



Master's Thesis

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Sustainability Goals and NPD: A Comparison Between Norway and Germany

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Declaration

I hereby declare in lieu of an oath that I have prepared this thesis independently and without unauthorised assistance, that I have not used any sources or aids other than those indicated, and that I have marked as such any passages taken verbatim or in substance from the sources used.

Oslo, Norway, 26.09.22

Chrstopper H. Gridnheim

Abstract

As sustainability has gained more importance in recent years, some firms are trying to integrate sustainability into their new product development processes. However, few studies assessed this from the perspective of product managers. This paper investigates how firms work to make such integration happen and which challenges they meet on their way by comparing the efforts and challenges of 11 Norwegian and German firms using a qualitative approach. The efforts and challenges found are discussed in three categories: (1) Cultural sustainability efforts; (2) Practical sustainability efforts; and (3) Challenges. Finally, this study provides seven propositions for further research to gain a deeper understanding on the efforts needed and the challenges encountered when integrating sustainability into NPD.

1 Introduction

As sustainability has gained more focus in society, it has also found its way into new product development (NPD). However, introducing sustainability goals into the traditional NPD also introduce an extra layer of complexity (Peters and Buijs, 2022; Alblas et al., 2014; Wicki and Hansen, 2019; Kim et al., 2018). Therefore, inexperienced teams may end up falling back on traditional targets for their NPD process (Peters and Buijs, 2022). In contrast, successful integration of sustainability into the NPD function can lead to improved NPD success (Kim et al., 2018), and over time be leveraged as a competitive advantage (Dangelico et al., 2013).

The move from strategy to sustainable products has shown to be easier said than done, and prior literature has examined this phenomenon from different angles. Some studies look at how firms shape their practices on sustainable NPD and what role uncertainty plays in this learning process (Peters and Buijs, 2022). Others look at the challenges firms face when pursuing the integration of sustainability into their NPD process and how they can effectively integrate sustainability considerations into these processes (Brockhaus et al., 2019). Meanwhile, by examining German consumer goods companies, Petersen investigates how corporate sustainability affects product developers' decisions in improving product sustainability (Petersen, 2019).

This paper aims to use a pragmatic research approach to explore how sustainable NPD teams in small- and medium-sized enterprises (SMEs) work to integrate sustainability into their NPD processes. This will be done by taking the perspective of the product manager (PM) to understand what efforts they take and which difficulties they meet when implementing a firm's goals for sustainability into a new product. The efforts and challenges will be compared between two European, industrialised countries, Norway and Germany, to find differences and similarities and draw on experience from both countries. The research questions of this paper are as follows:

RQ1: What are the differences and similarities in sustainability efforts between German and Norwegian SMEs?

RQ2: What are the differences and similarities in sustainability challenges between German and Norwegian SMEs?

The paper is structured as follows. Chapter 2 presents a limited literature review presenting the concepts and tools used in the research. Chapter 3 presents the methodology. Afterwards chapter 4 presents the study's findings, followed by a discussion and conclusions in chapter 5.

2 Background Theory

2.1 Sustainability and SMEs

Sustainability can be defined in many ways (Faber et al., 2010), but is commonly defined as "to meet the needs of the present without comprising the ability of future generations to meet their own needs" (WCED, 1987, p. 43). From a corporate perspective, the 'triple bottom line' concept is often used to emphasise the equal weighting and importance of the economic-, environmental- and social dimensions of sustainability (Elkington, 1994). Here, economic performance is achieved through economic outcomes such as return on investment and business growth. Environmental performance depends on factors such as energy usage, resource optimisation and waste reduction, often related to CO2 emissions. Social performance refers to improving the life quality of all stakeholders concerned (Dey et al., 2020).

This study will focus on sustainability in SMEs, which can be defined as a company employing less than 250 persons and having an annual turnover not exceeding EUR 50 million or an annual balance sheet total not exceeding EUR 43 million (European Commission, 2015). Moreover, even though the impact on the sustainability of one SME is not significant in itself, they collectively contribute up to 70% of global pollution (Dey et al., 2020).

Research suggests that small businesses are not simply miniature versions of larger firms, and sustainability practices which are successful in large firms may not work in smaller firms (Roxas et al., 2017). SMEs are prone to disadvantages such as resource constraints, lack of formalised planning, and difficulty attracting finance. On the other hand, they have advantageous characteristics such as an entrepreneurial style with a lean organisational structure, may be strongly value-driven and are generally more flexible than larger firms (Klewitz and Hansen, 2014; Hansen et al., 2002).

2.2 New Product Development and Sustainability

NPD can be defined as "the transformation of a market opportunity and a set of assumptions about product technology into a product available for sale" (Krishnan and Ulrich, 2001, p. 1). The goal is to satisfy the needs of some customers by creating a product offering some superior value (Van Kleef et al., 2005).

The field is inherently multidisciplinary and is closely tied to research areas such as engineering design, operations management, strategy, strategic management, marketing, consumer behaviour, organisational studies, and supply chain management (Krishnan and Ulrich, 2001;

Marzi et al., 2020). Early research focused on the antecedents and sources of success- and failure for NPD (Page and Schirr, 2008). However, the field has grown considerably with efforts to understand tools, techniques and methods that can offer the firm competitive advantages (Andrade-Valbuena and Merigo, 2018).

In prior literature, the NPD process was divided into four basic stages: opportunity identification, development, testing, and launch. Here, tools and methods for each of these steps have been proposed (Van Kleef et al., 2005). Today, research has moved from models of NPD following the steps in a rigid linear fashion to more flexible dynamic models like the Stage-Gate model (Marzi et al., 2020; Cooper and Edgett, 2008). Also, as it is found that understanding the customer is critical for NPD success, research has investigated how to integrate the customer into the various activities of the NPD process (Van Kleef et al., 2005). For example, today, the lead user approach is well-recognised for its ability to generate attractive and novel ideas (Kratzer, 2020).

Sustainability is described as an emerging megatrend (Lubin and Esty, 2010), and society puts growing pressure to take efforts against factors contributing to global warming and other sustainability-related problems (Alblas et al., 2014). Also, research suggests that innovating without sustainability consideration is no longer a strong competitive priority for firms, and sustainable NPD will emerge as a competitive priority in practice (Behnam and Cagliano, 2016).

Over the years, firms have included sustainable considerations in their product development strategies (Driessen et al., 2013), and much research has investigated how this is integrated into the NPD processes of the firms (Brockhaus et al., 2019; Thomé et al., 2016; Dangelico et al., 2013). Such efforts have been given many names, such as 'green NPD' (Driessen et al., 2013), 'eco-innovation' (OECD, 2009), and 'green product innovation' (Peters and Buijs, 2022). Further, sustainable NPD will be used in this paper as it refers to integrating all triple bottom line dimensions into the NPD process (Thomé et al., 2016). Nevertheless, sustainable NPD success can be reflected by economic success since sustainable new products and services need to be financially viable for firms to continue investing in other sustainable improvements of their products in the medium to long term (Claudy et al., 2016).

Some researchers state that there is no fundamental difference between sustainable NPD and 'traditional' NPD (Driessen et al., 2013), but this is an ongoing topic of debate (Peters and Buijs, 2022). Meanwhile, there seems to be a consensus that introducing sustainability into the NPD process will lead to additional uncertainties and complexity for the firms (Peters and Buijs, 2022; Wicki and Hansen, 2019; Alblas et al., 2014; Kim et al., 2018).

2.3 Sustainability Orientations

Sustainability orientation (SO) refers to a firm's view on corporate responsibility toward sustainability (Banerjee, 2002) and can be divided into two dimensions: sustainability culture and sustainability practices. The first refers to integrating sustainability values and ideas in the organisational culture, and the second refers to integrating social and environmental concerns

into operational plans, programs, and practices (Claudy et al., 2016).

