Do sustainability investments pay off?

The influence of sustainable process innovation in manufacturing firms in the Netherlands, on firms' total production costs.

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Abstract

The main goal of this research is to explore if investing in energy-saving technologies, hereafter referred to as ‘sustainable process innovation’ does have an effect on the total production costs of an organisation. While in many publications a positive effect of Corporate Social Responsibility (CSR) on performance is assumed, there is no empirically proven evidence that this positive effect always exists. By analysing the results of the European Manufacturing Survey (EMS) of Dutch manufacturing firms, the researcher aims to answer the following question: “Do investments in sustainable process innovation, in manufacturing firms in the Netherlands, pay off?”. The result is expressed in the total production costs.

Keywords

Process innovation, investment in energy-saving technologies, energy consumption, production costs, manufacturing firm

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Chapter 1. Introduction

1.1 Background

Corporate Social Responsibility (CSR) has emerged as a global trend involving corporations, states, international organisations and civil society organisations (Sahlin-Andersson, 2006). Although, there are many different definitions for CSR, it becomes clear that there is not one definition that captures the whole concept. However, to get an idea of what CSR is about, the definition of (Jones, 1980) is used: "Corporate social responsibility is the notion that corporations have an obligation to constituent groups in society other than stockholders and beyond that prescribed by law or union contract". The growing international and domestic interest shown on corporate social responsibility and sustainability stems largely from the concerns held by many in every society about the real and perceived effects of rapid globalization and development issues (Eweje, 2014). Over the years, society became more aware about the environment and the role that organisations play in regards to this. People realise that their future is at stake. Sustainable business development (SBD) in manufacturing and services has become a critical issue in recent years owing to the impact of global warming, terrorism, earthquakes, hurricanes, and carbon footprint awareness (Gunasekaran, Spalanzani, 2012). Organisations are expected to take care of the environment, and the welfare of the society. Nowadays, this is part of doing business. The basic idea behind CSR is the notion that corporations should be responsible not just to their shareholders, but also to society as a whole (Eweje, 2014). It is clear that for the economy to move towards a more sustainable way of doing business, it will be necessary to transform firms, their products, production systems and management practices. Due to this shift in orientation, the competitive landscape will eventually change as well (Shrivastava, 1995).

Besides, there is an exceedingly need to reduce the energy consumption in manufacturing in order to cut down CO2 emissions. According to a study of Zhao et al. (2017) in the USA, the industrial sector accounts for 31% of the total energy consumption and manufacturing counts for 60% of the energy consumption in the industrial sector. Manufacturing has a large share and due to this, the energy consumption reduction in machining is of great importance to achieve sustainable manufacturing. Sustainable manufacturing is becoming crucial for businesses more than ever before (Gupta, Dangayach, & Singh, 2015).

However, this situation also raises questions for the organisations such as: "Does it actually pay to be green?", that the researchers S. Hart and G. Ahuja, in their article in 1996 ask themselves (Hart & Ahuja, 1996). In addition to the challenge for companies to manage

the conflict of sustainability and profitability, firms also have to cope with the question whether sustainable investment does contribute to lower production costs and when this effect will be sufficiently noticeable to remain healthy, taking into account the possible external factors such as changes in energy prices and taxes.

THE BENEFIT OF CSR: OPPOSITE RESULTS FROM PREVIOUS STUDIES SO FAR

In this paragraph the researcher wants to give insight in the results of previous research studies, in regard to the relation of sustainable investments and firm performance in terms of production costs and energy consumption. Since the studies often show opposite findings, it led to the design of this research study.

Energy demand is expected to increase significantly. The modelling of a UK government white paper from 2020 suggests that overall demand could double out to 2050. Furthermore by 2050, emissions from industry will need to fall by around 90 percent from today's levels. It is expected that electricity could provide more than half of final energy demand in 2050, up from 17 percent in 2019 (Government, 2020). Energy consumption reduction and energy efficiency improvement in manufacturing is essential to achieve sustainable manufacturing. The government states that improving energy efficiency is one of the most cost-effective mechanisms for businesses to reduce their energy bills, while reducing their carbon emissions. This points at a positive effect of energy consumption on the total production costs. However, a lack of information and the upfront capital costs of installation can deter investment by small businesses in sustainable measures, so this have to be taken into account.

Brossog, Bornschlegl, & Franke (2015) describe that reducing the energy consumption of industrial robots (IR) that are used in manufacturing systems has become a main focus in the development of green production systems. This is clarified by the fact that almost all automated manufacturing processes are using IR as the main component. Thus, reducing the energy consumption of IR by sustainable investment will automatically reduce operating costs and CO2 emissions. The researchers did study the different stages of manufacturing systems' development for reducing energy consumptions with IR. They state that energy consumption reductions can be achieved at the stage of production planning, commissioning processes or at optimization stages. Nevertheless, in order to reduce the energy consumption, the productivity requirements and environmental conditions of the manufacturing systems must be considered. They suggest that firms should combine several reduction methods such as reducing the payload by for example using light-weight material for tooling system components, smoothing the IR motion planning or optimizing the IR operating speed.

The paper of researchers Meike, Pellicciari & Berselli (2013) outlines their quantitative research about potential energy savings on robotic assembly lines for the automotive industry. In the context of the global industry trend towards sustainable energy optimisation as a primary goal, an energy consumption optimisation method for multirobot production systems is discussed. The results of their research, based on energy simulation, show that robots have excessive idle times after task completion. By implementing the proposed energy saving methods, which are readily applicable to existing equipment, the idle times can be used to achieve significant energy savings while still taking into account robot dynamic limitations, cycle times and production constraints. The results show a potential energy saving around 12,1% for a single industrial robot and up to 7,3% for the overall cell.

Srivastava (2007) emphasizes the increasing importance of investment in 'green supply chain management'. This is defined by them as "the integration of environmental thinking into supply chain management", which, amongst others, includes investment in sustainable product design and the manufacturing process. In addition to Srivastava (2007), the study of Gimpel et al (2019) indicates that transforming a business to more sustainability, not only has positive effects on societies, but also improves performance metrics within the organization. It endorses the theory that integration of sustainability has an effect on the performance of a company. However, this study describes that transformation towards sustainability has been integrated in firms for years already, but mostly in singular business activities. They used a game-theoretic framework to examine if and when the implementation of a sustainable business model would pay off and found that nowadays, a more holistic view is needed to implement sustainability not only in the single business activities and processes, but in the core business model. This would mean that a company should focus both on product innovation as well as on process innovation.

For an increasing number of firms in the capital goods industry, combinations of products and services, so called integrated solutions, are becoming part of their future growth strategies. Windahl et al. (2004) analysed three case studies in which a variety of solutions are highlighted. One of the solutions developed by a service division, called Facilities Management (FM), includes a feasibility study which is offered before signing a contract. This is called a pre-study period which is carried out in cooperation with the customer to show in a certain amount of time that energy savings will occur. If this study shows sufficient possibilities to lower the customer's energy consumption by installing new equipment the contract is concluded. The better the performance of the control system, the larger the savings and hence also the income for FM. The length of the contractual period is usually three to seven years.

This plays a significant role for the provider's internal planning and investment margin. Future business success depends on several factors, where a key aspect would be the company's ability to leverage its installed equipment base. This article underlines the research of Srivastava (2007) that integrating product and service innovation is important, but is also emphasizes that it takes time for a company to gain results in energy consumption reduction. This was also found by López, Garcia & Rodriguez (2007).

In contrast to the results of Srivastana (2007) and Gimpel et al. (2019), López, Garcia & Rodriguez (2007) found in their research, concerning sustainable development and the effect on corporate performance, based on the Dow Jones Sustainability Index, that there was not immediately a significant effect visible between sustainable development and the performance of a company. They did not find grounds for claiming that the adoption of sustainability practices will have positive effect on the performance indicators (López et al., 2007, p. 296). They developed this particular research study, because often business advantages are linked to the adoption of socially responsible behaviour (López et al., 2007). Due to this general thought, sustainability indexes were developed, in order to be able to keep track of the difference in performance of companies that do adopt sustainability initiatives, and of companies that do not invest in sustainable technologies. The results from their analysis do not show an immediate significant effect between the investment in process innovation and firm performance. As a conclusion, the writers mention that the expenses that firms incur as a result of their socially responsible actions, can even result in economic disadvantage compared to other, less responsible firms, at least in the short-term (López et al., 2007, p. 296). They argue that a positive effect might become visible over a longer time period.

In addition to the study of López et al. (2007), the results of the study of Hami, Muhamad, & Ebrahim (2015, p. 194) indicate that pursuing more environmentally friendly products and business operations, as well as being socially responsible by directly adopting external sustainable manufacturing practice, may even lead to negative economic results.

Firms will only invest in sustainable technologies if the investments have an economic pay-off. The results of a research study from T. Stucki (2019) based on unique firm-level data from Austria, Germany and Switzerland show that the marginal effect of investment in sustainable technologies on productivity is positive for only 19% of firms with the highest energy costs. Different results are found for firms with low and medium energy costs. While the productivity effects of investment in green energy technologies turn out to be significantly positive for firms with high energy costs, no significant effects are found for firms with medium energy costs, and the effects are even significantly negative for firms with low energy costs.

The results from this study do have impact on the design of green energy policies and incentives made by policy makers.

1.2 Research objective

The contradictory findings of previous research studies, in regard to the effect of investment in process innovation on firm performance in terms of energy consumption and production costs, led to the design of this research project. This study aims to find out if there is an effect of investment in sustainable technologies on firm performance in terms of production costs, by using empirical data collected from Dutch manufacturing firms. The overarching research question is: *Do investments in sustainable process innovation in manufacturing firms in the Netherlands pay off in regards to the total production costs?*

In order to answer this question two sub-questions were developed and studied. Based on the study of Stucki (2019) which shows that energy costs play a large role in the effect on firm performance, the researcher chose to include the indirect effect of 'energy consumption' as a mediator.

One sub-question is focused on the direct effect of the independent variable on the dependent variable and the other sub-question is focused on the indirect effect, including the mediator variable:

1. To what extent does the investment in sustainable process innovation, as in energy-saving technologies, decrease the total production costs of a firm?
2. Is the relation between sustainable process innovation and production costs mediated by the energy consumption of a firm?

1.3 Societal relevance

Nowadays, climate change and sustainability are the order of the day. People become aware of the consequences of their own behaviour, as effect on the environment. With the 'National Climate Agreement' the Dutch government wants to combat climate change by focusing on emission reduction and on sustainability, throughout the whole society. By making agreements with different sectors, including the manufacturing industry, they hope to achieve the national climate goals. They encourage sustainable energy generation and energy savings by different measures (Netherlands, 2019).

It is a challenge to achieve sustainability goals and at the same time remain in a competitive position as a business. The government states: "*The focus is on a more sustainable world, while the innovative and efficient manufacturing industry continues to contribute to employment and welfare"*(Klimaatakkoord, 2018). It is clear that something has to happen and

that organisations have to invest in innovations aimed at reducing the negative impact on the environment. However, without the motivation and cooperation of the companies, it will be difficult. The changes will impose substantial demands on the innovation capability of businesses and therefore information should be available about the challenges, successes and experiences of firms that operate in the same sector.

This research contributes to the goals of the Dutch government and society, as well as to the manufacturing firms that will face challenges reaching these goals. The paper critically reviews the results of existing literature about investment in sustainability for the benefit of the environment, society and firms and zooms in on opposite outcomes. Furthermore, it provides results of an empirical study that indicate whether there is an effect of investment in sustainable innovation on firm performance, expressed in the production costs, and it shows whether this is a significant effect. Manufacturing firms in the Netherlands are able to see whether it would be valuable to invest in sustainability, specifically for process innovation. The results of the interviews can support or contradict the findings of the statistical study, and so highlight the advantages and disadvantages of incorporating sustainability in the processes of some manufacturing firms. The experience of firms in this particular sector, as well as the valuable information derived from this study, in terms of sustainability, which is nowadays a hot topic, could encourage society as well as firms in any sector, to see what steps they can take to reduce environmental impact.

1.4 Scientific relevance

Due to the upcoming awareness and the importance of this theme, there are many research studies that are focused on corporate sustainability. Sustainability goals require companies to develop a whole new strategy and to restructure their approach of doing business. Therefore, numerous studies (Tomšič, Bojnec, & Simčič, 2015; Xiao et al., 2018; Schönborn et al., 2019; Saufi, Daud & Hassan, 2016) in this field, both from a structural and social perspective have been conducted. However, when it comes to research concerning change in sustainability, it is often about the effects of companies and their strategy on the environment. This research study focuses mainly on the effects that such change has on the firms itself. It highlights the effects of investment in sustainable innovations on the performance of the firms, in terms of energy consumption and production costs, based in the Netherlands. As is also stressed by Millar, Hind, & Magala, (2012) much more clarity is required on how organisations must change to meet the sustainability challenge and how the necessary changes may be achieved. This master thesis is a contribution to the current scientific literature, since it

emphasizes the effect of investment in process innovation on firm performance. It supports the theory of Millar, Hind & Magala (2012) by highlighting a particular manner on how a company can change to a more sustainable company, and at the same time it gives insight in the firm performance, and thus the possible advantages and disadvantages of such change.

1.5 Thesis outline

The first part of the thesis, the introduction, describes the reason for developing this research project. It provides the reader with an idea of the increasing importance and awareness in regards to sustainability, as well as an elaboration on the academic and social relevance of the research project.

Chapter 2 elaborates on the theoretical framework that consists of a description of the concepts, the possible relation between the concepts, and the hypotheses. To give a clear overview, the concepts are visualised, and so a conceptual model is drawn, which captures all concepts, as independent and dependent variables, in one figure.

Subsequently, in chapter 3, the methodology is explained, through which the reader gains a deeper understanding of the methodology that was used and the steps that were taken for preparation of the analysis. Here, the research method, including the context, the case selection, data collection, and the research ethics are discussed. Furthermore, the researcher zooms in on the reliability and validity of this particular research project.

Chapter 4 shows the results of the analysis, that was carried out to answer the main research question and the sub-questions. The outcomes of the regression analysis and the mediation analysis are depicted in several SPSS outcome tables, to give a clear overview.

Eventually, an overall conclusion will be drawn, and the outcomes will be discussed in chapter 5, followed by some limitations and recommendations stressed by the researcher.

Chapter 2. Theoretical background

In this chapter the central concepts of this study are defined, linked to the theory and visualised in a conceptual model. The reader will gain a deeper understanding of the theoretical background of the study and the problem that is addressed.

2.1 Introduction

The key concepts of this research are derived from the research question and the sub-questions. In order to gain more in-depth knowledge about the elements that will be used for the analysis, to achieve the end result, the concepts are described below. At first, the concept sustainable process innovation is elaborated on. Subsequently, the causal relations between this concept and energy consumption as well as total production costs are explained. Energy consumption is a mediator which is expected to be influenced by the investment in process innovation and most likely will influence the total production costs. Furthermore, the hypotheses are discussed and substantiated by findings of several literature studies. At the end, the conceptual model is depicted, which visualises the expected causal relations between the concepts.

2.2 Concepts

2.2.1 Sustainable process innovations, c.q. energy and resource saving technologies

Sustainable process innovations, also regarded as energy- and resource saving technologies, are part of the broader concept 'environmental technological change', which refers to: "new or modified processes, techniques, practices, systems and products to avoid or reduce environmental harms" (Beise and Rennings, 2005, p.6). In this study, energy- and resource saving technologies are regarded as process innovations, which refers to the process to produce a given amount of output (goods, services) with less intput than before. This investment in process innovation is for the purpose to reduce environmental impact. A distinction can be made between end-of-pipe (EOP) and cleaner technologies (Del Río, 2004). End-of-pipe technologies use a reactive approach to environmental problems and cleaner technologies are preventive. In this study, the concept of process innovations, can be regarded as "more efficient use of energy or materials by technologies that reduce resources, lower generation of emissions, or both" (Fu et al., 2018, p. 5). In recent years, there have been many developments that contributed to the improvement of the manufacturing technology. The technologies that promote sustainable development, and thus contribute to energy savings and the reduction of emissions, in the manufacturing industry are digital technology, clean

production technology, short production process technology, waste-free manufacturing technology and automatic control technology (Shan et al, 2012). In the manufacturing industry, firms face many challenges, such as high energy consumption, low manufacturing accuracy, high machining allowance, a high waste rate, low production efficiency and high waste emissions (Shan et al, 2012, p. 1095). For firms it is important to pay attention to these challenges, in order to balance both the economic and social benefits.

The reasons for firms to incorporate sustainability are: to increase operational efficiency by reducing costs and waste, to reach new customers and increase competitive advantage, to strengthen brand reputation and build public trust, to build long-term business viability and success, and to respond to regulatory constraints and opportunities (Lee et al., 2019). According to Shan et al (2012) there are three types of manufacturing technologies in the machinery industry that reduce emissions and save energy: saving the consumption of raw and auxiliary materials, reducing energy consumption and minimizing or completely eliminating generated waste water, waste gas, waste residue and noise. The study of Hami, Muhamad, & Ebrahim (2015) describes that the results from their study, using survey data collected from 150 Malaysian manufacturers, suggest that the application of pollution prevention methods, clean technologies and sustainable human resource practices are linked to improvement of operational efficiency as well as increased financial and market performance. Anyhow when implementing sustainability in a firm in regard to process innovation, challenges in terms of change management are inevitable. Gebauer & Fleisch (2007) highlight the challenges that implementing such sustainable innovations could bring, in regard to cognitive processes within the firm. There could exist some counterproductive behavioural patterns that limit sustainable improvements, as for example risk aversion.

Thompson (1967) viewed organisations as open systems faced by environmental uncertainty but requiring certainty in order to function. He describes that every organisation has a technical core devoted to efficient performance and management's role is to handle uncertainty so that the core can operate as efficiently as possible.

The theory of Gerwin (1988) explains why it is so difficult to introduce a new technology into companies. Problems arise in deciding whether or not to purchase, in preparing the organization's supporting functions, and in deciding whether or not success has been achieved. He describes in his research study that uncertainty, defined as lack of information on goals, alternatives and consequences, is the starting point for developing a theory of the innovation process for a radical manufacturing technology, named computeraided manufacturing. In their study Gerwin and Tarondeau discovered that about half of the reasons

firms gave for adopting computerized manufacturing systems reflected production-related uncertainty reduction.

Despite the fact, that this production-related uncertainty reduction could be the reason for adopting energy saving technologies, in this research study the participating manufacturing firms were asked to provide information concerning their investment in computeraided energy- and resource saving technologies by filling out the European Manufacturing Survey. These technologies consist of the investment in control systems that stop the machines at underuse, automated management systems for energy efficient production, systems for kinetic and process energy recovery and technologies for energy- and/or heat generation by means of sun-, wind-, hydropower, biomass or geothermal energy.

The adoption of energy- and resource saving technologies by a firm, is associated with the development of the energy consumption, as well as with the development of the production costs, which will be elaborated on in paragraph 2.3.1.

2.2.2 Energy consumption

The research study of Hori (2014) revealed that a positive relation exists between CSR recognition and energy saving. Research data was collected by a questionnaire amongst 161 companies in Asia to see whether CSR recognition had an effect on energy savings. Their research results imply that energy saving actions reflect social norms. In Asian cities energy saving has become popular. This theory also demonstrates how social norms can improve cities' social reputations in the outside world. Therefore, companies consider energy-saving actions one of their social responsibilities. They believe their actions are both benefits and obligations to their societies.

When looking at the energy consumption in the industrial sector in The Netherlands approximately half of the energy is generated using petroleum raw materials and products. Other sources are; coal, gas and electricity. For many companies, electricity is the major energy source. Electricity is mainly used for lighting, followed by air conditioning, compressors and pumps. Coal, gas and oil are used to supply boilers (CBS, 2016).

In 2016, the energy consumption in the industrial sector in the Netherlands increased by 1.5% compared to 2015. Both developments in industrial activities and efficiencies in energy consumption influence consumption of energy carriers. In recent years, it becomes visible that the industrial energy consumption has decreased due to the introduction of more energy-efficient production processes (CBS, 2016).

Martinuzzi (2011) found in his research regarding environmental impact within the construction industry that about 85% of energy consumption occurs during the use phase and

another 15% is linked with the manufacturing phase. This research paper focuses on the impact on energy consumption during the manufacturing phase.

