Nordic Council of Ministers

Use of ecodesign tools and expectations for Product Environmental Footprint

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Foreword

In order to make contemporary society more ecologically sustainable, much emphasis is placed on the production of goods. Design is a crucial dimension of proactive planning with the aim of improving existing systems and transforming them into or creating completely new ones. Design is considered to be the most crucial step when improving the environmental performance of a product. Multiple approaches have been developed to help designers make more environmentally sustainable choices – including ecodesign and green innovations.

How many companies use different eco-design tools in the Nordic countries? How much do they already know about the new methodology developed by the EU, i.e. Product Environmental Footprint (PEF), and how do they see it? These were identified as important research questions in the project "Nordic Swan, Circular Economy and Product Environmental Footprint" (2016–2019) funded by the Nordic Council of Ministers (NCM) as one of the projects of Finland's Presidency of the EU in 2016.[1]

We decided to focus on the textile and IT sectors, as both have Swan ecolabel criteria and PEF category rules, and both sectors are the subject of ongoing discussion about ecologically sustainable products and evidently much interest in and activities related to ecodesign. In preparing the questionnaire used in this research, and in identifying companies in the sectors, we received significant help from many stakeholders, especially from the industrial associations in the Nordic countries.

This report is based on the material used by Hanna Salo for her master's thesis "Implementing green innovations and ecodesign in companies: Differences among the Nordic textile and IT sectors" (Salo, 2019).[2] For details about the methodology and many results dealing with the ecodesign tools, the reader is advised to see her thesis. However, results about PEF are dealt with only in this report.

We are grateful for the funding from Nordic Council of Ministers and the help from many stakeholders, and the companies that responded to the research. These efforts made this interesting insight into the implementation of ecodesign in many Nordic countries possible.

Helsinki, July 2019
The authors

[1] https://www.syke.fi/projects/scepef
[2] http://urn.fi/URN:NBN:fi-fe2019052817566

Executive Summary

The report examines how ecodesign and green innovations are implemented in textile and IT companies that manufacture and/or design products in the Nordic countries. The textile sector is here defined as textiles and wearing apparel. The IT sector includes electronic components, computers, communication equipment and consumer electronics. The IT sector was limited in this report to the manufacturing of hardware, excluding games and software, programming and repair of IT equipment.

The report looks at how and why ecodesign and green innovations are promoted by companies, what barriers they have faced, what tools they use to support their work and how they perceive the Product Environmental Footprint (PEF). It applies this framework in the context of the Nordic countries, which are perceived as forerunners in environmental matters.

Green innovations are defined as an approach to developing and implementing product, process, marketing, organisational or institutional innovations that reduce environmental impact in relation to a stated common reference. Ecodesign is a collaborative, proactive and systematic design and management process that integrates environmental issues into product development processes.

The data used in the report was collected using a structured questionnaire to gather a broad overview of the situation. The questionnaire was conducted in Webropol and sent by the national industrial associations and the researcher to the target population (N=104).

The findings of this report can be summarised into five propositions: 1) The respondents are fairly mature in terms of how they integrated environmental sustainability into their operations. The main stimulus for environmental proactivity is general willingness, whereas many companies are deterred by cost increases. 2) Companies remain focused on technical product and process innovations, and functional innovations in particular are lagging behind. 3) Ecodesign tools and research and development activities are highly relevant for promoting all types of innovations. 4) The main tools used are Type I Ecolabels, Life Cycle Assessment and Carbon Footprint. 5) Few respondents are familiar with PEF, but many are interested in it. PEF is predominantly seen as a way to evaluate the accuracy of environmental claims about products.

1. Introduction

Design is a crucial step in improving existing product systems and transforming them into or creating completely new ones with reduced environmental impacts (Arundel and Kemp 2009; Carrillo-Hermasilla *et al.,* 2010; Pigosso *et al.*, 2013). Green innovations and ecodesign are two approaches that help designers to consider the environment during the design process. Innovations and ecodesign share similar goals of improving, changing and creating products and processes. In addition, organisational, marketing and institutional characteristics related to the companies are relevant. The European Union set out the first Ecodesign Directive for energy-using products in 2005 and energy-related products in 2009, to guide national efforts towards sustainable production and consumption (Directive 2005/32/EC; Directive 2009/125/EC). The directive steers environmental performance by setting requirements on their energy-efficiency.

Many companies have recognised the value of environment-related product responsibility as a vital contributor to sustainable long-term success (Byggeth and Hochschorner 2006; Pigosso *et al.,* 2013). They are driven by both internal and external stimuli, such as general willingness, costs and legislation (van Hamel and Cramer 2002; Arundel and Kemp 2009). On the other hand, barriers discourage companies from introducing or implementing green innovation and ecodesign tools into their practices. The barriers are mostly similar to the stimuli but act in the opposite direction, such as uncertainty of environmental benefits, lack of legislation and proper alternatives.

Different levels of maturity have been identified in terms of integrating sustainability into business activities (Boks and Stevels 2007; Gouvinhas et al. 2016). On the lowest level of compliance, companies are immature and do not know how to cope with environmental issues. They are often pressured externally by different stakeholders and regulations. Following that initial phase, environmental issues can develop to a level in which several departments are involved and have basic information on environmental issues. They start to act more proactively and perceive it as a market opportunity. Lastly, a long-term vision is applied and information is spread throughout the company. They affect their value chains as well by requiring environmentally sound materials and components, but also customers by educating them and creating new kinds of conscious customer behaviour and demand. Thus, they start a "domino effect". At this stage, companies are ready to use specific tools customised for their operations.

Ecodesign tools aim to facilitate the integration of environmental aspects into the product development processes in a prescriptive, problem-solving way (Baumann *et al.,* 2002; Byggeth and Hochschorner, 2006). They can be used to highlight potential environmental problems and enable a choice between different environmental aspects. Environmental assessment tools provide a systematic vision at a specific level of product development or life cycle with a typically quantitative measures, including Life Cycle Assessment (LCA), simplified-LCA, ecolabels, matrices and footprints (Bovea and

Pérez-Belis, 2012). On the other hand, environmental improvement tools offer quick and simple information in the early stages of the product design process, when there is less data about a product. These include guidelines and manuals.

A wide variety of tools exist, which is why the European Commission proposed the use of a Product Environmental Footprint (PEF) to harmonise the various environmental impact assessment methods (Product Environmental Footprint (PEF) Guide, 2012). The PEF was developed to create a common, easy-to-use life cycle-based method to measure the environmental performance of products in order to establish a single market for green products in Europe. The PEF calculates the environmental performance of a product throughout the value chain in 16 impact categories including climate change, toxicity and resource depletion. The method was tested during a pilot phase between 2013 and 2018. It includes 17 product groups, which have tailored product group-specific rules, called Product Environmental Footprint Category Rules (PEFCRs), to guide the measurement. Thus, the PEF aims to increase the completeness, accuracy and transparency of environmental claims and to strive for comparability between products within the same product group. As a harmonised method, the PEF is expected to ease the adoption and implementation of LCA and to overcome some barriers related to the implementation of ecodesign tools (Rossi *et al.,* 2016).

The aim of this work was to analyse how and why ecodesign and green innovations are promoted by companies, what barriers they have faced, what tools they use to support their work, and how they perceive PEF. Textile and IT sectors were selected because both have Swan ecolabel criteria and PEF category rules, and both sectors are the subject of an ongoing discussion about ecologically sustainable products and evidently significant interest and activities for ecodesign. The textile sector is here defined to include NACE codes 13 and 14, namely the manufacture of textiles and the manufacture of wearing apparel (NACE Rev. 2 – Statistical Classification of Economic Activities, 2019). The IT sector here is covered by NACE codes 26.1–26.4. These codes include the manufacture of electronic components, computers, communication equipment and consumer electronics. The IT sector was limited in this report to the manufacture of hardware, which excluded games and software, programming and repair of IT equipment. In this report, the main results are presented. Before writing this report, the research material was used by Hanna Salo for her master's thesis "Implementing green innovations and ecodesign in companies: Differences among the Nordic textile and IT sectors" (Salo, 2019). It presents many details about the methodology and results dealing with the ecodesign tools. However, results concerning PEF are dealt only in this report.

