Chu et al., 2018). This is not surprising as the manufacturing industry has several sustainability challenges. However, to obtain an enhanced understanding, we propose that future studies include other industries as well in order to observe the differences between different industries (G. Li et al., 2019) regarding sustainability innovations, moderators, mediators, and competitiveness outcomes.

Furthermore, currently most of the research concerning the effect of sustainability innovations uses cross-sectional data. Many researchers argue that it takes time to see the effect of sustainability innovations (Hojnik and Ruzziek, 2016a). Because of this, we see a strong need for longitudinal studies. Only by using longitudinal studies can the real effects of sustainability implementation be observed (Chu et al., 2019; Tariq et al., 2017).

It is also clear from the literature review that sustainability innovations can take many forms, such as process, product, or managerial. However, many of the studies do not differentiate between the different types of innovations. Researchers argue that different innovations have different effects on competitiveness (Horváthová, 2010; Rexhäuser and Rammer, 2014). This has also been observed in this review. We see this issue as an important area of further research as this has critical influence on what kind of innovations firms should invest in and what the innovation success criteria are. In the same manner, we observe from the articles a broad variety of measurements of competitiveness. We purport that a standard measurement scale for competitiveness in the research field is necessary to measure and compare the sustainability outcomes in the same way (Dong et al., 2014).

Lastly, our findings reveal that the majority of studies (90%) used quantitative methods and that qualitative studies, including case studies, are not as commonly used. We propose, in line with, for example, El-Kassar and Singh (2019), that further research concerning sustainability innovations should conduct more case studies. As we now have uncovered that the majority of studies find a positive relationship between sustainability innovations and competitiveness, we see the need for more research taking a more practical approach in how firms should implement competitive

sustainability innovations considering the difference in national, market, industry, and firm factors. We also see a need for understanding more in depth how the moderating and mediating factors affect the relationship. For example, we find conflicting results on whether government subsidies have positive or negative effects on the sustainability innovations–competitiveness relationship (Xie et al., 2016, 2019). Further research can thus help in explaining what kinds of regulatory schemes, including subsidies, are effective in motivating industries to become more sustainable. This has great importance for future regulations. In this, we support prior researchers in the notion that the question is not whether firms should implement sustainability but rather *how* (Engert et al., 2016; Grekova et al., 2013).

6. Conclusion

Due to pressure from shareholders and tough competition in international markets, many firms focus on short-term profits (Leal-Rodríguez et al., 2018). In many cases, a short-term focus is not compatible with the necessary patience and risk associated with sustainability. Hence, there is often a conflict between economic results and sustainable development (Sjafjell, 2018). However, we argue that this conflict can be solved by sustainability innovations in which firms meet the increasing competition in changing markets while contributing to sustainability (Klewitz and Hansen, 2014).

In this literature review, 100 articles were reviewed with the goal of mapping the current state of the research on the relationship between sustainability innovation and competitiveness and identifying the factors that influence this relationship. By reviewing the literature, several contributions are made. First, the findings from this review show that a large majority of the reviewed studies has concluded that sustainability innovations have a positive effect on firm competitiveness and that only a small fraction of the studies found a negative relationship between the two. We find that the outcomes resulting from sustainability innovations can be divided into increased value creation, reduced costs, and non-financial assets. Hence, we show that the conflict between sustainability and economic results can be eased via sustainability innovations as they contribute both to the sustainability shift and competitive advantage. These findings support the revisionist view that the sustainability shift comes with a set of business opportunities that are so large and so many that they outweigh the costs. Thus, these findings also indicate that the traditionalist view of sustainability innovations predominantly driving costs lacks explanatory power.

Secondly, we contribute to the research field by including social innovation in our literature search. Corporate social innovation is an understudied topic and provides unexploited business opportunities (Dionisio and de Vargas, 2020). As the sustainability research is often reduced to the environmental pillar (Klewitz and Hansen, 2014), a more holistic perspective on sustainability is needed by researchers (Engert et al., 2016). Only by understanding that the pillars of sustainability must be addressed simultaneously can we sufficiently address the societal challenges.

Third, we contribute to the literature by investigating and presenting the extensive operationalization of terms and variables used to measure sustainability innovations and competitiveness in a systematic manner. The current review shows that there exists great heterogeneity in the terms and variables used. This makes it difficult to make direct comparisons across studies and accumulate knowledge and may be a reason for the inconsistent results concerning the relationship. The variation in conceptualizations and operationalization is a limitation often mentioned in the literature (Tariq et al., 2017). However, we argue that the heterogeneity is also a strength

because it shows that the sustainability innovation–competitiveness relationship is robust regardless of the method or operationalization of variables.

Fourth, this study contributes to the field by examining and listing the moderating and mediating factors that affect the sustainability innovation–competitiveness relationship. We have discovered that these factors can be classified according to context into national-, market-, industrial-, and firm-level factors. This makes important contributions to the field, both theoretically and practically, as this knowledge about the effects of moderators and mediators may shine light on which strategies are effective and which are not (Tariq et al., 2017). Understanding the factors influencing the relationship is also vital to manage the technological challenges associated with sustainability innovations (El-Kassar and Singh, 2019).

Finally, the review contributes with important suggestions for further research. In particular, we argue that the question is not whether firms should adopt sustainability innovations but *how* to do it successfully (Eiadat et al., 2008). Hence, we suggest that future research look into how firms should implement sustainability innovations that create win-win situations. By this, the sustainability innovation–competitiveness relationship can be disentangled from the conflict of traditionalist vs. revisionist views to the focus on *how and under what conditions* sustainability innovations become successful. These kinds of studies will have great implications for firms and governing bodies. In addition, there is a need for more studies on the moderating and mediating effects, which are still underdeveloped in the literature. We see these kinds of studies as utterly important for an increased understanding of the complexity of sustainability innovations.

6.1. Limitations of study

While this review makes important contributions to the literature concerning the effect of sustainability innovations, it has a number of limitations. Firstly, the choice of databases could have affected the number of relevant articles. Using other or additional databases could have increased the number of articles relevant to the research question. Secondly, because of the large variation in terms and definitions within the sustainability innovation topic (Engert et al., 2016; Klewitz and Hansen, 2014), it is possible that relevant studies using terms other than the keywords used were not found in the literature search. Thirdly, the inclusion criteria of keywords in abstracts could also have excluded relevant papers. Finally, the literature review approach, despite the use of inclusion and exclusion criteria, still entails making individual decisions on what is relevant versus irrelevant literature. This may be another limitation of conducting this type of study (Engert et al., 2016).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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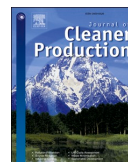
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PAPER 2



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Competitive sustainable manufacturing - Sustainability strategies, environmental and social innovations, and their effects on firm performance

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ABSTRACT

It is important for practitioners, policymakers, and scholars to understand how the adoption of sustainability strategies and innovations influence firms' overall performance. Practitioners obviously seek knowledge of the likely financial outcome of the adoption of sustainability strategies and innovations. Policymakers need the knowledge to devise effective policies to reach sustainability goals, and scholars seek to understand firm behavior and their ability to create financial value in the sustainability shift. Even though an increasing amount of empirical evidence indicate that the sustainability-firm performance relationship is positive, much debate remains concerning how and under what conditions firm-level competitiveness is created through sustainability. This study contributes by examining how sustainability strategies influence the implementation of social and environmental innovations in manufacturing firms, and in turn, how these innovations affect firm performance. Firm performance is measured in terms of value creation, cost reduction, and risk reduction, in which both perceived performance and objective longitudinal financial data are used. The study adopts a quantitative research approach using survey data from a representative sample of Norwegian manufacturing firms combined with publicly available financial data. Hypotheses are tested by structural equation modeling (SEM). The results indicate that sustainability strategies elicit a positive effect on the implementation of environmental and social innovations. Furthermore, environmental innovations were found to give a positive effect on all measured firm performance outcomes, while social innovations yielded mixed effects. We discuss the findings in relation to stakeholder and resource-based-view theories and the implications for practice and further research.

1. Introduction

Manufacturing and other forms of industrial activities' consumption of resources and energy, waste generation and emissions are major sources of the current sustainability challenges. As these challenges have become more evident and pressing, manufacturing firms have started to integrate sustainability into their core businesses strategies (Ghassim and Bogers, 2019). Moreover, stricter regulations of negative environmental and social externalities from the industry, combined with growing consumer awareness and environmentalism are changing how business is conducted across industries (Lin et al., 2019). Firms increasingly acknowledge that to remain competitive, environmental and social considerations need to be integrated into their core business strategies (Leal-Rodríguez et al., 2018).

While early research suggested that managers predominantly viewed

sustainability strategies as cost drivers (Christmann, 2000), more recent research suggest a shift towards perceiving the sustainability shift as an opportunity (Porter and Kramer, 2011). The latter is more in line with a recent review of published research on the sustainability innovation-firm competitiveness relationship, which supports the hypothesis that increased focus on sustainability also increases firm competitiveness (Hermundsdottir and Aspelund, 2021). Hence, from a policymaker's point of view, recent studies suggest that even though the manufacturing sector is one of the major sources for global sustainability problems, they also can be a key element of the solution (Fraj et al., 2015). Unfortunately, the sustainability challenge is multifaceted and there is little knowledge of which types of sustainability innovations – environmental or social – firms are financially motivated to adopt.

This leads us to the managerial problem. Even though multiple studies conclude that there is a positive relationship between adoption

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of sustainability and firm competitiveness, there must be limitations. Arguably, not all sustainability innovations create commercial value and the practical questions of how and under what circumstances sustainability is profitable remains largely unexplained (Hermundsdottir and Aspelund, 2021). Hence, because this relationship largely remains a black box and the limitations of the positive relationship remain unclear, managers are not very informed on how they can benefit from adopting sustainability innovations within their own industries. Practitioners need more knowledge on what types of sustainability innovations have commercial potential for either increased value creation, cost or risk reductions.

From an academic perspective, many questions have arisen from the value-creation mechanism and limitations of the sustainability-firm performance relationship. Naturally, transition costs are associated with changes in products, processes, management approaches, and policies required to improve sustainability performance (Silvestre and Tircă, 2019). But what is the corresponding value-creation mechanism that offsets the costs of change toward sustainability? Some scholars take a resource-based approach and argue that sustainability rents are offset by an internal focus on developing resource and environmental efficiency in production that lead to cost reductions and business efficiency (Gürlek and Tuna, 2018). Other scholars have taken an external stakeholder view and argued that the cost of sustainability changes is offset by better market performance through superior value creation or by eliminating market-related risks (Ghassim and Bogers, 2019).

This study contributes by offering some answers to these questions by providing new insight into the sustainability innovation-firm performance relationship with relevance for practitioners, policymakers and scholars. More specifically, this study investigates the question of whether the adoption of sustainability strategies leads to actual implementation of social and environmental innovations, or whether in only leads to ceremonial adoption. Further, it investigates the question of whether different types of sustainability innovations – environmental and social – have different effects on firms' ability to create value, reduce costs or reducing market risk. By adopting both inside-out (resource-based theory) and outside-in (stakeholder theory) perspectives (Kolk and Pinkse, 2007), the present study contributes to the ongoing scholarly discussion of how competitiveness is created from sustainability (Hermundsdottir and Aspelund, 2021). Finally, it poses the question of whether managers' perceived success for the adoption of sustainability strategies matches up to the actual long-term financial performance of the firm, addressing the common methods bias problem in previous studies (Lin et al., 2019; Wijethilake et al., 2018).

One key strength of the study is the empirical data. The analysis is performed on primary quantitative data of a representative sample of the whole manufacturing sector in Norway. The data is based on survey data collected in 2015/2016 on manufacturing firms' sustainability strategies, adoption of sustainability innovations and managers' expected economic outcomes. The survey data is combined with publicly available financial data on firm performance in the years from censoring (2015) to 2019.

2. Theory and hypotheses development

2.1. Sustainability - environmental and social innovations

In order to reach the United Nations' Sustainable Development Goals (SDGs), the manufacturing sector needs to adopt a range of sustainability innovations that lowers the sectors' environmental and social footprints. *Sustainability innovations* is defined in this study as innovations that "improve sustainability performance, where such performance includes ecological, economic, and social criteria" (Boons et al., 2013, p. 2). Thus, sustainability innovations can provide solutions to the conflict between environmental and social degradation and economic development (Lin et al., 2019).