In this research, energy consumption is measured as the development of power consumption and oil- and gas consumption between 2012 and 2014.

2.2.4 Production costs

Manufacturing firms are facing increasing pressure to reduce their carbon footprint, driven by concerns related to energy costs and climate change. The rising cost of energy is one of the important factors associated with increased production costs at manufacturing facilities, which encourages decision-makers to tackle this problem. The potential to reduce energy costs can lie in increasing the energy efficiency of production processes whereby the consumption of production systems is reduced (Shrouf et al., 2014). The production costs of a machine depend on several factors, as for example the duration of each machine status and transition, the energy consumption during each phase and the energy costs. In general, Patterson (1996) refers to energy efficiency as to achieve the same output with less energy consumption, thereby utilizing economic efficiency. Nevertheless, Gerwin (1988) states that during adoption of computerized technologies the long run advantages cannot be precisely determined and so if strategic management has a short-term focus, the financial considerations will play an inordinate role in decision making.

In this research paper, the effect of investments in sustainable process innovation on production costs is analyzed. The results on production costs will be based on the development, an increase or decrease, of production costs per unit in 2014.

2.3 Causal relations

Business advantages are often linked to the adoption of socially responsible behaviour. These advantages consist of increased efficiency in the use of resources, return on investment, increased sales, development of new markets, improved corporate image and enhanced competitive advantage (Dangelico, Pujari, 2010, p. 480). Due to the fact, that in many research studies, (Russo & Fouts, 1997); (Chen, Lai Wen, 2006); (De Brito, Carbone & Blanquart, 2008); (Ameer & Othman, 2012), a positive relationship between these advantages and sustainable development is measured, the researcher has developed several hypotheses. These hypotheses are stated in the following paragraphs.

2.3.1 Sustainable process innovation, energy consumption and production costs

Due to the rapidly growing world energy use, there are increased concerns in regard to supply difficulties, exhaustion of energy resources and heavy environmental impacts. According to the Global Energy & CO2 Status Report of the International Energy Agency (2019), energy consumption grew by 2.3% in 2018, which is nearly twice the average rate of growth since 2010. This can be explained due to higher heating and cooling needs in several parts of the world and the expanding global economy. Resulting from this higher energy consumption, is the 1.7% increase in energy-related CO2 emissions. Manufacturing is closely connected to natural resources, and industrial companies are large consumers of the primary sources of energy. As mentioned in the previous paragraph, the production costs related to a machine depend on several factors and one of them is the duration of each machine status and transition. By adopting computerized technologies, the production process is more efficiently designed and so the production costs per unit product can be reduced due to a shorter production time. This information led to the following hypothesis of the direct effect of sustainable process innovations on the production costs:

H1: The more a company invests in sustainable process innovations the lower the total productions costs will be.

However, energy consumption of manufacturing firms was brought to attention when energy prices were raised, ecological relevance became more important and the legislative pressure increased (Park et al., 2009). Manufacturing industries comprise one-third of the total world energy consumption, so efficient and effective manufacturing processes become more and more important (Yoon et al., 2015). From the study of Denkena et al. (2020) it can be learned that the energy demand of the machine tools' support units and auxiliary systems is high. In particular, cooling systems, cutting fluid supplies and hydraulic units have a decisive impact on the overall energy demand. As mentioned in paragraph 2.2.4, the rising cost of energy is one of the important factors associated with increased production costs at manufacturing facilities. Therefore, the trend raises to reduce the energy consumption costs of production systems (Shrouf et al., 2014). It is clear that energy consumption plays a large role when it comes to environmental effects. Energy consumption is included in the analysis to see whether there is an effect between the investment in energy- and resource saving technologies and the consumption of energy in the manufacturing industry. It is defined by the business dictionary (2019) as: "the amount of energy consumed in a process or system, or by an organisation or society". In this study this concept represents the amount of energy consumed and resources

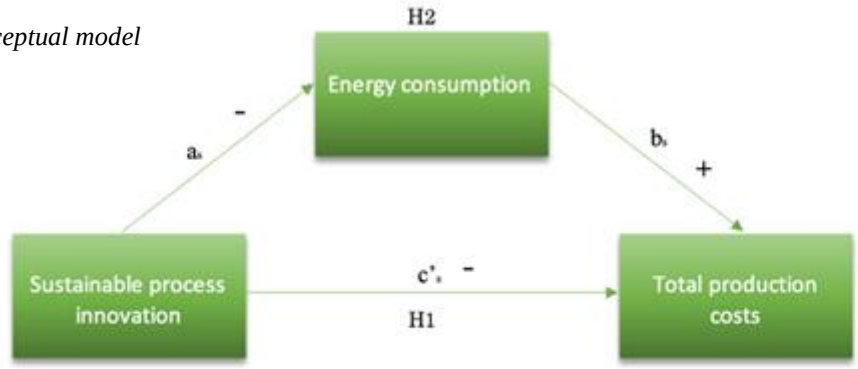
that are used by the manufacturing organisation, as a result of the investment in energy and resource saving technologies. The study of Greening, Greene, & Difiglio (2000) stresses that gains in the efficiency of energy consumption will result in an effective reduction in the per unit price of energy services. This more efficient energy consumption could lead to a reduction in production costs. In manufacturing industries, each machine involved in a different process has different levels of energy consumption. The level of energy consumption even varies in the same machine. According to Yoon et al. (2015) the total energy consumption and the total manufacturing costs affect each other, but are mainly affected by the process rate. The total process time decreases, as the process rate increases. As mentioned earlier, the study of Stucki (2019) states that firms with relatively high energy costs show significantly larger marginal effects of investments in green energy technologies on productivity than do firms with relatively low energy costs. By reducing the energy consumption, the costs could be reduced. It is expected that investment in sustainable practices, such as process innovation, will lead to better performance of the Dutch manufacturing firms by reducing the energy consumption. This increased performance should be reflected in a decrease in production costs. This assumption led to the following hypothesis including a mediator, which studies an indirect effect:

H2: Investment in sustainable process innovation leads to lower energy consumption of the firm, which in turn leads to lower total production costs.

2.4 Conceptual model

In this chapter the key concepts have been highlighted and subsequently, the hypotheses have been presented. A positive effect of process innovation on the total production costs of a firm is assumed. However, when including the mediator energy consumption, one expects a negative effect of the independent variable on the mediator and subsequently a positive effect from the mediator on the dependent variable. The conceptual model provides the reader with an overview of the concepts and their expected relation. To visualise the hypotheses of this research, the concepts are depicted in the conceptual model below.

Figure 1.1: Conceptual model



Chapter 3. Methodology

This chapter elaborates on the methodology used for this research study. The statistical program SPSS will be used to test the hypotheses quantitatively and open interviews will be held to test the hypotheses qualitatively. The reader will retrieve information about the research method and data collection. Subsequently, data inspection is addressed and the operationalisation of the research is explained. At last, the validity and reliability and the research ethics are elaborated on.

3.1 Context

In this research project, the research question, the concepts and the hypotheses were developed based on existing theory. Later on, the strategy on how to test the hypotheses was specified. This type of research is called 'deductive research' (Wilson, 2014). Deductive research is often used to explain causal relationships between concepts and variables and provides the researcher with the opportunity to measure the concepts quantitatively. The findings can, to a certain extent, then be generalised for a larger population.

3.2 Research method

For this thesis a quantitative research method is used. This type of research infers evidence for a theory through measurement of variables that produced numeric outcomes (Field, 2013).

At first, the data is examined and prepared. The error and the statistical power of the sample are determined. Then, the relationships between the variables are analysed using mediation analysis. Mediation analysis consists of executing multiple regression analyses. Regression analysis is a technique that tests and predicts a (possible) relationship (Field, 2013) between variables. Mediation analysis is used to determine the mechanism that explains the relationship between an independent and dependent variable (Field, 2013). It is conducted to set out the process underlying the relationship between the independent and dependent variable (Preacher & Hayes, 2004).

The sample for this research study was carefully selected to gain insight in the efforts of manufacturing firms in the Netherlands to modernise their production- and business processes. The survey was conducted throughout Europe, but for this research the researcher only focuses on the results of manufacturing firms located in the Netherlands. In total, integral, 8195 manufacturing firms in The Netherlands, with 10 or more employees, were approached to take part in the study. The firms were selected based on the type of industry, the economic activity and based on the number of employees. After 2 reminders, 502 firms started the online

questionnaire. At the end, the amount of valid cases retrieved, consisted of 177 firms, which is 5% of the total number of firms.

The data for research was collected from an existing data source, the European Manufacturing Survey (EMS) that covers the period from 2012 to 2014. The relationships between the different concepts were examined by using quantitative data from the European Manufacturing Survey, which was conducted between October and December, 2015. This online survey consists of questions that are based on modernisation of production and business processes and was executed by the Institute for Management Research of the Radboud University Nijmegen. To keep the scope of the project manageable for this timeframe, the researcher looked at a few key determinants in order to find relevant results particularly for the main research question and the sub-questions, as described in paragraph 1.2.

3.3 Operationalisation

In this paragraph it will be discussed how the concepts in the conceptual model will be measured. As mentioned in the previous paragraph, key determinants will be selected from the EMS survey and will be composed into measurable variables using the 'compute variable' function in SPSS. The relevant independent-, dependent- mediator- and control variables are mentioned below. Control variables are included in the analysis, since they might affect the dependent variables, so it is important to take them into account. The literature on statistical mediation analysis focuses predominantly on models with a dichotomous or continuous independent variable, yet in many studies, the independent variable is multi-categorical, which means that there are two ore more experimental conditions relative to a control group (Hayes & Preacher, 2014).

3.3.1. Independent variable

The independent variable is 'sustainable process innovation' (figure 1.1). Process innovation is measured by the degree of implementation of energy-saving technologies within the manufacturing firms. Since it cannot be assumed that all technological innovations are sustainable or energy-saving a distinction was made between the investment in energy-saving technologies as the independent variable and the remaining technological process innovations which are included in the analysis as control variables. Both types of process innovations can have a beneficial effect on the total production costs, but in this research study the focus lies specifically on the effect of energy- and resource saving technologies. When certain robots or software that stimulate sustainable energy are used, it indicates that sustainable technologies are adopted. Let it be clear that it cannot be stated that the adopted technologies do definitely

contribute to lower the energy consumption. They are called energy-saving technologies, but the actual effect must still be proven. The above-mentioned technologies in total consist of 23 separate technologies, so 23 items to include in the analysis. As stated earlier, a distinction is made between sustainable process innovations and remaining other process innovations which are included in the analysis as control variables. The researcher makes the assumption that all firms in the sample have the ability to adopt all types of technology. If they do is questionable and will also be a management decision, but for this research it is included in this manner. In the survey the respondents could answer for each of the technologies with 'yes', with a value of 1, or 'no', with a value of 0, indicating whether a technology is present in their firm. In addition, data was collected about the extent of used potential per technology implemented by the firm, but the researcher has chosen to remove these items from the analysis, since only approximately one third of the respondents has filled out these questions. Nevertheless, the researcher expects that the other items will give sufficient insight in sustainable process innovation.

An overview of the corresponding interview questions from the European Manufacturing Survey can be found in figure 2 below.

3.3.2. Dependent variable

The dependent variable is 'total production costs'. The variable 'total production costs' is of ordinal measurement level and is indicated by an increase or decrease in the development of the production costs per unit in 2014. The level of increase or decrease in the development of production costs is indicated by a scale ranging from -3, indicating a decrease of more than 10%, to 3, indicating an increase of more than 10%.

3.3.3. Mediator variable

A mediator variable is a variable that reduces the size and / or direction of the relationship between a predictor variable and an outcome variable and is associated statistically with both (Field, 2013). In this analysis, the mediator variable is 'Energy consumption'. This variable is measured by looking at the percentage decrease or increase of the development of Power consumption and oil- and gas consumption: difference 2014 – 2012 (Appendix 1, question 22.2, 22.3). For both the development of power and for the development of oil- and gas consumption there are 7 answer options that indicate the level of development. The researcher chose to add both power-, oil- and gas consumption to retrieve an overall picture of energy consumption, which results in a maximum value of 14. The score of the questions divided by the total sum score of 14 result in a percentage that indicates the total decrease or increase of

power- oil- and gas consumption. This is the mean development of power consumption and / or consumption of natural resources. In the end the values of the variable ‘Energy consumption’ indicate in the mediation analysis whether it interacts with the relationship between sustainable process innovation and total production costs.

3.3.4. Control variables

There are three control variables that are included in the analysis: ‘number of employees’ which indicates the firm size, ‘number of other technologies used’ and ‘energy costs as a percentage of turnover’. The differences in types of organization and the innovation processes in which they primarily engage are taken into consideration to help clarify the research results.

The ‘number of employees’ is included in the analysis as control variable, because when doing research in innovations the size of a firm could also have influence. In general, larger firms often possess more resources and knowledge, which they can use to develop innovations. They are likely to have an advantage over smaller organisations for the adoption of both radical and incremental innovations. To the contrary smaller firms are more flexible, which makes implementing new innovations easier (Damanpour & Wischnevsky, 2006). This variable is measured by the total number of employees at the firm establishment.

The ‘number of other technologies used’ is taken into consideration as control variable. As stated in paragraph 3.3.1. it cannot be assumed that all technological innovations are sustainable or energy-saving. Therefore a distinction was made between the investment in energy-saving technologies as the independent variable and the remaining technological process innovations which are included in the analysis as control variable.

At last ‘energy consumption as a percentage of the turnover’ is included as control variable. This control variable was included because the investment in process innovation by firms with a high energy consumption could have a larger effect compared to firms with a low energy consumption. The control variable corrects for this difference.

Variable type	**Variable name**	**Indicator**	**Min value**	**Max value**	**Corresponding EMS question (See appendix 2)**	**Code in SPSS**
Dependent	Production costs	Development of production costs per unit in 2014	*Decreased with 10% or more* 1	*Increased with 10% or more* 7	12	Vnl12a
Mediator	Energy consumption	Mean development of Power consumption and / or consumption natural resources: 2014 – 2012	*Decreased with 10% or more* 1	*Increased with 10% or more* 7	22.2, 22.3	pr_cons
Independent *Explanatory*	Sustainable process innovation	Number of technology process innovations used	0	1	8.1	EST
Control	Firm size	Number of employees (size classes)	1	5	21	sizelog
		Energy costs as a percentage of turnover (log)	0	1	21	1+v23k v23k_lg
		Number of other technologies used	0	1	8.1	OT

Figure 2: Overview of variables

3.4 Data analysis

As stated above, a quantitative analysis will be conducted using data from a survey in the form of a written questionnaire. The analysis is done using the software package SPSS Statistics. As soon as the data has been collected, it is important to check whether the data is suitable for the research project, which means that data inspection and preparation is required. This consists of assessing the sample size and checking for missing data as well as carrying out a reliability and validity analysis. Using the rule of thumb that missing values need to be < 10% (Field, 2013) the variables will be examined. Subsequently, the data can be transformed, if required, in order to make it fit with the type of analysis. The relationships between the variables will be analyzed using ordinal logistic regression analysis. Regression analysis is a technique that tests and predicts a (possible) relationship (Field, 2013). The reason that ordinal logistic regression was chosen is because the dependent variable is ordinal and has several categories and this type of regression assumes that the coefficients that describe the relationship between the lowest and the higher categories of the response variable are the same as those that describe the relationship between the next lowest category and all higher categories.

The chosen type of analysis for this research project is 'mediation analysis'. This choice is based on the fact that this technique is developed for a situation where the relationship between a predictor variable and an outcome variable can be explained by their relationship to a third variable (Field, 2013, p. 408). Mediation is said to have occurred if the strength of the relationship between the predictor and the outcome is reduced by including the mediator. A mediation analysis will be carried out and based on the statistical analysis, the research question will be answered.

In addition to the quantitative data collection method, a few semi-structured interviews are held to possibly gain some deeper understanding of the results of the data analysis. An interview script will guide the interviewer and interviewee through the interview, however there is room for extra subjects and follow up questions when needed. The interview transcripts can be found in appendix 3. The interviewer will ask open-ended questions in order to make sure that the interviewees can formulate their own answers and are not directed by the interviewer. The intention of the semi-structured interviews is to achieve clarification and understanding. Prior to the interview the interviewer asks permission for recording the interview.

3.4.1 The mediation model

Within mediation analysis, not solely the effect from the independent on the dependent variable is tested, but also the indirect effect of the variables when a mediator is added. The mediation model that is used for this analysis is called by Hayes (2009) 'the simple mediation model' and is depicted in figure 3 below.

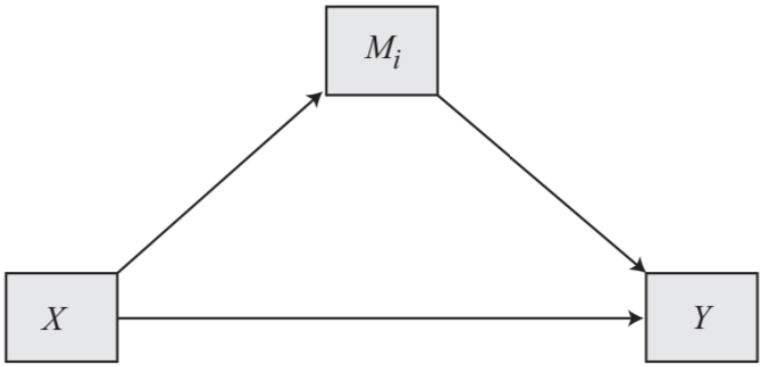


Figure 3: The mediation model (Hayes, 2009)

This model reflects a causal sequence in which X affects Y indirectly through mediator variable M. In this model, X, being the independent variable, is postulated to affect M, and this effect then propagates causally to the dependent variable Y. This indirect effect represents the mechanism by which X transmits its effect on Y. According to this model, X can also affect Y directly – the direct effect of X – independent of X's influence on M (Hayes, 2009).

According to Baron & Kenny (1986) to test for mediation, one should estimate a series of regression analyses, which are the following three regression equations: at first, a regression predicting the outcome from the predictor variable, second, a regression predicting the mediator from the predictor variable and third, a regression predicting the outcome from both the predictor variable and the mediator (Field, 2013, p. 410). However, this method has some limitations. The main limitation is the criterion by which mediation is assessed: the predictor variable must predict the outcome variable less strongly in model 3 (which includes the mediator) than in model 1 (where the mediator is not included). This is because, perfect mediation is shown when the relationship between the predictor and the outcome is reduced to zero in model 3, but this often does not happen. More likely is that one can see a reduction in the relationship between the predictor and the outcome, but not being reduced to zero.

Therefore, the researcher did consider to estimate the indirect effect and its significance by using the Sobel test, which assumes that mediation occurs if the relationship between the predictor and the outcome was significant when looking at the direct effect and not significant

when the mediator is included (Field, 2013, p. 411). Anyhow this test works well in large samples, but the method of Baron & Kenny is preferred with smaller sample sizes like in this research in order to attain the same statistical power.

The first analysis conducted will consist of the independent variable 'sustainable process innovation' and the dependent variable 'total production costs'. When this analysis results in a significant influence from sustainable process innovation on the total production costs, it indicates that there is a possibility that there is a mediating effect.

The next step in mediation analysis as described by Baron & Kenny (1986) includes the analysis of the both the independent variable 'sustainable process innovation' as well as the mediator 'energy consumption' on the dependent variable 'total production costs'.

3.4.2 Validity and Reliability

The validity and reliability of the study are checked in order to reduce measurement error. These are important characteristics of a measurement and should therefore be taken into account. Validity is defined as: "The extent to which a measure or set of measures correctly represents the concept of study - the degree to which it is free from any systematic or nonrandom error" (Hair, Black, Babin & Anderson, 2009, p. 3). Here a distinction is made between two types: external validity, which refers to the possibility of generalisation of the results, and internal validity, which is about the question whether you measure what you want to measure. The external validity is maximized by offering the participating firms a free benchmark report where companies could compare themselves with other companies on multiple indicators. The internal validity was increased by including detailed questions in the survey. Besides, pilot surveys were conducted and international meetings were held with representatives of 15 countries, where the formulation of the questions was intensively discussed and the survey was developed.