2. Materials and Methods

The report is based on a structured Webropol questionnaire sent to Nordic textile and IT companies directly and by national industrial associations. The response rate was 11.3%. The results were analysed statistically with cross-tabulations, Pearson's chi-squared tests, Mann-Whitney U-test and Kruskal-Wallis test. See Salo (2019) for details about the methodology.

The material consisted of a structured web questionnaire targeted at textile and IT companies that manufacture and/or design their products in the Nordic countries. A quantitative web questionnaire with multiple choice, numeric and open-ended questions was used to gather a general picture of the current situation of green innovations and ecodesign in the Nordic countries. The method was preferred to a less structured questionnaire because of the size of the target group and to ensure reliability and comparability between language versions (Santolaria *et al.*, 2011).

The questionnaire items were formulated based on past literature on ecodesign and innovations (Chen *et al.*, 2006; Dekoninck *et al.*,2016; Calik and Burdedeen, 2016; "Promoting better environmental performance of SMEs. Georgia", 2016). The questionnaire was complemented with knowledge gained from the PEFCRs of IT equipment and t-shirts in order to find out whether the companies had already taken the issues highlighted in the PEF into consideration (PEFCR 2016; PEFCR 2017). These issues included the energy-efficiency of a product, saving raw materials and using less packaging material, among other things.

The questionnaire was sent out to a total of 902 Nordic textile and IT companies via email and was conducted anonymously via Webropol in June–August 2018. The companies were given eight weeks to submit their responses. Two delivery methods were used to spread the questionnaire: 1) National industrial associations sent the questionnaire to 572 companies in total, and 2) the researcher sent the questionnaire directly to 330 companies. By the deadline, 104 questionnaires had been returned, representing a response rate of 11.3%. The textile sector had a higher response rate (16.9%) than the IT sector (6.6%). The two deliveries were used because the industrial associations were not allowed to give out the contact information of their members and thus it was important to guarantee that the sample would be extensive and as many of the significant companies in both sectors in each Nordic country as possible would have been contacted. The national industrial associations were the Finnish Tekstiili and Muoti, Finnish Teknologiateollisuus, Swedish Textil- and Modeföretag, Swedish IT and Telekomföretagen and Branchkansliet, Norwegian Norsk Industri, Norwegian Virke, Danish Dansk Industri and Dansk Mode and Textil, and Icelandic Samtök iðnaðarins. The companies that were contacted directly were identified from public lists provided by EuroPages, a European platform for manufacturing companies, and national registers. These companies were sent a separate link to the questionnaire in order to calculate response rates for both distribution types.

The statistical analysis was done using the SPSS 23.0 program (IBM Statistical Package for the Social Sciences) to compare the frequencies, percentages, location variables, correlations and significance levels, among other statistical characteristics. Most of the questions in the questionnaire were nominal, so the analysis was conducted mainly with cross-tabulation. Cross-tabulation explores the relationships between categorical variables by arranging them into a table and indicating the combination of variables together with frequencies and row percentages (Heikkilä, 2014). Alongside the cross-tabulations, Pearson's chi-squared test was used to test for statistical significance. This tests whether there is a statistically significant difference between the expected counts and the observed counts in one or more categories. The few ordinal-scaled variables, meaning the claims on ecodesign and green innovation principles, were analysed with nonparametric tests: Mann-Whitney's U Test and Kruskal-Wallis.

Materials and methods are explained in more detail in Salo (2019).

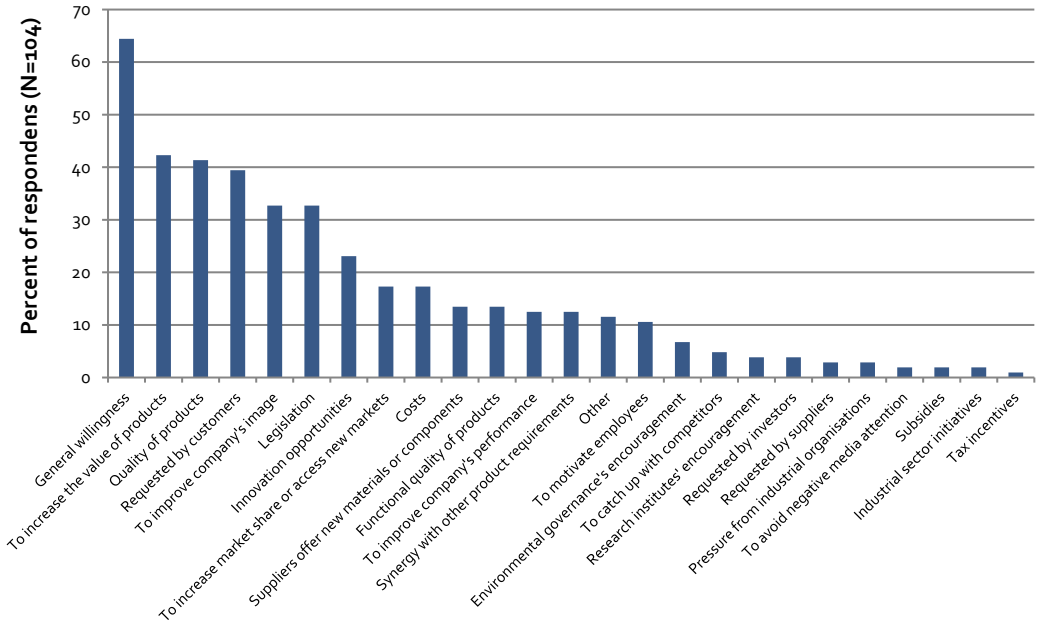
3. Results and Discussion

The Nordic textile and IT companies promote ecodesign and green innovations mainly because of internal determinants, such as general willingness. However, they are constrained by barriers including cost increases. Companies focus mainly on technical changes in products, while functional innovations, like offering services, are lagging. Ecodesign tools and R&D activities are remarkable for promoting different types of green innovations and ecodesign principles. Danish companies use tools more often. The majority of the respondents have not heard of the Product Environmental Footprint (PEF), but are eager to find out more. Those familiar with it feel that PEF would complement the ecodesign tools that they already use. PEF is most often seen as an evaluator of environmental claims for products, which is supported by Danish companies and textile companies in particular.

3.1 Stimuli for acting greener

The reasons why the respondent companies were working towards a lesser environmental impact in terms of their operations showcased the importance of internal stimuli. Overall, internal stimuli were considered to be much more important or at least were chosen more frequently and mentioned more than external ones. Four of the six most popular stimuli in the questionnaire are considered internal (i.e. willingness, value and quality of products, and the company's image) (Figure 1). Legislation and customer demand are exceptions to this phenomenon, but they have previously been considered to be of high importance by Belmane *et al.,* (2003: 7) and Horbach *et al.,* (2012). General willingness stood out in particular – 64% of questionnaire respondents chose it as one of their main stimuli. They further described reasons in the open-ended answer option by stating "Personal values of the entrepreneur", and "It's the right thing to do". These statements indicated that the companies were strongly driven by internal willingness to act in a way that they felt was morally right. Meanwhile, all the least important stimuli, with a share of less than 3% (e.g. sectoral initiatives, subsidies and request from suppliers) were considered external. This result is in line with the previous studies of van Hemel and Cramer (2002) and Santolaria *et al.* (2011), among others. It could thus be assumed that the majority of the respondents have reached a level of maturity at which they are motivated by internal stimuli and are "beyond compliance", as suggested by Willard (2005).