Some studies have described different typologies of environmental strategies exhibited by SMEs, and one study identified 11 typologies in earlier literature (Klewitz and Hansen, 2014). Meanwhile, researchers warn about the false assumption that a firm's vision for sustainability will 'trickle down' into the fabric of their organisation and permeate their value chain (Brockhaus et al., 2019). However, many firms work to integrate their strategies into their NPD process to let the products be manifestations of the firm's sustainability strategy of the firm (Brockhaus et al., 2019; Alblas et al., 2014). Lately, studies have described different typologies of SOs of firms by examining not only their higher-level general strategies but also which efforts firms make to integrate sustainability in the practices of the firm.

One study proposes a typology of six corporate sustainability approaches by assessing how a firm's SO affects product developers' decisions on improving the sustainability of products. At one end of the scale, "Minimalists" believe that their customers are not interested in product sustainability, and cost reductions and regulations mainly drive the firms. On the other end of the scale, "True Believers" have founded their business on the idea of corporate sustainability and integrated sustainability into every function of their company (Petersen, 2019).

Meanwhile, based on a systematic literature review of sustainability-oriented innovations of SMEs, Klewitz and Hansen (2014) described five approaches. These are Resistant (ignoring sustainability-related pressures), Reactive (responding to external pressure), Anticipatory (timing their innovations to anticipate future innovation opportunities), Innovation Based (seeking innovative solutions to environmental and social challenges), and Sustainability-rooted (where the business model build on the triple bottom layer principles) (Klewitz and Hansen, 2014).

Another study uses the Resource-based view (Barney, 2001) to explain how sustainability approaches can be leveraged as a firm resource and a competitive advantage. Here, the authors describe a typology of three different sustainability orientations. These are the "Dabblers", the "Do-It-Yourself (DIY) Ecopreneurs", and the "Codifiers". Dabblers have an opportunistic approach to sustainability. Their sustainability initiatives are sporadic and unorganised, they will not make trade-offs for profits, and they are mainly motivated by the "fear of missing out". Meanwhile, the DIY-Ecopreneurs have a more idealistic approach where sustainability is seen as a calling. They are willing to sacrifice profit and scale to optimise their sustainability performance. Last, the Codifiers see sustainability as an opportunity to build a competitive advantage and to ensure a structured roll-out of sustainable products. Furthermore, economic trade-offs are accepted, and the management has a clear mandate for achieving sustainable targets (Brockhaus et al., 2019).

Last, one study examines the SO of firms not as a static phenomenon being either "sustainable" or "not sustainable". Instead, the study uses a journey toward sustainability as a metaphor for a dynamic process that happens over time. Thus, three approaches to sustainability-oriented innovations are described, where each category refers to a level of maturity of the organisation's capabilities for sustainable innovation. These are operational optimisation (doing the same things better), organisational transformation (doing good by doing new things), and systems building (doing good by doing new things with others) (Adams

et al., 2016).

2.4 Sustainability Orientation and Firm Performance

Numerous studies have assessed the business outcome of SO. First, results describing the direct relationship between SO and economic firm performance are mixed (Hahn and Scheermesser, 2006; Hofmann et al., 2012; Kim et al., 2018). For example, some researchers report that SO can lead to increased efficiency in the use of resources, increased sales, development of new markets, improved corporate image and enhanced competitive advantage (Dangelico et al., 2013; Banerjee, 2002), but others state that these findings are merely casuistic "success stories" scattered across industries (Hofmann et al., 2012). However, recent research supports the positive association between SO and firm performance but argues that it is negatively moderated by sustainability decision trade-offs and industry growth (Khizar et al., 2021).

On the other hand, innovation and firm performance have a well-established positive link (Kim et al., 2018). Moreover, since research suggests that SO positively affects innovation, creativity and NPD success, it can be argued that it has an indirect positive effect on firm performance (Kim et al., 2018; Jacobsen et al., 2020; Nidumolu et al., 2009; Claudy et al., 2016; Dangelico et al., 2013; Jin et al., 2019; Khizar et al., 2021). Additionally, the SO of a firm is found to be the most important success factor for sustainable NPD together with having an orientation towards market- and non-market stakeholders of the firm (Driessen et al., 2013).

2.5 Efforts and Challenges in Integrating Sustainability

This section will briefly describe some known efforts and challenges for integrating sustainability into the NPD function of firms. The efforts are grouped into goals and targets; managerial; tools, methods and processes; and sustainability knowledge.

2.5.1 Goals and targets

Clearly projected scopes and quantifiable targets to define the design space are commonly mentioned as success factors for moving sustainability from strategy to practice and improving product sustainability (Alblas et al., 2014; Dangelico et al., 2013; Petersen, 2019; Brockhaus et al., 2019; Du et al., 2016; Driessen et al., 2013; Held et al., 2018). Here, clear targets are needed for product managers to prioritise their resources, justify further investments into sustainability initiatives, and to effectively steer and monitor their project (Brockhaus et al., 2019; Alblas et al., 2014). Moreover, clear targets are also required for tools and concepts for designing new sustainable products, such as 'design for environment' (Srivastava, 2007) and product life cycle planning (Alblas et al., 2014).

Empirical studies show that breaking high-level sustainability visions into operational targets can be demanding (Alblas et al., 2014; Brockhaus et al., 2019; Peters and Buijs, 2022). In many cases, such targets can conflict at a strategical level (Peters and Buijs, 2022; Brockhaus et al., 2019). If the firm's sustainability goals are not aligned with NPD goals, such as

profitability, return on investment or market share, the firm may be forced to make trade-offs between ecological and social objectives (Claudy et al., 2016). Also, if clear strategies, scopes and targets are lacking, traditional design criteria and parameters are likely to be prioritised at the cost of sustainability improvements (Alblas et al., 2014).

2.5.2 Managerial

Research suggests that a manager should enforce targets with a clear and genuine mandate and top-level management support for sustainability improvements (Brockhaus et al., 2019). Furthermore, to leverage sustainable NPD as a resource for the firm, the process should be codified (Brockhaus et al., 2019). For example, a minority of SMEs use environmental management systems such as ISO 14001 to manage their environmental issues systematically. However, integrating such systems stands in contrast to more informal management systems of SMEs (Klewitz and Hansen, 2014).

The manager should use resources to cultivate the firm's SO, highlighting the importance of sustainability and putting the topic on the agenda (Du et al., 2016; Jacobsen et al., 2020) so that sustainability is structurally embedded into all parts and employees of the company (Held et al., 2018). A challenge associated with such efforts is antagonising attitudes among external players towards doing new things (Jacobsen et al., 2020).

2.5.3 Tools, methods and processes

Much research has investigated tools, methods and processes for developing sustainable products. These range from simple checklists to expert-level systems (Peters and Buijs, 2022). The number and variety of tools and methods have grown large enough to be a field of research in itself (Brockhaus et al., 2019), and choosing the correct tool for a firm can be difficult (Held et al., 2018). However, it is also found that very few of the tools proposed in the literature are actually used in practice as many of them are too complex, need vast amounts of data, or are otherwise not adaptable to the specific needs of the given firm (Peters and Buijs, 2022; Brockhaus et al., 2019; Alblas et al., 2014; Held et al., 2018). The required time needed to use the tools, the required budget, and the lack of personnel and knowledge on how to use the tools are also challenges that firms meet when considering implementing them (Held et al., 2018).

One of the few tools commonly used in practice is life cycle analysis (LCA). This is used to assess the environmental impacts associated with all stages of a product's life. However, the effectiveness of the tool is debated in the literature, and it is criticised for its limited effectiveness in early product design and for using inaccurate, unreliable and costly-to-collect data, whose results must be interpreted subjectively (Alblas et al., 2014). Others argue that the tool mostly ends up being used for reporting purposes rather than improving products (Petersen, 2019).