Reliability is defined as: "The extent to which a variable or set of variables is consistent in what it is intended to measure. The reliability of this research study lies in the fact that the questions that are asked in the survey are very detailed and specifically designed for. Besides, no opinions are asked, it solely includes objective data, such as facts, investments and performance numbers. Furthermore, two reminders were sent in order to increase the amount of participating firms, and thus the generalizability of the study. Both analyses are carried out in SPSS to make sure that the data is appropriate for the subjects that are being studied.

3.5 Research ethics

When conducting research, it is inevitable that ethical tensions will occur. It is important to pay attention to the social side of doing research, like human morality and fairness, in order to be able to present a well-substantiated research report that complies with the general expectations of conduct. Guillemin & Gillam (2004) distinguish between two different dimensions of ethics in research: procedural ethics and "ethics in practice". Procedural ethics is focused on seeking approval from a certain ethics committee for doing research with humans. "Ethics in practice" is concerned with ethical issues that arise throughout the research study, in everyday life.

Most ethical issues seem to occur when doing qualitative research, since then people are often personally involved. However, also in quantitative research, it is important to take into account the norms and values of people as well as their expectations of ethical behaviour. Transparency in regards to the purpose of the study and the use of data, is of utmost importance. All participants of this study were asked and could voluntarily decide whether to participate or not. The researcher made sure to be transparent about the use of data, and guaranteed confidentiality and anonymity, unless otherwise indicated. By providing the participants the opportunity to receive results of a benchmark of a company of their choice, the research results can contribute to the performance of companies. The participants were aware of the availability of the data for this purpose and were informed to be able to withdraw from the research study at any time. The researcher respected the privacy of data and the vulnerability of it. All data that was retrieved from the participants was treated and secured with the utmost care, in order to adhere to the General Data Protection Regulation (GDPR) and the GDPR Implementation Act (Europese Commissie, 2018). At the end of the research study, the researcher signed the research integrity form, which can be found in appendix 4, to guarantee and reconfirm, that this research study was carried out according to the expected ethical standards.

3.6 Summary

In this chapter the chosen research method has been addressed and it was necessary to operationalize the concepts to make them measurable. Now both the theory and methods have been discussed, the following chapter is about the results. This chapter consists of the results of the regression analyses which are part of the mediation analysis, and it gives the reader insight in the statistical outcomes, which were used to answer the research question.

Chapter 4. Results

In this chapter all results that are retrieved from the quantitative research study are stated. Several analyses in SPSS were carried out, in which the relevant data of the European Manufacturing Survey was implemented. All the statistical analyses are conducted with IBM SPSS statistics 25.

4.1 Introduction

In this chapter the analysis of data, gathered through the questionnaire, is covered and the results are presented. In paragraph 4.2 the sample is described and the sample size is checked. According to Hair et al.'s chapter 2 (2014), there are certain rules and assumptions you should follow when analyzing data. In paragraph 4.3 the variable construct is presented in which the impact of missing data is evaluated, extreme values are identified and the assumptions of multivariate analysis are tested. Paragraph 4.4 outlines the univariate analysis, paragraph 4.5 the bivariate analysis and at the end of this chapter, in paragraph 4.6, the results of the mediation analysis, consisting of an ordinal regression analysis, are stated. The hypotheses formulated in the second chapter are tested on the basis of these results.

4.2 Response

4.2.1 Sample size

As mentioned in paragraph 3.2, the sample size of this research study is 177. In total 177 firms participated in the questionnaire. The data retrieved is from the European Manufacturing Surveys that were held in 2015 to acquire insight in the efforts manufacturing firms make to modernize their operations in regards to sustainability. The aim of a survey is to collect representative data of a population (Bartlett et al., 2001). The participating organizations are operating in the production (manufacturing) industry and count at least 10 employees. The survey was answered by a chief executive officer or production manager of these organizations.

One of the aims, and at the same time a major issue of a survey, is the representativeness. This is required to be able to generalize the results and to increase reliability. Through cross-checking with statistics of the Central Agency of Statistics, representativeness of the Dutch EMS survey is confirmed. This means that the Dutch sample is representative for the Dutch manufacturing population.

The larger the sample, the larger the power of the statistical test. It is of high importance to keep track of the power, since it should not be too high or too low, because it could then either be difficult to find significant effects or almost any effect is significant (Hair, et al.,

2009). The sample size is related to the effect size and the choice of the value of alpha. Field (2013) describes the criteria from Cohen and his benchmark of .8 from 1988. It is stated that 55 as sample size is the absolute minimum and with six or fewer predictors a sample size of 100 is sufficient. Since in this research there is 1 predictor and the sample size is 177 it is sufficient for further analysis. In addition to the questionnaire, two interviews were held with manufacturing firms in order to see whether the answers support the results of the analysis. The two firms were selected on the basis of representativeness and equal characteristics as the firms in the questionnaire. One interview was held with the Managing Director of [Name company1].. The company focuses on electrical engineering and has 300 employees. Besides their service, [Company 1] also produces electrical solutions on request. The other interview was held with the Production Manager of [Name company 2].. This company develops and manufactures a wide range of flail and rotary mowers, shredders and strip cleaners. The firm size is 95 employees.

4.3 Variable construction

Some of the variables are constructed out of several items in the questionnaire. In this paragraph the results of a scale analysis, Cronbach's alpha, are stated in order to check whether the items are sufficiently interrelated for merging them and it is described how the several items are joined into one variable. Often when using categorical variables in the analysis as predictors, there are more than two categories. In order to be able to include the variable in the analysis a dummy variable is created. A dummy variable represents a way of recoding a categorical variable with more than two categories into a series of variables all of which are dichotomous and can take on values of only 0 or 1. These variables are also mentioned in this paragraph.

Cronbach's alpha is used to measure internal consistency. This means that it checks how closely related a set of items are as group. For all separate items this check was done, before constructing the variables. The researcher is aware of the fact that Cronbach's alpha only looks at the mutual correlations and so tells something about the reliability of the scale, but nothing about the validity. The assessment of validity is done with factor analysis and this is an iterative process in combination with the assessment of reliability.

All variables have a value for Cronbach's Alpha above the threshold of .7, this means that there is sufficient consistency between the answers of the respondents on the questions asked in the survey. Except from the independent variable 'sustainable process innovation', here Cronbach's alpha has a value of .619., which means that the consistency between the

answers of the respondents on the technologies used are lower than of the other variables. Nonetheless, a value between .6 and .7 indicates a moderate score on reliability. The researcher decides to not delete any items from the analysis.

4.3.1 Data transformation

In order to make sure that the data fits the type of analysis, in this case mediation analysis, the data should be prepared. In transformation, a variable is replaced by an adapted version of the variable to change the shape of a distribution or relationship.

The dependent variable 'production costs' consists of item Vnl12a which indicates whether there has occurred a decrease or an increase in production costs per unit in 2014. This variable has a scale of 1 to 7. A value of 1 indicates a decrease of more than 10% and a value of 7 indicates an increase of more than 10% of costs per unit.

The mediator variable 'energy consumption' consists of two items: Vnl22a_7c and Vnl22b_7c. These items represent the change in development of power consumption in 2014 and the change in development of oil and natural gas consumption in 2014. This change is expressed in a decrease or increase and consists of a range from 1 through 7. The items are summed and then the function 'rnd' in SPSS is used to round up the scores. The value must be numeric and cannot be 0, the default is 1. It returns the integer nearest to the higher value. Both items are merged in the mediator variable 'pr_cons'.

The independent variable 'sustainable process innovation' consists of in total 23 items that represent the sustainable technologies implemented by the firm. Respondents could answer this question with 0 when the technology was not implemented and 1 when the technology was implemented. The independent variable 'vTechnProcess' is recoded into two items: 'dTechnProcess' which represents the firms with technology process innovations used and 'd2TechnProcess' which represents the firms with 2 or more technology process innovations used. With the chosen values of 0 and 1 the calculated independent variable 'sustainable process innovation' could range between 0 and 1. When the firm adopted 0 or 1 sustainable technology the score is 0 and when the firm adopted 2 or more technologies the score is 1. Afterwards both results are merged to one variable 'EST' which stands for the number of energy and resource saving technolgies used'.

The control variable 'number of other technologies used' is represented by the sum of all technologies which are not considered as sustainable technology. This control variable is named in the analysis as 'OT'. Firm size is expressed by the number of employees. Except from the number of employees, all variables are normally distributed. Due to a transformation of this variable, it is now more normally distributed as well. The researcher used a log 10

transformation for number of employees. This transformation is used when data is highly skewed, the data is not symmetric. A log 10 transformation was also done for the 'energy costs as a percentage of turnover'. This is the third control variable and is named 'v23k_lg'.

4.3.2 Missing data

Missing data stands for the information that is not available for a certain subject, for which other information is available (Hair et al, 2009). In this study it could, for example, occur when a respondent fails to answer a question in the survey due to an accidental missing or mechanical fault. In order to define the missing values an analysis was done in SPSS checking whether any user missing- or system missing values needed to be specified. When an item has missing values above 10% or when a respondent has not filled in more than half of the questionnaire (Field, 2013) it might affect the results of the analysis and therefore should be acted upon. From all items, the missing values are below the threshold of < 10% and so the analysis can be continued.

4.4 Univariate analysis

This paragraph describes the results from the univariate analysis. Each individual variable is analyzed univariately, by looking at the descriptive statistics. In the tables below one can see the descriptive statistics per variable. Table 1 shows the descriptive statistics of the independent variable 'sustainable process innovation'. For this variable the respondents could get a score from 0 to 6. The mean (1,62) is rather low which implies that little respondents implemented many sustainable technologies. The level of skewness and kurtosis is both sufficiently low. The outcome of skewness / SE skewness = 4.38 and kurtosis / SE kurtosis = -.25. Hair et al. (2010) argued that data is considered to be normal if skewness is between -2 to +2 and kurtosis is between -7 to +7. A transformation of this variable was not needed (Field, 2013).

Sustainable process innovation (EST)

Valid	177
Mean	1,6158
Std. Deviation	1,5148
Skewness	,803
Std. Error of Skewness	,183
Kurtosis	-,093
Std. Error of Kurtosis	,363
Minimum	,00
Maximum	6,00

Table 1: Statistics independent variable

Furthermore, table 2 shows that the values for skewness and kurtosis from the dependent variable and the mediating variable are sufficiently low as well. This conclusion was drawn from the outcomes for the production costs: skewness / SE skewness = -.158 and kurtosis / SE kurtosis = -1.149 and the outcomes for the energy consumption: skewness / SE skewness = -.522 and kurtosis / SE kurtosis = 1.615.

	Percent change in production costs per product unit in 2014 (Vnl12a)	Development in energy consumption (pr_cons)
Valid	177	145
Mean	3,8757	3,9172
Std. Deviation	1,2776	,9754
Skewness	-,029	-,105
Std. Error of Skewness	,183	,201
Kurtosis	-,417	,646
Std. Error of Kurtosis	,363	,400
Minimum	1,00	1,00
Maximum	7,00	7,00

Table 2: statistics dependent variable and mediator

For kurtosis the dependent variable ‘production costs’ has a negative score. The variable ‘energy consumption’ has a positive value. The positive values indicate a peaked and narrow division and a negative value indicates a flat and broad division of scores, so for the above mentioned variable ‘production costs’ with a negative value the answers of the respondents are more widely spread than that there is an extensive high score on some of the questions.

From table 3 the conclusion can be derived that there are not a lot of firms who have implemented many technologies since the mean of this variable is 3,858 implemented technologies. This could be due to the fact that a new technology is often quite costly to invest in. Besides, the mean of the variable ‘number of employees’ which represents the size of a firm, is 1,604 which indicates that the firms in the response set on average have between 0 to 49 employees. Answer 1,00 is less than 20 employees and answer 2,00 stands for 20 to 49 employees.

	Number of other technologies used (OT)	% Number of employees (sizelog)	Energy costs as a percentage of turnover (v23k_lg)
Valid	177	177	128
Mean	3,8588	1,6041	,5587
Std. Deviation	2,6387	,4005	,3465
Skewness	1,125	1,490	,748
Std. Error of Skewness	,183	,183	,214
Kurtosis	1,995	5,744	1,383
Std. Error of Kurtosis	,363	,363	,425
Minimum	,00	1,00	,00
Maximum	15,00	3,89	2,00

Table 3: statistics control variables

4.5 Bivariate analysis

In order to test whether the different variables in the model correlate with each other a bivariate analysis was carried out. The correlations can be found in table 4.

	(1)	(2)	(3)	(4)	(5)	(6)
(1) Sustainable process innovation	1					
(2) Energy consumption	-,153	1				
(3) Other technologies	,434**	-,245**	1			
(4) Firm size	,426**	-,138	,498**	1		
(5) Production costs	-,019	-,004	-,039	-,061	1	
(6) Energy costs (% of turnover)	,133	-,017	-,060	-,004	-,025	1

** P < .01

Table 4: correlations between variables

What strikes is that the dependent variable ‘production costs’ does not correlate significantly with the mediator or the independent variable. This could lead to the conclusion that there is no mediating effect of energy consumption between the independent variable ‘sustainable process innovation’ and the dependent variable ‘production costs’ which means that hypotheses 1 and 2 are not supported. In these hypotheses it is assumed that investment in sustainable technologies would lead to lower production costs. Anyhow, from table 4 it can also be derived that ‘other technologies’ (r = -,245, P<.01) negatively correlate with ‘energy consumption’. Besides, ‘sustainable process innovation’ positively correlates with ‘firm size’ (r = ,426, P<.01) and ‘firm size’ also positively correlates with ‘other technologies’ (r = ,498, P<.01). These two results point at the possibility that it can be assumed that the larger the firm is, the more

sustainable technologies or other technologies are adopted or implemented. However, this should be further analysed.

Although the independent variable ‘sustainable process innovation’ does not correlate significantly with the mediator variable or the dependent variable as hypothesized, it does correlate with two control variables. According to the outcomes, it seems that the implementation of sustainable technologies is not significantly correlated with energy consumption, while the implementation of other technologies is.

4.6 Ordinal logistic regression

In this paragraph the results of the ordinal logistic regression are stated. By this ordinal logistic regression, the total effect is tested. The total effect (c) consists of a direct (c’) and an indirect relation (a*b). The analysis checks for multicollinearity and it is carried out for checking on the hypotheses. First, it will be checked whether there is a relation between sustainable process innovation and the development of the production costs. Then, the relation between sustainable process innovation and the development of energy consumption is assessed. At last, the relation between the development of energy consumption and the production costs will be tested.

4.6.1 Testing assumptions

Before a regression analysis can be conducted, it has to be checked whether the data meets the assumptions. There are four assumptions that are defined by Harrell (2015) concerning ordinal logistic regression:

- The dependent variable should be measured at the ordinal level.
- There are one or more independent variables that are continuous, ordinal or categorical (including dichotomous variables).
- There is no multicollinearity, correlation between the predictors, the independent variables.
- There are proportional odds, which is a fundamental assumption of this type of ordinal regression model and means that each independent variable has an identical effect at each cumulative split of the ordinal dependent variable.

The first two assumptions are met. The other assumptions will be tested and stated below. In order to check assumption number three to determine whether there exists correlation between predictor variables one can use the VIF value as described by Field (2013). However, since there is only one predictor variable in this analysis there is no indication for multicollinearity.

Table 5 shows the tolerance level and VIF value for the independent variable and the mediator variable. Since both VIF values are less than 10 and the tolerance levels are higher than .2, it can be assumed that there is no multicollinearity and this assumption is met.

	Collinearity statistics	
Variable	Tolerance	VIF
Sustainable process innovation	,977	1,024
Energy consumption	,977	1,024

a. Dependent variable: production costs

Table 5: Tolerance levels and VIF values of the independent and mediating variables

To check the fourth and last assumption regarding proportional odds, a full likelihood ratio test comparing the fitted location model to a model with varying location parameters is used. As can be seen in the model fitting table in appendix 1 the test shows, with a value of .983, it is not significant. This means that our full model, containing the independent variable 'sustainable process innovation', does not represent a significant improvement and fit over the null and does not fit the data well in relation to the intercept- or null only model. When looking at the 'goodness of fit' table which is useful for determining whether a model exhibits good fit of data, the Pearson Chi Square test is not significant since the value of .337 is above the threshold of .05. The deviance shows a significance value of 1 which means it is non-significant. Both results are non-significant and in this test this is the ideal situation, because this indicates that the model fits the data well (Field, 2018). As in this situation, it does occur that different tests do not agree with each other, so further research is required.

In the table 'parameter estimates' the regression coefficient and significance test for the independent variable are depicted. The regression coefficient can be interpreted as a positive and a negative estimate. A positive estimate can be interpreted as the predicted change in log odds of being in a higher category on the dependent variable, controlling for the remaining independent variable, per unit increase on the independent variable. This means that as scores increase on an independent variable, there is an increased probability of falling at a higher level on the dependent variable. For a negative estimate it means that as scores increase on an independent variable, there is a decreased probability of falling at a higher level on the dependent variable. As showed in the 'parameter estimates' table in appendix 1 the independent variable is not significant (.634). Because this is a binary variable, also called dichotomous, since it only has two possible levels, the slope can be regarded as the difference in log odds between groups. Then, the table of the test of 'parallel lines' shows a non-significant result of .997. When the result of this test is non-significant, the assumption of proportional odds is met.

One downside of using the full likelihood ratio test is that odds ratios are not shown. Moreover, the test results are based solely on the Wald test which can be less powerful than test results based on the use of Likelihood ratio chi-square tests. Therefore, an additional test was carried out using the generalised linear model option. At first, the P-value of .989 indicates that there is no statistically significant effect of the independent variable sustainable process innovation on the dependent variable total production costs.

In the table appendix 1 the Exp (B) values, can be found. This column contains the odds ratios reflecting the multiplicative change in the odds of being in a higher category on the dependent variable for every one unit increase on the independent variable, holding the remaining independent variable constant. An odds ratio > 1 indicates an increasing probability and an odds ratio < 1 indicates a decreasing probability. The independent variable 'sustainable process innovation' has a regression coefficient (B value) of .040, which indicates that for every one unit increase on sustainable process innovation, there is a predicted increase of .040 on the log odds of being in a higher level of the dependent variable total production costs.

According to the results of the analysis above, all assumptions mentioned in this paragraph in regards to ordinal logistic regression are met.

4.6.2 Model statistics

To be able to identify what the main effect of sustainable process innovation on the development of the total production costs is and to see what the effect is of the mediator variable energy consumption, three regression analyses were carried out. The results of these three analyses are depicted in table 6, 7 and 8. The mediator energy consumption consists of power and oil- and gas consumption and in order to test hypothesis 2, in the analysis these two energy sources are separated. In the tables, column 1 and 2 clarify the effect of sustainable process innovation on the development of production costs, column 3 and 4 of the table show the effect of sustainable process innovation on the mediator and column 5 and 6 show the effect of sustainable process innovation on the development of production costs mediated by the energy consumption.

At first, the R^2 needs to be assessed in order to check the amount of variance in the dependent variable that is explained by the model (Field, 2013). In table 6, 7 and 8 one can find the Nagelkerke R^2 values which provide an indication of this amount of variation. It is remarkable that for all three analyses the effect size is quite low with a value of .04. Anyhow, in table 7, when including the mediator power consumption, the effect size changes to .06, which indicates a moderate effect. The same occurs when including oil- and gas consumption. So when including the mediator with both power-, oil- and gas consumption, there is no

difference in effect size, but when separating these sources, the effect size becomes larger. This means that due to the inclusion of the mediator, power consumption or oil- and gas consumption, the model fits the data better.

4.6.3 Hypothesis testing

In table 6 one can find the overall, direct- and indirect relationship between investment in sustainable process innovation and the development of the production costs. For testing the hypotheses, regression analyses were carried out and these are depicted in table 6. The mediator 'development of energy consumption' operates in some analyses as the dependent variable and in some as an explanatory variable. Therefore, this variable is included in the rows (independent variable) as well as the columns (dependent variable).

THE EFFECT OF SUSTAINABLE PROCESS INNOVATION

Hypothesis 1 stated that: *The more a company invests in sustainable process innovations the lower the total productions costs will be.* At first, as can be seen in table 6, column 1, the overall effect was shown. The overall effect indicates whether there is a correlation between the independent variable sustainable process innovation (EST) and the dependent variable total production costs (vnl12a) As the result in figure 4 indicates (.08, p =.52), there is no significant direct correlation between both variables with a P-value above the threshold of .05.