Figure 1: Stimuli for ecodesign and green innovation activities based on the questionnaire responses showcase the importance of internal stimuli and especially general willingness



There were few statistically significant differences between the textile and IT sectors (Table 1 in Appendix II). Legislation and cost reductions were found to be more important stimuli among IT companies, whereas the value of products was more important for textile companies. Interestingly, legislation was chosen by IT companies even more often (66%) than general willingness (63%). Cost reductions were also more frequently chosen by IT companies. Cost reductions are considered to be mainly related to manufacturing processes and material choices (van Hemel and Cramer, 2002; Dekoninck *et al.*, 2016), whereas product value is linked to the end product. Thus, it could be concluded that IT companies are more concerned about satisfying the legislative requirements and improving their processes to save money, i.e. doing more with less, whereas textile companies see ecodesign and green innovations more as means to improve the product and its perceived value. In addition, it should be noted that the choice of suppliers offering new materials as a stimuli was significantly more common for textile companies, as none of the IT respondents chose it. Based on these observations, it seems that product value and new available materials are very important for textile companies, but not for IT companies. IT in turn was mostly driven by legislation, which again is seen as a "stick" to motivate industries to take the environmental field seriously (Bey *et al.*, 2013).

Differences among the Nordic countries indicated that Sweden was an exception in relation to many stimuli (Table 2 in Appendix II). Notably, Swedish companies were driven by external stimuli more than other respondents. General willingness was the

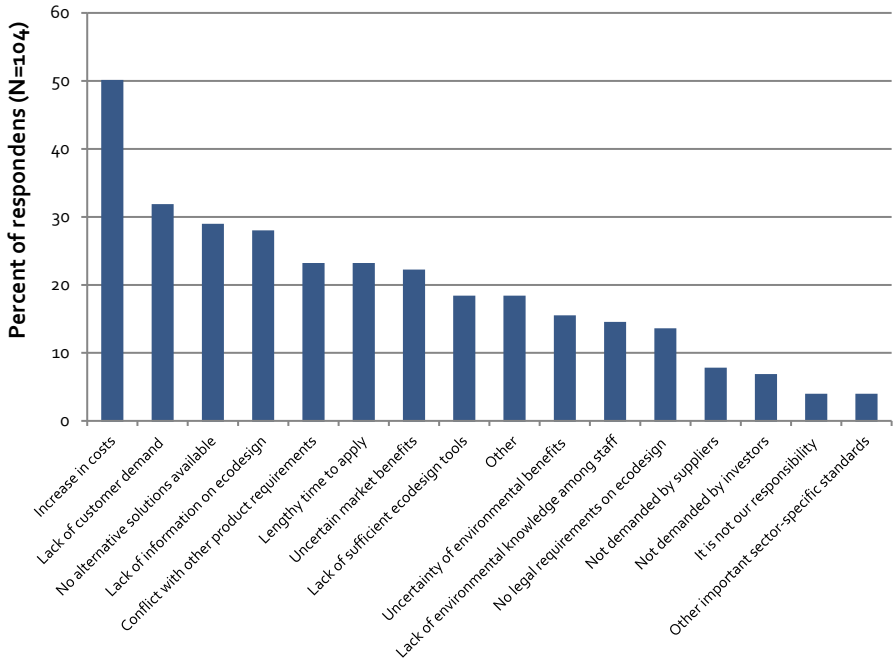
most popular response option (49%), but it was less evident and clear than in the case of Denmark, Finland and Norway, all with more than two-thirds choosing that option. At the same time, they mentioned legislation as the second main stimulus for ecodesign, together with customer demand. On the contrary, product value and innovation opportunities were chosen by Swedish respondents less often. Product value was also less frequently chosen by Swedish companies, but more among Finnish companies. This together with the cost reduction shares indicates that Swedish companies are less concerned about money than Finnish companies. Furthermore, innovation opportunities were important for Norwegian and Icelandic companies. Another observation from the statistics is that Danish companies less often perceived improvement of company image as a stimulus.

Differences between stimuli according to other background variables and related to each other have been presented in Salo (2019).

3.2 Barriers standing in the way of ecodesign

Half of the questionnaire respondents were concerned that ecodesign would increase their costs (Figure 2). This observation correspond with the results of Belmane *et al.* (2003: 7), Bey *et al.* (2013) and Dekoninck *et al.* (2016) because an increase of costs can negatively affect the firm's performance or drive away customers due to higher prices. After the increase of costs, the other barrier options were quite evenly distributed among the questionnaire respondents. This distribution indicates that the respondents may perceive fewer barriers than stimuli or that the barriers could be stronger than stimuli and therefore they chose fewer options in this question.

Figure 2: Barriers to promoting ecodesign. The main barriers are costs, lack of customer demand, alternative solutions and lack of knowledge, based on the questionnaire



The "other" answer option in the questionnaire was chosen by 19 respondents who articulated that, for example, they were "not supported educationally", they faced a "lack of applicable, truly ecological raw materials" and that "customers lack knowledge and understanding". One group of three respondents said that there was a "lack of technical data to evaluate different options objectively", it is "hard to find information about how ecological mohair is" and "research into recycled nylon is lacking". They had in common the barrier of not having enough information, but also that there was no information available. These examples highlight a growing need for research in this field to provide reliable information on how to do things in a more sustainable way.

There were only minor differences between the sectors in relation to barriers (Table 3 in Appendix II). The only statistically significant difference was that textile companies were more concerned about increase in costs (57%) than IT companies (28%). This observation is the opposite to the case of cost reductions as a stimulus, as IT companies were statistically more often driven by cost reductions. Hence, it seems that IT companies try to lower their expenses while textile companies try to minimise their increase.

Sweden differed from the Nordic countries the most, as Swedish companies were statistically different from the rest in terms of three barrier options (Table 4 in Appendix II). Based on the analysis, Swedish companies lacked customer demand more, but did have alternative solutions available and saw the market benefits of ecodesign. Danish companies had problems with customer demand. On the contrary, Finland was the opposite in both customer demand and market benefit, as Finnish

companies were less likely to face lack of customer demand, but were uncertain of the market benefits.

Differences between stimuli according to other background variables and related to each other have been presented in Salo (2019).

3.3 Innovative targets and mechanisms

Product-related innovations made by companies were considered to focus on material choices. These included selecting materials whose production creates less emissions, producing products with fewer materials, or using recycled materials. According to Roos *et al.* (2015), the majority of the environmental impacts of textile sectors are derived from materials, hence the respondents had been focusing on the appropriate issues. Another highly supported viewpoint of ecodesign was the reliability and durability of products, with more than 70% of the questionnaire respondents strongly agreeing with it. Few differences between the respondents were observed. Textile companies in particular stated that they have been selecting materials whose production pollutes less. In terms of other background variables, notably only a third of Finnish respondents had undertaken product redesign changes in comparison to more than 50% of other respondents. Icelandic companies were found to be more active in improving their products incrementally. A majority of the respondents disagreed strongly with the claim about renting products, although IT companies disagreed less often. All in all, the study showed that among the respondents, functional innovations including offering of services, renting, repairing, guiding and taking back a product once it has reached the end of its life cycle were rare. Based on the literature, the lack of functional innovations can be attributable to the scarcity of interplay between many sectors within a company and its stakeholders and the absence of long-term strategies (Tukker *et al.*, 2001, 2006).

All the process-related innovations were, in general, evaluated either positively or neutrally by the questionnaire respondents. These included the reduction of raw materials, waste, hazardous substances and energy consumption. The reduction of hazardous substances in the manufacturing process was the most strongly agreed-with claim. In line with the findings of Belmane *et al.* (2003), it can be concluded that replacing hazardous substances has been popular in both Baltic and Nordic countries for almost two decades.