Embedded in this definition of sustainability innovation is the

distinction between environmental and social innovations. Due to the current focus on environmental problems and climate change, environmental innovations are most studied in recent years (Hermundsdottir and Aspelund, 2021; Seuring and Müller, 2008) and they primarily deal with innovations for energy efficiency, emissions, waste management, recycling, reuse, and durability (Amores-Salvadó et al., 2014).

Interestingly, even though environmental sustainability gets most attention it is only directly related to 6 of the 17 SDGs. Most SDGs deal with social challenges, but they seem to have caught less attention in the sustainability business literature (Mulgan, 2006; Tabares, 2020). Social sustainability is perceived differently across different disciplines (Cajaiba-Santana, 2014). In this study, we define social innovations as innovations that contribute to increased life quality, social beneficence, and the overall public good (Dawson and Daniel, 2010; Pol and Ville, 2009).

This study seeks to investigate the differentiated effect of environmental and social innovations on firm performance. This makes sense as they are defined differently, interacts with different environmental and social factors, and receive different levels of attention in current society. It is therefore reasonable to assume that the potential for creating competitive advantage will differ too. Moreover, the distinction allows us to investigate whether type of sustainability innovation gives rise to different dimensions of firm performance. While the effect of environmental innovations has been examined in numerous studies there is still a question of what type of competitiveness is created and under what circumstances (Cai and Li, 2018). Social innovations' impact on firm performance, on the other hand, is understudied and remains largely unknown (Phillips et al., 2015; Hermundsdottir and Aspelund, 2021).

2.2. Sustainability strategies' influence on the adoption of sustainability innovations

Sustainability was for a long time kept separate from firms' core business strategies (Schrettle et al., 2014). This has changed in recent years and today most firms see sustainability strategies as important (Engert and Baumgartner, 2016) and are integrated with core business strategy (Burki et al., 2018; Ghassim and Bogers, 2019). The term *sustainability strategies* implies "formalization of sustainability into businesses through implementation of new procedures for planning, evaluating, and reporting, in addition to new goals and responsibilities" (Reyes-Rodríguez et al., 2016; Reyes-Rodríguez et al., 2016, p. 195). Moreover, adopting sustainability strategies indicates proactive strategic behavior (Reyes-Rodríguez et al., 2016; Reyes-Rodríguez et al., 2016) – that firms exceed complying standards from regulations and actively seek to improve their environmental and social performance by modifying products, processes, and technologies to reduce negative impacts (Fraj et al., 2015).

Consequently, strategic management includes both the formulation and implementation of strategies (Mintzberg and Waters, 1985), similarly to the distinction between strategic intention and actual behavior (Long et al., 2017). Hence, if there is – as hypothesized in this study – a potential to create competitive advantage in adopting sustainability, creating a sustainability strategy is not sufficient. The mobilization of resources, capabilities, managerial attention, and opportunity recognition are necessary for success (Long et al., 2017; Wijethilake et al., 2018).

There are at least two reasons why sustainability strategies might not be followed up with actual implementation. One is often referred to as ceremonial adoption – meaning that the strategy is implemented only in ceremony and not in practice. This is a well-known phenomenon from the literature of production systems (Netland and Aspelund, 2014) and in the sustainability literature it is most often referred to as "green-washing" – the phenomenon that firms misleadingly communicate sustainability efforts without implementing them in practice (Vries et al., 2015). Second, non-execution can also stem from inability due to complexities in implementation. Implementation of sustainability strategies can be difficult and time-consuming if the organization is engrained in

unsustainable practices and the implementation requires significant changes in organization, practices, mindset and resource efforts (Engert and Baumgartner, 2016).

Still, if the underlying hypothesis of this study holds true – that there is a potential for increased firm performance through increased value creation or reduced costs or business risk – firms with ceremonial adoption of sustainability strategies or inability to implement sustainability for other reasons are not able to leverage those benefits. After all, strategy is ultimately about managing how resources and capabilities are employed in actual behavior (Bacinello et al., 2019; Long et al., 2017). Hence, we hypothesize:

H1a. Adoption of firm sustainability strategies positively affect adoption of environmental innovations.

H1b. Adoption of firm sustainability strategies positively affect adoption of social innovations.

2.3. Creating value: Sustainability innovations and firm performance

The sustainability – firm performance relationship has received increased attention in the academic literature the past few years (Hermundsdóttir and Aspelund, 2021; Rezende et al., 2019). Despite the number of studies, the debate continues due to inconsistent and sometimes conflicting results (Fraj et al., 2015; Li et al., 2019). Two main reasons why there is still a debate despite the number of studies is that the relationship is complex and methodologically challenging.

2.3.1. Sustainability innovation – firm performance relationship: complexity and methodological challenges

The first reason why the sustainability – firm performance relationship is challenging to study is complexity. Sustainability innovations are often the result of significant investments in new technological solutions that require change on multiple levels of the organization and across supply chains (Fraj et al., 2015). Moreover, firm performance outcomes might depend on national, market, industry, and firm context variables outside of managers' control, which complicates the relationship even more (Hermundsdóttir and Aspelund, 2021). Hence, the context in which the study is executed will influence the result.

Second, the relationship is methodologically challenging due to time lag, uncertainty of directionality, and common method bias (CMB). As for time lag, some argue that the findings are mixed because of a time lag between adoption of the innovation and economic results (Rezende et al., 2019). Uncertainty of directionality is also widely discussed (Martínez-Ferrero and Frías-Aceituno, 2015; Pătări et al., 2012) and relates to the question of whether firms that adopt sustainability innovations perform better, or whether financially successful firms implement more sustainability innovations. To address both these issues, studies with longitudinal economic performance data are needed (Chu et al., 2019; Lin et al., 2019). Finally, CMB occurs when dependent and independent variables are measured using the same method. It is particularly problematic when measures are dependent on respondents' perceptions, or include topics in which the respondent intrinsically wants to be positive or sociable (Podsakoff et al., 2003). CMB is common in many sustainability studies and may affect their findings.

Due to these empirical and methodological challenges, the sustainability – firm performance relationship is often treated like a black box, providing both scholars and practitioners with limited insight into the mechanics of sustainability value creation. The present study seeks to contribute in investigating some of the mechanics of sustainability value creation using a method that avoids some of the challenges. But first we need to return to the rationale for how firm performance is created.

2.3.2. Stakeholder theory: increased value creation and reduced risk through sustainability

Stakeholder theory is the most used theoretical framework in studies that seek to investigate the sustainability innovations and firm

performance relationship (Hermundsdóttir and Aspelund, 2021). The theory emphasizes the influence of the firm's stakeholders in strategy formulation (Freeman, 1984), where stakeholders are defined as the groups and individuals who can influence and be influenced by the firm's performance or objectives (Freeman, 1984). The reason why this theory is so popular among sustainability researchers is that it broadens the view of business by considering the firm to be part of a bigger societal and natural environment in which the purpose is to create value for all stakeholders (Freeman et al., 2010).

Several studies have examined how stakeholder pressure from e.g. customers and regulators influence firms' efforts to implement sustainability (Ramanathan et al., 2014; Yu et al., 2017). The rationale is that failing to meet requirements from stakeholders – such as governments, customers, NGOs, and the media – can lead to economic and reputational loss (Guoyou et al., 2013) while meeting stakeholders' demands can lead to increased reputation, customer satisfaction, growth in market share, and stronger financial performance (Liao, 2018). In many ways, stakeholder theory, market orientation, and the positioning school within strategy are closely related, as all focus on the external environment (Leal-Rodríguez et al., 2018) and argue that firms who manage to satisfy customer needs and react to new requirements will gain a competitive advantage (Day, 1994).

Even in the instances where development and implementation of environmental innovations require significant investments, stakeholder theory can explain why it is still economic beneficial if increased revenues or margins offset the associated costs (Eiadat et al., 2008). This view has been supported in several studies where environmental innovations have been found to positively affect firm performance in terms of increased competitive advantage (Chang, 2011), market value (García-Sánchez et al., 2019), and firm profitability (Chan et al., 2016). Hence, we hypothesize:

H2a. Implementation of environmental innovations positively impact a firm's value creation in terms of growth in revenues and profitability.

Stakeholder theory also can explain how companies implement sustainability innovations to improve company reputation and reduce business risk, but this relationship has been less studied. However, some studies have found that environmental measures systematically reduce risk (Sharfman and Fernando, 2008). Likewise, Eiadat et al. (2008) and Tariq et al. (2019) found that green innovations reduce risk, in that firms become more prepared for future regulations and the increase in environmentally concerned customers. Hence, we hypothesize:

H3a. Implementation of environmental innovations reduce firms' overall business risk.

Research on social innovations' effect on firm performance is scarce, but the basic stakeholder rationale also applies to social innovations. The only difference is that the general stakeholder pressure for social innovations might have been less than for environmental innovations the past decade. However, the discussion is older and spans back to the early industrial revolution. The few studies on the topic conclude that social innovation is positively related to economic performance (Osei and Zhuang, 2020; Svensson et al., 2019), especially in terms of market related measures such as firm value, customer loyalty and stakeholder retention (Cacciolatti et al., 2020). Other studies find that social innovations increase legitimacy and as such implies reduced business risk (Cacciolatti et al., 2020; Li et al., 2018; Padgett and Moura-Leite, 2012). Based on these studies we hypothesize:

H2b. Implementation of social innovations positively impact a firm's value creation in terms of growth in revenues and profitability.

H3b. Implementation of social innovations reduce firms' overall business risk.

2.3.3. Resource-based theory: cost reductions and increased efficiency through sustainability

The second most used framework in research on the sustainability innovation – firm performance relationship is resource-based theory (Hermundsdottir and Aspelund, 2021). Resource-based theory (RBT) conceptualizes the firm as a bundle of resources and capabilities that create the basis for firm's competitive advantage (Barney, 1991). In this context, a resource is "something that a firm possesses, which can include physical and financial assets, as well as employees' skills and organizational (social) processes" (Hart and Dowell, 2011, p. 1465). Capabilities are resources and routines that the firm needs to accomplish a certain output that is important for the firm's survival and prosperity (Winter, 2000). In other words, RBT is an inside-out perspective, which means that a firm's strategy process departs from an analysis of internal resources and capabilities.

There is a long tradition to use RBT to analyze firms' sustainability strategies. Hart (1995) extended the RBV perspective to incorporate natural resources as they have become increasingly important for strategic outcome. Natural resource-based view (NRBV) states that in order for firms to achieve sustainable development they need to possess specific strategic resources and capabilities and result in desired outcomes (Hart and Dowell, 2011).

In the years after Hart's seminal work, RBT and NRBV have been used extensively in the literature to explain the relationship between sustainability innovations and competitiveness (Shin et al., 2018). Several studies have investigated how different kinds of resources and capabilities influence implementation of sustainability innovations (Albert-Morant et al., 2016; Huang and Li, 2017).

One particular strand of research has focused on how environmental innovations can lead to cost reductions and increased operational efficiency due to reduction in the use of input factors such as energy, materials and labor as well as reduction of waste costs (Chan et al., 2016; Christmann, 2000; Hojnik et al., 2017). This strand of research has been labelled *Lean and Green* (Garza-Reyes, 2015) as the effect of improvements in environmental performance occurs simultaneously as the firm is implementing a company-wide production system based on the lean manufacturing system (King and Lenox, 2001). A production system is a good example of a strategic company resource with implications for financial and environmental performance (Netland and Aspelund, 2013). The rationale is that generation of waste, emissions and other environmental footprints are simply symptoms of inefficient production and there is a potential for cost reductions by removing those footprints (Hojnik et al., 2017). The *Lean and Green* phenomenon is well established in the sustainability manufacturing literature and shows how firms can systematically reduce their environmental footprints through implementing and refining a key strategic firm resource such as a company-wide production system. Hence, we hypothesize:

H4a. Implementation of environmental innovations reduce firm's costs.