2.5.4 Sustainability knowledge

Since much of the research focuses on developing and evaluating methods and tools, there must be an implicit assumption that any firm can implement them regardless of firm-specific or human factors (Petersen, 2019). It is argued that the availability of sustainability information is a prerequisite for building sustainable design expertise (Brockhaus et al., 2019). However, due to the increased complexity of integrating sustainability into the NPD process, a firm's ability to absorb knowledge from external sources (external integrative capabilities (Verona, 1999)) is found to be of great importance. This concerns both the integration of sustainability issues in manufacturing and sustainable product design expertise. Product managers are advised to build networks to gain sustainable know-how (technology, knowledge, expertise, etc.) from external sources (e.g. partners, universities, and formal collaborations through the value chain) (Dangelico et al., 2013).

Furthermore, a significant gap between the customer's stated preferences for sustainability and their willingness to accept changes, e.g. in price and quality, increase the need for market knowledge when making sustainable products (Claudy et al., 2016). If the existing market competencies are inadequate for addressing future and current market conditions, the technological competencies cannot be leveraged to create successful sustainable products (Peters and Buijs, 2022).

It is suggested that knowledge of sustainability should be built in-house. The employee's design expertise is one of the success factors for implementing a SO (Held et al., 2018). It is advised to recruit employees with specialised knowledge, training employees on specialised topics on sustainability issues, and invest in software to improve sustainable NPD. At the same time, this must be used to create new market opportunities and increase financial performance (Dangelico et al., 2013; Alblas et al., 2014). Furthermore, it is advised to use resources on knowledge transfer between functions of the firm (Alblas et al., 2014).

3 Methodology

3.1 Research Design

Research philosophy is the system of beliefs and assumptions about the development of knowledge. The paradigm within which this paper operates will first be examined to describe the research philosophy of this paper. A paradigm is a set of basic assumptions that are often taken for granted, underpinning the frame of reference, mode of theorising, and ways of working in which a group operates. Here, business and management research commonly operates within the functionalist paradigm, which leans towards the objectivist viewpoint. Therefore, the concern of the paper will be to generate rational explanations and develop recommendations that can be used in a different context. The key assumption is that organisations are rational entities, in which rational explanations offer solutions to rational problems (Saunders et al., 2019; Burrell and Morgan, 2017).

There are five major philosophies within business and management research. However,

the most fitting philosophy for this paper will be the pragmatist research philosophy. This philosophy asserts that concepts are only relevant where they support action. It aims to reconcile objectivism and subjectivism by considering theories, concepts and findings in terms of their practical consequences in specific contexts. Furthermore, pragmatists recognise that the world can be interpreted in many ways and that no point of view can give the entire picture (Saunders et al., 2019).

The research question is exploratory, and therefore an inductive approach seems fitting. Here, the goal is to generalise from specific to general by using known premises to generate untested conclusions. Thus, the theory is built based on the collected data (Saunders et al., 2019). Specifically, grounded theory will be employed for this study as this is particularly useful in new, applied areas where there is a lack of theory and concepts to describe and explain what is going on (Robson and McCartan, 2011). For the data collection, semi-structured interviews are seen as a good approach when working with grounded theory (Gioia et al., 2013). Furthermore, sampling in grounded theory is purposive. This means that a representative sample is not sought for its own sake and that sampling is not randomised but hand-picked to obtain new information in every interview to aid in generating conceptual categories (Robson and McCartan, 2011).

3.2 Validity

Ensuring the validity of qualitative research is difficult (Robson and McCartan, 2011). However, it is a consensus that researchers must demonstrate that their research is credible. Accordingly, procedures for establishing validity in qualitative projects have been identified, one of which is triangulation (Creswell and Miller, 2000). Triangulation is a widely used strategy used to enhance the rigour of the research and help counter all threats to validity (Robson and McCartan, 2011). As a validity procedure, it is a systematic way process of sorting through the data to find common themes and categories by eliminating overlapping areas (Creswell and Miller, 2000). In this research, efforts were made to employ triangulating of data sources and triangulation of investigators (Mathison, 1988; Patton, 1999; Robson and McCartan, 2011).

3.3 Data Sources

All informants of this study took part in the product development processes of their firm, and most of the informants functioned as the head of product. However, in some firms, the 'head of product' role was, divided among all employees because of the firm's early stage and size. In larger firms, informants were responsible for one out of many products that a firm delivered. The informants were employed in SMEs based in Norway and Germany, and all firms were founded less than ten years ago. The Norwegian firms had between 5 and 200 employees, while all the German firms had less than 20 employees. Furthermore, all firms developed some new product or technology and were picked from a wide range of different industries. For eight of the firms, manufactured goods were their main product. Meanwhile, three of the firms developed software only. An overview of the case firms can be seen in table 1.

These variations of the data sources are in line with data source triangulation, which can be obtained by cross-checking the consistency of the information from different sources within one method and comparing perspectives of different points of view (Patton, 1999).

The firms were discovered based on personal network tips and web pages of investors and incubators operating in the countries. Interesting firms were contacted using the e-mail address found on their web page or by directly contacting potential informants using the social network LinkedIn. In Norway, 12 companies were contacted, and six were willing to participate in the study. Meanwhile, in Germany, more than 70 firms and employees were contacted, and five persons agreed to participate in the study. This resulted in a total of 11 interviews conducted in the study.

When using a grounded theory approach, the researcher is expected to visit the field cyclically to collect data until all categories found during the analysis are 'saturated', meaning when new interviews show little or no new information (Robson and McCartan, 2011). However, due to time constraints, an effort was made early in the process to ensure at least five interviews from each country would be conducted. Nevertheless, as the return of information for each new interview was diminishing, a reasonable degree of theoretical saturation was achieved (Robson and McCartan, 2011).

Table 1: Companies Overview

#	Role	Product category	Primary Type Business	Industry
DE1	Founder/PM	HW	B2B	Transport
DE2	Founder/CEO	SW	B2B	Health
DE3	Founder/PM	HW	B2B	Medical
DE4	Founder/CEO	HW	B2C	Electronics
DE5	Founder/CEO	SW	B2B	Real Estate
NO1	PM	HW	B2C	Electronics
NO2	PM	HW	B2B	Electronics
NO3	PM	HW	B2B	Electronics
NO4	CTO	HW	B2B	Electronics
NO5	PM	HW	B2C	Power
NO6	Founder/PM	SW	B2B	Power

3.4 Interviews

Before the interviews, an interview protocol was prepared (Gioia et al., 2013). This consisted of open-ended questions, which have multiple advantages when used in an interview. They are flexible; allow for going into greater depth and clearing misunderstandings; enable testing of limits of the respondents' knowledge; encourage cooperation and rapport; allow for making a "truer" assessment of what the respondent really believes, and can produce unexpected or

unanticipated answers. On the other hand, disadvantages are the risk of losing control and increased difficulty of analysis (Robson and McCartan, 2011). Therefore, an interview guide was made containing two layers of questions to ensure that all information needed would be gathered from each of the informants.

The interview protocol was based on the sequence framework proposed by Robson and MacCartan, which includes the steps: introduction, warm-up, the main body of the interview, cool-of, and closure (Robson and McCartan, 2011). Also, the goal was to explore efforts taken and challenges met by PMs of Norwegian and German SMEs to improve the sustainability of their products. Therefore, the interview is divided into three stages: introduction, firm-level sustainability, and sustainability in the NPD process. The interview protocol was tested on persons independent of the project in order to check that all questions were understood as intended and that time needed to conduct the interview was expedient. See appendix B for the full interview protocol.