Marketing innovations concerning packages, prices and informing customers and suppliers were agreed on a general level by the respondents. The questionnaire claim on reducing the amount of packaging materials was somewhat agreed with by one third of the respondents, and no background variable was associated with it. Based on the results of Belmane *et al.* (2003), packaging materials were expected to be more agreed with than they ended up being. The affordability of products was found to be more disagreed with in Finnish and Norwegian companies compared to Swedish ones. According to Gouvinhas *et al.* (2016), more environmentally mature companies educate their customers and suppliers towards a socially and environmentally conscious value

chain. Those companies also integrate the demands into their own marketing. Marketing innovation claims related to providing information to customers and suppliers were more often agreed with by textile companies, companies headquartered in Denmark, and those with research and development (R&D) activities related to environmental matters.

Meeting the criteria of an ecolabel is also a marketing method for which a company must improve or redesign its products and processes (Kjeldsen, 2014; Calik and Badurdeen, 2016). An ecolabel attached to a product endorses its environmental friendliness and superiority in the case of the EU Ecolabel and the Nordic Swan, for example. They also count as innovation outputs according to Calik and Badurdeen (2016). However, only four out of 65 respondents to the voluntary question had Nordic Swan ecolabelled products and nine had EU ecolabelled products. Eighteen companies had made their own environmental product declaration. Textile companies usually had Öko-Tex 100 and Global Organic Cotton Standardised products, whereas the IT companies had EU Energy Labelled products.

Organisational innovations, namely Environmental Management System (EMS) and R&D activities, were found to be significantly related to many ecodesign and green innovation principles. Almost half of the respondents used an environmental management system (45%), but the shares between the sectors were clearly divided, as 69% of the IT companies used an EMS while 39% of the textile companies did. The users were, in addition, mostly larger companies. Wagner (2007) stated that the implementation of EMS is associated with the probability of pursuing green innovations, and according to Barbieri *et al.* (2016), EMS stimulates green innovations that alter production processes rather than products. However, in this study, no statistically significant relationships were noted between the use of an EMS and process innovations or product innovations. In fact, EMS users disagreed more often with product-related claims. A little less than 40% of the questionnaire respondents had activities for R&D specifically related to environmental matters. There were no statistically significant differences in relation to background variables. Companies that had environmentally-related R&D activities more often agreed on all innovation types. This applied especially to the processing of waste coming from their manufacturing processes, usage of renewable energy, informing of the environmental performance of products and how to prolong the life cycle of their products, as well promoting discussion and challenging the status quo surrounding existing products, materials or processes. Based on these results, it could be stated that R&D activities related to environmental matters are extremely important for all types of green innovations, although they have previously been acknowledged as being important only in relation to technological innovations (e.g. Oslo Manual, 2005; Arundel and Kemp, 2009).

The final type of green innovation concerned *institutional innovations*. They were measured by asking how the respondents saw environmental legislation and how they evaluated their participation in public discussions (Carrillo-Hermosilla *et al.*, 2010; Promoting better environmental performance of SMEs, Georgia, 2016). Almost half (46%) of the respondents aimed to exceed the legislative requirements on environmental matters. This observation reflects that the respondents were fairly

environmentally oriented to begin with and had passed the preliminary, immature levels of sustainability integration (Hallstedt *et al.,* 2010; Gouvinhas *et al.,* 2016). The second biggest respondent group represented those who complied with the requirements but did not aim to exceed them (36%), which reflects a compliance level of maturity. More than a third of the respondents strongly agreed with the claim on participation in public discussions to challenge the status quo. Companies acting this way are perceived to be mature in the environmental sense, as they educated their value chain on both the supplier and customer sides and thus were creating new behaviour. Furthermore, renewed cooperation with stakeholders in several R&D projects or in public-private collaboration can be seen as institutional innovations. In addition, R&D activities are themselves an institutional innovation if they change the way companies cooperate with each other and the public to promote changes in norms and values (Carrillo-Hermosilla *et al.,* 2010).

In moving towards a closed-loop system such as the circular economy, performing eco-efficient actions is crucial (Carrillo-Hermosilla *et al.,* 2010). Hence, sub-system and system innovations are perceived to be of high importance and they were the most inclusively described innovation mechanism in the questionnaire. Respondents, however, saw different sub-systemic changes in very different ways. The evaluations of claims differed from those who agreed strongly (63% of the respondents (claim on reliable and durable products)) to many claims that were neither agreed nor disagreed with, by one third of all respondents. However, the only statistically significant difference in terms of background variables was that the Finnish companies were found to do less product-related redesign. System innovations related to the creation of new products and processes had relatively high rates among other type of innovations with the same targets.

The Nordic countries showed up to be quite similar in terms of how their IT and textile companies executed ecodesign and green innovations. Finnish companies had less often redesigned their products, whereas Icelandic companies focused relatively more on incremental improvement of the product. Danish companies, on the other hand, paid more attention to marketing innovations that aim to change the value chains towards sustainability.

3.4 Use of ecodesign tools

Ecodesign tools were used by 27% of the questionnaire respondents (N=104). The majority were interested in using a tool but had not taken any action (54%). Companies headquartered in Sweden or Denmark were much more likely to use tools than Finnish companies, which opposed tools relatively more often. Tool users were most often Danish companies, as 53% of Danish respondents used an ecodesign tool, followed by Swedish (35%), Finnish and Norwegian companies (14%). Those who were not interested in using ecodesign tools were most often Finnish (26%) or Norwegian (29%).

The most common tools were Type I Ecolabels, Life Cycle Assessment (LCA) and Carbon Footprint. Type I ecolabels, such as the Nordic Swan Ecolabel or the EU Ecolabel,

were used by 48% of textile respondents and 20% of IT companies. However, Finnish companies had a Type I Ecolabel less often. LCA, on the other hand, was more often used by Danish companies and mostly by IT (58% of IT respondents) rather than textile companies (14% of textile respondents). Carbon footprint was again used quite evenly in relation to the background variables. The benefits of the tools included suitability for communication and being detailed and extensive. Thus, it seems that companies look for tools that offer a vast amount of quite specific information that can be used for communication purposes, which has also been noted by Le Pochat *et al.* (2007), Bey *et al.* (2013) and Dekoninck *et al.* (2016). However, all tools were associated with disadvantages that were mainly related to the requirement of a lot of data (36%) and environmental expertise (32%). The respondents somewhat felt that ecodesign tools have high implementation and certification costs (43%), and take a long time to apply (29%).

Implementing an ecodesign tool is positively associated with several types of innovations. This observation is in line with the study of Boks and Stevels (2007), who state that practices and needs for tools relate to the maturity level of environmental awareness within companies. Positive relationships between the use of ecodesign tools and innovations were found in this study, especially in relation to process and marketing innovations, supporting the results of Horbach (2008). The respondents who used ecodesign tools agreed more often with claims concerning reduced polluting emissions; the use of materials that are easy to recycle; and informing customers and suppliers about the environmental performance of products. The last thing mentioned was agreed significantly more by companies who had a Type I Ecolabel. In addition, they were more active in reducing their use of water, electricity, coal or oil coal.

3.5 Product Environmental Footprint

The questionnaire was also related to the Product Environmental Footprint (PEF) and how companies see it. The majority of the respondents had not heard of PEF before it was introduced to them in the questionnaire (57%) (Table 5 in Appendix II). The share reported here was somewhat similar to that of a public consultation conducted by the European Commission, where 46% of the respondents representing citizens, organisations, NGOs and public authorities had not heard of it before (European Commission, 2019: 49). Eleven per cent of the respondents had heard and searched for more information about it, whereas 32% had heard but had not explored it more specifically. Finnish companies had heard of PEF less often, whereas Swedish companies had heard of it but had not searched for more information relatively more than companies from other countries. The textile and IT sectors were very even in terms of having heard about PEF beforehand (Table 6 in Appendix II).