Extant research on the relationship between social innovation and cost reduction is sparse, but some researchers have discussed how specific types of social innovation can lead to cost reductions and minimize the use of resources for both manufacturers and customers. These types of innovations have been labelled frugal innovations and was initially used in the context of emerging economies. However, the concept has been broadened out to all innovations that fulfil three criteria: substantial cost reduction, focus on core functionality and optimized performance level (Weyrauch and Herstatt, 2017). Frugal innovations are argued to have potential for global socio-economic impact simultaneously as they deliver both reduced costs and environmental footprints for manufacturers (Agarwal and Brem, 2017). Hence, we hypothesize that there is a potential for cost reduction by adopting social innovations:

H4b. Implementation of social innovations reduce firm's costs.

In summary, both stakeholder theory and RBT offers substantiated, but complementary, arguments for how firm performance can be created from the adoption of sustainability innovations. We argue that the stakeholder view predominantly explains a path to increased value creation and risk reduction, while RBT offers the explanation for how cost reductions and operational efficiency can be achieved. Thus, these theories together can form the argument why firms are economically motivated to adopt sustainability innovations (Doran and Ryan, 2016; Kolk and Pinkse, 2007).

Based on the hypotheses above, we propose the following research model (Fig. 1):

3. Method

3.1. Research approach, data collection and sample

The main motivation for this study is to empirically test the path from adoption of sustainability strategies to implementation of sustainability innovations, and finally to firm performance. For this purpose, a quantitative research approach is appropriate.

The empirical investigation relies on combining two data sources – a survey and longitudinal financial data reports from the years after the survey. The logic is that the survey measures the extent firms are adopting sustainability strategies, innovations, and managers' expected financial outcomes of those, while the longitudinal financial data measures the actual financial performance of the firms in the years after censoring (2015–2019). This method provides a better indication of directionality than if historical financial data were used and contributes to the discussion of directionality in the literature.

The survey was conducted between November 2015 and February 2016. A list of the total population of Norwegian manufacturers (NACE Group C – Industry) was extracted from the Brønnøysund Business Register – a register mandatory for all businesses in Norway. This list returned approximately 4,300 manufacturing firms, which were reduced to 2,638 after removing companies with incomplete contact information and financial inactivity.

An online questionnaire was developed that included 110 questions about internationalization, growth strategies, sustainability strategies and innovations, managerial motivation, and expected financial effects from sustainability innovations. The questionnaire was pilot tested on 10 managers in manufacturing firms before it was e-mailed to the firms addressed to the CEO.

When data collection ended in February 2016, we had received 682 completed responses, which yields a response rate of 25.9%. To ensure that the sample was representative of the whole population of Norwegian manufacturers, the sample was compared with the population in terms of firm size, firm age, and industry code. No notable differences were found, indicating that the sample was representative of the population.

Longitudinal financial data records were collected for the years 2015–2019 from the online financial service provider Proff Forvalt. These records provide reliable credit and accounting data from all legal Norwegian firms in the Brønnøysund Business Register. We used financial information from the year of censoring (2015/2016) and the following four years. This is in line with the recommendations of Rezende et al. (2019), who found that the financial effects of green innovations peaked after two years, but remained significant for at least one more year. We could in principle also extract data from 2020 to 2021, but these data would be influenced by the pandemic as recent research has shown that the pandemic changed the extent that firm could benefit from sustainability innovations (Hermundsdottir et al., 2022).

Table 1 provides the characteristics of the final sample. On average, responding firms were founded in 1978 (SD = 30.9) and had 58 employees (SD = 144.3). Even though all firms are categorized as manufacturers, many offer a mix of products and services, with 83% reporting

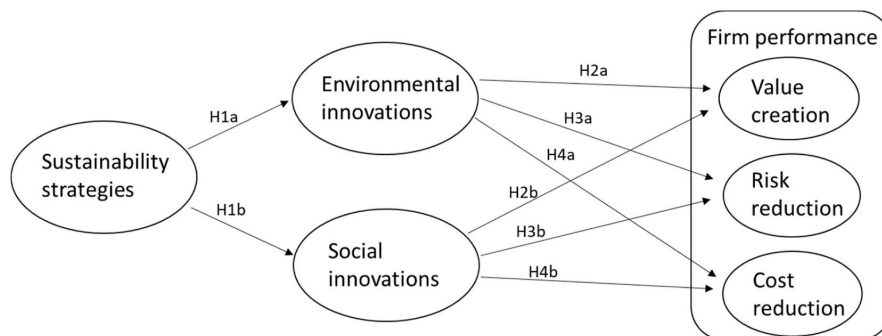


Fig. 1. Research model and hypothesized relationships.

Table 1
Descriptive statistics of sample.

Variable	Mean	Std. Dev
Establishment year	1978.06	30.906
Number of employees	57.55	144.34
	Percentage	
Type of firm		
	Goods-producing	82.9%
	Service-delivering	17.1%
International sales	48.7%	
International suppliers	77.5%	
International production	8.8%	

that they are mainly goods-producing firms, whereas the rest offer a mix in which services dominate. Most firms are exposed to international business, with about half involved in international sales, 78% describing themselves as international suppliers, and 9% operating international production facilities.

3.2. Variables

To the extent that it was possible, the variables are based on scales from previous research or established frameworks and adapted to the Norwegian manufacturing context. A description of the variables and their sources follows below. The specific survey questions including validity and reliability analysis can be found in the Appendix. Apart from the financial variables from the financial data records, responses were measured on seven-point Likert scales (1 = “Not at all” to 7 = “To a great extent”).

Below, we provide a brief description of key variables:

Strategy for sustainability is a nine-item index and measures to what extent sustainability is integrated into the firm’s general business strategy (adopted from Eide et al., 2020). The variable measures the extent to which sustainability is integrated in core business strategy, is a core value of the firm, is an ongoing discussion in top management and the executive board, is measured and published, incentivized, invested in, and something the firm seeks external collaboration to solve.

Environmental innovation is a four-item scale based on the FutureFit framework (see futurefitbusiness.org and Willard, 2012) and measures the extent to which the firm implements actual environmental innovations. The variable consists of items regarding firms’ reduction of greenhouse gas emissions and other harmful emissions, design for recyclability and reuse, and access to recycling and reuse services.

Social innovation is a three-item scale also based on the FutureFit framework (Willard, 2012) and measures the extent to which the firm includes social considerations when implementing activities. Items are focused on ensuring standard of living for all actors in the value chain,

fair working conditions, and transparent management of social concerns.

As mentioned above, the measuring of firm performance in sustainability research is marred with methodological challenges. One is the directionality challenge that we seek to ease by using longitudinal financial data. Another is the common methods bias problem that arise with subjective measuring of expected performance outcomes. To address this challenge this study uses self-reported perceived performance measures and objective financial data to measure firm performance. This strategy has been used before in similar studies (see e.g. Christmann, 2000; Wilderom et al., 2012). They argue that perceived performance captures a broader picture of performance and financial investments that have not yet produced returns – however, they are prone to rater bias. Objective performance is relevant, as it is something that all firms must consider and is crucial for their operation (Wilderom et al., 2012). Our main strategy to avoid CMB is to measure firm performance both subjectively and objectively like the two studies mentioned above. In addition, the present study’s strength is that we have time series of objective financial data after the time of censoring. Thus, we observe whether perceived outcomes deviate significantly from the firms’ actual financial performance during the following years. Perceived firm performance is measured as follows:

Perceived value creation comprises eight items and includes questions about how managers expect sustainability to influence value creation in their firms (adopted from Willard (2012), see Chang, 2011; Bacinello et al., 2019 for similar scales). The variable measures the extent managers believe their sustainability strategies will contribute to sales growth, higher perceived value, customer loyalty, ability to develop new products, services and avoid direct competition, as well as improving external relations to stakeholders, partners and gaining political goodwill.

Perceived cost reduction comprises two items and includes questions about how managers think sustainability will affect their costs (adopted from Willard (2012), see Chan et al. (2016) and Reyes-Santiago et al. (2019) for similar scales). The variable measures the extent managers believe their sustainability strategies will contribute to reduce operating costs and costs to hire and retain competent personnel.

Perceived risk reduction refers to the way managers perceive how sustainability can affect risk reduction. This is a three-item scale (adopted from Willard (2012), see Dyllick and Muff (2016) and Rasche et al. (2017) for similar scales). The variable measures the extent managers believe their sustainability strategies will contribute to reduced risk of reputation failure, decline in sales, or inability to meet future regulations.

The complementary objective firm performance measures from the 2015–2019 financial data records were measured as follows:

Profitability was measured using Return on Assets (ROA) according to previous literature (e.g., Rezende et al., 2019; Tariq et al., 2019). In this

study, profitability was calculated using the firms' mean ROAs from the years 2015–2019. ROA was calculated using the following equation:

$ROA = \text{operating profit} + \text{financial income} / \text{total capital}$, where total capital is the sum of equity and debt.

Cost margin is a measure of efficiency and productivity (Antonioni et al., 2016) and was measured using the firm's operating costs over operating revenues from the years 2015–2019. A small cost margin value indicates that the firms have small operating costs compared with operating revenues. Thus, the smaller value, the better.

Risk is calculated using the firm's standard deviation of ROA (SDROA), in line with other studies (e.g., Li et al., 2013; Tariq et al., 2019). Thus, this measures the overall risk imposed on the firm in terms of volatility of corporate earnings. Risk was calculated by the mean SDROA during the 2015–2019 period. A small risk value indicates that the firm has small variations in its ROA and, thus, low earnings volatility, thereby indicating low risk (Li et al., 2013).

If economic data from 2019 were missing, the time series were stopped in 2018.

3.3. Statistical analysis

For the statistical analysis, we used SPSS Statistics 26 for descriptive analyses and StataMP 16 for structural equation modeling (SEM). SEM was used to analyze causal relationships between the latent variables in the research model (Fig. 1) and is viewed as appropriate to use when one wants to estimate relationships between several independent variables and more than one dependent variable simultaneously, such as in this case (Hair et al., 2012).

In the SEM, we used latent path analysis (LPA), which is the most commonly used technique in the social sciences. LPA is used to investigate the structure of latent variables and to test the hypothesized relationships (Mehmetoglu and Jakobsen, 2017). The LPA was conducted in two parts: measurement and structural parts. The measurement part includes conducting a confirmatory factor analysis (CFA), which is used to "assess a hypothesized latent factor structure containing a set of indicators and one or more latent variables" (Mehmetoglu and Jakobsen, 2017, p. 296). Thus, CFA includes examining the relationships between the observed indicators and latent variables and is a way of measuring the reliability and validity of the measurement model (Mehmetoglu and Jakobsen, 2017). After establishing a valid and reliable measurement model, we proceeded with the structural part, in which the whole model was tested, including the relationships between the latent variables.

4. Results

4.1. Measurement model

The first step of the SEM analysis is to conduct a CFA to assess the measurement model's validity and reliability (Fornell and Larcker, 1981). Appropriate to this data, the CFA used a maximum likelihood estimation method with missing values (MLMV).

The measurement model's strength was assessed. Standardized factor loadings of latent variables should be above or equal to 0.4 (Mehmetoglu and Jakobsen, 2017), which was the case in this study (see Appendix). Next, we assessed the scales' reliability using Raykov's reliability coefficient (RRC), in which values over 0.7 indicate sufficient reliability (Mehmetoglu and Jakobsen, 2017). All RRC values exceeded 0.7 in this study. To assess discriminant validity, the latent variables' average variance extracted (AVE) values should be larger than the squared correlations between the latent variables (Fornell and Larcker, 1981). Furthermore, to claim convergent validity, AVE values should be larger than 0.5 (Fornell and Larcker, 1981). We observed that all squared correlations were less than the AVE values, indicating adequate discriminant validity, and that all AVE values exceeded 0.5 (see

Appendix). Thus, we concluded that the measurement model had high reliability and validity.

Regarding CMB, the main methodological strategy to avoid the problem was to use two sources to measure performance (perceived and objective). In addition, we also performed a Harman's single factor test to check for CMB (Craighead et al., 2011). The unrotated principal axis-factor analysis indicated that the first factor accounted for 37.97% of the variance, which suggest no significant issues with CMB in the data. A single-factor model was also tested using CFA. As the single-factor model showed poor model fit (CFI = 0.566, TLI = 0.532, RMSEA = 0.142), it confirms that CMB is not an issue in the data (Serrano Archimi et al., 2018).