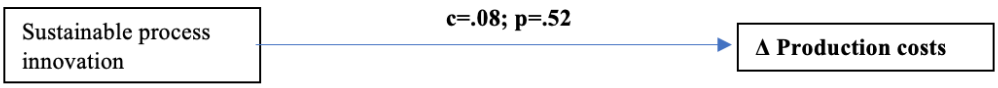


Figure 4: The overall effect of the IV on DV

This outcome does not support hypothesis 1. A negative correlation was expected and this outcome does not even show a significant correlation. This result will be further elaborated upon in the paragraph with 'other findings'.

Hypothesis 2 stated that: *Investment in sustainable process innovation leads to lower energy consumption of the firm, which in turn leads to lower total production costs.*

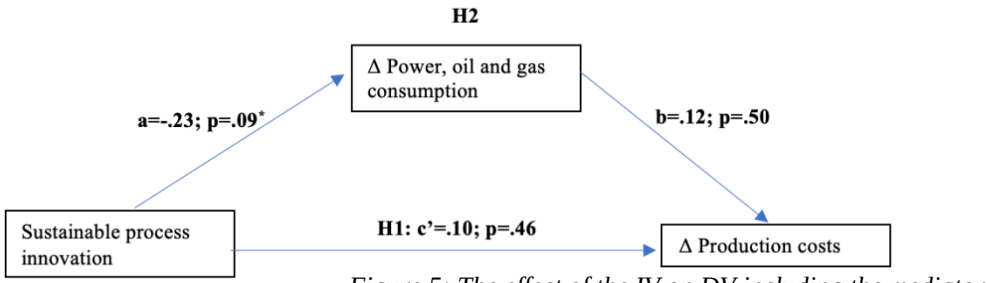


Figure 5: The effect of the IV on DV including the mediator

In figure 5 all variables that are included in the analysis are depicted. Both hypothesis 1 and hypothesis 2 are shown with the corresponding effects as stated in table 6. As mentioned above the first part of hypothesis 2, which states that there is a negative relation between sustainable process innovation and energy consumption, can be confirmed. This is in line with the interview with the Managing Director of [Company 1] which is paraphrased: What has always been important are the fuel costs that we have at [Company 1]. We have about 150 cars driving around and yes, the fewer traffic movements we have, the less time the mechanic is on the road and also the less fuel is used. I think if you add that translation that we do make a considerable contribution to the reduction of energy, but I have no idea how much that we consume in total ([Director], 2019).

However, when testing whether there is a significant effect between the development of energy consumption and the development of production costs per unit in 2014, the conclusion was derived that there was no significant effect (column 5), which means that investments in sustainable process innovation do not have significant effect on the total production costs when mediated by the energy consumption of a firm. Moreover, it is certainly no beneficial effect which would lead to a decrease in production costs, because the sign is positive. This outcome is not supported by the outcome of the interview with the Managing Director of [Company 1] since he stated that since they automated many processes and reduced their waste flows they could produce faster, by using less light and energy and so he stated that that is where there profit lies ([Manager], 2019).

Nevertheless, with the result of hypothesis 1 this result could be expected, since this hypothesis states that reduction in energy consumption would result in a decrease of the production costs, but there is no significant direct correlation between the independent variable and the dependent variable, so an indirect effect would not be possible either. Anyhow, in order to check, the researcher assessed the effect of sustainable process innovation on the total energy consumption as shown in table 6 (column 3) and the mediator variable, including both power consumption and oil- and gas consumption. It shows a negative relation (-.23, $p < .10$). As expected by the researcher, this means that the more sustainable technologies are implemented, the stronger the decrease in energy consumption. Successively, hypothesis two was tested including the predictor, the mediator and the outcome variable. The results are depicted in column 5 and 6 of table 6.

Table 6: Overall, direct and indirect relationship between sustainable process investments and change in production costs							
		Δ Production costs				**Δ Production costs**	
		B (SE)	**Wald**		**Wald**	**B (SE)**	**Wald**
Control variables							
Sizelog	Number of employees (log)	.36 (.57)	.39	-.28 (.61)	.20	.40 (.59)	.46
Industrial sectors	Metal	**Δ Power, oil and gas consumption B (SE)**		Reference			
	Food	-.37 (.63)	.35	1,16 (.67)*	3.01	-.3 (.64)	.37
	Textile	-.59 (.56)	1.10	-,02 (.60)	.00	-.57 (.56)	1.03
	Construction	.003(.67)	.00	-,42 (.71)	.36	.04 (.67)	.00
	Chemistry	-1.06(.59)*	3.21	1,9 (.74)***	8.50	-1.11 (.61)*	3.34
	Machinery	.057 (.54)	.01	,30 (.58)	.27	.08 (.55)	.02
	Electronics	-.13 (.51)	.06	-,09 (.54)	.03	-.10 (.51)	.04
OT	Other technologies used	-.62 (.08)	,57	-.09 (.09)	1.08	.47 (.08)	.53
V23k_lg	Energy costs as a percentage of turnover	-.15 (.48)	.10	.15 (.52)	.08	.74 (.49)	.11
Explanatory variabele							
EST	Energy Saving Technologies	.08 (.13)	.42	-.23 (.14)*	2.81	.10 (.13)	.55
Mediator							
pr_cons	Δ Power, oil and gas consumption					.12 (.18)	.45
Model information:		Ordinal logistic regresssion					
Model χ^2		4.58		22.43**		4.98	
Nagelkerke R^2		.04		.18		.04	
N		127		126		126	
Notes:	(*)p <,15; *p <,10; **p <,05; ***p <,01						

Mediation occurs when the relationship between predictor and outcome variable becomes less strong due to the addition of the mediator. The regression parameter for c' is then smaller than for c. If c' is 0, there is perfect mediation. When the mediator is added, there would be no further relationship between predictor and outcome. In mediation you can have a direct effect, the relationship between the predictor and the outcome, while you control for the mediator, and you can have an indirect effect, the effect of the predictor on the outcome through the mediator (Field, 2013). As can be derived from table 6, the result when the mediator is not included in the model: c' = .08. The result when the mediator is included in de model: c = c' + a*b = .10. In this analysis the regression parameter for c' with a value of .08 is smaller than for c with a value of .10. This indicates that mediation does not occur since the relationship

between the predictor and the outcome variable becomes slightly higher due to the addition of the mediator. If c' is 0 there would be perfect mediation, however this is not the case. Besides, since the results are not significant there is no ground to derive statistical conclusions regarding the effects of the variables.

Thus, investments in sustainable process innovation by implementing sustainable technologies have no significant effect on the development of production costs nor energy consumption.

OTHER FINDINGS

In general, the results from table 6 lead to the conclusion that the indicators which were included in the analysis do not clearly explain the development of energy consumption. This could be due to the fact that the investments have been implemented a short time ago which would mean that the economic benefits were not visible yet. As stated by Gerwin (1988) the long run advantages cannot be precisely determined on forehand and it takes time before result will be visible. The study of Hami, Muhamad, & Ebrahim (2015) describes that the results from their study, using survey data collected from 150 Malaysian manufacturers, suggest that the application of pollution prevention methods, clean technologies and sustainable human resource practices are linked to improvement of operational efficiency as well as increased financial and market performance. As described by them, financial performance can be dependent on the number of emissions. Following their theory, firms with high emissions have higher benefit on financial performance than firms with low emissions. Furthermore, the study of Stucki (2019) states that firms with relatively high energy costs show significantly larger marginal effects of investments in green energy technologies on productivity than do firms with relatively low energy costs. As mentioned in paragraph 2.2.4, the rising cost of energy is one of the important factors associated with increased production costs at manufacturing facilities. However, the reason that the indicators included in the analysis do not sufficiently represent the development of energy consumption could also lie in the operationalisation of the study. The researcher chose to only include the data in the analysis which explained whether a technology was adopted by a firm or not, but the potential for implementation and the level of adoption was not taken into account. Besides, the time frame since when a technology had been implemented was not included. This could have said something about the possibility for the effect on the production costs. Also, the rising cost of energy and the current energy costs were not taken into account, which could have led to different results.

The first regression analysis tested whether there was a relation between the independent variable and the dependent variable at all. No correlation could be retrieved from

this analysis and so there was no direct effect from sustainable process innovation on the total production costs of a firm. Anyhow, the researcher carried out additional analyses to check for this effect, but focused in the second hypothesis on the mediation effect. From the analysis possible other significant effects could become visible. One of the results did expose the negative relationship between the independent variable and the mediator, which was also supported by the qualitative interviews with two manufacturing firms. Both firms stated that the investment in sustainable process innovation did contribute to lower energy consumption, however they could not directly confirm the reduction in the total production costs per unit. Paraphrased from the production manager of [Company 2].: Suppose we have 10,000 m2 of solar panels in a year. That is an investment of about 1 million euro. It would lead to a reduction in electricity- and gas costs, but it will take a while before it is earned back. Nevertheless, we do think that this will have a significant effect.

What further occurs from the results is that in the chemistry sector, there is a negative significant effect on the production costs. This is the only control variable that is significant. The chemical industry seems to experience relatively strong decreases in production costs, which, however, do not seem to be due to the development in energy consumption. According to the univariate analysis, it can be seen, in table 9, that at firms which do consume much energy (column 2) the production costs decrease faster (column 5) than at firms that have lower energy consumption. It is remarkable that the construction-, machinery- and the chemical sector consist of the largest firms in terms of the number of employees, but the energy costs as percentage of turnover are relatively low. Although, the energy costs of the firms in the chemistry sector are a large part of the turnover (51%), it is not the highest percentage compared to textile sector, in which 73% of the turnover consists of energy costs. This would be contradictory to the findings in the study of Stucki (2019) in which is stated that firms with relatively high energy costs show significantly larger marginal effects of investments in green energy technologies than do firms with relatively low energy costs. However, since it is a percentage, it would not say that the energy costs are not high, they are relatively a smaller part of the turnover.

Additionally, an interesting result is that ‘other technologies used’ does negatively correlate with ‘energy consumption’. There is a strong correlation and therefore the researcher checked this possible relation in the regression analyses. As shown in table 6, 7 and 8 it can be seen that there is a negative direct effect of ‘other technologies used’ on the dependent variable production costs. Which would mean that the more a firm invests in other technologies, the more a firm would be able to decrease its production costs. However, in table 6 it is also shown

that when including the mediator variable energy consumption, there is no negative effect at all and the sign even becomes positive. After separation of both power-, oil- and gas consumption, the negative effect occurs (table 7 and 8). Anyhow, it is noteworthy that in none of the regression analyses a significant effect between 'other technologies' on 'energy consumption' could be found. This means that the data does not sufficiently represent this relation and therefore no conclusions can be derived.

Besides, for all firms, the number of employees ranges from 20 to 99 employees. There are some differences in the mean which are displayed in appendix 1, bivariate analyses, but no large differences are identified. At last, what strikes is that for all firms in the sample, the change in production costs per product unit in 2014 was not more than between -5% to remaining stable. Although the independent variable 'sustainable process innovation' does not correlate significantly with the mediator variable or the dependent variable as hypothesized, it does correlate with a few control variables. According to the outcomes, it seems that the implementation of sustainable technologies is not significantly correlated with energy consumption, while the implementation of other technologies is. This might be interesting for further research to gain a deeper understanding of what the effect of other technologies on energy consumption could be.

POST HOC ANALYSIS

Since the effect of the independent variable sustainable process innovation, on the mediator energy consumption provided a significant result, the researcher decided to carry out a post hoc analysis in which the types of energy sources in oil- and gas consumption and power consumption were separated to see whether the difference in energy source would lead to additional results. In table 7 and 8 one can find the overall, direct- and indirect relationship between investment in sustainable process innovation, the development of the production costs and the role that energy consumption plays in terms of power and oil- and gas. At first, power consumption was added as the mediator variable. When comparing the results of this analysis with the results from the initial analysis (table 6) it becomes visible, as shown in figure 6,

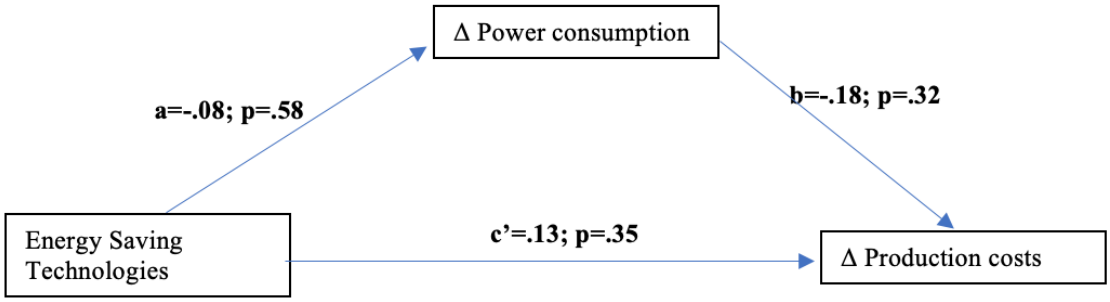


Figure 6: The effect of the IV on DV including the mediator power consumption

that the significant negative effect from sustainable process innovation on energy consumption (-.23, p <,10) has disappeared when only testing for power consumption. This would mean that there is no statistically significant effect when power consumption is included and so the data does not confirm that investments in sustainable technologies do have influence on the development of power consumption of a firm. Anyhow, table 7 also shows that there is a significant positive effect (p <,01) between oil- and gas consumption and power consumption, which indicates that when the oil- and gas consumption becomes higher, the power consumption also increases and vice versa. Again a significant result can be seen at the chemical sector.

Table 7: Overall, direct and indirect relationship between sustainable process investments and change in power consumption							
		Δ Production costs				**Δ Production costs**	
		B (SE)	**Wald**		**Wald**	**B (SE)**	**Wald**
Control variables							
Sizelog	Number of employees (log)	.36 (.57)	.39	-,16 (.66)	.06	,38 (59)	,41
Industrial sectors	Metal	**Δ Power consumption B (SE)**		Reference			
	Food	-.37 (.63)	.35	,04 (.70)	,00	-,43 (64)	,44
	Textile	-.59 (.56)	1.10	-,25 (63)	,16	-,67 (57)	1,40
	Construction	.003(.67)	.00	,03 (.75)	,00	,07 (67)	,01
	Chemistry	-1.06(.59)*	3.21	,68 (66)	1,08	-1,05 (61)*	3,01
	Machinery	.057 (.54)	.01	,36 (.61)	,34	,15 (55)	,08
	Electronics	-.13 (.51)	.06	,07 (.57)	,02	-,05 (51)	,01
OT	Other technologies used	-.62 (.08)	,57	-,06 (09)	,40	-,07 (08)	,66
V23k_lg	Energy costs as a percentage of turnover	-.15 (.48)	.10	.47 (.54)	.78	-,09 (49)	,04
NL22b_7c	Δ Oil and gas consumption			2.17 (.27)***	66.97	,31 (22)	1,97
Explanatory variable							
EST	Energy Saving Technologies	.08 (.13)	.58	08 (.15)	.30	,13 (.13)	,87
Mediator							
NL22a_7c	Δ Power consumption					-,18 (.18)	1,00
Model information:							
Model χ^2		4.58		95.32***		6.90	
Nagelkerke R^2		.04		.56		.06	
N		127		126		126	
Notes:	(*)p <,15; *p <,10; **p <,05; ***p <,01						

Secondly, the analysis was carried out with oil- and gas consumption as a mediator. The results can be found in table 8 and the conceptual model including the corresponding results is shown in figure 7. Power consumption was excluded from the analysis. What strikes is that in contrast to power consumption, gas- and oil consumption does significantly decrease when a firm invests in sustainable technologies (-,30, p <,05). In contrast to power consumption, it seems that the more firms choose to invest in sustainable innovations, the higher the decrease in oil- and gas consumption. Then it would be interesting to invest in sustainable process innovation, however no conclusions can be drawn regarding the production

costs, except that there is still no statistically significant effect between the sustainable investments and the development of the production costs per unit in 2014.

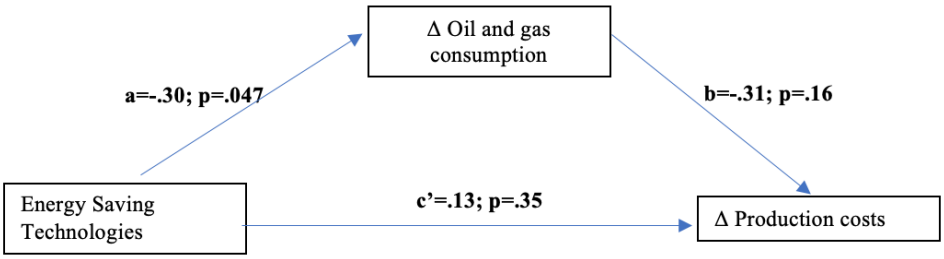


Figure 7: The effect of the IV on DV including the mediator oil- and gas consumption

Table 8: Overall, direct and indirect relationship between sustainable process investments and change in oil and gas consumption

		Δ Production costs				Δ Production costs	
		B (SE)	Wald	Δ Oil and gas	Wald	B (SE)	Wald
Control variables							
Sizelog	Number of employees (log)	.36 (.57)	.39	-,05 (69)	01	,38 (59)	,41
Industrial sectors	Metal	Reference					
	Food	-.37 (.63)	.35	,98 (.74)	1,78	-,43 (64)	,44
	Textile	-.59 (.56)	1.10	,23 (.66)	,13	-,67 (57)	1,40
	Construction	.003(.67)	.00	-,25 (.80)	,10	,07 (67)	,01
	Chemistry	-1.06(.59)*	3.21	,33 (.70)	,23	-1,05 (61)*	3,01
	Machinery	.057 (.54)	.01	-,00 (.66)	,00	,15 (55)	,08
	Electronics	-.13 (.51)	.06	,13 (.60)	,05	-,05 (51)	,01
OT	Other technologies used	-.62 (.08)	,57	-,04 (.10)	,16	-,07 (08)	,66
V23k_lg	Energy costs as a percentage of turnover	-.15 (.48)	.10	-,27 (.58)	,22	-,09 (49)	,04
NL22a_7c	Δ Power consumption			1,86 (24)***	62,26	-,18 (.18)	1,00
Explanatory variable							
EST	Energy Saving Technologies	.08 (.13)		-,30 (15)**	3,93	,13 (.13)	,87
Mediator							
NL22b_7c	Δ Oil and gas consumption					,31 (22)	1,97
Model information:							
Model χ^2		4.58		93.32***		6.90	
Nagelkerke R^2		.04		.57		.06	
N		127		126		126	
Notes:	(*)p <,15; *p <,10; **p <,05; ***p <,01						

One downside of solely using the results of the above-mentioned analyses, including the B-values and the Wald test, is that these results can be less powerful than test results based on the use of Likelihood ratio Chi-Square tests. Crucial to the interpretation of logistic regression is the value of the odds ratio which is the exponential of B. The odds ratio is an indicator of the change in odds resulting from a unit change in the predictor (Field, 2013). Therefore, the researcher carried out an additional analysis using the Generalized linear models option in SPSS to obtain this additional information. Below in table 9 the odds ratios are depicted based on a confidence interval of 95%. An odds ratio > 1 suggests an increasing probability of being in a higher level on the dependent variables as values on the independent variable increase, whereas a ratio < 1 refers to a decreasing probability with increasing values on the independent variable. When the odds ratio is equal to 1, no change is predicted.

Variable	Exp (B)
Number of employees (sizelog)	1,43
Food	,691
Textile	,555
Construction	1
Chemistry	,347
Machinery	1,06
Electronics	,882
Other technologies used (OT)	,940
Energy costs as a percentage of turnover (V23k_lg)	,859
Energy saving technologies (EST)	1,09

DV: Percent change in production costs per product unit in 2014 (Vnl12a)

Table 9: Odds ratios

As can be seen in table 9, the number of employees, construction and the energy saving technologies show a result higher than 1. Before, these variables were not significant predictors in the model. The odds ratio of the number of employees indicates that the odds of being in a higher category on the total production costs increases by a factor of 1,43 for every one unit increase on the number of employees. However, because the results of the regression coefficient were not significant, no conclusions can be derived. All the other variables show an odds ratio below 1 which point at a decreasing probability of being in a higher level on the total production costs variable as scores increase on these variables. Machinery equals the value of 1 which means that no change is predicted. Chemistry was the only significant negative predictor of the total production costs with a B-value of -1,11 (P<.10) which indicated that the

chemical industry seems to experience relatively strong decreases in the production costs. According to the odds ratio, the odds of being in a higher category on the total production costs increases by a factor of 0,347 for every one unit increase in the chemistry sector.