Most of the respondents did not know how to use PEF but were eager to receive more information about it (54%). A little less than a third of the respondents could not say what their opinion of PEF would be (28%). Those respondents that had heard of PEF before usually felt that it would complement the ecodesign tools that the company was already using (11% of all respondents, 55% of those that had heard of PEF). The only

significant difference in accordance with the background variables was that the Danish respondents were much more likely to see PEF as a complementary tool to existing ecodesign tools (Table 7 in Appendix II). No difference between the sectors was observed (Table 8 in Appendix II).

The respondents mainly saw PEF as a tool for evaluating the accuracy of environmental product claims (31%). This was supported especially by Danish (41%) and textile companies (38%) and by those who had previously heard of and searched for information about PEF (67%) (Tables 9 and 10 in Appendix II). In the working document of the European Commission (2019, p. 49), it is stated that the stakeholders of the PEF also strongly supported the use of PEF for substantiating green claims in case an organisation wishes to make an environmental claim about their products. In our study, less than nine per cent of the respondents saw PEF as a way of strengthening the existing EU product policy instruments or supporting ecolabels. Notably, none of the Swedish companies saw PEF as a supporter of ecolabels. In addition, half of the respondents could not tell how PEF should be used, and the Swedish companies were more likely to be unsure of the use of PEF in policy instruments.

4. Conclusions and recommendations

Overall, the respondents were fairly mature in terms of integrating sustainability into their operations based on the stimuli and barriers they perceived. This was probably due to mature firms being more interested in sharing their opinions and experiences and others not perceiving it as their responsibility. Based on their responses, the respondents were most commonly driven by internal stimuli and especially by a general willingness to act proactively. The external stimuli breaking up the pattern of the prevailing internal stimuli were customer demand and legislation, which were especially strong for IT companies. Therefore, the tightening of legal requirements seems to be a pushing element for several companies and the criteria should be revised regularly. Then again, barriers acting against the companies related strongly to costs.

Despite the perceived maturity of the Nordic companies based on the previous literature and the stimuli and barriers, in reality their actions remained focused on mainly technological changes. The respondents focused primarily on products and sub-system change especially concerning material choices and prolonging life cycles. Some of the questionnaire respondents stated that they had had difficulty finding information on the environmental performance of different options regarding materials, for example, which indicates a growing need for research in this field to provide reliable information on how to operate more sustainably. An area where innovations were lacking was revealed to be the functional change of developing product-service systems. Still, no remarkable change had taken place based on these results in comparison to the previous studies from the beginning of the 21st century.

Organisational innovations proved to be of high importance when aiming for different kinds of innovations, in contrary to previous literature stating its importance only for technological change. The majority of the respondents were interested in using an ecodesign tool, and based on the results they should take action in applying tools. Danish companies were the most common tool users, whereas Finnish companies used ecodesign tools the least. Tool users were found to have significantly more product-, process- and marketing-related innovations. The most promising tools are suitable for assessing environmental performance specifically and provide for communication at the same time. No single, superior tool was found, but instead, companies used different tools for different purposes, such as LCA and ecolabels. Thus, it is recommended for companies to make long-term roadmaps concerning their future and include the application of ecodesign tools and R&D activities in them to support their operations and innovativeness.

The majority of the respondents had not heard of the Product Environmental Footprint (PEF) before. Finnish companies were more often among those that had not

heard of it. However, most of the respondents were eager to find out more about PEF, and as a result they were sent a short and informative document about it, together with the results of the study and its recommendations. Those respondents that had heard of PEF before usually felt that it would complement the ecodesign tools that the company was already using. The respondents mainly saw PEF as a tool for evaluating the accuracy of environmental product claims, which supports existing studies.

We identified a need for future policy development in the area of ecodesign in terms of:

- supporting the use of ecodesign tools in companies to help them assess environmental impacts and then improve their operations accordingly, as ecodesign tools were considered very important for promoting a variety of green innovations and ecodesign principles;
- research funding for studies on the environmental impacts of materials, as it is not clear to companies which materials are preferable;
- encouraging research projects to involve companies in their work to study corporate operations and support them. The opposite also applies: Companies should be encouraged to participate in projects as it can be easier and less resource consuming than having their own R&D activities;
- Nordic Innovation and Nordforsk, as key funding organisations promoting innovation and research in the Nordic countries, could offer programmes and funding for capacity building through research projects where companies are involved;
- helping companies to dematerialise their business model by supporting a transition from a product- to a service-based market by e.g. taxation. This could include, for example, repair, renting, guidance and take-back of products at the end of their use;
- the Ecodesign Directive (2009/125/EC) sets a minimum level for energy-related products, and therefore, in order to improve products from an environmental perspective, the Directive should be reviewed on a regular basis. Similar regulations should be developed in other product sectors (i.e. not energy-related);
- the Product Environmental Footprint was not yet well-known among the respondents but they were eager to find out more. Therefore, it is important to share information about PEF more actively with companies;
- the respondents mainly see PEF as a policy tool for evaluating the accuracy of environmental claims about products.

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Sammanfattning

I rapporten granskas på vilket sätt ekodesign och gröna innovationer införs i textilföretag och IT-företag, som tillverkar och/eller formger produkter i de nordiska länderna. Med textilsektorn avses här textiler och kläder. IT-sektorn inbegriper elektroniska komponenter, datorer, kommunikationsutrustning och konsumtionselektronik. IT-sektorn avgränsades till tillverkning av hårdvara. Spel och programvara, programmering och reparation av IT-utrustning utelämnades.

I rapporten granskas på vilket sätt och varför ekodesign och gröna innovationer främjas av företag, hurdana hinder de har mött, vilka verktyg de använder som stöd för sitt arbete och deras uppfattning om produkters miljöavtryck (Product Environmental Footprint, PEF). Kontexten för granskningen är de nordiska länderna, som uppfattas som föregångare när det gäller miljöfrågor.

Gröna innovationer definieras som ett tillvägagångssätt för utveckling och tillämpning av produkt-, process- och marknadsföringsinnovationer samt organisatoriska och institutionella innovationer, som minskar miljöeffekterna i förhållande till en fastställd allmän referenspunkt. Ekodesign är en kollektiv, framåtsiktande och systematisk formgivnings- och ledarskapsprocess som integrerar miljöfrågor i produktutvecklingsprocesserna.

De data som användes i rapporten samlades in med en strukturerad enkät för att få en bred överblick över situationen. Enkäten utfördes med Webropol-programmet. Nationella industriorganisationer och författaren till avhandlingen skickade ut enkäten till målpopulationen (N=104).

Observationerna i rapporten kan sammanställas i fyra påståenden: 1) Svarandena är tämligen långt hunna beträffande sättet på vilket de har integrerat ekologisk hållbarhet i sin verksamhet. Det huvudsakliga incitamentet för proaktivt miljöarbete är allmän beredvillighet, samtidigt som ökade kostnader utgör ett hinder för många företag. 2) Företagens fortsätter att fokusera på tekniska produkt- och processinnovationer och i synnerhet de funktionella innovationerna släpar efter. 3) Verktyg för ekodesign såväl som forskning och utveckling har stor betydelse för att främja alla typer av innovationer. 4) Endast ett fåtal svarande känner till PEF, men många är intresserade av det. PEF betraktas företrädesvis som en metod för bedömning av tillförlitligheten när det gäller miljöargument om produkter.

Appendix I

This appendix includes the text version of the questionnaire in English, although the actual questionnaires were conducted in Webropol separately for textile and IT sectors and in all the Nordic national languages.

Countries where company has operations*: _____
Year of foundation: _____
Number of employees*: _____
What is your company's main field of operation? You can choose multiple options.

- Clothes and accessories (textile)
- Home décor textiles (textile)
- Technical textiles (textile)
- Fibre (textile)
- Other textile (textile)
- Consumer electronics (IT)
- Industrial electronics (IT)
- Telecommunication electronics (IT)
- Other, please specify: _____

Who use the end product of your company? You can choose multiple options.