Table 2 provides the mean values, standard deviations, and squared correlations among the latent variables.

4.2. Structural model

After testing the measurement model, we tested the structural model, in which the full LPA model was estimated (Mehmetoglu and Jakobsen, 2017). Like above, the LPA was run using the MLMV estimation method. In line with recommendations from Brown (2015) and Petrescu (2013), the unstandardized factor loadings of single indicators – profitability, cost margin, and risk – were set to 1, and these variables' error variances were set to 0, as they are actual financial numbers without known sources of measurement error. Model fit indices were RMSEA = 0.056, CFI = 0.917, and TLI = 0.908, which are acceptable. The LPA model's estimation results are provided in Table 3 and illustrated in Fig. 2.

The results in Table 3 provide us with an assessment of the proposed hypotheses' validity. First, and fundamentally, the results indicate that sustainability strategies elicit a positive and significant effect on both environmental innovations ($\beta = 0.81$; $p < 0.001$) and social innovations ($\beta = 0.49$; $p < 0.001$). Thus, firms that place a strong emphasis on sustainability strategies also implement environmental and social innovations in practice, thereby supporting Hypotheses H1a and H1b.

Moving on to outcomes, the results indicate that environmental innovations elicit a positive and significant effect on all perceived firm performance measures, including value creation ($\beta = 0.54$; $p < 0.001$), cost reduction ($\beta = 0.48$; $p < 0.001$), and risk reduction ($\beta = 0.54$; $p < 0.001$). These findings indicate that Norwegian manufacturing firms' managers have high expectations of economic gains from their sustainability innovations, supporting Hypotheses H2a (perceived), H3a (perceived), and H4a (perceived).

One also can argue that these expectations are justified, as the objective measures on financial outcomes have been found to affect profitability positively ($\beta = 0.65$; $p < 0.001$) and negatively impact cost margin ($\beta = -0.78$; $p < 0.001$) and risk ($\beta = -0.53$; $p < 0.001$). Please note that due to the manner in which cost margin and risk are measured in this study, a negative effect on cost margin and risk means reduced costs and risks. Therefore, in our study, the findings fully support Hypotheses H2a, H3a, and H4a (both objective and perceived).

Social innovations also elicited positive and significant effects on perceived value creation ($\beta = 0.15$; $p < 0.05$), perceived cost reduction ($\beta = 0.10$; $p < 0.1$), and perceived risk reduction ($\beta = 0.20$; $p < 0.001$), supporting Hypotheses H2b (perceived), H3b (perceived), and H4b (perceived), although the effects for social innovations systematically are statistically weaker than for environmental innovations.

The final set of investigated relationships concerns objective outcomes from implementing social innovations, and the results differed from those of the environmental innovations. Social innovations negatively affect profitability ($\beta = -0.89$; $p < 0.001$), and leads to increased cost margin ($\beta = 0.89$; $p < 0.001$) and risk ($\beta = 0.86$; $p < 0.001$). Due to the way cost margin and risk are measured, positive coefficients indicate that social innovations increase cost and risk. Thus, Hypotheses H2b (objective), H3b (objective), and H4b (objective) were not supported, leading to Hypotheses H2b, H3b, and H4b only being partially supported. Actually, the analysis suggests a significant opposite relationship

Table 2
Factor means, standard deviations, and squared correlations among latent variables.

	Mean	St. dev	1	2	3	4	5	6
1. Sustainability strategies	3.41	1.37	1.000					
2. Environmental innovation	4.83	1.58	0.432	1.000				
3. Social innovation	6.18	0.89	0.045	0.054	1.000			
4. Value creation	4.31	1.04	0.220	0.127	0.040	1.000		
5. Cost reduction	3.95	1.04	0.104	0.065	0.014	0.303	1.000	
6. Risk reduction	4.44	1.13	0.237	0.121	0.026	0.313	0.394	1.000

After assessing the measurement model for sufficient validity and reliability, we performed a model fit indices assessment (Mehmetoglu and Jakobsen, 2017), which returned model fit indices of RMSEA = 0.062, CFI = 0.922, and TLI = 0.912, which were all at acceptable levels.

Table 3
Results from the LPA model.

Model link	Std. coefficients	Hypotheses supported
Direct effects		
Sustainability strategies -> Env. Inno.	0.81***	H1a: Supported
Sustainability strategies -> Soc. Inno.	0.49***	H1b: Supported
Env. Inno -> Perceived Value Creation	0.54***	H2a (perceived): Supported
Env. Inno -> Profitability	0.65***	H2a (objective): Supported
Env. Inno -> Perceived Risk Reduction	0.54***	H3a (perceived): Supported
Env. Inno -> Risk	-0.53***	H3a (objective): Supported
Env. Inno -> Perceived Cost Reduction	0.48***	H4a (perceived): Supported
Env. Inno -> Cost margin	-0.78***	H4a (objective): Supported
Soc. Inno -> Perceived Value Creation	0.15**	H2b (perceived): Supported
Soc. Inno -> Profitability	-0.89***	H2b (objective): Not supported
Soc. Inno -> Perceived Risk Reduction	0.20***	H3b (perceived): Supported
Soc. Inno -> Risk	0.86***	H3b (objective): Not supported
Soc. Inno -> Perceived Cost Reduction	0.10*	H4b (perceived): Supported
Soc. Inno -> Cost margin	0.89***	H4b (objective): Not supported

***: $p < 0.001$; **: $p < 0.05$; *: $p < 0.1$; NS: non-significant. Note: Due to the manner objective risk and cost margin are measured, negative values indicate reduced risk and cost margin.

among the hypotheses, in which increased emphasis on implementing social innovations led to poorer performance in terms of both profitability, cost margins, and risk. Fig. 2 provides the research model's results.

5. Discussion

Before we go into the details, implications and limitations, it makes sense to take an overall assessment of the findings. This study finds, from a representative sample of the whole population of Norwegian manufacturers, that adoption of sustainability strategies leads to implementation of sustainability innovations. Furthermore, the adoption of environmental innovations leads to improved firm performance in terms of increased value creation, reduced risk and cost. For social innovations, the picture is more complicated as subjective and objective measures are conflicting. However, overall this study provides further evidence that the environmental sustainability shift should be an opportunity for firms that seek to improve financial performance (Hermundsdottir and Aspelund, 2021; Porter and Kramer, 2011), and as such, improved performance can be created along several dimensions. In the following, we will discuss implications and limitation for each step in the model in more detail.

5.1. Sustainability strategies' influence on the adoption of sustainability innovations

The study's findings indicate that sustainability strategies positively affect the extent to which firms conduct environmental and social innovations. The correlations are especially strong for environmental innovations, but also significant for social innovations. This shows that when sustainability is integrated with the overall firm strategy (Banerjee, 2002), it has consequences for business development and investment decisions (Papagiannakis et al., 2014). The finding also indicates that there is limited ceremonial adoption or 'greenwashing' among the firms. The correlation to environmental innovations is surprisingly high (std. coefficient 0.81***), while the correlation to social innovations is lower, but still significant (0.49***). The latter can be explained by the context as social concerns are highly institutionalized in the Norwegian manufacturing sector. Consequently, the score on social innovations is very high (mean value 6.18 on a scale to 7) and variance is low indicating that social concerns are to a high degree taken care of. We will return to the role of the context below, but the difference can also be a sign that manufacturers prioritize environmental innovations, because social issues to a great extent are solved and offers little opportunity for strategic differentiation. Environmental innovations are currently more potent for strategic differentiation because it remains unsolved. Regardless, the results imply that firms with sustainability strategies develop specific capabilities that make them better equipped to deal with future sustainability issues (Papagiannakis et al., 2014; Schrettle et al., 2014).

5.2. Creating value: Sustainability innovations and firm performance

5.2.1. Environmental innovations on firm performance

The results reveal that environmental innovations elicit a significant and positive effect on both perceived and objective firm performance in terms of value creation, cost reduction, and risk reduction. These findings are strongly statistically significant (all p-values below 0.001) and surprisingly consistent and robust across different ways of measurement. Positive findings for improved financial performance (Scarpelini et al., 2019), cost reduction (Chan et al., 2016), and risk reduction (Rezende et al., 2019) have been found independently in recent studies, but this is the first study to our knowledge with such robust findings across a whole population of manufacturers.

Form a practitioner and policy-maker point of view this finding shows that a shift towards more sustainable practices in the manufacturing sector actually should be conceptualized as a business opportunity (Porter and Kramer, 2011) more than a threat to industry or firm survival. That said, the limitation of these types of studies is that we only study those innovations that firms have actually decided to adopt, and it is reasonable to assume that firm prioritize innovations with the highest expected return. Hence, a statement such as sustainability is profitable in general is unreasonable. A more fitting statement is that the green transition offers so many business opportunities and innovations that they offset the associated costs of transition (Hermundsdottir and Aspelund, 2022), and this is also the finding from this study.

For an academic point of view, this study renders support both to the

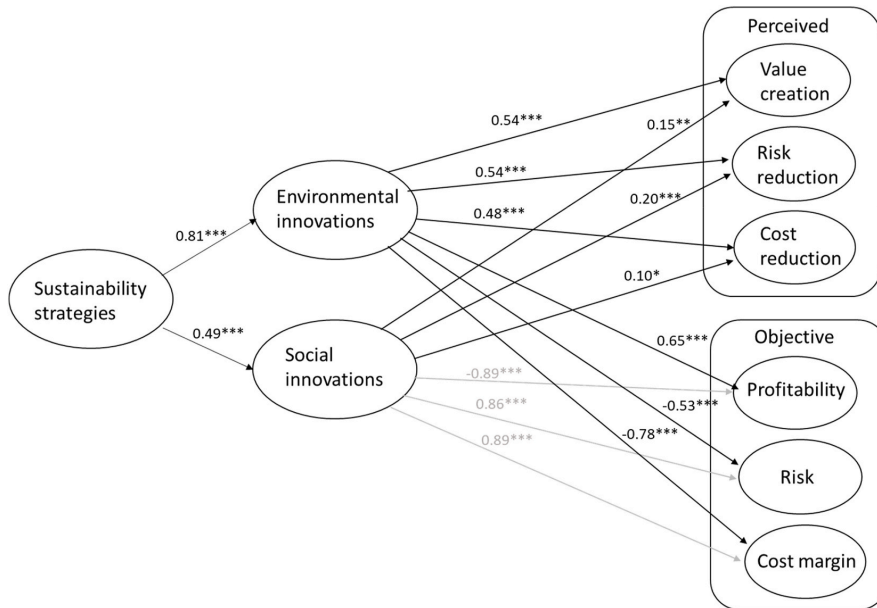


Fig. 2. The results from the research model. Black arrows represent supported hypotheses, while gray arrows represent unsupported hypotheses. Note: Due to the manner objective risk and cost margin are measured, negative values indicate reduced risk and cost margin.

outside-in stakeholder perspective and the inside-out resources-based perspective. According to the outside-in perspective market value is created by the ability to respond to the external environment (Wijethilake et al., 2018). In the green transition, external stakeholders are creating business opportunities that proactive firms can leverage either through first mover advantages (Pryzhodsen et al., 2019), differentiation advantages (Fraj et al., 2015; Liao, 2016), or by going beyond stakeholders’ expectations (Buysse and Verbeke, 2003). According to the inside-out perspective, firms can build strategic resources and capabilities around new environmental innovations and enjoy efficiency and cost advantages (Hojnik et al., 2017). Our findings suggest that environmental innovations can be leveraged equally well by taking a strategically beneficial market position which pleases stakeholders (Liao, 2018) and by developing internal resources and capabilities that increases efficiency (Chan et al., 2016).