The 11 interviews were conducted between the 14th of June and the 15th of July in 2022. They lasted between 15 and 55 minutes. Due to the large distances between the informants, all interviews were performed digitally. The video conferencing software Zoom was used for conducting the interviews and for recording the sessions. Before the interviewees, informants were asked for permission for the session to be recorded and transcribed (Robson and McCartan, 2011). During the interviews, the interviewee was interrupted minimally. However, follow-up questions such as "how", "why", and "why not" was posed when touching on the research question (Gioia et al., 2013). After the interview, additional remarks were noted by hand, and the interview was transcribed and made anonymous. The author did all of the transcripts himself and was, therefore, able to become very familiar with the data and see more nuances in the following analysis (Gioia et al., 2013).

3.5 Data analysis

The data analysis was based on the 'Gioia method' (Gioia et al., 2013), and the software AtlasTI was used to keep track of interesting quotes, codes and memos throughout the analysis.

From 11 transcribed interviews, an end total of 390 quotes were highlighted. By staying faithful to the terms of the informants, 90 1st-order concepts emerged from the interviews (Gioia et al., 2013). After this, axial coding (Robson and McCartan, 2011) was used to group the 1st-order concepts into a more manageable number of 2nd-order categories, which were given phrasal descriptions. Now, it was ready to look for deeper structures among the codes (Gioia et al., 2013).

Coding should not be seen as a linear process but as a feedback loop between low-levered descriptive codes and higher-level categories (Linneberg and Korsgaard, 2019). The 1st order codes were grouped in relevant 2nd-order categories. Based on the 2nd-order categories that emerged, the 1st-order codes were refined and adjusted. Then, the 2nd-order categories were again revisited to see if they were true to the refined 1st-order concepts. In parallel, the author cycled between the emergent data, themes, concepts and dimensions, and the relevant

literature to see whether the findings have precedents or if any new concepts were discovered (Gioia et al., 2013). While gradually reading more background theory, the 2nd-order categories were further grouped into 14 second-order themes in order to answer the question, 'what is going on here?' (Gioia et al., 2013). Finally, the 2nd-order themes were leveraged into the theoretical realm as 2nd-order 'aggregate dimensions' (Gioia et al., 2013).

To see a summary of the findings, look at appendix A. Here, the categories are represented by the aggregate dimensions. These are again divided into the 2nd-order themes found in the analysis process. These are again based on the 1st order concepts and 2nd order categories mentioned earlier.

As only one researcher was involved in the research project, the risk of blind interpretive bias threatens the validity of the analysis (Patton, 1999). To counter this risk, an independent observer was asked to contribute to the analysis to help with investigator triangulation (Mathison, 1988; Patton, 1999). Here, the observer was asked to group the 2nd-order categories into 2nd-order themes in order to see if the same categories were made. When this review resulted in similar groupings, the analysis was completed.

4 Findings

The findings chapter is structured as follows. First, the sustainable efforts are presented in categories of cultural sustainability efforts and practical sustainability efforts. Then, the challenges are described. A summary of the findings can be seen in appendix A.

4.1 Cultural Sustainability Efforts

4.1.1 Goals and Vision for Sustainability at the Firm Level

All firms interviewed in both Norway and Germany have, to some degree, a defined vision and goals touching upon sustainability or describe that their product has some sustainable outcome. For example, a German firm state that their product will "shape cities and urban areas, and make them a more liveable space". Other firms put most of their efforts into becoming economically sustainable. A German firm explains, "we don't have any venture capital money yet, so we are trying to build a sustainable, long-lasting business". Also, a Norwegian firm with a vision of reducing the energy usage of their customers explains: "if something is not economically sustainable, then it is not really environmentally sustainable either".

Many Norwegian firms use the values to set sustainability on the agenda. For example, a firm express that "sustainability is one of the core values of the firm (...) so we accomplish our mission by reducing emissions". Another firm had not introduced sustainability as a value in itself but notes that: "the whole backbone of the company is to make high-quality products. Before, it was not communicated that this is a good thing for sustainability; it is more a general wish of creating high quality".

4.1.2 Goals and Vision for Sustainability at the Product team Level

Amongst the German firms, all PMs were a part of the founding team which resulted in common goals for sustainability at the firm- and the product-team level. However, most Norwegian PMs were not founders of the firms. Sometimes, the PMs themselves may have more significant goals for sustainability than what is stated at the firm level and try to integrate their personal values into their product development process. A Norwegian PM described: "as a company, we don't do a whole lot [on sustainability], but I pay much attention to the topic because I have a special interest in it". To enhance the firm's sustainability, the PM introduced product values that exceed the firm's sustainability goals: "we should do a much better job with this, but as a product manager, I communicate our view on sustainability through the product values". The PM further describes the goal of making the whole firm more sustainability-oriented: "I spend much time making sure that everybody [in the firm] understands the product values. Then, when they go and make decisions when I am not in the room, they think about these principles, whereas one of them is sustainability".

4.1.3 Searching for Ideas for Sustainability

Some informants say that they make no effort to generate ideas for sustainability. For example, In Germany, none of the SW firms sees any need or way of integrating environmental or societal sustainability into their product: "we develop SW, so there is not that much that we could do about sustainability". Furthermore, they state that "we are an SW company, so we don't really emit through our product or manufacturing or anything like this. It is just the employer emissions". According to the informants, looking for a feature to improve the sustainability of their product is not applicable to their product: "it feels that if it is somehow a feature you would build anyway, then it is super cool. But would you build a feature just for the sake of sustainability? I don't know. It is very abstract for me. Because for us as a software tool, there are no 'sustainable features', you know. Like, I cannot really imagine anything under that term".

Other firms describe that the ideas come from 'always having sustainability in mind'. A Norwegian firm describes that they do not explicitly look for opportunities to improve sustainability, but stating it as a product value integrates it into the mindset of the product team: "it is fascinating, because earlier we did not make any such efforts, and people choosing the design before me never had that mindset. But when you set it as a value, then it just happens in everything you do". Here, the goal is to focus on sustainability in everything that is being done rather than actively searching for sustainability improvements. Similarly, two more firms explain that they frequently discover 'small' ideas for sustainability. A German firm explains that "if we have a component or a piece that needs to be changed, or did not work or anything. Then we evaluate which options we have, and one of the points in the decision process is sustainability. But we don't have a sustainability database where we look for what we can integrate. It is more that we have a problem, or we can do something different, and we try to make it as sustainable as possible". Similarly, a Norwegian firm explains: "on a daily basis, it

is quite random. But, when we do things in the design process, it is a little more systematic, plus we run an LCA on the product”.

Meanwhile, in order to improve the sustainability of their products, a German firm looked for a knowledgeable production partner to lean on: “we rely on tips and communication coming from the outside. Since our production partner has more resources to dive into those topics, we use his resources a lot. We ask, for example, ‘how do you overcome the problems on sustainability when using this material?’ and it is mostly about his knowledge on the topic. Currently, unfortunately, it is not the case that we bring a lot of new ideas to him - it is more the other way around”.

4.2 Practical Sustainability Efforts

4.2.1 Sustainability Assessments

Amongst the German firms, most of the PMs stated that their firm was currently conducting a life cycle assessment (LCA), but the efforts have been of varying magnitude. One firm said they are “in the progress of introducing (...) tracking of our CO₂ emissions and looking at how we can reduce them”. Another firm employed a working student to collect and analyse their LCA data, but the data was never used. Another firm recently finished a comprehensive LCA, which included both the product and the company’s internal processes. According to the firm, “this was a step to see where we are standing right now, and then the next step will be to build something to enforce sustainable decisions”. Finally, a firm tried to integrate LCAs into the daily operations of the firm, “after buying each individual component, we looked in detail at what the component is doing for the carbon footprint, and how it affects our footprint. Then, we have a huge excel table where the carbon footprint of every capacitor and resistor is calculated”.