- Consumers
- Companies
- Public organisations

Are you a designing and/or manufacturing company?

- Designing
- Manufacturing
- Both designing and manufacturing

Among these statements, which one applies best to your company?*

- We meet the requirements of environmental legislation which is a suitable target level for us.
- We find environmental targets to be very important and aim to significantly exceed the requirements of environmental legislation.
- We comply with environmental legislation but it is not one of our priorities.
- We find the requirements of environmental legislation to be oversized.

Does your company use an Environmental Management System (EMS)?*

- Yes
  - ISO 14001
  - EMAS
  - Other, please specify: _____
- No

Does your company have activities for research and development specifically related to environmental matters?*

- Yes
  - If yes, how many employees take part in it? _____ / Do not know.
  - Do you have a specific budget for supporting research and development related to environmental matters?
  - Yes / No / Do not know.
  - If yes, what approximate percentage of your total budget for research and development has been allocated for environmental matters during the last two years? _____/ Do not know.
- No

Ecodesign/ecological product design is a design and management process that integrates environmental issues into product development. Ecodesign/ecological product design provides an opportunity to focus on eliminating, avoiding or reducing upstream and downstream environmental impacts with a preventive approach. It aims to reduce the consumption of resources, prolong the lifespan of a product, use less hazardous materials, optimise the production and distribution and ensure the safe disposal of products. Ecodesign/ecological product design is synonymous with Design

for Environment (DfE), green design and environmentally conscious product development and design.

References: Tischner 2001; Belmane *et al.* 2003; Byggeth and Hochshorner 2006; Johansson 2006; ISO 14006:2011; Liao *et al.* 2013; Pigosso *et al.* 2013; Dekoninck *et al.* 2016; Prendeville *et al.* 2017.

Please evaluate how your company promotes ecodesign/ecological product design and environmental matters in its activities.*

Table 1: Please evaluate how your company promotes ecodesign/ecological product design and environmental matters in its activities*

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Do not know
We choose materials whose production requires less energy than usual						
We choose materials whose production pollutes less emissions than the ones that are usually used						
We use the fewest amount of materials possible for producing a product						
We use materials that are easy to recycle						
We manufacture products that are easy to recycle, reuse and decompose						
We manufacture products that are reliable and durable						
We use recycled materials in our manufacturing						
We reduce the weight of our products						
We reduce the amount of used package materials						
Our manufacturing process reduces the consumption of water, electricity, coal or oil						
Our manufacturing process reduces the use of raw materials						
Our manufacturing process effectively reduces the emission of hazardous substances						

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Do not know
Our manufacturing process effectively reduces the amount of waste						
We handle the waste coming from our manufacturing process, so that they can be better utilised						
We use renewable energy instead of non-renewable						
Our products use less energy in usage than usual						
Our products fulfil the various environmental criteria of a type 1 ecolabel (e.g. EU Ecolabel, Nordic Swan)						
Our products are affordable						
We create different service-based business models instead of traditional supply of goods						
We offer services related to our products (e.g. repairing, consulting or taking back worn-out products)						
We rent our products to customers instead of selling them						
We promote discussion and challenge the status quo surrounding existing products, materials or processes						
We inform our customers and suppliers about the environmental performance of our products						
We inform our customers about the proper use, maintenance and end-of-life management of our products						

What are the main reasons for you taking action to promote ecodesign/ecological product design?*

- Legislation or regulation
- Subsidies or other government support
- Tax incentives
- Cost reduction

- It is requested by customers
- It is requested by investors
- It is requested by suppliers
- Public environmental governance encourages to do so
- Research institutes and universities encourage to do so
- Suppliers offer new eco-efficient materials or components
- To increase the working motivation of our employees
- To increase the quality of our products
- To avoid negative media attention
- To improve the company's image
- To improve the company's performance
- Synergy with other product requirements
- To increase the functional quality of our products
- Synergy with other product requirements
- Industrial sector initiatives
- Due to environmental pressure from industrial organisations
- To increase market share or access new markets
- To increase the value of our products
- To catch up with competitors who have already applied ecodesign/ecological product design
- Innovation opportunities
- To reduce our environmental impacts
- Other, please specify: _____

What are the main problems your company has faced when promoting ecodesign/ ecological product design?*

- Lack of information on ecodesign/ecological product design and its benefits
- Lack of environmental knowledge and skills among the company's staff
- No legal requirements on ecodesign/ecological product design for our product groups
- Uncertainty of environmental benefits
- Lengthy time to apply
- Lack of sufficient tools
- Cost increase
- Not demanded by customers
- Not demanded by investors

- Not demanded by suppliers
- Lack of alternative solutions available
- Uncertain market benefits
- It is not our responsibility
- It conflicts with other product requirements
- There are more important sector-specific standards
- Other, please specify: _____

Among these statements, which one applies best to your company?*

- We already use an ecodesign/ecological product design tools
- We have made plans to use an ecodesign/ecological product design tool
- We are interested in using an ecodesign/ecological product design tool, but have not taken action
- We are neither interested in nor concerned about ecodesign/ecological product design tools

If chose the first option:

- Which tools does your company use?
- How many years have you used the tool that has been used for the longest period?
- Who uses the tool(s) in your company?

What benefits and disadvantages do the tool(s) that you use have?

Table 2: What benefits and disadvantages do the tool(s) that you use have?

Tool		Benefits	Disadvantages
ABC analysis	Employee	Simple to use	Difficult to use
Type 1 ecolabel (e.g. Nordic Swan, EU Ecolabel)	Group of employees	Effective	Requires environmental expertise
Type 3 ecolabel, ISO 14025, i.e. environmental declarations (e.g. EPD)	Consultant	Systematic	Expensive
LCA (e.g. SimaPro, GaBi, OpenLCA)	Other, who:	Detailed	Time consuming
Streamlined LCA (e.g. EIME, LCA to Go)		Extensive	Requires a lot of data
Econcept Spiderweb		Quick to apply	Lack of clarity when to use the tool
		Affordable	Not detailed

Tool	Benefits	Disadvantages
LiDS Wheel	Supports product design and development	Scope is too narrow
ERPA		
MIPS		Scope is too broad
MET-matrix	Does not require environmental expertise	
MECO		Does not provide practical guidance
Philips Fast Five Awareness		
Ten Golden Rules	Data is easily available	
PILOT	Flexible to be applied for different products	Subject to subjectivity
EcoDesign Checklist		
Black, Grey and White List	Suitable to be used in different product development stages	The results are not concrete
Design for Sustainability		Does not work in communication purposes
Carbon Footprint	Results are easy to utilise	
Water Footprint	Suitable for communication	Other, please specify:
Other, please specify:	Other, please specify:	

What problems has your company faced when using an ecodesign/ecological product design tool?

- Difficulty to choose a suitable tool
- Difficulty to implement a new tool in product development
- The existing tools do not sufficiently support our specific situations
- Lack of environmental knowledge and skills among the company's staff
- Lack of a proper technical alternative to replace the current material/product, etc.
- Lengthy time to apply
- High implementation and certification costs
- Ecodesign is not integrated into any general product design software
- Exchange of data between tools is not possibl
- Other, please specify: _____
- None.

If chose the second option:

- Which tool have you planned to use?
- When did you plan on using the tool?

In your opinion, what benefits and disadvantages does the tool that you planned to use have?

Table 3: In your opinion, what benefits and disadvantages does the tool that you planned to use have?