5.2.2. Social innovations’ effect on firm performance

Maybe the most intriguing finding in this study is that social innovations had a positive effect on all perceived firm performance measures of value creation, cost and risk reduction, while regarding the objective performance measures they are found to negatively affect profitability, and increase risk and cost margin. These results not only contradict previous research (Svensson et al., 2019; Osei and Zhuang, 2020), but the difference between perceived and objective performance outcomes indicates that firm managers are highly optimistic about the effects from social innovations, while when objectively measured the effects are negative. This demands further reflection and can stem from several effects:

First, the optimism about social innovation could be a consequence of high stakeholder pressure. In Norway, firms generally score high on social sustainability (Fonseca and Lima, 2015; Mulgan, 2006) and we also observed very high scores on social innovation (see Table 2). Socially responsible behavior is regulated and institutionalized in the Working Environment Act and cannot be a differentiation strategy the way environmental innovations potentially can. Thus, assuming that

social innovations follow the “S-curve” (Mulgan, 2006), we assume that they have reached maturity level in the Norwegian context, and hence such innovations no longer lead to significant positive returns.

Second, it could be that what we are observing here is the result of social desirability in which variables can be influenced by respondents wanting to gain social acceptance and approval (Podsakoff et al., 2003). This might be the case in questions regarding social innovations as they involve the extent the firm seeks to contribute to social prosperity.

Third, environmental and social innovation have different objectives (Mulgan, 2006) and there are also different value creating logics. For social innovations, the key purpose is to create social value by interacting more with other social actors and institutions (Phillips et al., 2015; Dawson and Daniel, 2010). For environmental innovations the logic is opposite. One seeks to reduce the interaction with natural resources to reduce environmental footprints. As such environmental innovations are closer to a business performance logic of reduced costs (Hojnik et al., 2017) and social innovations represents less of a business case (Porter and Kramer, 2011).

Finally, social innovations are dynamic and complex (Silvestre and Țircă, 2019), and can span across sectors and disciplines, requiring collective learning among different actors and often resources and capabilities found outside of the firm’s expertise and environment (Phillips et al., 2015). The firm’s learning capacity and the social system in which the social innovations are conducted are important for success (Phillips et al., 2015). Hence, it could also be a result of the complexity issue explained above – that firms fail to implement social innovations properly because they are too complicated to handle (Engert and Baumgartner, 2016).

To sum up, there could be different explanations to the conflicting finding on social innovations in this study. Either it could stem from the context, the methods or the business logic or complexities connected to the concept itself. Still, none of these explanations explain why managers have such positive expectations of the firm performance potential of social innovations. We call for more research on the firm performance implications of social innovations.

5.3. Limitations and further research

This study’s key strength is in the data. It is based on a representative sample of the whole manufacturing sector in Norway combined with longitudinal financial data. The biggest limitations are that it draws empirical evidence from the Norwegian manufacturing context alone. First, we call for more research to investigate how well these finding transfer to other industries and country settings. Second, even though the findings related to the firm performance effects of environmental innovations seems clear and robust, it fails to provide the same clarity and robustness about the effects of social innovations. Considering that social innovation is an important part of sustainability, and that businesses ultimately operate in market-based economies (Baumgartner, 2014), we specifically recognize the need to examine how social innovations create shared value and what innovations are solely philanthropic. Third, as we only examined environmental innovations as a whole, it would be interesting to study how different types of environmental innovations contribute to firm performance. This knowledge is valuable in better understanding different innovations and how to manage them successfully (Silvestre and Țircă, 2019). Finally, regarding resource-based theory, future case studies should be conducted to better assess how capabilities and resources for sustainability develop, what kinds are most effective, and how they contribute to successful implementation of sustainability innovations.

6. Conclusions

This study investigate the extent Norwegian manufacturing adopt sustainability strategies and innovations, and how this ultimately influenced firm performance over time. We conclude the adoption of sustainability strategies positively influence implementation of both environmental and social innovations. This implies that sustainability strategies work as a driver and catalyst for the development of sustainability innovations. Furthermore, we find clear and robust evidence that environmental innovations positively affect both perceived and objective firm performance measures in terms of value creation, risk and cost reduction. Social innovations, on the other hand, were found to positively affect perceived performance measures, whereas they negatively affected objective firm performance measures.

These findings carry important implications for theory and practice. For theory, they deliver a robust empirical argument for the positive relationship between environmental innovations and firm performance. This increased firm performance through environmental sustainability can be created in a variety of ways – increased value creation, cost reductions or risk reductions, which indicates that both outside-in

perspectives such as stakeholder theory and inside-out perspectives such as resource-based theory can be valuable complementary frameworks to explain the phenomenon.

Another important theoretical contribution is the incorporation of social innovations, answering the call for more holistic sustainability studies (Silvestre and Țircă, 2019). We find that social innovations’ effects on firm performance are ambiguous dependent on subjective or objective measures. There can be several explanations for this result, but more research is needed before we can arrive at similar robust answers as for environmental innovations.

Finally, the study contributes methodologically by including both objective and perceived performance measures and longitudinal financial performance data, and as such, contributes to solving some of the methodological challenges on topics such as causation and directionality (Chu et al., 2019) and the problem associated with common methods bias.

For practitioners and policymakers, this study demonstrates beyond any doubt that the sustainability shift does not represent industry death, but rather that the number and size of business opportunities that comes with the green shift overcome the transition costs. There are openings to increase competitiveness for firms that seek those opportunities by implementing strategies and adopt environmental innovations to pursue them (Porter and Kramer, 2011). For social innovations the picture is more complicated, especially in countries like Norway where almost all social concerns related to industry are regulated and institutionalized. We argue that the business opportunities related to social challenges are minimized because Norwegian industry is socially sustainable. This is not the case for environmental sustainability. There will be business opportunities in environmental sustainability until it is as mature and institutionalized as social sustainability is today. Unfortunately, there in a long way to travel until we are there.

CRedit authorship contribution statement

Fanny Hermundsdothir: Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft. **Arild Aspelund:** Conceptualization, Investigation, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Factor loading, Raykov’s reliability coefficient (RRC), and average variance extracted (AVE).

	Standardized factor loading	RRC	AVE
Sustainability strategies (SS)		0.940	0.638
Sustainability (environment and society) is integrated into our business strategy – we see new business opportunities in sustainability	.797		
Sustainability (environment and society) is a fundamental value for our business – we want to change the industry we work in	.800		
Sustainability (environment and society) is an ongoing discussion within our top management team	.886		
We have established clear objectives and indicators concerning sustainability for our company	.868		
We publish our sustainability activities’ results	.710		
In our company, incentives are offered to employees to achieve results concerning sustainability (environment and society)	.657		
We use capital and resources in such a way that our sustainability goals (environment and society) are reached	.849		
Sustainability (environment and society) is an ongoing discussion on our board	.845		
We work with other actors to solve the major challenges related to sustainability (environment and society) in our industry	.744		

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	Standardized factor loading	RRC	AVE
Environmental Innovation (EI)		0.848	0.581
We strive to reduce or eliminate emissions of potentially harmful substances	.675		
We strive to reduce or eliminate emissions of greenhouse gases	.751		
We strive to have all products and packaging designed to be recycled or reused	.82		
We strive to provide customers with access to recycling and/or reuse services for all our products and packaging	.795		
Social Innovation (SI)		0.752	0.523
Everyone who contributes in our value chain is paid in such a way that it provides them an adequate standard of living	.726		
Everyone who contributes to our value chain has fair working conditions	.796		
Everyone's concerns are solicited actively, judged impartially, and addressed transparently	.638		
Value Creation (VC)		0.900	0.580
How does the company's commitment to sustainability (environment and society) affect the company's ...			
Sales growth (increased volume)	.797		
Perceived value for the customer (willingness to pay)	.883		
Customer loyalty	.872		
Ability to avoid direct competition	.745		
Ability to introduce new products and services	.813		
Political goodwill for allocations of social resources (regulations, licenses, permits)	.512		
Relationship with company stakeholders	.723		
Position as an attractive partner	.678		
Cost Reduction (CR)		0.742	0.597
How does the company's commitment to sustainability (environment and society) affect the company's ...			
Operating costs	.702		
Costs of hiring and retaining competent personnel	.837		
Risk Reduction (RR)		0.885	0.724
How does the company's commitment to sustainability (environment and society) affect the company's ...			
Risk of damage to reputation	.876		
Risk of a sales decline	.876		
Risk of not being able to meet future regulatory requirements	.798		

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PAPER 3



Analyzing the impact of COVID-19 on environmental innovations in manufacturing firms[☆]

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ABSTRACT

COVID-19 has had a significant impact on the manufacturing industry, and manufacturers have responded to the crisis in different ways. This study investigates Norwegian manufacturers' response to the crisis, particularly how it has influenced their adoption of environmental innovations. More specifically, the study investigates whether firms choose "general" or "green" strategic responses to the crisis and how this influences the overall adoption of environmental innovations. In addition, the study investigates how the degree of environmental innovation adoption occurring before COVID-19 affects how the crisis impacted firms. The study adopts a quantitative research approach using survey data from 526 manufacturing firms—a representative sample of manufacturers in Norway. The findings reveal that those manufacturers the most environmentally innovative before COVID-19 were more impacted by the crisis. Moreover, firms adopted both general and green responses to the crisis, and the overall conduction of environmental innovations decreased during the pandemic. The main contribution is the empirical findings related to the overall impact of COVID-19 on sustainability-oriented manufacturing. The implications are discussed for both theory and practice.

1. Introduction

Two major global crises are now in the spotlight for leaders and policy makers: climate change and the COVID-19 pandemic. The former may no longer be considered novel, and there is an increasing amount of research on how businesses can reduce their negative environmental footprints to reduce the inevitable and undesirable consequences of modern industrial activity [1]. Businesses use environmental innovations to address and reduce their environmental footprints, and research has shown how such deliberate and strategic innovation practices are beneficial to firms' overall economic performance [2]. 'Environmental innovation' is a broad term that includes, for instance, improved circular economy practices [3], initiatives motivated by corporate social responsibility [4], transition to renewable energy [5], and 'eco-innovation' and 'green innovation' practices such as improving efficiency and new products that contribute to cleaning, healing, and recovery [6–8]. The COVID-19 pandemic struck during early 2020 and has continued to be a global challenge through 2021. The effects of high infection rates—resulting in stringent restrictions and lockdowns—have led to immediate and enormous challenges for businesses worldwide

[9–11]. The economic effects of the pandemic have been observed across nations and industries, and many firms were forced to abruptly cut every cost not essential for firm survival [12,13]. The purpose of the present paper is to investigate how the COVID-19 pandemic has impacted firms' focus on environmental innovations.

Recent research has called for a focus on how COVID-19 impacts environmental innovations [14] as a way to enhance our understanding of how external disruptions, such as COVID-19, impact the implementation of sustainability strategies [15–17]. The literature has discussed how one environmental impact of the pandemic is reduced emissions from reduced economic activity [18] and how firms acted deliberately and strategically to cope with COVID-19 [11,19]. The pandemic may be considered an opportunity for igniting sustainability transitions, on the one hand [20], while on the other hand, it has been shown to hamper firms' corporate sustainability efforts [21]. Nevertheless, the current literature relating to how COVID-19 has impacted environmental innovations is still nascent and scarce (cf [17]). Although COVID-19 represents a unique crisis in history [22], there is literature considering prior financial crises [23–28], health crises [29], natural disasters [30–32], agricultural crises [33], and urban riots [34]. Hence,

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managing in times of crisis, such as during COVID-19, is indeed not “business as usual” [35], and the pandemic has had significant impacts on how firms respond to crises, as well as the consequences of those responses, both generally and environmentally.

The present paper responds to recent calls [14,17] by answering the research question: *How are efforts toward environmental innovations impacted by a sudden exogenous shock such as COVID-19?* The current paper provides a novel research contribution by considering if, how, and to what degree innovations for the environment are impacted by major crises. The paper is timely because it addresses a current and important issue for practice, policy, and research [11,14,17]. Being one of the first empirical papers addressing environmental innovations and major crises by analyzing a relatively large sample ($N = 526$) of firms, the current paper motivates an increased research focus on *how* and *why* businesses pursue those opportunities that involve innovations for the environment when facing a major crisis. For policy, the current paper suggests that efforts to facilitate sustainable development should be nurtured by acute crisis support for the most impacted firms and strategic innovation support for all other firms. Thus, this paper complements recent research stressing the importance of support measures to ensure survival and continued innovations in businesses more generally [11,36].