Accessorily, the researcher carried out the analyses with power consumption and oil- and gas consumption as the response variable. The ratio odds are stated in appendix 1. What stands out is the food sector. With a relatively high odds ratio of 3 on power consumption and a value of 4 on oil- and gas consumption one could draw the conclusion that the relationship between these variables is causal. It could be said according to these results that companies in the food sector are more likely to have higher energy consumption. Anyhow, no statistically significant result was found, so this conclusion cannot be confirmed.

The variable 'Energy saving technologies' has a statistically significant negative effect on the oil- and gas consumption. With an odds ratio of ,716 it can be stated that there is a decreasing probability of being in a higher level on the total oil- and gas consumption variable as scores increase on the number of energy saving technologies implemented.

4.7 Summary of the findings

The regression analyses do not provide support for hypothesis 1 and 2. These hypotheses assumed that the investment and implementation of sustainable process innovations, as sustainable technologies, would decrease the production costs of a firm. The explanatory variable sustainable process innovation is no predictor for the development of production costs. Besides, it became clear that there is no mediating effect of the development of energy consumption from the independent variable on the dependent variable either. From the odds ratios some deeper understanding of the results concerning the likelihood of an event happening could be derived. Nevertheless, only the statistically significant results could be supported by the odds ratio in order to see in what way the change in odds results from a unit change in the predictor variable.

The conclusions drawn from the results of the analysis can be found in chapter 5.

Chapter 5. Conclusion and discussion

5.1 Introduction

In this chapter, a short summary of the study and its results are presented. The main question will be answered and a conclusion is drawn. Thereafter, the theoretical and managerial implications of this study are described. At last, the limitations of this research will be discussed and recommendations for future research are provided.

5.2 Summary and conclusions

Nowadays, climate change and sustainability are the order of the day. People become aware of the consequences of their own behaviour, as effect on the environment. Energy demand is expected to increase significantly. Modelling of a UK government white paper from 2020 suggests that overall demand could double out to 2050. Furthermore by 2050, emissions from industry will need to fall by around 90 percent from today's levels. Energy consumption reduction and energy efficiency improvement in manufacturing is essential to achieve sustainable manufacturing. According to a study of Zhao et al. (2017) in the USA, the industrial sector accounts for 31% of the total energy consumption and manufacturing counts for 60% of the energy consumption in the industrial sector. Manufacturing has a large share and due to this, the energy consumption reduction in machining is of great importance to achieve sustainable manufacturing. Sustainable manufacturing is becoming crucial for businesses more than ever before (Gupta, Dangayach, & Singh, 2015).

This research aimed to identify whether sustainable investment for manufacturing firms pays off. Based on a quantitative and qualitative analysis of investment in sustainable process innovation on the development of the total production costs, mediated by energy consumption and conducted with data from 177 Dutch manufacturing firms, the following research question could not be confirmed:

Do investments in sustainable process innovation in manufacturing firms in the Netherlands pay off in regards to the total production costs?

Surprisingly, there were no significant results found that support the fact that the total production costs of manufacturing firms are influenced by the investment in sustainable process innovation. This is in contrast with the theory of Yoon et al. (2015) which states that the total energy consumption and the total manufacturing costs affect each other. However in that study it is also described that the manufacturing costs are mainly affected by the process rate. The total process time decreases, as the process rate increases. This data was not included

in the analysis. Anyhow, although a significant effect of the investment in sustainable process innovation on the energy consumption of a firm was found, specifically on the oil- and gas consumption, no mediation effect could be confirmed. Both hypotheses 1 and 2 have been rejected.

- H1: The more a company invests in sustainable process innovations the lower the total productions costs will be.
- H2: Investment in sustainable process innovation leads to lower energy consumption of the firm, which in turn leads to lower total production costs.

It does not explicitly prove that there is no relationship at all in general, but by using this particular data of this sample, the relationship is not significant. This outcome was not expected by the researcher since the existing data, as the study of Brossog et al. (2015), Hart & Ahuja (1996), Greening et al. (2000) and Hami et al. (2015) indicated that it pays off to be green and that the environmental and economic aspects are intertwined.

Although no significant relationship between the investment in sustainable process innovation on the total production costs was identified in this research, other remarkable results were identified. For example, the negative significant effect of the independent variable sustainable process innovation on the development of the energy consumption which was hypothesized by the researcher and is in line with part of the theory of Hami et al. (2015) in which they describe that the energy consumption would decrease when a firm implements sustainable technologies. The significant effect of the investment in sustainable process innovation on the energy consumption of a firm is too weak to explain a significant part of the variance, however it could be a reason for further analysis. Especially when looking at the post hoc analysis, where the significant effect on oil- and gas consumption became visible. Furthermore, the control variables ‘firm size’ and ‘other technologies’ significantly correlate with sustainable process innovation, which means that these aspects could influence the number of sustainable technologies that are implemented by a firm. The conclusion can be drawn that ‘other technologies’, which have not been specified in the sample, were adopted by firms and could lead to different results. Moreover, the chemical sector is one of the industries with the highest energy consumption and it shows a relatively strong decrease in production costs, which did not seem to be due to the development in energy consumption. The results show that firms which do consume much energy decrease faster in production costs than at firms that have lower energy consumption.

All in all, the results point to the conclusion that there is not one clear answer to the question whether investment in sustainable process innovation has effect on a firm's performance, but that further research might be of high relevance.

5.3 Theoretical and practical implications

This study led to the result that neither the explanatory variable sustainable process innovation nor the development of energy consumption has a significant effect on the development of production costs. From this research it could be concluded that there is still no clear answer to the question in what way sustainable investments could also contribute to economic performance. The researcher expected to be able to answer the main question, namely: Whether sustainability investments in the Netherlands would pay off. However, with the results from the analysis this answer could not be derived.

Dangelico and Pujari (2010) describe in their study that often business advantages are linked to the adoption of socially responsible behaviour. The researcher found by collecting data from existing literature that in many research studies (Russo & Fouts, 1997); (Chen, Lai Wen, 2006); (De Brito, Carbone & Blanquart, 2008); (Ameer & Othman, 2012), a positive relationship between these advantages such as efficient use of resources, increased sales and return on investment, and sustainable development is measured. Manufacturing industries comprise one-third of the total world energy consumption, so efficient and effective manufacturing processes become more and more important (Yoon et al., 2015). The studies of Greening, Greene and Difiglio (2000), Yoon et al. (2015) and Stucki (2019) all stress that the total energy consumption and the manufacturing costs affect each other and when investing in sustainable technologies the production costs can be reduced. Surprisingly, in contrast to the hypothesis of the researcher, the overall effect of sustainable process innovation on the total production costs is not statistically significant. The researcher did at least expect a significant effect since the collected data implies that there is a relationship between the investment in sustainable process innovation and the production costs of a firm.

The sample size of 177 is considered sufficient and the data retrieved from the European Manufacturing Survey that was held in 2015 do reflect what the researcher aimed to measure. Nevertheless, as mentioned in the previous paragraph, the reason for the non-significant result could be that the indicators which were included in the analysis do not clearly explain the development of energy consumption. This would mean that the sample would not be reliable due to the fact that the investments have been implemented a short time ago which would mean that the economic benefits are not visible yet. As stated by Gerwin (1988) the long run

advantages cannot be precisely determined on forehand and it takes time before result will be visible.

However, despite the fact that the research question could not be confirmed and both hypotheses 1 and 2 were rejected, the researcher is of the opinion that this research still contributes to the general body of existing literature. The results suggest that the investment in sustainable technologies could lead to lower levels of energy consumption, especially in terms of oil- and gas consumption. When looking at the main model including oil- and gas consumption as the type of energy consumption a significant result was shown. The first part of the second hypothesis could be confirmed. A negative relation between sustainable process innovation and energy consumption is shown. Especially when only testing for oil- and gas consumption, it was remarkable that in contrast to power consumption, the more firms choose to invest in sustainable process innovation, the higher the decrease in oil- and gas consumption. The researcher did expect the negative effect, but did not know what to expect from the two different energy sources. Future research on the type of energy sources and the difference in possible effects would be interesting. This model, including this type of energy would be an improvement over the null-model for the energy consumption in manufacturing firms. Furthermore, since the bivariate analysis shows a significant relation of the control variable 'other technologies used' and 'energy consumption' and a positive correlation between 'sustainable process innovation' and 'firm size' it can be of interest to zoom in on the difference in results in a longer time frame or to see what other technologies specifically would have an effect on the energy consumption and possibly on the development of production costs.

From the interviews it emerged that the firms did invest in sustainable process innovation and that especially the investment in the sustainable processes seemed to have an effect on the energy consumption. This carefully could be confirmed in this research. Anyhow, the researcher did not take the types of machines and the lifecycle of the machines into consideration.

From a managerial perspective, this research does not provide the results as initially aimed for. The aim of this research was to be able to show whether investments in sustainable process innovation in manufacturing firms in the Netherlands pay off, based on evidence derived from quantitative data. However, with no significant relationships found on the dependent variable there are no specific results that indicate and further explain the effect on total production costs and the relationship with the sustainable investments. According to the researcher, further research would be highly recommended. Unfortunately, the study will not provide enough aspects to motivate firms for immediately adopting sustainable technologies,

since firms will look at the economic benefits, or at least want to enhance their current situation. Nevertheless, there is a chance that the energy consumption decreases which could eventually lead to lower production costs on the longer term.

This research enhances our knowledge on the effect of sustainable investment by manufacturing firms in the Netherlands on their total production costs. With hypotheses, based upon empirical data from existing literature, being rejected this research suggests that this subject could use more insight on other factors explaining the effect on the total production costs of a firm. The literature was carefully collected, but since the manufacturing industry is still evolving, it would be of high relevance to follow the developments and proceed with research based upon future data. Although the main purpose was not accomplished, instead of the confirmation of significant relationships, managers gain insight in the overall view on sustainable investment and the factors that do or do not influence the construct total production costs. In combination with other research studies, it can provide the reader with a more holistic view of the environment they are operating in.

5.4 Limitations and recommendations for future research

The limitations of this research can partly be explained by the lack of significant results. Within this research a deductive research method was used, which means that this research was based on existing theory and the tests were run according to these insights. Since the data was already determined in the European Manufacturing Survey database, the theoretical constructs could not be fully operationalised to make them fit especially for this research. The items were chosen by the researcher based on the content and information that could be derived from these items, but the quantity or quality of the content were not measured on forehand. By preparing the data, the researcher noted that some of the items were less representative to measure a whole construct. Part of the items were recoded in order to fit the analysis, but the quantity of the response cannot be influenced. For total production costs the result consisted of one item, which does not provide an extended view of the construct. Although the variables were carefully selected and were the best fit for this research, when the data would not have been captured already by the European Manufacturing Survey, more items possibly would have been added to explain the constructs. This could have been a factor that makes the results less generalisable in this research, because there are no significant effects. Besides, another limitation might be that perhaps the hypotheses were too much based on logic reasoning instead of on research outcomes of sustainable technologies in specific terms. The literature that exists on this subject is contradictory and there is not much evidence that supports the hypotheses yet.

Additionally, two interviews were held to add qualitative data to this research in order to gain a probable better understanding of the quantitative results. The researcher managed to have two interviews, which are of value for this research, but ideally the researcher aimed for more interviews to see whether there were similarities or differences. Six firms were approached by the researcher, but two of them found time to substantiate their answers.

At last, the sample size might also be a limitation to this research analysis. Field (2013) described that based on the benchmark of Cohen, a sample size of 55 would be the absolute minimum and with six or fewer predictors the sample size of 100 would be sufficient. Although the sample does meet this requirement, there are many different statements about the required or ideal sample size. There is not one clear statement on what the required or even ideal sample size would be for mediation analysis. Due to the fact that there is no further elaboration on the sample size, the researcher could regard this as a limitation as well, because then there will still be the suspicion that the sample of 177 Dutch manufacturing firms might be too small for the analysis conducted. At last, the time frame on how long a technology was implemented and the extent of it were not part of the analysis. This information could have made the results better interpretable.

To conclude, as mentioned above, due to the fact that there is not yet much empirical evidence available regarding the effect of sustainable process innovation on the development of production costs, this thesis confirms that more research needs to be done on the subject of the implementation of sustainable technologies. It is clear that the importance to become more sustainable increases and the urgency is getting higher. Manufacturing firms can make a large difference in changing to a more sustainable environment. However, future research should then also focus on how to make sustainable investments beneficial on economic aspects.

5.5 Reflection

Since there were quite some limitations at this research there are still some open ends that could be of high interest for gaining deeper understanding by doing future research. No significant outcomes could be derived from the mediation analysis. When looking at existing literature there are results regarding the effect of investment, but improving the efficiency of production firms is relatively little studied and therefore it would be of value to investigate this further, probably by including other factors as mediator and for example gain deeper understanding of the effect of different types of resources for energy consumption or to gain more detailed information on the types of processes.

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[Director] (2019). Interview [Company 1], [wat wel altijd belangrijk is geweest is de brandstofkosten die we bij [Bedrijf 1] hebben want we hebben ongeveer 150 auto's rond rijden en ja hoe minder verkeersbewegingen dat we hebben, hoe minder tijd de monteur onderweg is, maar ook hoe minder brandstof. Ik denk als je die vertaalslag erbij maakt dat we wel een behoorlijke bijdrage leveren aan de reductie van energie, maar hoeveel dat we totaal verbruiken daar heb ik geen idee bij.]

[Manager] (2019) Interview [Company 2], [Stel dat wij over een jaar 10.000 m2 zonnepanelen hebben. Dat is wel een investering van ongeveer 1 miljoen, maar dan gaan we toch in elektriciteits- en gas kosten naar beneden. Het zal wel even duren voordat het terug verdiend is, maar we denken wel dat dit echt effect gaat hebben.]

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Appendices

Appendix 1: Frequencies, descriptives and correlations

The researcher decided to only add some of the complementary tables in the appendices since most of the tables are included in the main text.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,500
Bartlett's Test of Sphericity	Approx. Chi-Square	,481
	df	1
	Sig.	,488

Mediator_Changeinconsumption Development of Power consumption and oil- and gas consumption: difference 2014 – 2012

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	,14	1	,6	,7	,7
	,21	2	1,1	1,4	2,1
	,29	9	5,1	6,2	8,3
	,36	5	2,8	3,4	11,7
	,43	23	13,0	15,9	27,6
	,50	7	4,0	4,8	32,4
	,57	64	36,2	44,1	76,6
	,64	12	6,8	8,3	84,8
	,71	16	9,0	11,0	95,9
	,79	3	1,7	2,1	97,9
	,86	2	1,1	1,4	99,3
	1,00	1	,6	,7	100,0
	Total	145	81,9	100,0	
Missing	System	32	18,1		
Total		177	100,0		

CHECKING THE ASSUMPTION FOR MODEL FIT (PARAGRAPH 4.6.1)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept only	411,063			
Final	410,371	,692	5	,983

Model	Chi-Square	df	Sig.
Pearson	760,642	745	,337
Deviance	408,984	745	1,000

TESTING ASSUMPTION OF PROPORTIONAL ODDS

Parameter Estimates

							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
Threshold	[vnl12a = 1,00]	-2,687	1,210	4,933	1	,026	-5,057	-,316
	[vnl12a = 2,00]	-1,506	1,155	1,702	1	,192	-3,769	,757
	[vnl12a = 3,00]	,132	1,140	,013	1	,908	-2,102	2,367
	[vnl12a = 4,00]	1,175	1,145	1,054	1	,305	-1,069	3,419
	[vnl12a = 5,00]	2,983	1,181	6,379	1	,012	,668	5,297
	[vnl12a = 6,00]	4,662	1,340	12,096	1	,001	2,035	7,289
Location	EST	,059	,124	,227	1	,634	-,184	,301
	v23k_lg	-,204	,470	,188	1	,665	-1,124	,717
	OT	,001	,074	,000	1	,987	-,144	,147
	pr_cons	,073	,171	,182	1	,669	-,262	,407
	sizelog	,162	,566	,082	1	,774	-,947	1,271

Link function: Logit.

TEST OF PARALLEL LINES

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	410,371			
General	400,715	9,655	25	,997

DESCRIPTIVES

Sustainable process innovation (EST)

Valid	177
Mean	1,6158
Std. Deviation	1,5148
Skewness	,803
Std. Error of Skewness	,183
Kurtosis	-,093
Std. Error of Kurtosis	,363
Minimum	,00
Maximum	6,00

	Percent change in production costs per product unit in 2014 (Vnl12a)	Development in energy consumption (pr_cons)
Valid	177	145
Mean	3,8757	3,9172
Std. Deviation	1,2776	,9754
Skewness	-,029	-,105
Std. Error of Skewness	,183	,201
Kurtosis	-,417	,646
Std. Error of Kurtosis	,363	,400
Minimum	1,00	1,00
Maximum	7,00	7,00

	Number of other technologies used (OT)	% Number of employees (sizelog)	Energy costs as a percentage of turnover (v23k_lg)
Valid	177	177	128
Mean	3,8588	1,6041	,5587
Std. Deviation	2,6387	,4005	,3465
Skewness	1,125	1,490	,748
Std. Error of Skewness	,183	,183	,214
Kurtosis	1,995	5,744	1,383
Std. Error of Kurtosis	,363	,363	,425
Minimum	,00	1,00	,00
Maximum	15,00	3,89	2,00

CORRELATIONS

	(1)	(2)	(3)	(4)	(5)	(6)
(1) Sustainable process innovation	1					
(2) Energy consumption	-,153	1				
(3) Other technologies	,434**	-,245**	1			
(4) Firm size	,426**	-,138	,498**	1		
(5) Production costs	-,019	-,004	-,039	-,061	1	
(6) Energy costs (% of turnover)	,133	-,017	-,060	-,004	-,025	1

** P < .01

BIVARIATE ANALYSES

	Mean development in energy consumption	Mean number of employees	Energy costs as a percentage of turnover	Mean change in production costs per product unit in 2014
Metal	3,87	2,11	57%	4,05
Food	4,12	2,44	66%	3,88
Textile	3,86	2,23	73%	3,64
Construction	3,50	2,62	41%	4,08
Chemistry	4,44	2,50	51%	3,50
Machinery	3,95	2,55	43%	3,87
Electronics	3,65	2,09	53%	3,94

GENERALIZED LINEAR MODELS – ODDS RATIO - EXP (B)

Variable	Exp (B)
Number of employees (sizelog)	1,43
Food	,691
Textile	,555
Construction	1
Chemistry	,347
Machinery	1,06
Electronics	,882
Other technologies used (OT)	,940
Energy costs as a percentage of turnover (V23k_lg)	,859
Energy saving technologies (EST)	1,09

DV: Percent change in production costs per product unit in 2014 (Vnl12a)

Variable	Exp (B)
Number of employees (sizelog)	,902
Food	3
Textile	1,02
Construction	,827
Chemistry	3,77
Machinery	1,35
Electronics	1,16
Other technologies used (OT)	,913

Energy costs as a percentage of turnover (V23k_lg)	1,40
Energy saving technologies (EST)	,846

DV: Change in development power consumption in 2014 (NL22a_7c)

Variable	Exp (B)
Number of employees (sizelog)	,778
Food	4,33
Textile	1,29
Construction	,669
Chemistry	3,28
Machinery	1,12
Electronics	,988
Other technologies used (OT)	,931
Energy costs as a percentage of turnover (V23k_lg)	,848
Energy saving technologies (EST)	,716

DV: Change in development oil- and gas consumption in 2014 (NL22b_7c)

Appendix 2: European Manufacturing Survey for corresponding questions

Radboud Universiteit Nijmegen

Institute for Management Research

Modernisering van de productie Enquête 2015

Deze vragenlijst heeft als doel inzicht te krijgen in de inspanningen van industriële bedrijven in Nederland om hun productie en bedrijfsprocessen te moderniseren. Het onderzoek richt zich op productiebedrijven met een omvang van tenminste 10 werknemers. Bij ondernemingen met meerdere vestigingen hebben de vragen betrekking op de aangeschreven vestiging en niet op de totale onderneming.