LCAs were also commonly mentioned amongst Norwegian firms, also with varying magnitude. One firm made an effort to become certified for the ISO 14001 standard because of demands from the firm’s shareholders. In another firm, a PM initiated a small-scale carbon footprint calculation of one of the firm’s products. This was done as an effort to improve the focus on sustainability of the firm and found that “it was very revealing that we have false assumptions and that there are opportunities for us to improve them”. Finally, a Norwegian firm has worked to integrate LCAs into the NPD process: “we run an LCA all the way down to the component level, including transport and the use phase. We have tools to do that, and we have one person responsible for it in the HW department”. The firm has acknowledged that many of its assumptions regarding sustainability may be false. Therefore, they try to always base their decisions on data from LCAs when evaluating sustainability. To facilitate their LCAs, they have invested in a software tool including databases of components and their carbon footprint.

4.2.2 Choice of Materials and Components

In Germany, one firm was built on the idea of using a new material which was more environmentally friendly than the existing alternatives in the industry. Another firm tries integrating sustainability into decision-making when selecting components and materials. It describes that: "we are only using other components or processes if it has a huge advantage. Either if it has a much better performance, or if it is the only material available". Finally, a PM explains that the firm wanted to reduce its product's weight and carbon footprint and used an LCA to find areas of improvement. They found that "the easiest way to reduce the carbon footprint is to change the material enclosure since there are now coming new materials that have a better carbon footprint".

Common for Norwegian firms is the focus on plastic usage in products. Several firms have evaluated using more sustainable materials in new products but chose not to do it due to increased risk and complexity. One firm describes: "if we were to introduce sustainability into all parts of the product, using bio-plastic and things like that, it would raise the costs. It is not a very widespread material; it is bio-plastic (...) it creates more complexity than the value". For another firm, sustainability in itself is not the most important part of their NPD process: "we have equipment which is lowered into the fish farms, and then we evaluate for example which rope we use. What is better for the health of the fish? At the same time, what will work well technically? Like that, we have sustainability with us in the development process, but it is not the highest priority". Last, one firm regularly performs evaluations during the product development phase to ensure that the component count is kept to a minimum and that the use of noble metals is as low as possible. Their decisions are backed up by LCAs, which are conducted by a person responsible for sustainability in the respective department of the firm. This person also contributes to design reviews with feedback and tips on the component choice from a sustainability viewpoint. The firm also made efforts to reduce its carbon footprint from plastic.

4.2.3 Choice of Producers and Suppliers

Firms in Norway and Germany ensure that their products are produced ethically and environmentally sustainable. In each country, one interviewed firm tries to source and produce most of its components in Europe. The German firm explains that "if we have the choice, and if it makes sense, we always try to get components from Europe to increase the sustainability in our supply chain". Meanwhile, the Norwegian explained: "from our analysis, the best thing is to move all components to Europe for assembly". The firm acknowledges that most "small components" are made in Asia. Therefore, the firm tries to choose the right suppliers and set up the product so that the emissions from transporting and packaging do not overrule the gains from an assembly in Europe: "it is a difficult calculation because the components are small, but they are packed in with much more on the outside. And it is difficult to have answers from the producers on how it was transported from Taiwan. Was it with a ship? Was it using a plane? But we try to get to the bottom of it".

Some of the German firms tried to choose a producer with common values. In the process, one of the firms explained that they discussed, "what kind of factors are necessary in order to say that it is in line with our sustainability goals? This is a topic that often comes across in our meetings". Meanwhile, realising the difficulty of sourcing a sustainable alternative for some components, one of the German firms took action: "there are initiatives that try to bundle demands of multiple small companies and to do joint procurement (...) to have a bigger demand, and to be more likely to get a component that is more sustainable than others". Finally, one of the German firms wanted to reduce all emissions related to production, but "we noticed that a hardware product would of course always produce some negative carbon footprint". Therefore, the firm made an extra effort in reducing their carbon footprint: "the solution for us was that we want to compensate for the carbon footprint of the product. By increasing the price of the product, we let the customer pay to have a product that has no carbon footprint".

In Norway, many of the firms showed an extra focus on social sustainability in their supply chain. For example, one firm describes: "we use a firm which is a sheltered workshop to do our assembly for us, and that is here in Norway. In some way, it is sustainable that we do all production here, and it is sustainable to employ a lot of people who would otherwise be left out of employment". Another Norwegian firm also focuses on social sustainability when choosing their suppliers: "we have audits on all of our suppliers. (...) There we assess which working conditions the people making our products have. So, we set quite strict demands for our suppliers, and we have processes we go through when we onboard a supplier".

4.2.4 Transport and Packaging

In Germany, one firm developed new ways of transporting their temperature-sensitive product more sustainably and effectively: "we used an eco-friendly packaging system, because, usually you need a lot of dry-ice to cool down the product that is produced and we decided to do it in a powder form not to need the ice. Then we could just ship it in a freeze-box and not in a big package". Also, this and two other firms worked to optimise the transportation routes for environmental sustainability.

Firms in both countries made an effort to design more sustainable packaging. The German firm found themselves with a dilemma between aesthetics or carbon footprint: "if you unpack the product, it shall be the feeling of having a Playstation, and it should look as nice as unpacking a Playstation. But in the end, it became clear that a package designed like a Playstation has a really negative carbon footprint, and it won't be a feasible solution". The German firm ended up reducing its demands for design aesthetics in order to make a more sustainable design. A similar story was told by a Norwegian PM who worked to improve the sustainability of the packaging in their firm: "at first, we needed a box and did not think more about it. So, for consumer goods, a typical design is how Apple do their packaging, and we copied that". However, feedback from the market made them aware of their waste generation. Realising this, the firm worked to improve the product packaging and assessed:

"which materials are our packaging made of? Is it necessary"? The effort resulted in a redesign of the product packaging, with the goal of having as little waste as possible after the product was packed out: "could we find a material which is completely recyclable? And could we make a cutting-process so that the packages are shipped flat?" .

Meanwhile, another Norwegian firm tried to reduce the waste within their value chain, "we have seen that there is a lot of packaging which is discarded at one of the suppliers, and it becomes quite large volumes of waste. (...) we now assess whether it is possible to reuse some of the packaging utilised earlier in the supply chain". Finally, a Norwegian firm made efforts to optimise the transport route of the product: "a chip was produced in Taiwan, and then it was sent to the US. Then we bought it from the US, and, at the time, it was sent back to China and assembled on a card. Finally, the card was sent to Norway. (...) So we chose a European distributor, which now goes directly from Taiwan to Germany, and the production is in Poland. This we have done for all of our components" .

4.2.5 Product Use Phase

In both countries, efforts were made to increase the longevity of the products. For example, a German firm made an effort to improve the lifetime of the product by choosing replaceable batteries: "we discussed whether to use built-in batteries or to use replaceable batteries. We decided to go for replaceable batteries for different reasons, first of all, because our customers are interested in it (...) but secondly because it is easier to remove the battery from the vehicle and recycle it if the lifetime comes to an end". The same effort was made by a Norwegian firm that went from built-in batteries to using replaceable batteries in their new products.

Some of the Norwegian firms also tried to improve their product lifetime. One firm with an explicit goal of making a product that lasts as long as possible explains: "it is the goal to make the product last longer, but it is not because we have thought of sustainability. It is, however, two sides of the same coin". To achieve this goal, they make extra efforts by choosing high-quality components, improving plastic mixtures for extra durability, and refining their electronics. Meanwhile, another Norwegian firm tries to ensure that the product lasts as long as possible by using softer methods: "we have a strong focus on making products that people get a strong connection to with beautiful and timeless design which can work in a lot of different settings, and not jump on the current trends. This is something we work with very actively" .