The next section presents the literature background of the research on how firms pursue innovation for the environment and how major crises have impacted firms’ innovation activities. Based on the literature, a set of six hypotheses is postulated. In section three, the quantitative research methods applied to test the hypotheses on a sample of 526 manufacturing firms in Norway are presented. Then, a presentation of the analysis results is given, as well as the discussions and conclusions.

2. Literature background and hypotheses development

2.1. Environmental innovations

The adoption of environmental innovations—including, for instance, eco-innovation and green innovation—is still an immature research area but has been receiving increased attention and emphasis among researchers, practitioners, and policymakers [6–8]. Environmental innovations are commonly defined as “*new or modified processes, techniques, systems and products to avoid or reduce environmental harms*” [37]; p. 11) or “*innovation that improves environmental performance*” [38]; p. 1075). The European Commission [39] defines environmental innovation as “*any form of innovation aiming at significant and demonstrable progress toward the goal of sustainable development, through reducing impacts on the environment or achieving a more efficient and responsible use of natural resources, including energy.*” Although many definitions exist, a commonality is that the main aim of environmental innovations is to reduce environmental harm while using resources more efficiently [40], thus maintaining “*natural capital*” in the world [41]. For the current study, we will adopt Hojnik and Ruzzier’s [40] definition.

Research has identified several important drivers for implementing environmental innovations: *external factors*, such as regulations, market pull, technology push, and cooperation, as well as *internal factors*, including cost savings, capabilities, managerial concerns, and competitive outcomes [7,40,42]. Because firms are experiencing increasing pressure to implement environmental innovations, their interest in how such types of innovations can create competitive advantages has increased. A literature review including 100 studies about the relationship between sustainability innovations and competitiveness reveals that most studies have found that sustainability innovations lead to positive outcomes, such as increased value creation (e.g., profitability, market shares, sales growth, new market opportunities), cost savings (e.g., increased productivity), and increased nonfinancial assets (e.g., reputation, image, quality, and customer satisfaction) [2].

2.2. Environmental innovation and crisis impact

The implementation of environmental innovation is a complex process requiring experience and skills beyond common industry experience [43]. Christmann [44] suggests that the “*best practices*” of environmental innovation are path dependent, where path dependency indicates that where and what a firm does is a function of previous investments and routines [45]. Hart [46] argues that sustainability implementation can be seen as a kind of sequential logic of activities in which capabilities and resources are accumulated along the way. As Aragón-Correa and Sharma [47] state, “*The capabilities are complex and path dependent on the accumulation of, and the interaction between, resources such as physical assets, technologies, and people*” (p. 73). Therefore, we argue that firms that have already implemented environmental innovations to a high degree have accumulated enough resources and capabilities to continue to go along this “*path*,” even after an external shock like COVID-19. Put differently, for these firms, sustainability has already been incorporated into their strategies and become part of their daily operations. Thus, it is reasonable to assume that despite an external shock, sustainability will continue to be a highly important part of their business. Hence, we argue that these firms are better able to maintain “*stability*,” which is an important dimension of resilience [48]. In addition, firms that have adapted environmental innovation possess dynamic capabilities [49], which are defined as a firm’s ability to build and reconfigure competences to rapidly address changing environments [45]; p. 516). The ability to rapidly adjust to external environments has been proven important in responding to a crisis [50], and this ability could further indicate flexibility, which is another important dimension of resilience [48]. Thus, we postulate that firms with high environmental innovation adaptation are more flexible, have a higher degree of dynamic capabilities, and are more capable of maintaining stability, which can make firms more resilient to an external shock like COVID-19.

Further, Ding et al. [51] find that the stock prices of companies with a high degree of implemented sustainability measures fell less because of COVID-19 compared with other firms because of higher levels of trust among the stakeholders, who made a greater effort to support more sustainability-oriented firms after the shock. Similarly, Huang et al. [48] find that firms with higher sustainability engagement prior to COVID-19 have been less impacted by the pandemic because of stakeholder relationships, reputation, and innovation capacity. The capacity to innovate may be a result of a firm’s creativity [6,52], and creativity and experimentation are considered important factors in coping with COVID-19 [11,53]. Hence, firms with higher sustainability engagement are expected to be more resilient to negative impacts from the pandemic [48]. In this way, environmental innovation can contribute to reducing business risk [54,55]. Based on the arguments above, we propose the following hypothesis:

H1. Firms that conducted a high degree of environmental innovation before the COVID-19 outbreak have been less impacted by COVID-19.

2.3. Crisis impact and strategic response

COVID-19 has led to reduced supply for businesses because of lockdowns, as well as reduced demand for products and services because of reduced consumption and investments [56]; p. 1). The impacts from a major crisis such as COVID-19 force firms to respond strategically to adapt to novel market conditions and increase the likelihood of firm survival [57,58]. Previous research has pointed to two types of general strategic responses to crises. The first is strategic responses that are protective and reactive in nature, and these responses typically imply postponing investments and laying off employees [13]. The second type is proactive [25] and typically implies accelerating strategic actions [59], such as adopting new technologies [60] and innovative business procedures [61]. The perceived potential to leverage opportunities that arise during a crisis may result in firms’ proactive attitude toward the

situation, hence leading to proactively making strategic responses to the crisis. Examples include looking for new distribution activities, improving products or services, establishing new market channels or partners [56], business model innovation [50] and collaborating inter-organizationally [19]. Strategic responses to COVID-19 may also positively take into account environmental sustainability because they can, either as a deliberate choice or because of a direct response to COVID-19, include measures that involve new environmental sustainability changes as part of the firm's new business activities. For example, this could include creative and experimental business practices [6,11]. Although COVID-19 has had a positive effect on the environment because of less energy use and emissions of harmful pollution because of lockdowns, travel restrictions, and quarantines [14,62], it has also positively influenced environmental awareness, sustainable consumption, and social responsibility [14]. Here, we distinguish the specific "green" strategic responses that directly take into consideration environmental sustainability from the more general strategic responses, hence proposing the following two hypotheses:

H2a. The impact of COVID-19 has led firms to make "general" strategic responses to the crisis.

H2b. The impact of COVID-19 has led firms to make "green" strategic responses to the crisis.

2.4. Changes in environmental innovation

Research on how COVID-19 affects the implementation of environmental innovation is still lacking. Regarding socio-technical transitions, some researchers have discussed how external shocks, such as COVID-19, can change established policies and systems, leading to transitions toward increased sustainability and facilitating more sustainability-oriented businesses and consumption [63,64]. The pandemic has already altered economic activities, consumption, and energy demand worldwide [64,65]. Because of this, the industrial and public sectors may be more aware of, incentivized, and motivated to commit to solving sustainability issues [15,66–68]. Hence, researchers argue that the COVID-19 pandemic can be an opportunity to exploit and accelerate solving the sustainability challenge by a transition toward clean energy [64,65].

On the contrary, it can be argued that major economic challenges because of COVID-19 can lead to firms deprioritizing ongoing and planned efforts in environmental innovation activities in favor of survival strategies [15,65,69]. During crises like COVID-19, firms face increased liquidity issues and budget constraints, often resulting in reduced R&D and willingness to innovate and, thus, reduced innovation activities [70]. COVID-19 has had a negative impact on firm performance [71], leading to less room for environmental innovation adaptation. Thus, investments in environmental innovation become riskier and more uncertain regarding firms' performance outcomes [72]. In addition, policymakers have focused on stabilizing industries instead of continuing to push forward a sustainability transition [64], such as, for instance, how emission regulations in the US were eased for industrial firms to have better chances of survival. Easing regulations is likely to reduce the environmental innovation activities in firms because regulations are one of the most important drivers of environmental innovations [40]. Thus, based on firms' economic challenges, as well as changes in policies, we propose the following hypothesis:

H3. COVID-19 has negatively impacted firms' environmental innovation change.

Moreover, potential green and general strategic responses conducted by firms because of COVID-19, as hypothesized in hypotheses H2a and H2b, may materialize in environmental innovation activities. Hence, the following two final hypotheses are proposed:

H4a. General strategic responses have positively impacted firms'

environmental innovation changes during COVID-19.

H4a. Green strategic responses have positively impacted firms' environmental innovation changes during COVID-19.

The six proposed hypotheses can be combined into a conceptual model, as shown in Fig. 1.

3. Method

3.1. Sample and data collection

A quantitative research approach was used. This research approach is appropriate because statistical methods can be used to generalize and uncover patterns and regularities from observable environments [73]. Quantitative research often follows an approach in which hypotheses are developed based on theory, followed by hypothesis testing [74]. Because the current study aims to investigate the relationships among the impact of COVID-19, environmental innovation, and strategic responses, a quantitative research approach was deemed appropriate.

The data were collected using a questionnaire. Manufacturing firms contribute highly to climate change and resource consumption [8] and have been severely impacted by COVID-19 [75]. Thus, the sampling criteria included all Norwegian firms within the NACE¹ code C–Manufacturing. For the sampling procedure, an initial list of firms was extracted from the Norwegian registry of commercial entities and consisted of approximately 8500 firms. Based on the available email addresses for the managers and/or business owners of commercial entities, the questionnaire was sent out by email in December 2020. The survey closed in January 2021. As expected, the authors received a significant number of email replies from potential respondents who responded that their firms were inactive or merely a hobbyist activity (e.g., manufacturing jewelry as a hobby). In addition, the authors received a significant number of email error messages, indicating that the contact information was not valid. Based on extrapolation of the number of firms found as ineligible, the authors estimated that the list of 8500 commercial entities would contain between 3000 and 4500 actual manufacturing firms. A total of $N = 526$ firms ultimately responded to the questionnaire, corresponding to a response rate of 11.7–17.5%. The response rate is deemed sufficient when considering comparable questionnaire-based studies [19,76,77].

To test whether the sample was representative of the whole population, two-tailed t-tests were performed on the following variables: number of employees, foundation year, turnover, profit, and labor costs. No significant differences were found between the whole population of firms and the sample. In addition, a comparison between the types of sectors within manufacturing showed that the distribution was similar between the groups. Together, these results indicate that the sample is representative of the entire population of manufacturing firms in Norway.

3.2. Questionnaire design

The questionnaire was developed based on constructs used in prior research. To validate the questionnaire items before they were sent out to the manufacturing firms, a group of industry practitioners and peer academics were consulted, and the authors adjusted the questionnaire based on their feedback. The questionnaire contained questions regarding how the firms have been affected by COVID-19, what kinds of changes the firms have conducted in response to COVID-19, and the firms' prior and current efforts toward environmental innovation. In

¹ NACE is short for "Nomenclature des Activités Économiques dans la Communauté Européenne," which is a statistical classification for economic activities in Europe and is used in the public database of registered firms in Norway.

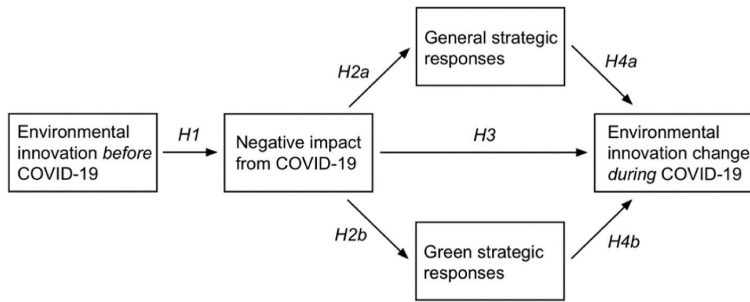


Fig. 1. Conceptual model.

addition, the questionnaire asked about the firm’s revenues right before the pandemic, firm size, firm foundation year, and type of firm (mainly goods producing, service delivering, or both). Descriptive statistics from the dataset are shown in Table 1.

We used the following constructs in the analysis: *the impact of COVID-19*, *green strategic response because of COVID-19*, *general strategic response because of COVID-19*, *environmental innovation before COVID-19*, and *environmental innovation change during COVID-19* (see the Appendix for the items). The respondents were asked to answer the questions using a 7-point Likert scale ranging from 1-Strongly disagree to 7-Strongly agree. The measures are presented below.