Tool		Benefits	Disadvantages
ABC analysis	Less than 6 months ago	Simple to use	Difficult to use
Type 1 ecolabel (e.g. Nordic Swan, EU Ecolabel)	6–12 months ago	Effective	Requires environmental expertise
Type 3 ecolabel, ISO 14025, i.e. environmental declarations (e.g. EPD)	1–2 years ago	Systematic	Expensive
LCA (e.g. SimaPro, GaBi, OpenLCA)	3–5 years ago	Detailed	Time consuming
Streamlined LCA (e.g. EIME, LCA to Go)	More than five years ago	Extensive	Requires a lot of data
Econcept Spiderweb	Do not remember	Quick to apply	Lack of clarity when to use the tool
LiDS Wheel		Affordable	Not detailed
ERPA		Supports product design and development	Scope is too narrow
MIPS		Does not require environmental expertise	Scope is too broad
MET-matrix		Data is easily available	Does not provide practical guidance
MECO		Flexible to be applied for different products	Subject to subjectivity
Philips Fast Five Awareness		Suitable to be used in different product development stages	The results are not concrete
Ten Golden Rules		Results are easy to utilise	Does not work in communication purposes
PILOT		Suitable for communication	Other, please specify:
EcoDesign Checklist		Other, please specify:	
Black, Grey and White List			
Design for Sustainability			
Carbon Footprint			
Water Footprint			
Other, please specify:			

What problems with ecodesign/ecological product design tools did you face, so that you did not apply a tool?

- Lack of potential benefits
- Difficulty to choose a suitable tool
- The existing tools do not sufficiently support our specific situations
- Lack of environmental knowledge and skills among the company's staff
- Lack of a proper technical alternative to replace the current material/product, etc.
- Lengthy time to apply
- High implementation and certification costs
- Ecodesign is not integrated into any general product design software
- Exchange of data between tools is not possible
- Other, please specify: _____
- None

Product Environmental Footprint (PEF)

Product Environmental Footprint (PEF) is a measure of product environmental performance under development for creating a single market for green products in Europe, proposed by the European Commission. It is based on Life Cycle Assessment, but defines stricter rules for making the analysis (so-called Product Environmental Footprint Category Rules, PEFCRs) than LCA standards and by this strives for comparability of product-specific PEF results. The pilot takes place in 2013–2018 and includes 21 product groups. After the pilot phase, there will be a transition phase of a few years, after which it will be decided whether PEF will be a mandatory or a voluntary method and how it will be used in policy instruments.

Have you heard of PEF before?*

- Yes and I have searched for more information about it
- Yes, but I have not explored it more specifically
- No

What would be your company's opinion towards PEF?*

- PEF would complement the ecodesign/ecological product design tools that we are already using
- PEF would replace the tool we are currently using
- We don't know yet how to use it but we are eager to get more information about PEF
- We would not be interested in using PEF
- Cannot say

What kind of a policy instrument do you see PEF to primarily be?*

- Strengthening the existing EU product policy instruments
- Supporting ecolabels
- Evaluating the accuracy of environmental claims of products
- Cannot say

Free comments: _____

Please mark down if your company has applied for patents or brought energy labelled or ecolabelled products to the market during the last two years:

- Patents in general
- Patents which you consider to be linked with environmental goals
- EU Ecolabelled products
- Nordic Swan Ecolabelled products
- Bra Miljöval labelled products
- Blaue Engel labelled products
- Öko Tex 100 labelled products (textile)
- Öko Tex 1000 labelled products (textile)
- Global Organic Textile Standard labelled products (textile)
- Fair Trade products (textile)
- EU Energy Labelled products (IT)
- EPET labelled products (IT)
- Energy Star labelled products (IT)
- TCO certified products (IT)
- Products with other ecolabels, please specify: _____
- Products with company's own environmental declaration

Please mark down if your company has taken the following objects into use or brought them to the market during the last two years:

- Completely new products developed with environmental improvements compared to alternative products
- Products that we have improved by adding in a component
- Products whose materials or components we have improved or switched to reduce environmental impacts
- Products have been replaced by services
- New products created outside of our company, but which we have implemented
- Completely new environmentally friendly manufacturing techniques that we have developed to reduce environmental impacts
- Environmentally friendly manufacturing techniques we have improved
- New manufacturing techniques created outside of our company, but which we have implemented
- Other, please specify: _____

Thank you very much for your time and valuable answers!

If you would like to participate in the research in the future and receive information on the results, please leave your e-mail address here _____ or send it to Hanna Salo, hanna.h.salo@ymparisto.fi. Your contact information will not be associated with the survey.

The results of the study will help companies to better consider environmental issues. At the same time, the study identifies tools that companies can use to promote ecological product design/ecodesign and environmental innovations in their operations as easily as possible. Thus, the results can enhance the environmental performance of companies, reduce costs and improve the company's image. In addition, if you so wish, you can present your best practices in a video that shows consumers the operations of your company.

If you have any additional thoughts about the topic or the survey, please share them here:

Appendix II

Results of the statistical tests are presented here at the level of individual countries. Iceland was excluded from the country-specific analysis due to the low number of respondents in order to increase the potential of fulfilling the preconditions of the chi-squared test. Differences in relation to other variables have been presented in Salo (2019).

Table 1: Statistical associations between the most important stimuli for promoting ecodesign and green innovations classified according to the sectors. The table includes stimuli with a share of more than 15% (N=104)

		GW	PV	PQ	CD	CI	L	IO	MB	CR
Textile	Frequency	47	40	33	26	25	13	20	14	8
	AR	0.3	4.1	1.4	-1.0	0.7	-4.8	1.7	0.9	-2.5
IT	Frequency	20	4	10	15	9	21	4	4	10
	AR	-0.3	-4.1	-1.4	1.0	-0.7	4.8	-1.7	-0.9	2.5
Statistical significance (Pearson's chi-square, p-value)		0.785	<0.001 **	0.163	0.300	0.508	<0.001 **	0.088	0.388	0.012 *

Note: AR=Adjusted Residual.
* Statistically significant difference (p<0.05).
** Statistically very significant difference (p<0.001).
[a] Preconditions for Pearson's chi-squared test are not met.
Stimuli: GW=General Willingness, PV=Product Value, PQ=Product Quality, CD=Customer Demand, CI=Company Image, L=Legislation, IO=Innovation Opportunities, MB=Market Benefits, CR=Cost Reduction.

Table 2: Statistical associations between the most important stimuli for promoting ecodesign and green innovations classified according to country. The table includes stimuli with a share of more than 15% (N=104)

		GW	PV	PQ	CD	CI	L	IO	MB	CR
DEN	Frequency	13	7	6	7	2	3	4	4	2
	AR	1.1	-0.1	-0.6	0.2	-2.0	-1.4	0.0	0.7	-0.7
FIN	Frequency	29	24	17	13	17	12	10	3	9
	AR	0.8	2.5	-0.1	-1.5	1.4	-0.7	0.1	-2.3	0.9
NOR	Frequency	6	1	3	3	4	2	5	1	2
	AR	1.2	-1.6	0.1	0.2	1.4	-0.2	3.1	-0.2	0.8
SWE	Frequency	17	10	15	16	10	16	2	9	4
	AR	-2.4	-2.0	0.2	0.9	-0.6	2.0	-3.0	1.6	-1.1
ISL	Frequency	2	2	2	2	1	1	3	1	1
	AR	0.1	0.9	0.9	1.0	0.0	0.0	3.2	0.7	0.7
Statistical significance (Pearson chi-square, p-value)		0.153[a]	0.050[a]	0.894[a]	0.587[a]	0.152[a]	0.306[a]	<0.001[a]	0.214[a]	0.580[a]

Note: AR=Adjusted Residual.
* Statistically significant difference (p<0.05).
** Statistically very significant difference (p<0.001).
[a] Preconditions for Pearson's chi-square are not met.
Stimuli: GW=General Willingness, PV=Product Value, PQ=Product Quality, CD=Customer Demand, CI=Company Image, L=Legislation, IO=Innovation Opportunities, MB=Market Benefits, CR=Cost Reduction.