4.2.6 Product end phase

Some of the Norwegian firms mention that they work to increase the sustainability of the product when its lifetime comes to an end. Regularly, an effort is made to simplify the assembly and dismantling of the products: "we have specific reviews, for example, the assembly process, where we focus on making the product easy to open for reparation and recycling". Others mention efforts to recycle batteries, "the product is part of these battery programs where we can pay money to different countries so that you can deliver it to special waste and it will be

recycled". Last, one firm states that: "we will recycle hardware where we can, but we try not to glorify our sustainability efforts in any way. It must be practical and effective".

4.3 Challenges

4.3.1 Lacking tools and data for making the best decisions

Measuring sustainable performance can be challenging, and most firms made no efforts to set quantifiable targets for sustainability. One Norwegian describes the difficulty of finding out where to start: "what is the metric that can measure the success of our mission statement? Is it the reduction of CO2 equivalents? Can we find a metric that can connect the impact made to the discussion on what the product will do?" However, even when a scope is set, and measurement has been done, taking the data on sustainability into consideration when designing new products can pose challenges in itself. For example, after doing an extensive life cycle analysis on his product, a German PM described the difficulty of designing a product today to have a minimal impact in the future: "from my perspective, it is the biggest challenge to write a specification at the beginning that can estimate the footprint that a given decision or specification makes on the whole product life".

Collectively, there seems to be challenging to determine what is the most sustainable option. For example, a Norwegian PM explains the challenges of lacking knowledge on how to make sustainable decisions "We may have an idea that one is more sustainable than the other, but we don't know. We don't have any good databases with such info today. I don't have any tool available, but that is what I want to have in order to make data-driven decisions". However, the PM also sees the difficulties of making use of such tools for sustainability: "it takes high competency to use such tools, and you have to pay for access to the databases. It is not done in a jiffy to set up such a solution. (...) so it ends up with us just making rough estimates, googling a little, and if we are in doubt, then time to market will be prioritised".

Another challenge is to assess the value chain of the producer. A Norwegian firm explains that: "the company who produces the component is located in Switzerland, but it is not certain where their suppliers are located, and how the transport was conducted between them. Therefore, we contact the producers and ask them, where are [the components] being produced? And then we can make decisions based on this information". Furthermore, it may be difficult to balance the location of the producer with where the product will be sold, "if you produce in Norway, the energy mix is very nice. However, in Poland, it may be a lot of coal in the energy mix (...) but is it best if it is produced in Poland if it is to be sold in Poland? And what if it is sold in Germany?". Finally, the firm notes that it must also pay off financially, but "generally it will pay off because there is a coherence between CO2 and money".

4.3.2 Increased complexity and costs for the more sustainable choice

The firms face the common challenge of increased costs for increased sustainability. A Norwegian PM explains: "in order to be competitive, you choose the most inexpensive material. And when that is always the most unsustainable choice, then it is difficult since you must actively

try to find ways to cover your cost for taking the right choice". Another firm Norwegian firm states: "as a start-up, it is difficult to choose a more expensive solution just because it has a little lower CO2 footprint than something else".

Choosing sustainable components may also lead to additional challenges. Multiple Norwegian companies explain that the more sustainable materials often have other properties than what they are used to working with, adding complexity to the development process. For example, a Norwegian firm explains the increased complexity of using new, more sustainable plastic materials: "you cannot apply all the knowledge that people already have when making new products. It can be in the structural design and also the product development process. Either you don't have the equipment or knowledge on how to make saleable, repeatable production - how you make something from the material".

A significant challenge met by firms in both countries is the lack of suppliers and producers who can deliver and work with more sustainable materials. A German PM describes the challenge: "I think the challenge is always component availability. Because right now, it is very difficult to get the components that you want to have. In many cases, we do not have any choice on which component we integrate to our product, which makes it really hard to be sustainable". Another firm looking for a producer whose values aligned with the firm met significant challenges in an attempt to create a new sustainable product: "it was only affordable from one or two suppliers where we could not validate how sustainable the production was". After searching for producers, the firm had to discontinue the project: "in the end, it looked like the only production methods they [the suppliers] were using are really counteracting with how we are doing it, and then we said (...) we are not going for this project any longer". A Norwegian firm explained that "if you are going to design something which is one of these bio-composites then nobody can make them, few people have experience with them, and also it is super expensive".

4.3.3 Resource constraints and focus on time to market

According to Norwegian firms, one of the main reasons why efforts for sustainability are limited is lacking resources. Furthermore, it is mentioned that the time to market has been a priority for the firms. For example, one firm describes that they did not make any efforts to increase the sustainability of their product because "the goal was to go to market as fast as possible, and not so much sustainability. But I think that in the long term, we will do things more sustainably - when the opportunity is right and when we have more time and resources to do such things. There are probably multiple things we can do to increase our sustainability. But, right now, it is not something we have the resources for". Similarly, another Norwegian firm explains: "until now the main priority has been time to market, meaning to ensure that the product is finished on time. So if we face problems, or do not know the right answer [of sustainability-related decisions], then we have not had the time to do research on it". The PM suggests that a lot can be gained just by setting sustainability as the premise, which will result in more resources and focus on sustainability. A third Norwegian firm explains their lack of

efforts to improve their products' sustainability: "the main reason I believe is lack of resources or prioritising. We have other things that may be more fire fighting, or it is not correct to say firefighting, but other things have to first come in place". Last, a Norwegian PM has ambitions about making considerable efforts to develop their knowledge on sustainability when they have grown to a bigger size: "if we had been a bigger company, I would like to have a dedicated R&D process specifically on sustainable improvements".

A German firm also describes the challenge of lacking resources, "since we are a small team, we do not have too much time to dive into this topic as we have loads of customer projects going on, and, we are still not break even. But when we break even, we can have a better view on this, make better sustainability decisions and invest more time to rethink how we can do things". It is worth mentioning that this challenge was not met by the German firms whose business was founded on the idea of improving sustainability and for those having sustainability as customer demand. For them, some resources had to be allocated towards sustainability improvements, similar to any other important aspects of their businesses.

4.3.4 Customer demand for sustainability

Some firms mentioned that a challenge is the lack of customer demand for sustainability. Many of the firms interviewed state that customer feedback guides their decisions on what projects should be allocated resources. Lacking customer focus may make it hard to justify sustainability efforts. A German firm explains: "often, we have customers and users that are very reluctant to use digital products - they are somehow resistant to innovation. (...) having a very traditional conservative customer base is probably the main hurdle for us". Another German explained that they do not see business value for sustainability: "I would probably say that maybe not all there is not always a directly positive business impact. That is always a challenge to overcome". Another German firm describes the challenge of changing the industry mindset from using an unsustainable but well-recognised alternative to using their new sustainable product. The firm explains its approach to this challenge: "we can do your products in the quality you need but, also, it is more eco-friendly and less animal-harming, and we don't need genetically modified cells and so on (...) but it was always about the price, the quality and all the other factors". A Norwegian firm facing a similar challenge explains: "we experience that our customers are incentivised by economic factors only. Therefore we have to portray things like an economic incentive".

5 Discussion and conclusions

The study aimed to investigate how SMEs in Norwegian and Germany work to integrate sustainability into their NPD process, seen from the viewpoint of the PMs. It describes efforts taken and challenges met from the perspective of the PM. This is done by assessing the research questions:

RQ1: What are the differences and similarities in sustainability efforts between German and

Norwegian SMEs?

RQ2: What are the differences and similarities in sustainability challenges between German and Norwegian SMEs?