The impact of COVID-19 consisted of four items developed based on Haneberg [19] and Riom and Valero [78]; in which the respondents were asked to answer how COVID-19 had affected their firm in terms of obtaining deliveries, demand, financing, and pressure on liquidity ($\alpha = 0.797$).

Green strategic response because of COVID-19 consisted of four items adapted from Burki et al. [79] and Przychodzen and Przychodzen [80] and were adjusted for the study. The measure included questions about firms’ different COVID-19-related green strategic responses—such as new green products, services, and customer groups—were concerned with the environment and redefined operation and production processes for sustainability ($\alpha = 0.884$).

General strategic response because of COVID-19 consisted of four items developed from Cesaroni et al. [81] and included questions about what kind of changes the respondents have made, such as new sales channels, improved products or services, or new suppliers ($\alpha = 0.831$).

Environmental innovation before COVID-19 was adapted from the items of Chen et al. [82] and Doran and Ryan [83]. The measure consisted of nine items asking about the firm’s efforts before the pandemic in reducing the negative impacts on the environment, including reduced material energy use and emissions and increased recycling and reuse ($\alpha = 0.946$).

Environmental innovation change during COVID-19 was calculated by the difference between environmental innovation during COVID-19 and environmental innovation before COVID-19 (see the Appendix). *Environmental innovation during COVID-19* ($\alpha = 0.958$) included the same items as in *environmental innovation before COVID-19*; however, instead, the respondents were asked about their environmental efforts during the pandemic.

Control variables: In the analysis, several control variables were used. More specifically, following other researchers (e.g. Refs. [84–87], we controlled for firm age, firm size, revenue, and type of firm. Firm age was measured by the year the company was founded, firm size was measured by the number of employees, revenue was measured by the revenue the firm had in autumn 2019, and type of firm was measured by the activity of the firm (mainly goods producing, service delivering, or both), where a dummy variable from 1 to 3 was used (1 = product, 2 = both, and 3 = service).

Table 1
Descriptive statistics.

	Mean	S.D.	Min.	Max.
Firm age	31.28	34.020	0	363
Firm size	28.32	95.3968	0	1100
Firm revenue (2019)	79,258,536.41	381,021,695.0	0	7,000,000,000
Impact from COVID-19	3.34	1.33	1.00	7.00
Green strategic response	3.32	1.43	1.00	7.00
General strategic response	3.73	1.36	1.00	7.00
Environmental innovation before COVID-19	3.58	1.65	1.00	7.00
Environmental innovation after COVID-19	3.52	1.73	1.00	7.00
Environmental innovation change	-.05	.64	-2.78	4.00
Type of firm			Percent	
Service			9.5%	
Product			68%	
Both			22.5%	

3.3. Data analysis

To analyze the data, the structural equation modeling (SEM) method was used. The analysis was conducted in Stata/MP version 16. SEM analysis is often used to test hypotheses using a theoretical model in which there are sets of causal relationships of latent variables measured by observable indicators [88]. Thus, one of its advantages is that it allows for estimation and hypothesis testing of unobserved constructs, which can have important implications for theory development [89]. SEM analysis consists of a measurement model and a structural model. To assess the measurement model, confirmatory factor analysis (CFA) was conducted to assess the relationship between the construct (or latent variable) and its corresponding variables, whereas in the structural model, the relationships between the constructs were assessed [88]. The measurement model must show acceptable levels of validity and reliability before one goes further with the assessment of the structural model [89]. CFA and SEM analysis were conducted using the maximum likelihood (ML) method.

Prior to SEM analysis, the data were checked for missing values and normality. Because Stata uses listwise deletion by default, in which observations with missing data are removed, it is important that the data are missing completely at random (MCAR) [73]. Little’s MCAR test was conducted, and the results showed that the MCAR assumptions were met

($\chi^2 = 22.002$, $df = 15$, $p = 0.108$), indicating that the listwise deletion for missing values was acceptable [90]. Regarding normality, our analysis shows that the constructs have skewness and kurtosis values within the range $[-1,1]$, indicating that the constructs are within what is considered normal distribution [91].

4. Results

4.1. Descriptive statistics

Table 1 presents the descriptive statistics for the constructs and control variables. The table shows that the mean year of foundation was in 1990 (31 years ago), and the mean number of employees was 28. The mean revenue for the firms is approximately 79 MNOK (equivalent to ~\$9 million), and 68% of the firms are mainly goods producing, 9.5% are mainly service delivering, and 22.5% describe themselves as a combination of these two.

Table 2 shows the correlation table between the constructs and control variables.

4.2. Measurement model

CFA was used to assess the measurement model. The table in the Appendix shows how all the variable loadings load above 0.6 to their respective constructs, indicating acceptable individual item reliability [92]. Further, the measurement model shows satisfactory validity and reliability because the average variance extracted (AVE) for all constructs exceeds 0.5, the composite reliability (CR) exceeds 0.6, and Cronbach's alpha and Raykov's reliability coefficients exceed 0.7 [73, 89,93] (see the table in the Appendix). Multicollinearity was tested using the variance inflation factor (VIF), in which all values were found to be below the acceptable levels of 3 [91]. The model fit indices show acceptable values, indicating an appropriate model fit [73,94]: RMSEA: 0.086, CFI: 0.913, TLI: 0.899, SRMR: 0.063.

4.3. Structural model and hypothesis testing

The hypotheses were tested using the structural model, in which the model fit indices also show acceptable values, illustrating an appropriate model fit [73,94]: RMSEA: 0.069, CFI: 0.914, TLI: 0.899, SRMR: 0.087. Table 3 and Fig. 2 show the results of SEM analysis.

The results show that environmental innovation before the pandemic positively influenced the impact of COVID-19 ($\beta = 0.17$, $p < 0.01$). Hence, H1 is not accepted. In fact, the results illustrate that the opposite is the case—more environmentally innovative firms have been impacted more.

Further, the results show that the impact of the pandemic had a positive significant effect on the general strategic responses made ($\beta = 0.50$, $p < 0.01$) and on green strategic responses ($\beta = 0.34$, $p < 0.01$). Hence, H2a and H2b are accepted because the firms that have been

Table 3
Results of SEM analysis.

Model link	Standardized coefficients	Hypothesis support
Direct effects		
Env.inno.before → Impact covid	.17***	H1: Not supported
Env.inno.before → Green strategic response	.32***	
Env.inno.before → General strategic response	.26***	
Env.inno.before → Env.inno.change	−0.11**	
Impact covid → General strategic response	.50***	H2a: Supported
Impact covid → Green strategic response	.34***	H2b: Supported
Impact covid → Env.inno.change	−.22***	H3: Supported
General strategic response → Env.inno.change	−.02 (NS)	H4a: Not supported
Green strategic response → Env.inno.change	.19***	H4b: Supported
Indirect effects		
Impact covid → General strategic response → Env.inno.change	−.008 (NS)	
Impact covid → Green strategic response → Env.inno.change	.063**	
Env.inno.before → Green strategic response → Env.inno.change	.060**	
Env.inno.before → General strategic response → Env.inno.change	−.005 (NS)	
Env.inno.before → Impact covid → Env.inno.change	−.037**	
Control variables		
Firm age → Env.inno.change	−.025 (NS)	
Firm size → Env.inno.change	.052 (NS)	
Revenue → Env.inno.change	.027 (NS)	
Type of firm → Env.inno.change	−.053 (NS)	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, NS = not significant.

impacted by COVID-19 have made strategic responses, both green and general, in their businesses.

Next, SEM analysis shows that the impact of COVID-19 had a direct negative influence on environmental innovation change ($\beta = -0.22$, $p < 0.01$). Hence, H3 is accepted.

Finally, the results show that general strategic responses had a nonsignificant direct effect on environmental innovation change, resulting in H4a not being supported. In contrast, the green strategic response shows a positive significant direct effect ($\beta = 0.19$, $p < 0.01$) on environmental innovation change, supporting H4b. Additionally, when looking at the indirect effects in Table 3, it becomes clear that the green strategic response has positively mediated the effect of the impact of COVID-19 on environmental innovation change ($\beta = 0.063$, $p < 0.05$). That is, those firms that implemented a green strategic response experienced positive changes in their environmental innovations. No such

Table 2
Pairwise correlations.

	Age	Size	Rev.	Type	IC	GRSR	GENSR	EIB	EIC
Age	1								
Size	.295**	1							
Rev.	.240**	.659**	1						
Type	−.143**	−.053	−.090*	1					
IC	−.131**	−.026	−.035	.084	1				
GRSR	.073	.131**	.035	−.008	.348**	1			
GENSR	.038	.100*	.000	.028	.342**	.720**	1		
EIB	.199**	.131**	.133**	−.032	.208**	.376**	.304**	1	
EIC	.004	.052	.062	−.044	−.104*	.088*	.027	−.067	1

Age = Firm age; Size = Firm size; Rev. = Revenue (2019); Type = Type of firm; IC=Impact COVID-19; GRSR = Green strategic response; GENSR = General strategic response; EIB = Environmental innovation before COVID-19; EIC = Environmental innovation change; ** Correlation is significant at the 0.01 level (two-tailed); * Correlation is significant at the 0.05 level (two-tailed).

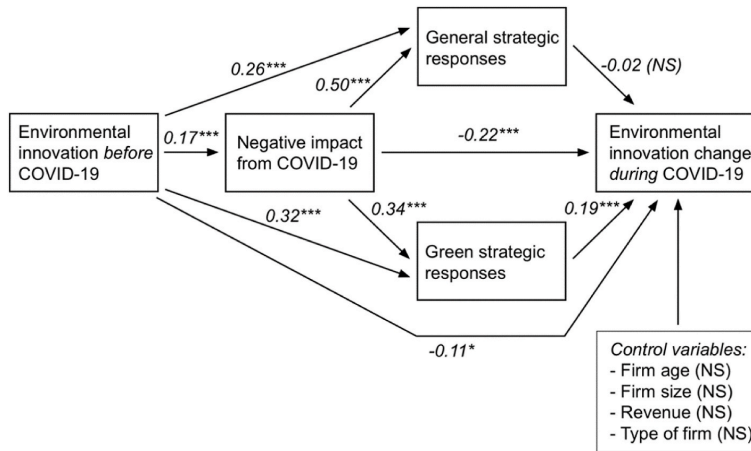


Fig. 2. Results of SEM analysis (only direct relationships are illustrated). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$, NS=not significant.

mediating effect (NS) was observed from the impact of COVID-19 on environmental innovation change through a general strategic response.

Finally, Table 3 shows how the control variables of firm age, firm size, revenue, and type of firm do not have any significant effect on environmental innovation change in the model. Fig. 2 summarizes the results.

5. Discussion

The current study investigated the role of the COVID-19 crisis in the adoption of environmental innovations among Norwegian manufacturers. More specifically, it examined how the degree of environmental innovation before the pandemic influenced the impact of the crisis on firms (H1). We also assessed how the impact of COVID-19 has led Norwegian manufacturing firms to execute general (H2a) and green strategic responses (H2b). Finally, we investigated how the negative impact of the crisis (H3) and the general (H4a) and green (H4b) strategic responses have impacted the degree of adoption of environmental innovations during the pandemic.

Overall, the present study shows that the crisis has had a negative effect on the adoption of environmental innovations in the Norwegian manufacturing industry. However, there are several findings that contribute to a better understanding of why this is the case.

5.1. Environmental innovation before COVID-19 and the crisis impact

First, the analyses revealed that firms that had already adopted a sustainability strategy were more influenced by the crisis. This is an intriguing finding that is contrary to expectations from prior research and that deserves both discussion and further investigation. In previous research on environmental innovations, the adoption of such innovations has been conceptualized as a resilience strategy. For example, some studies discuss how more sustainable firms experience less financial and market risk [54,55], which can make them more resilient to external shocks because of support from key stakeholders and regulators, good market reputation, and innovation capacity [48,51]. In addition, highly environmentally innovative firms could be argued as being more flexible and possess high levels of dynamic capabilities. Based on these arguments, we expected that firms with a high degree of environmental innovation before the pandemic would be less impacted by COVID-19. The current study suggests that it is the other way around: firms with a lower degree of environmental innovation before the pandemic were less impacted than the “greener” firms. This indicates

that less “green” firms are better able to maintain business operations after an external shock like COVID-19 [95].