Table 3: Statistical associations between the most important barriers for promoting ecodesign and green innovations classified according to sector. The table includes barriers with a share of more than 15% (excluding other) (N=104)

		IC	CD	LS	LI	CPR	T	MB	ET	EB
Textile	Frequency	41	21	19	20	14	19	14	12	13
	AR	2.1	-0.8	-0.8	0.0	-1.3	1.2	-1.0	-0.6	1.1
IT	Frequency	11	12	11	9	10	5	9	7	3
	AR	-2.1	0.8	0.8	0.0	1.3	-1.2	1.0	0.6	-1.1
Statistical significance (Pearson's chi-square, p-value)		0.034 *	0.399	0.407	0.971	0.187	0.229	0.325	0.526	0.257[a]

Note: AR=Adjusted Residual.
* Statistically significant difference (p<0.05).
** Statistically very significant difference (p<0.001).
[a] Preconditions for Pearson's chi-square are not met.
Barriers: IC=Increase of costs, CD=Not demanded by customers, LS=Lack of alternative solutions, LI=Lack of information on ecodesign and its benefits, CPR=Conflict with other product requirements, T=Lengthy time to apply, MB=Uncertain market benefits, ET=Lack of sufficient ecodesign tools, EB=Uncertainty of environmental benefits.

Table 4: Statistical associations between the most important barriers for promoting ecodesign and green innovations classified according to country. The table includes barriers with a share of more than 15% (excluding other) (N=104)

		IC	CD	LS	LI	CPR	T	MB	ET	EB
DEN	Frequency	10	9	7	4	3	4	2	5	5
	AR	0.8	2.1	1.2	-0.4	-0.6	0.0	-1.1	1.3	1.8
FIN	Frequency	23	7	13	12	9	6	14	5	6
	AR	0.8	-2.7	0.4	0.1	-0.3	-1.8	2.3	-1.4	-0.3
NOR	Frequency	4	1	3	3	0	3	3	0	1
	AR	0.4	-1.0	0.8	0.9	-1.5	1.3	1.4	-1.3	-0.1
SWE	Frequency	13	16	5	9	12	11	3	9	4
	AR	-1.9	2.2	-2.3	-0.4	1.9	14	-2.4	1.4	-0.8
ISL	Frequency	2	0	2	1	0	0	1	0	0
	AR	0.6	-1.2	1.5	0.2	-1.0	-1.0	0.5	-0.8	-0.7
Statistical significance (Pearson's chi-square, p-value)		0.448[a]	0.009[a]	0.102[a]	0.898[a]	0.213[a]	0.227[a]	0.044[a]	0.193[a]	0.466[a]

Note: AR=Adjusted Residual.
* Statistically significant difference (p<0.05).
** Statistically very significant difference (p<0.001).
[a] Preconditions for Pearson's chi-square are not met.
Barriers: IC=Increase of costs, CD=Not demanded by customers, LS=Lack of alternative solutions, LI=Lack of information on ecodesign and its benefits, CPR=Conflict with other product requirements, T=Lengthy time to apply, MB=Uncertain market benefits, ET=Lack of sufficient ecodesign tools, EB=Uncertainty of environmental benefits.

Table 5: Statistical associations of the responses on whether the respondent has heard of PEF before classified by country. The preconditions of the chi-squared test were not met (p=0.023, 50% of cells with an expected count of less than 5) (N=101)

		Denmark	Finland	Norway	Sweden
Yes, and I have searched for more information about it	Frequency	4	5	0	3
	AR	1.6	0.0	-1.0	-0.7
Yes, but I have not explored it more specifically	Frequency	6	6	4	16
	AR	0.4	-3.2	1.5	2.2
No	Frequency	7	31	3	16
	AR	-1.4	3.0	-0.8	-1.6

Note: AR=Adjusted Residual.

Table 6: Statistical associations of the responses on whether the respondent has heard of PEF before classified by sector. The difference was not statistically significant (p=0.979) (N=104)

		Textile	IT
Yes, and I have searched for more information about it	Frequency	8	4
	AR	-0.2	0.2
Yes, but I have not explored it more specifically	Frequency	23	10
	AR	0.1	-0.1
No	Frequency	41	18
	AR	0.1	-0.1

Note: AR=Adjusted Residual.

Table 7: Statistical associations of the responses on what would be the company's opinion towards PEF classified by country. The preconditions for the chi-squared test were not met (p=0.079, 75% of cells with an expected count less than 5) (N=101)

		Denmark	Finland	Norway	Sweden
PEF would complement the ecodesign tools that we are already using	Frequency	6	2	0	2
	AR	3.8	-1.5	-0.9	-1.0
PEF would replace the tool we are currently using	Frequency	1	2	0	0
	AR	0.8	0.9	-0.5	-1.3
We don't know yet how to use it but we are eager to get more information about PEF	Frequency	6	23	4	22
	AR	-1.7	0.1	0.1	1.2
We would not be interested in using PEF	Frequency	0	2	0	2
	AR	-0.9	0.3	-0.6	0.7
Cannot say	Frequency	4	13	3	9
	AR	-0.5	0.4	0.9	-0.5

Note: AR=Adjusted Residual.

Table 8: Statistical associations of the responses on what would be the company's opinion towards PEF classified by sector. The preconditions for the chi-squared test were not met (p=0.415, 50% of cells with an expected count less than 5) (N=104)

		Textile	IT
PEF would complement the ecodesign tools that we are already using	Frequency	8	3
	AR	0.3	-0.3
PEF would replace the tool we are currently using	Frequency	1	2
	AR	-1.4	1.4
We don't know yet how to use it but we are eager to get more information about PEF	Frequency	42	14
	AR	1.4	-1.4
We would not be interested in using PEF	Frequency	2	2
	AR	-0.8	0.8
Cannot say	Frequency	19	11
	AR	-0.8	0.8

Note: AR=Adjusted Residual.

Table 9: Statistical associations of the responses on what kind of policy instrument they see PEF primarily to be classified by country. The preconditions for the chi-squared test were not met (p=0.015, 62.5% of cells with an expected count less than 5) (N=101)

		Denmark	Finland	Norway	Sweden
Strengthening the existing EU product policy instruments	Frequency	4	3	0	2
	AR	2.3	-0.5	-0.9	-0.8
Supporting ecolabels	Frequency	2	5	2	0
	AR	0.5	0.9	1.9	-2.3
Evaluating the accuracy of environmental claims of products	Frequency	7	16	1	8
	AR	0.9	1.2	-1.0	-1.4
Cannot say	Frequency	4	18	4	25
	AR	-2.4	-1.3	0.4	3.1

Note: AR=Adjusted Residual.

Table 10: Statistical associations of the responses on what kind of policy instrument they see PEF primarily to be classified by sector. The preconditions for the chi-squared test were not met (p=0.057, 25% of cells with an expected count less than 5) (N=104)

		Textile	IT
Strengthening the existing EU product policy instruments	Frequency	5	4
	AR	-0.9	0.9
Supporting ecolabels	Frequency	6	3
	AR	-0.2	0.2
Evaluating the accuracy of environmental claims of products	Frequency	28	4
	AR	2.7	-2.7
Cannot say	Frequency	33	21
	AR	-1.9	1.9

Note: AR=Adjusted Residual.

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Use of ecodesign tools and expectations for Product Environmental Footprint
The report examines the implementation of ecodesign and green innovations in Nordic textile and IT companies. The findings of this report are:

1) The respondents are fairly mature in terms of how they integrated environmental sustainability into their operations. Companies are mainly driven by general willingness but deterred by cost increases.
2) Companies remain focused on technical innovations, whereas functional innovations are lagging behind.
3) Ecodesign tools and research and development activities are highly relevant for promoting innovations.
4) The main tools used are Type I Ecolabels, Life Cycle Assessment and Carbon Footprint.
5) Few respondents are familiar with PEF, but many are interested in it. PEF is predominantly seen as a way to evaluate the accuracy of environmental product claims.

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