In this section, first, the efforts for creating a culture for sustainability are compared, then practical efforts are compared, and finally, challenges are compared. Propositions for further research will be developed throughout the discussion. For an overview of the efforts and challenges mentioned, see appendix A. Lastly, a concluding summary and limitations of the study will be described.

5.1 Cultural efforts

The findings suggest that goals and visions for sustainability are set on a high level in both countries, and no firm seems to make any effort to translate them to measurable targets. This is similar to what is described as the 'fallacy of trickle-down product sustainability', where firms erroneously assume their sustainability vision is enough to spark efforts for a sustainable product and value chain (Brockhaus et al., 2019). However, the Norwegian firms seem to make an extra effort in specifying written values for the product and the firm overall, and the PMs seem to do their best to enforce these values in their day-to-day product decisions. Research suggests that an advantage of SMEs is that they are more value-driven than larger firms (Klewitz and Hansen, 2014), and the Norwegian firms may try to utilise this to their advantage. Furthermore, the findings suggest that Norwegian PMs may be inclined to initiate bottom-up efforts to push the firm in a more sustainable direction. On the one hand, such efforts are in line with the advice of dedicated resources on cultivating the firm's SO (Du et al., 2016), but without management support and explicit strategic targets, the efforts may not be enough to create a mature, sustainable NPD function on its own (Alblas et al., 2014). Others argue that PMs have little exercisable leverage to enhance product sustainability in their routine development tasks (Peters and Buijs, 2022). Still, the findings of this paper lead to the first proposition:

P1: SMEs with clearly communicated values for sustainability are more likely to see more bottom-up initiatives to impact the SO of the firm positively.

P2: SMEs with clearly communicated values for sustainability are more likely to increase their sustainability performance.

To fulfil the goals and visions for sustainability, the firms should look for opportunities to improve their sustainability performance. However, in both countries, many firms make no such efforts. The remaining firms are found to generate these ideas ad hoc manner from day-to-day decisions mainly. This is similar to what is described as the first stage of sustainability, 'operational optimisation'. Here, firms' innovations for sustainability are described as incremental improvements to business as usual. According to this study, transitioning to a

more sustainable business is an information and learning challenges, making new knowledge and knowledge management essential (Adams et al., 2016). However, some firms have made efforts to generate in-house knowledge on sustainability. A Norwegian firm made an effort to give one person in each branch of the firm responsible for sustainability. This person contributes knowledge and suggestions for improvements, thereby supporting the decision-making of the PMs. Such efforts to build sustainability knowledge are in line with recommendations from previous literature (Brockhaus et al., 2019; Alblas et al., 2014). This leads to the proposition:

P3: Appointing employees in SMEs as responsible for sustainability positively impacts the SO of a firm.

Furthermore, a German firm, lacking resources and inexperienced with sustainability, leveraged its competencies with the help of its production partner to identify opportunities for improved sustainability. In the literature, such partnerships can be an important source of knowledge for sustainable inventions to meet the increased complexity of sustainable NPD (Dangelico et al., 2013; Driessen et al., 2013). This leads to the proposition:

P4: SMEs with goals of becoming more sustainable will be more likely to increase their sustainability performance by building their sustainability knowledge with an experienced production partner.

5.2 Practical efforts

This study suggests that the most commonly used tool in both countries is the LCA, but one Norwegian firm uses a certified environmental management system. Only a few companies have made efforts to use the data resulting from the assessment for design purposes. In contrast, most have the ambition to use it as a first step to create a baseline for the product's sustainability performance. These findings agree with previous literature, which describes that LCA is the tool most used in practice. Also, it touches on warnings suggesting that LCAs may end up being used solely for reporting purposes if the other systems are not in place for operational sustainability goals (Alblas et al., 2014; Petersen, 2019).

In both countries, firms make efforts to choose sustainable materials and components. Some firms make an effort to use the data from their LCAs in the design of their products, while others make no such efforts. However, the findings suggest that Norwegian firms are specifically concerned about using plastic materials in their product. All the Norwegian firms mention the reduction of plastics or usage of bio-plastics but none of the German firms. A study found that German producers in the consumer goods industry rushed to conclusions regarding the sustainability impact of bio-plastics and doubted its benefits based on feelings (Brockhaus et al., 2016). In contrast, Norwegian PMs are seemingly positive about the sustainability effects of bio-plastic. Therefore, a proposition of this paper is:

P5: Norwegian firms who seek to improve their sustainability performance are more likely than German firms to experiment with bio-plastics in their design.

When selecting suppliers and production partners, firms in both countries try to find partners with aligned values. Furthermore, firms in both countries worked to optimise transport routes for environmental sustainability. However, the German firms seem to make efforts to create partnerships where the firms work together to increase the sustainability of the product and value chain. Meanwhile, Norwegian firms appear to focus on collaborations but rather work to ensure both the social and environmental sustainability of their value chains. All of these efforts are seen in mature NPD functions (Alblas et al., 2014) and the second step of sustainable development, where sustainability is on its way to being integrated into the firm (Adams et al., 2016).

In both countries, multiple firms tried to improve how the product was transported. And interestingly, a similar effort was found in the learning process of designing a more sustainable product packaging in both firms, moving from being inspired by high-end consumer product packaging into more minimalist and functional designing after gaining experience. An additional difference between the countries is that Norwegian firms seem to put in extra effort in the later stages of a product's lifetime. The Norwegian firms worked actively to extend the product's lifetime but also had systematic reviews on the product to ensure that it would be possible to repair and recycle. The German firms described no such efforts.

5.3 Challenges

In both countries, firms encounter challenges translating goals for sustainability to quantifiable targets. This agrees with findings from earlier research discussed in section 2.5.1. Concerning tools such as LCA, challenges were met when setting up the tools, retrieving data from the value chain, and using the data in the new product development. This is in line with categorisations of 'immature NPD firms', which are described as lacking the knowledge and data required to conduct an LCA and adequately interpret the results (Alblas et al., 2014). Seemingly, LCAs are seen as a tempting tool for NPDs to use to improve their sustainability, but they underestimate the effort needed. This leads to a proposition:

P6: SMEs inexperienced with sustainability are likely to underestimate the complexity of conducting an LCA.

In both countries, firms describe the challenges of lacking suppliers for sustainable components and materials. Furthermore, Norwegian PMs describe the challenges of higher costs and the complexity of working with new, more sustainable materials. Norwegian firms also mention that time-to-market is to be prioritised. This can be seen in connection to earlier research suggesting that if clear strategies, scopes and targets are lacking, traditional design criteria are likely to gain higher priority than sustainability (Alblas et al., 2014; Peters and Buijs, 2022; Claudy et al., 2016). Another challenge for Norwegian firms is lacking the resources needed to build competencies for sustainability. However, this can be seen as a general challenge of being an SME (Klewitz and Hansen, 2014).

Meanwhile, the German firms seem to see the lack of customer demand for sustainability as a challenge to such solutions. On the other hand, earlier research suggests that if a firm's

sustainability strategy is not aligned with the NPD goals of the firm (e.g. return on investment), the firm may be forced to make trade-offs between economic, ecological and societal objectives (Claudy et al., 2016). Furthermore, given that setting the targets for sustainability is both challenging and important for improving product sustainability (Alblas et al., 2014; Brockhaus et al., 2019; Peters and Buijs, 2022), it seems that the challenge commonly met in both countries is lacking knowledge on sustainability. Accordingly, this may set the firms off to a bad start in their efforts to improve sustainability, which impact more efforts down the line. Therefore, the last proposition is:

P7: Some threshold level of sustainability knowledge will significantly increase the probability of sustainable NPD success.