Perhaps the explanation lies in the specificity of the business risk factors. Previous research shows that environmental innovations often entail high investment costs, complexity, and uncertainty [96,97]. Environmental innovations also have long payback times [98]. For these reasons, environmental innovations can be more vulnerable to external shocks, such as the COVID-19 pandemic, in the short term. In other words, sustainability-oriented manufacturers might be positioning themselves toward a trajectory of a future market with stricter standards for environmental sustainability. Because an external market shock disrupts that trajectory, it can leave future-oriented firms with a greater problem than those focusing on an environmental *status quo*.

Another particularity of risk associated with environmentally oriented firms can be found in their supply chains. Researchers argue that the firms least impacted by COVID-19 are those that can rapidly adapt to the changing environment [56,99]. During crises, firms that focus on their main strategies and competencies are the most resilient [100]. Previous research has found that dynamic firms with a flexible, diverse supply chain and network with a good culture of collaboration are more resilient to external shocks because they can adopt and reconfigure rapidly [101]. Similarly, Obrenovic et al. [102] find that shorter and more diversified supply chains with a network structure and high levels of decentralized decision making improve firms’ resilience toward external shocks. In fact, research has shown that during the pandemic, renewable energy suppliers were highly impacted, and many renewable energy supply chains were disrupted [65]. This may indicate that firms highly engaged in environmental innovations were more prone to the impact of COVID-19 because they depended on less diversified and more volatile supply chains. We suggest that more research efforts should be directed at understanding how firms with particularly strong sustainability strategies are affected by external market shocks.

5.2. Crisis impact: Environmental innovation change and strategic responses

The main contribution of the current study is the empirical investigation of the overall effect of the COVID-19 crisis on the adoption of environmental innovations in manufacturing firms. Because of the crisis, halts in production processes, disruptions in supply, heterogeneous decreases in demand, and similar occurrences around the world, it is reasonable to assume that firms have paused or stopped their focus on environmental innovation activities and concentrated on daily

operations and firm survival. This assumption is also supported by the present study, which has found that COVID-19 had a direct, negative influence on the adoption of environmental innovations in the Norwegian manufacturing sector. This finding is consistent with Barreiro-Gen et al. [21], who show that because of COVID-19, firms reduced their efforts in environmental issues, regardless of how long the firms have worked with sustainability. In addition, Zhang et al. [103] conclude that among Chinese firms, environmental sustainability was the least prioritized pillar during and after COVID-19; instead, they prioritized the social and economic pillars. Similarly, Hosseini [104] finds that the renewable energy transition has slowed down because manufacturing firms have been forced to put renewable energy technology projects on hold to focus on other activities. In their study of COVID-19's impact on firms, Zou et al. [105] show that COVID-19 impacted firms' innovation efforts because their R&D processes were hampered. In addition, nearly half of the surveyed firms expected financial losses because of the pandemic [105], which can explain why firms divested into environmental innovation. Moreover, COVID-19 had a negative effect on firm performance [71], and together with reduced liquidity, firms are meeting increased challenges in both ongoing and future sustainability projects [65]. Thus, the reduced adoption of environmental innovation may indicate a crisis response in which firms narrow their business scope by focusing on cost and complexity reductions to maintain liquidity and long-term recovery [50,106]. Hence, because of the financial and market risks associated with the COVID-19 pandemic, environmental innovations lose priority [69].

However, the current study shows little support for the notion that there is a general focus on the *status quo*, nor is there a lack of strategic response. In contrast, COVID-19 led to significant business responses among manufacturers (see Fig. 2), more so among those most affected. This shows how crises can lead to opportunities for strategic renewal and innovation [70,106]. The current study has shown that COVID-19 led to a broad range of general strategic responses, such as new sales channels, improved products or services, redefined operations, and production processes. In addition, it led to green strategic responses, including new green products or services, new green customer groups, and redefined operation and production processes for sustainability. These findings imply that COVID-19 has influenced firms to implement changes to adjust to their new external environment, but also to pursue the new business opportunities that come with these changes. In line with this, Riom and Valero [78] find that since the COVID-19 outbreak, many firms have adjusted their business operations, including adopting new technologies, management practices, and capabilities. During a crisis, firms can find new opportunities because of the changed environment, leading to new temporary or long-term business models [50]. These types of changes can be motivated by preparing for similar occurrences in the future and by becoming more resilient and flexible [101]. This shows that although the pandemic has led to challenges for firms, on the one hand, it also drives firms to look for new opportunities for innovation, on the other hand [56].

The changes observed among firms can be seen as dynamic economic resilience, in which firms increase the speed of recovery from an external shock [95]. In fact, research has found that manufacturing firms were the most negatively impacted compared with other industries [107], and the findings of the current study suggest that the strategic responses are a direct result of the negative impact from COVID-19 and that they have initiated a range of changes in the industry. However, it remains to be seen what the long-term consequences will be. Will the innovations implemented during COVID-19 put a lasting imprint on the manufacturing industry, or will companies revert to old ways when the dust has settled?

Finally, even though the results show that COVID-19 has an overall negative effect on the adoption of environmental innovations, it is interesting to note that the relationship is positively mediated by green strategic responses (see Table 3). This means that a significant number of firms chose to respond to the crisis by increasing their environmental

innovation efforts, despite the other negative effects imposed on them by the pandemic. Even though the effect from environmental responses was canceled out by the more numerous general strategic responses, the current study shows that firms can use external shocks as an opening to look for new green opportunities; especially, we observe that this is more common for those firms that have already implemented environmental innovations to a certain extent.

5.3. Limitations and further research

The current study has its strengths in representing a population of manufacturers. The limitations are predominantly from the time dimension and particularities of the country context. Because the current study was limited in time to activities and outcomes during an ongoing crisis, it could be that the long-term effects are different. Hence, because of the limited time frame, we encourage future research to study the effects of COVID-19 on environmental innovation in the long term.

Furthermore, even though the manufacturing sector is global in nature, our sample of Norwegian manufacturers entails some particularities to the Norwegian context that might not transfer well to other country settings. Norway has a long tradition of focusing on environmental regulations in industry, and regulators have set ambitious goals for a long time. Norway is also one of the countries that has been the least affected by the COVID-19 pandemic, both economically and otherwise. It is not unlikely that the findings would be different in a country setting where environmental regulations are less strict and less prioritized and where the impact of the pandemic has been more severe. Thus, further research could study the research questions in industries other than the manufacturing sector and in different country contexts.

Finally, the present study did not investigate the specifics of the firms that are the least impacted by COVID-19. Future research should dig deeper into what characterizes firms that are more resilient to COVID-19 and how business managers can learn from the pandemic for future scenarios.

6. Conclusion

The current paper studied the effect of COVID-19 on environmental innovation in manufacturing firms in Norway. Overall, the COVID-19 crisis had a negative influence on the adoption of environmental innovations in the industry. The crisis had a more negative impact on firms that were the most environmentally innovative, or "greener," before the pandemic. Finally, COVID-19 has imposed both general and green strategic responses in the firms most severely hit by the crisis; these firms also responded most actively to a broad range of strategies. Hence, the notion that they simply pause environmental development processes or revert to old and safe practices is inaccurate. However, the tendency for general strategic responses that crowd out green responses leads to the overall finding that the pandemic has had a negative effect on the adoption of environmental innovation among manufacturers. Overall, these findings have important contributions to theory, policy, and practice.

Regarding the theoretical contributions, the study contributes to both the growing crisis management and COVID-19 literature, as well as the environmental innovation literature, by demonstrating how external market shocks work as a barrier and downgrade for environmental innovations. In short, the results show how external shocks slow down the green transition, not by a lack of innovation, but rather from an abundance of it, where environmental innovations are crowded out by other strategic responses. It also shows how proactive environmental strategies can be a liability in times of crisis if the crisis interrupts the projections of how strict and fast new environmental standards and regulations are implemented in the market. This is a new perspective in the literature that generally regards environmental sustainability strategies to be resilient. Finally, the study reveals that green strategic responses can positively mediate the relationship between the impact of

COVID-19 and adoption of environmental innovations. This shows that a significant portion of the firms in the sample increased their environmental focus as a strategic response during the crisis.

The reduced pace of adopting environmental innovations in such a large sector as the manufacturing one certainly also has policy implications. Governments have lost time on their projections to meet international obligations, and the current study demonstrates the importance of incentives stimulating environmental innovations during and after a crisis. Previous studies have shown the importance of political measures and support for firms to adopt environmental innovations in the future [65,104]. The current study shows the importance of stable market environments for firms to stay focused on improving their environmental performance instead of fighting for survival in a market crisis. Researchers have discussed how the downgrading of environmental sustainability among firms during COVID-19 may lead to an environmental rebound effect, where resource efficiency measures lead to increased resource use instead of a desired and expected decrease [103,108]. Thus, during external shocks that lead to market crises, businesses need increased support and incentives to

continue toward a green transition of society.

Finally, for practitioners, the most important implication is the issue of business risk and sustainability strategies as resilience strategies. Sustainability strategies might not be as resilient to market changes as previously argued, and an external market shock can significantly slow down the projections of demand for environmentally friendly products and services. Business managers should prepare for similar future external shocks by preparing management plans to decrease uncertainty and risk when it comes to environmental innovation implementation [72]. On the other hand, even though the results indicate that environmental innovations are less prioritized during COVID-19, we also observe some support for the strategy that crises can be mitigated by increasing attention to environmental innovations.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Constructs and items	Standardized factor loading	α	RRC	AVE	CR
Impact from COVID (IC)		.797	.803	.509	.801
COVID-19 has affected our companies in the following ways:					
IC1 We have had or will have major challenges in obtaining deliveries	.61				
IC2 We experience or expect a large decline in demand for our products/services	.63				
IC3 We find it difficult to obtain financing	.70				
IC4 We experience or expect great pressure on our liquidity	.88				
Green strategic response resulting from COVID-19 (GRSR)		.884	.811	.619	.864
COVID-19 has affected the firm in making the following changes or adjustments:					
GRSR1 We have developed new green products and or services during the COVID-19 period	.67				
GRSR2 We have oriented ourselves toward new customer groups that are concerned about the green shift	.69				
GRSR3 We have redefined our operations and production processes to implement sustainability more efficiently	.88				
GRSR4 We have redefined our operations and production processes to meet new environmental criteria	.88				
General strategic response resulting from COVID-19 (GSR)		.831	.832	.573	.840
GSR1 We have used new sales channels	.65				
GSR2 We have improved products	.85				
GSR3 We have improved services	.86				
GSR4 We have used other suppliers and/or used alternative input factors that are available	.64				
Environmental innovation before COVID-19 (EIB)		.946	.932	.657	.943
To what degree did you before COVID-19 have measures to:					
EIB1 Reduce material use per unit of output	.72				
EIB2 Reduce energy use per unit of output	.80				
EIB3 Increase the use of renewable energy	.83				
EIB4 Reduce emissions of greenhouse gases	.91				
EIB5 We strive to reduce or eliminate impacts on local ecosystems	.91				
EIB6 Replace materials with less polluting or hazardous substitutes	.81				
EIB7 Reduce soil, water, noise, or air pollution	.90				
EIB8 Recycle waste, water, or materials	.68				
EIB9 Improve recycling and/or reuse of product and packaging after use	.69				
Environmental innovation change (Environmental innovation after COVID-19 – Environmental innovation before COVID-19) (EIC)			Mean	SD	
EIC1 Reduce material use per unit of output			-.14	1.257	
EIC2 Reduce energy use per unit of output			-.14	1.144	
EIC3 Increase the use of renewable energy			.12	1.059	
EIC4 Reduce emissions of greenhouse gases			-.03	1.037	
EIC5 We strive to reduce or eliminate impacts on local ecosystems			-.07	.996	
EIC6 Replace materials with less polluting or hazardous substitutes			-.04	1.107	
EIC7 Reduce soil, water, noise, or air pollution			.07	1.019	
EIC8 Recycle waste, water, or materials			-.19	1.159	
EIC9 Improve recycling and/or reuse of product and packaging after use			-.06	.994	

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PAPER 4

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