Voor het onderzoek is beantwoording van alle vragen van belang. Ook als niet alle genoemde technologieën of organisatieconcepten van toepassing zijn op uw bedrijfsvestiging, verzoeken wij u vriendelijk de vragenlijst toch volledig in te vullen. Bij het invullen van de vragenlijst kunt u zowel de muis als de tab-toets gebruiken.

Voor vragen kunt u terecht bij. dr. Peter Vaessen E-Mail: P.Vaessen @ fm.ru.nl Tel.: 024 3611266 Fax: 024 3611933

1.1 **Is uw bedrijfsvestiging** (kruis slechts één optie aan):

- Het hoofdkantoor van een onderneming/groep met ook buitenlandse vestigingen ☐
- Een dochter/divisie van een buitenlandse onderneming/groep ☐
- Het hoofdkantoor van een onderneming/groep met alleen binnenlandse vestigingen ☐
- Een dochter/divisie van een onderneming/groep met alleen binnenlandse vestigingen ☐
- Een zelfstandige onderneming ☐

1.2 Bedrijfstak (bijv. textiel, chemische industrie, machinebouw, enz.): _____ hoofdproductgroep _____ aandeel van hoofd-product (groep) in omzet ca. _____ %

1.3 **Is uw bedrijfsvestiging gericht op uw hoofdproduct(groep) leverancier van eindfabricaten of een toeleverancier van onderdelen/ materialen of bewerkingen?** (Kruis slechts één optie aan)

producent van eindfabricaten		toeleverancier		aanbieder van bewerkingen
☐ voor consumenten	☐ voor bedrijven	☐ van systemen/ installaties	☐ van halffabricaten/ onderdelen	☐ aanbieder van bewerkingen (draaien, coaten, lassen, vermalen, e.a.)

1.4 **Als u uw hoofdproduct(groep) levert aan andere bedrijven (als eindfabrikant of toeleverancier), aan welke bedrijfstak levert u dan hoofdzakelijk?** (Kruis slechts één optie aan)

Machinebouw ☐ Chemische industrie ☐ Automotive industrie ☐ Elektro-techniek ☐ andere bedrijfstak, nl.: _____

1.5 **In hoeverre voert uw bedrijfsvestiging voor het hoofdproduct de volgende activiteiten uit van het waardecreatieproces?**
Kruis voor elke activiteit aan in welke mate die in uw eigen bedrijfsvestiging dan wel elders wordt uitgevoerd.
Kruis ook aan of een activiteit in het geheel geen deel uitmaakt van het waardecreatieproces

	Waardecreatie-activiteiten					
	Onderzoek en Ontwikkeling	Ontwerp/ Vormgeving	Productie/ Verwerking/Recycling	Assemblage	Onderhoud/ Dienstverlening	Verpakken/ Distributie
grotendeels intern > 85%	☐	☐	☐	☐	☐	☐
relevant deel intern (25%-85%)	☐	☐	☐	☐	☐	☐
klein deel intern (<25%)	☐	☐	☐	☐	☐	☐
niet nodig voor vervaardiging van het hoofdproduct	☐	☐	☐	☐	☐	☐

2 **Hoe belangrijk zijn de volgende factoren voor de concurrentiepositie van uw bedrijfsvestiging?** (geef de volgorde van belangrijkheid aan met een score van 1 tot 6; 1 is het belangrijkst, gebruik elke score slechts één keer)

productprijs	productkwaliteit	innovatieve producten	aanpassing producten aan klantenwensen	tijdige levering/ korte levertijden	dienstverlening en service
☐	☐	☐	☐	☐	☐

Welke van de volgende organisatieconcepten en werkwijzen worden momenteel in uw bedrijfsvestiging toegepast?

Toepassing gepland voor 2018	Nee	Organisatieconcepten	Ja	Voor het eerst toegepast[1]	Omvang van het toegepaste potentieel [2]
		Organisatie van het werk			
☐	☐	Gedetailleerde voorschriften voor de werkplekinrichting van apparatuur en opslag van tussenproducten (bijv. 5-S methode)	☐	19/20 ☐	☐☐☐
☐	☐	Gestandaardiseerde en gedetailleerde werkinstructies	☐	19/20 ☐	☐☐☐
☐	☐	Taakverrijking productiemedewerker (integratie van planning, uitvoering of controle)	☐	19/20 ☐	☐☐☐
		Organisatie van de productie			
☐	☐	Maatregelen ter verbetering van de interne logistiek (Value Stream Mapping/Design, ruimtelijke inrichting van productiestappen)	☐	19/20 ☐	☐☐☐
☐	☐	Klant- of productgeoriënteerde inrichting van productie-eenheden (i.t.t. functionele indeling)	☐	19/20 ☐	☐☐☐
☐	☐	Vraaggestuurde productie (bijv. KANBAN, afschaffen van tussenvoorraden)	☐	19/20 ☐	☐☐☐
☐	☐	Voorgeschreven methoden voor het verkorten van omstel- en aanlooptijden bij productwisseling (bijv. Single Minute Exchange of Die; Quick Change Over)	☐	19/20 ☐	☐☐☐
		Productiemanagement/ -beheersing			
☐	☐	Grafische weergave werkprocessen en -status (Visual Management; dashboard)	☐	19/20 ☐	☐☐☐
☐	☐	Kwaliteitsmanagement (bijv. preventieve onderhoud, total quality management/TQM, total productie-onderhoud/TPM)	☐	19/20 ☐	☐☐☐
☐	☐	Methoden voor operation management o.b.v. wiskundige analyse van productie (bijv. Six Sigma methode)	☐	19/20 ☐	☐☐☐
☐	☐	Methoden van continu verbeteren (Kaizen, kwaliteitscirkels e.d.)	☐	19/20 ☐	☐☐☐
		Energie- en milieubeheersing			
☐	☐	Gecertificeerd energie-management systeem volgens ISO 50001, voorheen: EN 16001	☐	19/20 ☐	☐☐☐
☐	☐	Instrumenten voor productlevenscyclus-analyse (bijv. EU Ecolabel, Cradle-to-Cradle certificaat, ISO-14020)	☐	19/20 ☐	☐☐☐
☐	☐	Het opnemen van sociale en duurzaamheidseffecten in het vaststellen van bedrijfsprestaties	☐	19/20 ☐	☐☐☐
		Human resource management			
☐	☐	Maatregelen voor het behoud van oudere werknemers of hun kennis voor uw bedrijfsvestiging (bijv. teams met verschillende leeftijdsgroepen, begeleidingsprogramma's, senior-junior tandems)	☐	19/20 ☐	☐☐☐
☐	☐	Instrumenten ter bevordering van werknemersbetrokkenheid (bijv. gratis kantine, ondersteuning kinderopvang, gezinsvriendelijke werktijden)	☐	19/20 ☐	☐☐☐
☐	☐	Gestandaardiseerde methoden van functie-ontwerp ter verbetering van gezondheids- en veiligheidsomstandigheden op het werk (bijv. Methods-time measurement (MTM))	☐	19/20 ☐	☐☐☐
☐	☐	Financiële participatie toegankelijk voor alle werknemersgroepen (bijv. winstdelingsregelingen, aandelen(optie)plannen, enz.)	☐	19/20 ☐	☐☐☐

Toelichting:

1 Het jaar waarin deze technologie voor het eerst werd toegepast in uw bedrijfsvestiging (maak een schatting indien u onzeker bent over het exacte jaar)

2 Daadwerkelijke toepassing ten opzichte van maximaal zinvolle toepassingsmogelijkheden: omvang van het gebruikte potentieel is "gering" bij eerste aanzetten, "midden" bij gedeeltelijke toepassing en "hoog" bij omvangrijke toepassing

Welke van de volgende activiteiten worden uitgevoerd voor uw productiepersoneel in uw bedrijfsvestiging?

Aanwezige competenties van productiewerknemers worden systematisch vastgelegd? ☐ nee ☐ ja

Functiebeschrijvingen zijn ontwikkeld voor specifieke functiegebieden in de productie? ☐ nee ☐ ja

Er bestaan specifieke competentieprogramma's voor bepaalde functies ☐ nee ☐ ja

Bij welke personeelsgroepen worden deze instrumenten gebruikt?

☐ LBO of ongeschoold personeel ☐ MBO geschoold personeel ☐ Hooggeschoold personeel (HBO+WO)

Bestaat er afzonderlijk beleid voor competentie-ontwikkeling en training van productiepersoneel?

☐ nee ☐ ja → Is er in uw bedrijf voor dit beleid een vast jaarlijks budget beschikbaar? ☐ nee ☐ ja

Is er een vastgesteld aantal dagen per jaar voor verdere kwalificatie, training en ontwikkeling van het productiepersoneel?

Welke van de volgende technologieën worden momenteel in uw bedrijfsvestiging toegepast?

Toepassing gepland voor 2018	Nee	Technologieën	Ja	Voor het eerst gebruikt (Jaar)[1]	upgrade sinds 2012 Ja	upgrade sinds 2012 Nee	Omvang van het toegepaste potentieel[2]
		Automatisering en robotisering					
☐	☐	Industriële robots voor bewerking en fabricage (bijv. lassen, coaten, snijden)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Industriële robots voor hanteren van gereedschap en werkstukken in productie (bijv. verplaatsen, assemblage, sorteren, verpakken)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
		Energie- en grondstoffenbesparing					
☐	☐	Controlesystemen die machines stilleggen bij onderbenutting (bijv. PROFI-energy)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Geautomatiseerde beheerssystemen voor energie efficiënte productie	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Systemen t.b.v. terugwinning van kinetische en procesenergie (bijv. terugwinnen afvalwarmte)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Technologieën voor energie- en/of warmteopwekking door middel van zon-, wind-, waterkracht, biomassa of geothermische energie	☐	19/20 ☐	☐	☐	☐ ☐ ☐
		Bewerkingstechnologieën voor nieuwe materialen					
☐	☐	Productietechnologieën voor micromechanische componenten (micromachinale bewerking, lithografie, micro-injectie e.d.)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Nanotechnologische productieprocessen (bijv. oppervlaktebewerking)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Technieken voor verwerking van composietmaterialen (bijv. carbonvezel, glasvezel)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Bio- en gentechnologie in fabricageprocessen (bijv. catalysatoren, bioreactoren)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Technieken voor verwerking van legeringen (aluminium-, magnesium-, titaniumlegeringen, enz.)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
		Additieve productietechnologieën					
☐	☐	Additive productietechnologie voor maken van prototypes (bijv. 3D printing, rapid prototyping; Selective Laser Sintering; Stereolithografie, Laser Beam Melting)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Productie met additieve productietechnologie (incl. enkelstuksproductie; kleine productieseries; reserveonderdelen)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Systemen voor Machine2Machine communicatie, Multi-agent systemen	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Systemen voor Cyber-Physical systems, cloud-computing	☐	19/20 ☐	☐	☐	☐ ☐ ☐
		Digitale fabriek / IT netwerken					
☐	☐	Digitale productieplanning en roostering (bijv. ERP-systeem)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Bijna real-time productiebeheersingssystemen (bijv. systemen voor gecentraliseerde aansturing en machinegegevensverwerking	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Digitale uitwisseling van productieplanningsgegevens met toeleveranciers en/of klanten (supply chain management)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Systemen voor geautomatiseerd management van interne logistiek en orderverzameling (e.g. RFID, warehouse management system)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Mobiele/draadloze apparaten voor programmering en bediening van installaties en machines (e.g. tablets)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Product Lifecycle Management (PLM) systemen of Product/Productieproces datamanagement	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Technologieën voor veilige mens-machine interactie (bijv. coöperatieve robots, open werkstations e.d.)	☐	19/20 ☐	☐	☐	☐ ☐ ☐
☐	☐	Digitale oplossingen voor het direct beschikbaar maken van tekeningen, werkschemas en -instructies op de werkvloer (e.g. tablets, smartphones)	☐	19/20 ☐	☐	☐	☐ ☐ ☐

Toelichting:

1 Het jaar waarin deze technologie voor het eerst werd toegepast in uw bedrijfsvestiging (maak een schatting indien u onzeker bent over het exacte jaar)

2 Daadwerkelijke toepassing ten opzichte van maximaal zinvolle toepassingsmogelijkheden: omvang van het gebruikte potentieel is "gering" bij eerste aanzetten, "midden" bij gedeeltelijke toepassing en "hoog" bij omvangrijke toepassing

Welke van de volgende maatregelen nam uw bedrijfsvestiging om energieverbruik te verminderen?

	Toepassing gepland voor 2018	nee	ja
Afschakelsystemen voor onderdelen, machines of installaties indien niet in gebruik (bijv. afschakeling luchttoevoer, aangepaste verlichtingssensoren)	☐	☐	☐
Verbeteren van bestaande machines of installaties (bijv. hoogefficiënte motoren (IE3), aanbrengen isolatie, warmtewisseleraar)	☐	☐	☐
Voortijdige vervanging van bestaande machines of installaties door nieuwe machines of installaties	☐	☐	☐

Welke van de volgende redenen en welke van de genoemde barrières zijn van doorslaggevende betekenis voor het wel of niet invoeren van energie en warmte opwekkende technologieën op basis van hernieuwbare energie in uw vestiging?

Redenen voor invoering	Energie	Warmte	Belangrijke barrières	Energie	Warmte
Verwachte ontwikkeling van de energieprijzen	☐	☐	Te grote investeringen of voordelen ontbreken	☐	☐
Strategische redenen (bijv. "groen imago")	☐	☐	Administratieve last (bijv. goedkeuringsprocedures)	☐	☐
Terugdringen broeikasgassen	☐	☐	Niet van toepassing in deze bedrijfsvestiging	☐	☐
Eigen energie-opwekking ter vergroting aantal energiebronnen	☐	☐	Vooralsnog geen relevant onderwerp in deze vestiging	☐	☐
Politieke of wettelijke bepalingen	☐	☐	Andere barrières	☐	☐

Heeft uw bedrijf sinds 2012 producten geïntroduceerd die nieuw waren voor uw bedrijf of die technisch ingrijpend zijn vernieuwd?
(Bijv. door nieuwe grondstoffen of materialen te gebruiken, veranderingen in productiefuncties of werking e.d.)

☐ nee ☐ ja → Hoe groot was het aandeel van deze producten in de omzet van het jaar 2014? ca. ☐ %

→ Hoe lang duurde gemiddeld genomen de ontwikkeling van zo'n product? (van productidee tot en met lancering) ca. ☐ maanden

Hebben deze productvernieuwingen ook geleid tot betere milieu-effecten bij gebruik of verwijderen van deze nieuwe producten?

☐ nee ☐ ja → Welke verbeteringen in de milieu-effecten zijn met deze producten bereikt? (Kruis aan wat van toepassing is)

☐ Vermindering van gezondheidsrisico's bij gebruik
☐ Vermindering van energieverbruik bij gebruik
☐ Vereenvoudiging van onderhoud of herstel
☐ Verlenging productlevensduur
☐ Vermindering van milieuvervuiling bij gebruik (van grond, water, lucht, of geluid)
☐ Verbeterde recycling, terugwinning of verwijderingseigenschappen

Bevonden zich bij deze nieuwe producten (nieuw sinds 2012) ook producten, die nieuw-voor-de-markt waren en die uw bedrijfsvestiging als eerste op de markt introduceerde?

☐ nee ☐ ja → Wat was hun aandeel in de omzet van 2014? ca. ☐ %

→ Zijn deze producten speciaal ontwikkeld vooral voor (kruis slechts één optie aan):

☐ bestaande klanten binnen uw huidige markt
☐ aantrekken van nieuwe klanten binnen uw huidige markt
☐ toetreding tot markten nieuw voor *uw bedrijfsvestiging*
☐ het ontwikkelen van geheel nieuwe markten

Heeft uw bedrijfsvestiging producten in het programma die u al langer dan 10 jaar aanbiedt?

☐ nee ☐ ja → Welk percentage van de omzet hadden deze producten in 2014? ca. ☐ %

Welke van de volgende productgerelateerde diensten biedt u uw klanten aan?
Als uw bedrijfsvestiging dergelijke diensten aanbiedt, worden zij dan ook aangeboden voor producten van andere bedrijven?

	nee	ja	Voor producten van andere bedrijven		nee	ja	Voor producten van andere bedrijven
Installatie, inbedrijfstelling	☐	☐→	☐	Software-ontwikkeling (bijv. software-aanpassing)	☐	☐→	☐
Onderhoud en reparatie	☐	☐→	☐	Klantondersteuning op afstand (helpdesk, service hotline, website)	☐	☐→	☐
Training	☐	☐→	☐	Reviseren, vernieuwen (incl. functie opwaardering of software-uitbreidingen)	☐	☐→	☐
Ontwerp, technisch advies (incl. testen, simulaties, O&O voor klanten)	☐	☐→	☐	End-of-life dienstverlening (bijv. recycling, opheffen, terugname)	☐	☐→	☐

10.2 **Indien u productgerelateerde diensten aanbiedt, hoe hoog schat u het aandeel daarvan in de totale omzet van 2014?**
► In geval van geen omzet, vul in „0".

Aandeel in totale omzet van diensten die u in 2014 direct, d.w.z. apart, in rekening heeft gebracht ca. ☐ %

Aandeel van diensten die u in 2014 indirect in rekening heeft gebracht (via de productprijs) ca. ☐ %

10.3 **Heeft uw bedrijfsvestiging vanaf 2012 nieuwe productgerelateerde diensten aangeboden, die geheel nieuw zijn voor uw bedrijfsvestiging of belangrijke verbeteringen bevatten?**

☐ nee ☐ ja → Hoe groot was het aandeel in de omzet van 2014 van deze sinds 2012 nieuw aangeboden productgerelateerde diensten, die uw bedrijfsvestiging direct of indirect in rekening heeft gebracht? ca.. ☐ %

11 **Hoe vaak heeft uw organisatie vanaf 2012 de volgende activiteiten verricht?**

		(0=niet; 1=1 keer; 2=vaker)
Spin-offs	Opstarten van nieuwe organisaties of activiteiten buiten de onderneming	☐ ☐ ☐
Uitgaand intellectueel eigendom	Verkopen, of aanbieden van licenties/patenten aan andere organisaties	☐ ☐ ☐
Werknemer-betrokkenheid	Benutten van kennis en initiatieven van niet-O&O medewerkers bij het realiseren van innovaties	☐ ☐ ☐
Klantbetrokkenheid	Direct betrekken van klanten in uw innovatieprocessen	☐ ☐ ☐
Extern netwerken	Het samenwerken met andere organisaties (niet klanten) voor innovatie	☐ ☐ ☐
Externe participatie	Deelnemen (met bijv. vermogen, kennis) in ondernemingen om toegang te krijgen tot hun kennis of om andere synergieën te creëren?	☐ ☐ ☐
Uitbesteden van O&O	Uitbesteden van O&O (diensten) aan andere organisaties, zoals universiteiten, publieke onderzoeksinstellingen, commerciële ingenieurs of leveranciers?	☐ ☐ ☐
Inkomend intellectueel eigendom	Kopen of in licentie nemen van intellectueel eigendom van andere organisaties	☐ ☐ ☐

12. **Hoe hebben zich in uw bedrijfsvestiging de productiekosten per eenheid product (eenheidskosten) ontwikkeld in 2014?**

Gedaald met 10% of meer	Gedaald 5 - < 10%	Gedaald 0 - < 5%	Gelijk gebleven	Gestegen 0 - < 5%	Gestegen 5 - < 10%	Gestegen met 10% of meer
☐	☐	☐	☐	☐	☐	☐

13 **In de voorafgaande vragen heeft u informatie gegeven over verschillende velden van innovatie. Rangorden deze innovatievelden naar mate van belangrijkheid voor uw bedrijfsvestiging.**
Geef met een score van 1 tot 4 de volgorde van belangrijkheid aan met 1 als het belangrijkst; gebruik elke score slechts één keer.