5.4 Concluding summary

The findings suggest that the efforts to create a culture of sustainability in Norway and Germany are quite similar. Most firms in both countries seemingly set goals and visions for sustainable performance for the firms but rarely make an effort to translate them to measurable targets. Meanwhile, Norwegian firms seem more inclined to actively use visions to make sustainability a part of their culture. When generating ideas, the firms' approaches seem unstructured and mainly rely on chance to spot improvement opportunities.

Also, regarding practical efforts, only minor differences are found between the firms. Firms in both countries made efforts to conduct LCAs to improve their products' sustainability performance. Meanwhile, it seems that Norwegian firms make efforts which include more phases of the product life cycle than German firms and are more inclined to work on reducing plastic usage. Also, Norwegian firms seemingly have a slightly larger focus on social sustainability in their value chains. The phases are broader regarding the product's life phases, with a slightly larger emphasis on social sustainability. On the other hand, German firms seem more inclined to work to optimise the transport of their products.

This study suggests that the underlying challenges in both countries are lacking resources, lacking knowledge, lacking targets for sustainability, and misalignment between sustainability strategy and NPD goals. When initiating an effort to become more sustainable, the firms seem not to know where to start. Therefore, and end up with ad hoc solutions only partly grounded in data and with small or large misalignment with the firm's overall strategy.

5.5 Limitations and suggestions for further research

A range of factors limits this study. First, the study is qualitative and therefore, generic limitations of flexible designs also apply to this study (Robson and McCartan, 2011). Triangulation was used in an effort to counter these issues (Mathison, 1988; Robson and McCartan, 2011). However, for the case of this study, limited resources and time will affect the amount of triangulation that is practical. For example, this study used only one method and could have benefited from several qualitative methods like observation and document analysis to gain a

broader perspective (Patton, 1999). Furthermore, no effort was made to assess whether the efforts described by the firms had any impact on sustainability or their method of implementing the effort. Therefore, future studies could also combine interviews with observations and integrate some form of sustainability performance assessment.

Constraints in time and resources also resulted in a sample size that was relatively small for each country, and the sample of firms was not one-to-one between the countries in firm sizes, industries, or the position of the informant in the firm (see table 1). Also, due to the low response rate, especially in Germany, the firms willing to participate in the study may have been particularly interested in sustainability. All of this may have resulted in some bias in the data. Future studies should work to create a sample where the firm characteristics are more similar to each other.

The lacking experience of the author in the field and the methods used may lead to not being able to set the findings in a proper context. Also, even though some investigator triangulation was performed in the analysis phase, having one more researcher to observe the interview and go through all data could have enhanced the reliability of the data obtained (Robson and McCartan, 2011). Therefore, future studies are suggested to include multiple researchers.

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Appendices

A Summary of findings

Category	Effort	Germany	Norway
Cultural sustainability efforts	Goals and Vision for Sustainability at the Firm Level	Two firms had no vision of improving sustainability (except for economic), and three firms had a vision of improving environmental sustainability.	Three firms had goals and visions for improving environmental sustainability, and the remaining firms focused on time to market. Four firms had worked to integrate sustainability into their company values.
	Goals and Vision for Sustainability at the Product team Level	Same as firm level.	Two of the PMs made an extra effort to push the firm towards increased sustainability.
	Searching for Ideas for Sustainability	Two PMs do not look for sustainability improvements, one PM depends on knowledge from its producers, and two PMs actively search for ways to improve sustainability.	Three PMs do not look for sustainability improvements. Three PMs mainly make small ad hoc sustainability improvements, but one of these firms also facilitates sustainability reviews of the products.
Practical sustainability efforts	Sustainability Assessments	Three firms have conducted detailed LCAs. Of these, one of them uses it in their design processes, and two will use it for benchmarking. The remaining firms have not performed assessments.	One firm is ISO 14001 certified. One firm has integrated LCAs into the firm's routines and the NPD process. Three firms have not made any substantial efforts.
	Choice of Materials and Components	One firm is based on the usage of new sustainable materials, two firms make an effort to use the most sustainable choice in a product decision.	Three firms have evaluated and started using bioplastics. One firm works systematically to choose the most sustainable alternative and ensure that the component count is minimal. One firm work to ensure that materials are not harmful to animals.
	Choice of Producers and Suppliers	One firm work to source all components from Europe, and two firms focus on finding suppliers with ambitious goals for sustainability. One of these firms looked for a production partner with knowledge of sustainable production to enhance their process.	One firm does its assembly in Norway at a sheltered workshop, one firm uses strict audits to ensure the social sustainability of its suppliers. One firm sources most of its components within Europe and works to optimise assembly location to reduce its overall footprint.
	Transport and Packaging	Three firms work to optimize the transport route. Of these, one firm also tries to improve how the product is transported, and one firm works to improve the product packaging.	In Norway, one firm works to optimize the transport route, while two firms try to create more sustainable packaging.
	Product Use Phase	All but one firm describe a sustainable outcome from their product.	All but one firm describe a sustainable outcome from their product. Two firms work to increase the lifetime of the product. One firm makes an effort to educate its customers on behaving more sustainably.
	Product end phase	None mentioned.	Three firms work to make their products easier to repair and recycle.
Challenges	Lacking tools and data for making the best decisions	One country has trouble retrieving data from suppliers, one firm has problems using the data found in the LCA for design, and one firm has problems measuring the sustainability impact of their product.	One firm has problems which metrics to be used, one lacks tools, data and competencies to make good solutions for sustainability, one firm has trouble retrieving data from producers
	Increased complexity and costs for the more sustainable choice	Three firms face problems related to lacking availability of sustainable components.	Four firms describe challenges related to the high complexity of working with sustainable materials. Of these, three specifically mention bio-plastic. Two firms describe a high cost of the sustainable alternative, and three firms describe lacking suppliers for sustainable components.
	Resource constraints and focus on time to market	One team describe that they are limited by size, time, and resources.	Four firms describe that they are limited b resources, and two firms say they prioritize time fo market.
	Customer demand for sustainability	Three firms state that customers are not interested in sustainability	One firms states that customers are not interested in sustainability.

B Interview Protocol

Section	1st order questions	2nd order questions
Introduction	<p>What is your responsibility in the company?</p> <p>Who do you report to?</p> <p>What is sustainability for you personally?</p>	
Firm level sustainability	<p>What is your company's view on sustainability?</p> <p>How is sustainability enforced operationally?</p>	<p>How important is sustainability for your company? How does the firm communicate its view on sustainability to its employees?</p> <p>What are the firm's routines for managing and measuring sustainability?</p>
Sustainable NPD	<p>How do you as a product team contribute to sustainability in new products?</p> <p>Take me through the process of developing a new product/feature from idea to market?</p>	<p>To which degree do you as the product team meet the sustainability goals of the firm? Do you discuss sustainability issues related to products or features within the product team? What was your last discussion about? How are sustainability initiatives from the product team received by the management of the firm? Have you ever initiated a sustainability initiative that goes beyond the ambition level of the firm? What happened? Why not? Where do ideas for products/features usually come from? How do you decide whether an idea is worth following? How do you determine whether an idea should be abandoned? Which other stakeholders are involved within the firm when deciding to execute an idea? How is the idea 'sold in' to the other stakeholders of the firm?</p>

<p>Please tell me about the last time you worked with an idea aiming to improve a product's sustainability performance.</p> <p>What was the last challenge you met when attempting to make a product or feature more sustainable?</p>	<p>Do you ever specifically look for sustainable opportunities in the product development process? How do you look for such ideas? What is the difference between assessing an idea aiming to improve sustainability and ideas without such goals?</p> <p>What are typical challenges when working with sustainable products and features? Why is sustainability not a bigger part of the NPD Process? What are the attempts to address these challenges?</p>
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