Toevoegen van diensten aan uw producten	Organisatie-vernieuwing	Technische vernieuwing in het productieproces	Ontwikkeling van nieuwe producten
○	○	○	○

14 **Welke van de onderstaande informatiebronnen zijn het meest relevant voor belangrijke innovatie-impulsen/ideeën in uw bedrijfsvestiging op de volgende gebieden?** (Kruis maximaal drie informatiebronnen aan voor elk gebied van innovatie)

	intern				extern			
	O&O, engineering	productie-afdeling	Klanten-service	Leiding bedrijfsvestiging	Klant of gebruiker	Leverancier	Onderzoeks-instellingen, universiteiten	Conferenties, beurzen
Nieuwe producten	☐	☐	☐	☐	☐	☐	☐	☐
Nieuwe proces-technologieën	☐	☐	☐	☐	☐	☐	☐	☐
Nieuwe diensten	☐	☐	☐	☐	☐	☐	☐	☐
Nieuwe organisatie-concepten	☐	☐	☐	☐	☐	☐	☐	☐

15.1 **Wat is het opleidingsniveau van het personeel van uw bedrijfsvestiging?**

Hoger onderwijs (HBO+WO)	ca. ☐ %	
MBO technische opleiding	ca. ☐ %	
MBO adminstratieve en commerciële opleiding	ca. ☐ %	=100%
LBO of ongeschoold	ca. ☐ %	
Personeel in opleiding (leerlingen, stagiaires)	ca. ☐ %	

15.2 **Hoe is het personeel in uw bedrijfsvestiging verdeeld over de volgende werkterreinen:**

Onderzoek en ontwikkeling	ca. ☐ %	
Ideevorming, ontwerp en vormgeving	ca. ☐ %	
Fabricage en montage	ca. ☐ %	=100%
Klantenservice	ca. ☐ %	
Overige (administratie, inkoop, logistiek/distributie, onderhoud, productieplanning enz.)	ca. ☐ %	

16 **Heeft uw bedrijfsvestiging in de afgelopen twee jaar delen van de productie of delen van onderzoek en ontwikkeling (O&O) overgeheveld naar andere bedrijven (uitbesteding) of eigen vestigingen in het buitenland (verplaatsing) danwel vestigingen vanuit het buitenland teruggeplaatst?**

Overheveling:

	nee	Ja:(meerdere opties mogelijk) Naar andere bedrijven in Nederland	Naar andere bedrijven in het buitenland	naar eigen vestigingen in het buitenland	Naar welk land (landen)?	**Redenen:** (meerdere opties mogelijk) Arbeidskosten	Ontsluiting nieuwe markten	Nabijheid belangrijke klanten	Toegang tot nieuwe kennis technologieën/clusters	Belasting, heffingen, subsidies	Gebrek aan gekwalificeerd personeel in eigen land	Importbeperkingen	Nabijheid van O&O of productie die reeds is overgeheveld	Toegang tot natuurlijke hulpbronnen leveranciers	Aanwezigheid van concurrenten
Overheveling van **productie-activiteiten** sinds 2013	☐	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Verplaatsing **onderzoeks- en ontwikkelingsactiviteiten** sinds 2013	☐	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Terugplaatsing (repatriëring) vanuit het buitenland naar het thuisland

	Nee	Ja	Vanuit andere bedrijven in het buitenland	Vanuit eigen vestigingen in het buitenland	Uit welk land/landen	Kwaliteit	Flexibiliteit, leversnelheid	Capaciteitsbenutting	Beschikbaarheid gekwalificeerd personeel	Arbeidskosten	Transportkosten/ logistieke kosten	Kosten van coördinatie en toezicht	Nabijheid van binnenlandse O&O	Verlies van kennis/ -kopiëren/piraterij	Infrastructuur
Terugplaatsing van (delen van) de **productie** sinds 2013	☐	☐ →	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

17 **Geef a.u.b. de herkomst van uw toeleveringen (inputs) en de bestemming van uw producten in 2014.**
► Toeleveringen zijn gekochte onderdelen, (ruwe) materialen, productiemiddelen en diensten. Geef alleen het aandeel aan van producten gemaakt in uw bedrijfsvestiging.

Toeleveringen afkomstig uit

binnenland ca ☐ % } =100% van de inkoopwaarde

buitenland ca ☐ % }

Producten verkocht in:

binnenland ca ☐ % } =100% van de omzet

buitenland ca ☐ % }

18.1 **Heeft uw bedrijfsvestiging onderzoek en ontwikkelingsactiviteiten (O&O) uitgevoerd of laten uitvoeren door externe partners in 2014?**

☐ nee ☐ ja → O&O-uitgaven in procenten van de omzet in 2014 ca. ☐ %

18.2 **Heeft uw bedrijfsvestiging sinds 2012 continu O&O uitgevoerd of laten uitvoeren door externe partners?**

☐ nee ☐ ja

19 **Welk van de volgende kenmerken zijn het meest van toepassing op uw hoofdproduct(groep)?**

Productontwikkeling (kruis slechts één optie aan)

- Op specificatie van klant ☐
- Voor een standaardprogramma waarbinnen klantspecifieke wensen gerealiseerd kunnen worden ☐
- Voor een standaardprogramma, waaruit de klant kan kiezen ☐
- Niet aanwezig in deze bedrijfsvestiging ☐

Fabricage/montage (kruis slechts één optie aan)

- Na binnenkomst klantorder (make-to-order) ☐
- Eindmontage van het product wordt uitgevoerd na binnenkomst klantorder (assemble-to-order) ☐
- Op voorraad (make-to-stock) ☐
- Niet aanwezig in deze bedrijfsvestiging ☐

Seriegrootte (kruis slechts één optie aan)

- Enkelstuksproductie ☐
- Kleine of middelgrote series (20-1.000 stuks per maand) ☐
- Grote series (meer dan 1.000 stuks per maand) ☐
- Geen discrete productie (procesindustrie) ☐

Productcomplexiteit (kruis slechts één optie aan)

- Eenvoudige producten ☐
- Producten van middelgrote complexiteit ☐
- Complexe producten ☐

20 **Beantwoordt u de volgende vragen over uw hoofdproduct(groep).**

Wat is de gemiddelde productietijd van uw hoofdproduct(groep)? (doorlooptijd vanaf moment dat opdracht binnenkomt bij productie tot product klaar is voor levering) ca. ☐ werk-dagen of ☐ uren

Hoeveel procent van de orders wordt op tijd afgeleverd? ca. ☐ %

Hoeveel procent van uw productie moet na kwaliteitscontrole nabewerking ondergaan of geheel worden afgekeurd? ca. ☐ %

Welk percentage van de geleverde bestellingen heeft klachten van klanten opgeleverd vanwege kwaliteitsproblemen? ca. ☐ %

21 **Hier worden enkele gegevens over uw bedrijfsvestiging gevraagd:**

Jaaromzet 2014 ☐ miljoen € 2012 ☐ miljoen €

Aantal werknemers (excl. uitzendkrachten) 2014 ☐ aantal

Aantal werknemers dat is afgevloeid in 2014 2014 ☐ aantal

Had uw bedrijfsvestiging uitzendkrachten in dienst in 2014? ☐ nee ☐ ja → Hoeveel uitzendkrachten waren in 2014 gemiddeld in dienst bij uw bedrijfsvestiging? ca. ☐ aantal

Inkoop 2014 (ingekochte onderdelen, materialen en diensten) ☐ miljoen €

Afschrijvingen op machines en installaties 2014 (zonder grond en gebouwen) ☐ miljoen €

Investeringen in machines en installaties 2014 ☐ miljoen €

Personeelskosten als percentage van de omzet in 2014 (incl. loonnevenkosten) ☐ %

Graad van capaciteitsbenutting (gemiddeld in 2014) ☐ %

Totale energiekosten als percentage omzet 2014 ☐ %

Rendement op de omzet (vóór belasting in 2014) ☐ negatief ☐ 0 tot 2% ☐ > 2 tot 5% ☐ > 5 tot 10% ☐ > 10%

Jaar van oprichting, c.q. inschrijving bij de Kamer van Koophandel jaar: ☐

Heeft uw bedrijfsvestiging een ondernemingsraad? ☐ nee ☐ ja

22.1 **Geef uw energieverbruik aan als volgt:**

Wat was het aandeel groene stroom in het totale stroomverbruik van uw bedrijfsvestiging in 2014? ca. ☐ %

Hoe groot is de te verwarmen oppervlakte van uw bedrijfsvestiging? ca. ☐ m^2

22.2 **Hoe heeft het stroomverbruik van uw bedrijfsvestiging zich ontwikkeld in 2014?**

Gedaald met 10% of meer	Gedaald 5 - < 10%	Gedaald 0 - < 5%	Gelijk gebleven	Gestegen 0 - < 5%	Gestegen 5 - < 10%	Gestegen met 10% of meer
☐	☐	☐	☐	☐	☐	☐

22.3 **Hoe heeft het olie- en gasverbruik van uw bedrijfsvestiging zich ontwikkeld in 2014?**

Gedaald met 10% of meer	Gedaald 5 - < 10%	Gedaald 0 - < 5%	Gelijk gebleven	Gestegen 0 - < 5%	Gestegen 5 - < 10%	Gestegen met 10% of meer
☐	☐	☐	☐	☐	☐	☐

23 **Wie is in meerderheid of exclusief eigenaar van het bedrijf waartoe uw bedrijfsvestiging behoort?**

☐ Private eigenaar/ familie ☐ Financiële investeerder (bijv durfkapitaal) ☐ Ander bedrijf (bijv. niet-financiële investeerder) ☐ stichting ☐ overige eigenaren ☐ Geen meerderheidseigenaar

→ Is de familie actief in het management? ☐ Nee ☐ Ja

Hartelijk dank voor uw bijdrage aan dit onderzoek.

Wij verzoeken u de ingevulde vragenlijst terug te sturen per e-mail naar: P.Vaessen@fm.ru.nl

of per post naar:

Radboud Universiteit Nijmegen, t.a.v Dr P.Vaessen, Antwoordnummer 1908, 6500 VC Nijmegen

Appendix 3: Transcription of interviews

1. INTERVIEW – BEDRIJF 1

(Directielid)

Voorstellen, uitleg onderzoek + gebruik van gegevens

Interviewer: Kun je kort beschrijven wat de hoofd producten en / of services zijn van jullie bedrijf?
Interviewee: Ja, wij zijn een elektrotechnisch engineeringbedrijf wat ook de uitvoering doet. Dus wij ontwerpen elektrotechnische installaties. Die leggen we vervolgens bij de klant aan, die sluiten we aan, dus die stellen we in bedrijf en daarna zorgen we voor de service in lengte van dagen. Dit doen we zowel in Nederland als in het buitenland.
Interviewer: oké
Interviewee: ja echt op het gebied van elektrotechniek. Dus de verlichting die je ziet, de stopcontacten, maar ook de productieinstallaties die bijvoorbeeld bij een bedrijf als Heinz staan, waar de tomatenketchup doorheen komt, die worden in Elst gemaakt en op locatie geleverd en in bedrijf gesteld.
Interviewer: aah oké. En productie zit alleen in Elst?
Interviewee: Nou de fysieke productie, het maken van machines, gebeurt in Elst. En het aansluiten en het leggen van kabels dat gebeurt vanuit deze locatie in Druten. Dus vanuit hier gaan de monteurs op pad met hun bus naar de klant en in Elst worden de installaties gemaakt die de monteurs dan op locatie bij de klant installeren.
Interviewer: ja oké. En wat doen ze dan zeg maar in het buitenland, in Hamburg en Monaco? Wat is daar jullie ..uh?
Interviewee: Nou we hebben een tak van sport, dat is luxe jachten. Dus wij bouwen ook, bij Heeze in Oss maken wij luxe jachten
Interviewer: ja dat weet ik inderdaad van Joris mijn broer
Interviewee: oja dat klopt ja. In het buitneland verlenen wij service aan die luxe jachten. Want de mensen die zo'n jacht kopen zitten in een wat hoger segment en als die iets nieuws zien qua techniek dan willen ze dit ook meteen hebben.
Interviewer: ja precies
Interviewee: Door heel dicht bij die mensen aanwezig te zijn kunnen wij een mooie omzet met een mooie marge maken. En in Hamburg is dat eigenlijk wel vergelijkbaar, maar daar doen we

het voor de binnenvaart, de schepen die over de waal varen richting Hamburg. Die hebben ook nog wel eens een storing bijvoorbeeld.

Interviewer: hmm m.

Interviewee: dus Monaco en Hamburg zijn echt twee service vestigingen.

Interviewer: En wat is jouw functie binnen het bedrijf?

Interviewee: ik ben een van de drie directieleden, samen met [naam directielid] en [naam directielid] en ik zelf vormen wij de directie. Ik ben verantwoordelijk voor de totale uitvoering die we doen [naam directielid] is verantwoordelijk voor technisch en commercieel, [naam directielid] is verantwoordelijk voor het financiële gedeelte en algemene zaken en ik ben er dan voor alle uitvoering die er voorbij komt.

Interviewer: oké. Nou ik doe dus onderzoek naar duurzame investeringen in technologieën en / of producten om te kijken of dat effect heeft op de totale energiekosten van het bedrijf.

Interviewee: oké

Interviewer: Nou is er al meer onderzoek gedaan, maar ik gebruik data van de European Manufacturing Survey, dat is een enquete die wordt gedaan 1 keer in de 5 jaar over heel Europa door verschillende universiteiten. En dan willen ze kijken bij productiebedrijven of er inderdaad effecten zijn.

Interviewee: Ja

Interviewer: Er zijn meerdere criteria in de enquete die ze onderzoeken, maar een daarvan is duurzaamheid en zo wordt er gekeken of er in de loop van de jaren of er inderdaad effecten zijn. Je kunt de focus leggen op het effect op het milieu, maar ik onderzoek voornamelijk het effect op de bedrijven zelf. Kun je een indicatie geven van de omvang van de totale energiekosten?

Interviewee: nee echt niet. Die heb ik niet paraat. We zijn er zeker wel mee bezig, we hebben ook een ISO14001 certificaat wat ons ook dwingt, of misschien het verkeerde woord, maar wat ons wel verplicht om goed na te denken over het energieverbruik en de vermindering daarvan.

Interviewer: hmm m ja

Interviewee: de panden die we hebben liggen vol met zonnepanelen, de verlichting die we hebben is LED verlichting en we proberen steeds vaker over te stappen op een elektrische auto. De digitalisering is, zijn we misschien een beetje laat mee gestart, maar is wel een heel actueel onderwerp. We willen steeds meer digitaal te werk gaan. Dat is onze bijdrage aan het verminderen van het energieverbruik.

Interviewer: ja precies

Interviewee: wat wel altijd belangrijk is geweest is de brandstofkosten die we bij [Bedrijf 1] hebben want we hebben ongeveer 150 auto's rond rijden en ja hoe minder verkeersbewegingen dat we hebben, hoe minder tijd de monteur onderweg is, maar ook hoe minder brandstof. Ik denk als je die vertaalslag erbij maakt dat we wel een behoorlijke bijdrage leveren aan de reductie van energie, maar hoeveel dat we totaal verbruiken daar heb ik geen idee bij.

Interviewer: oké nee, en je noemde net al een aantal investeringen, die zonnepanelen bijvoorbeeld. Denk je dat ze die technologieën, maken jullie daar gebruik van in jullie marketing activiteiten? Promoten jullie actief de investeringen op het gebied van duurzaamheid?

Interviewee: we zien het met name terug bij aanbestedingen voor Alliander bijvoorbeeld, dat is ook een van onze klanten of bijvoorbeeld bij andere overheidsbedrijven. Die vragen expliciet in hun aanbesteding wat doet een bedrijf, in dit geval [Bedrijf 1], aan een beter milieu. Ja bij dit soort zaken benoemen wij dan wel expliciet onze investeringen zoals dus de zonnepanelen, elektrische auto's, digitalisering, de LED verlichting.

Interviewer: ja precies.

Interviewee: Andere klanten, in de meer commerciële wereld, die vragen daar nooit naar. Bij hen gaat het echt om prijs. Daarbij voelt het echt als 'het zal hun een zorg zijn of wij zonnepanelen op het dak hebben liggen of niet', zij willen gewoon weten wat er onder aan de streep staat bij een offerte. Maargoed de overheid is er wel echt fanatiek mee bezig

Interviewer: ja

Interviewee: en omdat wij van de 31 miljoen omzet die we maken 20% bij de overheid vandaan halen is het voor ons wel een behoorlijk belangrijke tak van sport, dus het dwingt ons wel, net als die ISO 14001 om te blijven investeren in de mogelijkheden die er zijn op het gebied van duurzaamheid.

Interviewer: oke en als je dat moet uitdrukken op een schaal van 1 tot 7, waarbij 7 zeer nadrukkelijk is of jullie gebruik maken als bedrijf van jullie duurzame investeringen als marketing activiteit en 1 helemaal niet

Interviewee: nou wij kunnen echt verbeteren nog op het gebied van marketing. Ik denk dat ik het dan houd op een 3.

Interviewer: oke, en je gaf net al even aan dat de duurzame investeringen nauwelijks invloed heeft op de commerciële klanten

Interviewee: ja

Interviewer: hebben jullie wel gekeken naar de investeringen op het gebied van de producten die jullie bijvoorbeeld in Elst maken? Of op het productieproces zelf?

Interviewee: ja, goede vraag. Wij krijgen vanuit onze klanten aangeleverd wat wij moeten maken, bijv. zo'n paneel of zo'n machine. Dus op het uiteindelijke resultaat of de materialen hebben wij geen invloed want dat wordt gewoon voorgeschreven, maar de wijze hoe dat een machine tot stand komt daar zit onze invloed. We hebben behoorlijk veel geautomatiseerd, waardoor de afvalstromen ook beduidend minder zijn geworden. Waar we vroeger heel veel handwerk deden, is het nu allemaal machinaal, en hierdoor is onze afvalstroom gereduceerd. Als je het hebt over onze bijdrage aan het milieu is dit wel de grootste slag die we hierin gemaakt hebben. Het verminderen van de afvalstroom, het verminderen van het koper- en aluminiumafval. Hoe sneller je produceert, hoe minder licht en energie je nodig hebt dus daar zit onze winst.

Interviewer: ja precies

Interviewee: maar heel veel impact op de gebruikte materialen, ja dat hebben wij niet. We hebben wel nachttransport, waarbij we twee nachtsluizen hebben en leveranciers 's avonds kunnen komen wat onze leveringsbetrouwbaarheid enerzijds heeft vergroot, maar anderzijds is het ook zo dat leveranciers beter door kunnen rijden en transporten gebundeld kunnen worden. Hierdoor zijn de reisbewegingen minder geworden. Het zal een minimale bijdrage zijn, maar alle beetjes helpen.

Interviewer: En ben jij ook actief onderdeel van dit soort investeringen / verbeteringen?

Interviewee: Nee, we hebben natuurlijk als directie wel ons milieubeleid opgesteld met bepaalde doelstellingen met betrekking tot impact op het milieu, maar uiteindelijk is de manager logistiek en inkoop verder verantwoordelijk hiervoor.

Interviewer: oké. Dan nog even terug naar de product innovaties. Jullie hebben in het proces wel wat investeringen gedaan om te automatiseren, maar bijvoorbeeld bij de producten zelf, die worden op aanvraag gemaakt. Merk je dat daarin wel gevraagd wordt naar duurzaamheid?

Interviewee: ja dat is echt klant afhankelijk. Een Heinz bijvoorbeeld die ik net noemde, dat is een Amerikaans bedrijf, die zitten heel erg op de veiligheid en veel minder op milieu. We zitten ook in de farmaceutische hoek waarbij veiligheid ook heel belangrijk is, maar we hebben een aantal klanten waarvan MSD er een van is en die willen voor bepaalde medicijnen die ze ook op de Afrikaanse markt afzetten dat er bepaalde wet- en regelgeving aan verbonden is. En het zou best wel eens kunnen dat er ook in iets staat over de materialen, maar dat weet ik zo niet uit mijn hoofd. Er zal ongetwijfeld iets instaan over dat wij materialen moeten gebruiken die moreel verantwoord zijn en dat materialen op een duurzame manier uit de grond gehaald moeten worden en recyclebaar zijn wat ze ook wel 'cradle to cradle' noemen.

Interviewer: ja oke. Want inderdaad nu jij cradle to cradle noemt, ik zag op jullie website iets over een duurzaam apparaat.

Interviewee: ja dat klopt een biovergistingsmachine. Die staat bij van der Valk in Cuijk en daar worden etensresten omgezet naar biogas waar elektriciteit uitgehaald wordt waar de taxi weer op rijdt. Ja dat is wel iets waar we mee bezig zijn en wat we zelf willen ontwerpen en op de markt willen zetten en vervolgens waar we simpel gezegd geld aan willen verdienen.

Interviewer: ja precies.

Interviewee: maar er is geen enkele leverancier geweest die ons opgedrongen heeft om zo'n machine te maken.

Interviewer: nee oke, maar is dit idee dan vanuit de klant gekomen of vanuit jullie zelf?

Interviewee: nou een combinatie. Het hele bedrijf bestaat bij ons uit technische mensen die op een gegeven moment dingen bedenken en daar een product van willen maken, maar daar moet natuurlijk wel een afzetmarkt voor zijn. Nou en 1 van onze relaties is Van der Valk in Cuijk en die gaven aan dat ze regelmatig eten over hadden en dan komen al die vrachtwagens op het terrein bij ons en dat was wel een trigger om zoiets in gang te zetten met elkaar. Uiteindelijk praat ik dan over 7 a 8 jaar terug. Het gros van onze dienstverlening daar kunnen wij weinig aan veranderen. We moeten toch altijd op prijs blijven concurreren. We kunnen wel zeggen dat [Bedrijf 1] heel duurzaam in gaat kopen en hierop gaat differentiëren, en ik denk dat er best een paar klanten zullen zijn die er wat meer voor willen betalen, maar het overgrote deel zal denk ik zeggen dat ze daar niet voor gaan betalen.

Interviewer: toch best apart, want ik zou zeggen dat jullie toch best in een rol zitten waar je kunt differentiëren op die manier.

Interviewee: Nou om eerlijk te zijn is uiteindelijk is het vakgebied elektrotechniek heel makkelijk. Onze concurrenten kunnen onze werkzaamheden zo overnemen want er zijn tekeningen waarop staat hoe dat je het draadje van A naar B moet leggen.

Interviewer: ja precies, daarom zou ik bijna zeggen dat je dan toch ergens op moet differentiëren.

Interviewee: ja je moet een verschil maken op aanpak en richting Alliander en andere overheidsinstanties noemen we wel de manier met hoe we omgaan met de wereld om ons heen, maar bij onze reguliere klanten is hier nu verder gewoon geen vraag naar.

Interviewer: oke en als we nu kijken naar het cijfer voor de investeringen in de producten zelf. Als je een cijfer moet geven voor in hoeverre de producten zichtbaar meer gericht zijn op duurzaamheid.

Interviewee: ja

Interviewer: 1 staat voor de duurzaamheid van onze producten is in geringe mate toegenomen en 7 staat voor een toename die zichtbaar is.

Interviewee: dan vindt ik dat we zitten op een 5. Omdat het wel echt binnen de organisatie meer aandacht heeft gekregen. Niet alleen bij de directie, maar ook bij onze verkopers, dat we in de markt wel bekend willen staan als een bedrijf wat meeloopt in de markt. Wij zullen steeds vaker met een elektrische auto komen voorrijden, dat promoten we wel. Wij zijn wel bij een klant waarbij we dan graag laten zien dat we investeren in dit soort zaken. Of het doorslaggevend is dat durf ik niet te zeggen. Dan zouden we dat moeten meten, maar dat doen wij zelf niet.

Interviewer: nou ja dat is dus wat ik wil bekijken met dit onderzoek of we hier wat meer inzicht in kunnen krijgen. Daarop volgend heb ik nog een vraag aan jou, denk je zelf dat het investeren in duurzame technologieën en producten invloed heeft op jullie omzet?

Interviewee: we hebben bij de ARN in Nijmegen 800 zonnepanelen op het dak gelegd omdat we referentie hebben dat wij deze ook op het dak hebben liggen. Daarmee heb ik kunnen aantonen dat wij in staat zijn om grotere volumes weg te leggen. Dit heeft zeker bijgedragen aan de omzet. Dus ik denk dat ik daarin wel je vraag kan beantwoorden in die zin dat ik denk dat het in bepaalde situaties wel indirect een bijdrage levert. Zo zijn er namelijk wel meer voorbeelden.

Interviewer: ja precies en als je dit moet uitdrukken op een schaal van 1 tot 7. Dus 1 is dat het geen effect heeft op de omzet en 7 is dat het wel degelijk effect heeft en dat je denkt dat het duurzaam investeren wel degelijk bijdraagt aan de omzet.

Interviewee: dat het zeker bijdraagt aan een verbetering van de omzet. Hoeveel, een 4. En waarom geen 6 of 7, omdat we nog steeds in een traditionele markt zitten waar een prijs heel erg belangrijk is. En als we 10 jaar verder zijn zou het zomaar kunnen dat duurzaamheid veel belangrijker is, maar dan moet de overheid ook veranderingen doorvoeren dat alle bedrijven worden gedwongen want dan kun je concurreren op gelijk niveau. Nu wil niemand, ook onze concurrenten niet, voorop lopen omdat de markt daar nog niet klaar voor is.

Interviewer: nee oke begrijpelijk. En in hoeverre communiceren jullie de duurzame investeringen aan jullie werknemers?

Interviewee: ja daar zijn we wel trots op. Deze dingen kosten heel veel geld en we vinden het leuk om te laten zien waar de euro's die we verdienen naartoe gaan. We hebben 1 keer in de maand projectleiders overleg. We hebben 20 projectleiders en die worden dan bijgepraat over de dingen die we gedaan hebben en die we nog gaan doen. De ISO 14001 verplicht ons ook om aan te tonen hoe onze communicatiestructuur is omtrent aspecten die het milieu kunnen

verbeteren. We hebben borden in de kantine hangen, we sturen mails rond en het maandelijkse projectleiders overleg en daar geven we het wel extra aandacht.

Interviewer: oke, ik ben benieuwd of het bij jullie effect zal gaan hebben op lange termijn. Wanneer zijn jullie begonnen met het investeren in duurzaamheid?

Interviewee: 3 jaar terug. Nog niet zo heel erg lang. We komen als bedrijf zijnde en als branche zijnde uit een best moeilijke periode. Het was crisis, bedrijven zetten hun investeringen op stop en dit hebben we ook echt gemerkt in onze orderportefeuille. Ja en heel simpel als er niet verdiend wordt kunnen we ook niet investeren in dit soort zaken. In die zin noemen wij het ook wel “bijzaak”.

Interviewer: Nou dit waren de vragen die ik had in lijn met het onderzoek. Hartelijk dank voor je tijd en de openheid.

Interviewee: ja bedankt voor het interview. Leuk om het hierover te hebben en mocht je nog vragen hebben schroom niet om contact met me op te nemen.

Afsluiting

2. INTERVIEW – BEDRIJF 2

Voorstellen, uitleg onderzoek + gebruik van gegevens

Voorstellen, uitleg onderzoek + gebruik van gegevens

Interviewee: in 1988 toen wij de eerste schetsen kregen waren we al bezig met hoe gaat het met verwarming en energie, maar ook met onze afvalstromen. Want wij maken machines en tijdens de productie heb je natuurlijk milieubelastende productieprocessen, denk aan lassen, lakken, energieverbruik. Ook de kosten komen hierbij kijken.
Interviewer: ja hmm m.
Interviewee: het mooiste verhaal wat ik ooit meegemaakt heb is 5 jaar geleden kwam hier de ambtenaar die verantwoordelijk was voor de milieuvergunning en die zei, jullie moeten als bedrijf een plan schrijven om energie te besparen. Toen zei ik tegen hem, weet je wel dat wij al 35 jaar proberen om energie te besparen want wij moeten het zelf betalen en in onze jaarlijkse kostenbalans is energieverbruik een hele grote post. Het is een groot pand dus daar gaat wat energie doorheen.
Interviewer: ja precies
Interviewee: en ik zei tegen die man, wij zijn hier in de omgeving een van de weinige panden waar in de pauze het licht uit gaat. Dat is een kwestie van aandacht hieraan besteden en met je medewerkers ervoor zorgen dat iedereen zich bewust is van het energieverbruik. Er zit overal dubbel glas in, we hebben een goed geïsoleerd dak. We besteden er echt aandacht aan.
Interviewer: hmm m
Interviewee: Daarnaast hebben wij een luchtverversingsinstallatie in het gebouw. Er wordt elk uur 70.000 m3 warme lucht naar binnen geblazen en ook afgevoerd om de lucht te verversen voor het welzijn van het personeel. Het is een hele dure installatie, voornamelijk op het gebied van energieverbruik. Dus was hebben we gezegd, we moeten dat gaan vervangen want zoals wij het doen is uit de tijd. Dit bedrijf gebruikt in de winter als het koud is op 1 dag 1000 m3 aardgas
Interviewer: Zo
Interviewee: dus dat is straks in de transitie niet meer houdbaar, dus we zijn nu bezig of we dit gaan vervangen door andere systemen en we leggen het dak vol zonnepanelen.
Interviewee: nee precies

Interviewee: we hebben ook overal led lampen en de verlichting schakelt automatisch uit als de zon naar binnen gaat schijnen. Dat is allemaal gedaan om energie te besparen. In 2003 hebben we in dit gebouw een speciaal laaddock gebouwd, helemaal naar eigen ontwerp omdat we voorheen buiten vrachtwagens moesten laden.

Interviewer: oke

Interviewee: en als je de vrachtwagen buiten moet laden dan staat de deur open en dan merk je dat in de hele hal en dat kost ontzettend veel gas. Dus onder andere energiebesparing was hiervoor een reden. 1 jaar later hebben we een energiemeting laten doen omdat we heel veel elektriciteit verbruikten en we wilden weten waar dit allemaal heen ging. Uit een meting van een extern bedrijf, met gebruik van een logger die op de elektriciteitscentrale zat, bleek de verlichting de grootste post, de tweede de lasersnijder, en de derde verbruiker was de perslucht. We hebben toen een advies gehad van de leverancier van de compressor die de perslucht maakt en die zei met een moderne compressor die zichzelf regelt in toerental en druk, kun je 25% makkelijk op energie besparen. Hier hebben we in geïnvesteerd. We hebben een nieuwe opstelling gebouwd en toen hebben we 65% stroomverbruik daar weten te reduceren. Dit was in 2007. De lasersnijder is de tweede grote verbruiker, maar daar kunnen wij niks in besparen want die kunnen we niet verkleinen en die heeft alle energie nodig. Als die machine werkt dan is al het licht uit in de fabriek.

Interviewer: En die zijn onbemand dan?

Interviewee: ja niet altijd, maar vaak wel.

Interviewer: Je hebt natuurlijk al een hele hoop verteld, maar om nog even terug te komen op het geheel, hoeveel mensen zijn er werkzaam in dit bedrijf?

Interviewee: globaal 95, 87 FTE.

Interviewer: en u bent dus productieleider en bent goed op de hoogte van alle ontwikkelingen, bent u ook medeverantwoordelijk voor de investeringen op het gebied van duurzaamheid?

Interviewee: Jazeker. Het energieverhaal is bij ons enorm belangrijk en ik ben mede verantwoordelijk voor voornamelijk de productieprocessen en het gebouw.

Interviewer: hoe groot was de omzet van jullie bedrijf in 2018?

Interviewee: ongeveer 14 miljoen

Interviewer: oké en weet u ook hoe groot het was in 2016?

Interviewee: 8% minder

Interviewer: oke, het gaat natuurlijk ook om de investeringen in energiebesparende technologieën, kunt u een inschatting geven wat de totale energiekosten waren van uw bedrijf in 2018?

Interviewee: een indicatie is 96.000 euro aan gas, 54.000 euro aan stroom en dan nog wat kosten aan transport en het meten.

Interviewer: en weet u ongeveer hoeveel de energiekosten deel uitmaken van de totale productiekosten in 2018?

Interviewee: dat durf ik zo niet te zeggen.

Interviewer: Hebben jullie de afgelopen 3 jaar investeringen gedaan in grondstofbesparende technologieën?

Interviewee: ja, ja twee jaar geleden hebben we de airco's van de kantoren vervangen door nieuwe airco's met een beter energielabel en daarmee kunnen wij ook de kantoren verwarmen. Elk jaar ben je er wel mee bezig. We zijn al 8 jaar bezig met de plannen om zonnepanelen te leggen, maar het is voor een bedrijf nog niet zo snel terug te verdienen. Je kunt ze natuurlijk ook aanleggen voor de uitstraling van het bedrijf om te laten zien dat je milieubewust bezig bent.

Interviewer: Ja precies, nou daar kom ik zo nog even bij u op terug, dat is namelijk wel interessant. Kunt u inschatten hoeveel de duurzame investeringen ongeveer gekost hebben?

Interviewee: nou in totaal ongeveer 56.000 euro, maar dat is nog exclusief de zonnepanelen.

Interviewer: oke, en wat was precies de reden voor die investeringen?

Interviewee: nou wat er zat was te oud en dan is het meteen ook energie slurpend. Dus de grootste reden was energiebesparing. Wij kijken altijd bij alle machines of er goede opvolgers zijn na een aantal jaar. Nieuwe systemen zijn altijd weer intelligenter, dus bij een lasapparaat bijvoorbeeld wat 10 minuten niet gebruikt wordt die schakelt zichzelf terug. Een nieuwe machine gebruikt echt veel minder elektriciteit.

Interviewer: ja precies. En in hoeverre maken jullie gebruik van de communicatie van dit soort investeringen in jullie strategie / verkoop?

Interviewee: wij zitten toch wel, als ik het zo mag noemen, in een hele conservatieve, rechtlijnige markt in de landbouwmachines en er is geen enkele klant die ons opbelt en vraagt hoe de CO2-footprint is als ze een machine gaan kopen. Dit heb je misschien wel bij andere bedrijven, maar in onze markt is dit niet zo.

Interviewer: hmm m

Interviewee: wat wel belangrijk is voor iedereen, de machines die wij maken bestaan voor 94% uit staal en dat is 100% recyclebaar. Alleen het staal wordt nergens zo gerecycled als in Nederland.

Interviewer: en als je bovenstaand moet vatten in een cijfer op een schaal van 1 tot 7 met betrekking tot het betrekken van de duurzame investeringen in de marketing strategie?

Interviewee: Dan zal het een 6 zijn. Het hele milieuvraagstuk, daar waar het redelijkerwijs kan doen we ons best. Wij zijn voorloper op het gebied van afvalstromen scheiden. Er is ontzettend veel overbodig transport in de wereld en er wordt ook overbodig veel verpakkingsmateriaal verbruikt. Wij bestellen heel veel staal en dan meteen heel veel soorten in een keer zodat wat ons betreft de chauffeur zo min mogelijk langs hoeft te komen.

Interviewer: je gaf net al even aan dat er vanuit de klanten niet echt naar marketing gekeken wordt. Als je dit moet uitdrukken op een schaal van 1 tot 7 dan?

Interviewee: dan zou ik een 2 geven. Wij betrekken het op dit moment niet in onze communicatie of strategie. Wij hebben veel klanten uit het buitenland die daar ook wat minder mee bezig zijn. In Nederland willen we altijd vooroplopen wanneer het op het milieu etc. aankomt. Onze concurrenten uit Tsjechië en Polen, die zijn hier helemaal niet mee bezig. En als je je veel meer bezighoudt met zoiets dan andere bedrijven uit de markt die in de omgeving zitten dan prijs je jezelf uit de markt.

Interviewer: ja precies.

Interviewee: wij zijn als productiebedrijf de op een na duurste in de wereld en dat weten de klanten ook. Wij kunnen alleen maar een marktpositie houden doordat wij ons onderscheiden in kwaliteit en service.

Interviewer: ja precies echt differentiatie op dat gebied. Ik heb nog 1 vraag wat betreft de technologieën. In hoeverre hebben de investeringen die gedaan zijn in de energie- en grondstof besparende technologieën geleidt tot vermindering van de totale productiekosten per eenheid product? En als je dit aan moet geven op een schaal van 7 = zeer sterk verminderd en 1 = niet verminderd, wat zou je dan schatten?

Interviewee: vijf. Wij hebben 8 jaar geleden de spuiterij vernieuwd en voornamelijk wordt dit spuitwerk nu gedaan door een robot. Het proces is geoptimaliseerd ten opzichte van de mens. Hij knoeit minder, werkt in een gesloten ruimte en hoeft daardoor niet veel luchtverversing te hebben in tegenstelling tot de mens. Dat is een enorme besparing in energie en het proces is alleen maar beter geworden. Onze verlichting is beter geworden en zo zijn er nog een aantal zaken waaruit blijkt dat het best sterk verminderd is.

Interviewer: oke dus u heeft wel daadwerkelijk effect gemerkt in de energiekosten?

Interviewee: ja ja zeker.

Interviewer: nou als het wat oplevert dan zijn het goede investeringen geweest natuurlijk. Dan kom ik op de duurzame product innovatie. Kunt u in het kort vertellen wat jullie aan producten verkopen?

Interviewee: wij maken een heel scala aan landbouwwerktuigen. De oorsprong ligt bij de grasmaaier bij de fruittelers. Milieuaspecten zijn hierbij heel belangrijk want er is nergens zoveel te doen met milieu als in de landbouwwereld. Onze producten gaan de hele wereld over, van Azië, Afrika, Australië, Noord-Amerika en Canada is een hele belangrijke markt. Hier is qua milieu steeds meer aan de orde. Boeren mogen bijvoorbeeld minder meststoffen gebruiken en dan gaan ze een plant verbouwen die zelf mest produceert. Voordat ze dan hun land gaan ploegen om een nieuw product te zaaien dan moet de groenbemester kapot gehakseld worden. Wij hebben daar een machine voor en dat gaat goed, maar het hakselen van dat gras vraagt nogal een vermogen van de tractor en dat gaat om dieselolie. Nu hebben wij bedacht om die machine aan te passen dat hij van achter automatisch open kan zodat op het moment dat de machine zwaar draait dat er dan meer groenbemester gelost kan worden en dat de tractor minder olie gebruikt.

Interviewer: ja dat is iets wat aan het product zelf is gewijzigd.

Interviewee: ja dat klopt. En 8 jaar geleden was dat geen item. Want dieselolie kostte niet veel geld en toen dachten ze laat maar roken. Maar goed nu hebben ze loggers op de trekkers en het gaat daarbij om de kosten, maar ook over de vermindering van uitstoot. En wij zijn daar dagdagelijks mee bezig om daaraan mee te werken. Wij hebben ongeveer 70 mensen in de productie en we hebben 6 mensen die tekenen die de hele dag tekenen om modificaties te verzinnen aan de machines. Die modificaties worden gedaan op aanvraag van de klant.

Interviewer: en zou je dan dus indirect ook kunnen zeggen dat er dus toch vraag is van klanten om producten meer milieuvriendelijker te maken?

Interviewee: ja dat wel. Niet de technologie, maar meer de producten zelf, maar de klant vraagt het dan voor zijn eigen energiebesparing.

Interviewer: ja precies. En sinds wanneer speelt dit precies?

Interviewee: ja dat is iets van de laatste 6 jaar ongeveer.

Interviewer: het staal van de machines is recyclebaar?

Interviewee: ja

Interviewee: en is er ook nog iets gedaan in de vereenvoudiging van herstel of onderhoud?

Interviewee: jazeker het is heel belangrijk dat de klant zelf eenvoudig onderhoud kan doen. Dat bespaart in de exploitatiekosten en dat is toch waar ze het aan het eind van de rit naar kijken. Commercieel gezien hebben wij een nadeel omdat de machines gewoon heel erg lang meegaan.

Interviewer: en als je op een schaal aan moet geven in welke mate de duurzame verandering van producten is toegenomen of niet. 1 = duurzaamheid van producten is in geringe mate toegenomen en 7 = sterk toegenomen.

Interviewee: 5.5 best wel hoog. Het is dagelijks aan de orde. In onze aandrijving van machines moet olie. Dat is ook milieubelastend. Steeds meer bedrijven werken met biologische olie. Voornamelijk in Nederland, Duitsland en België.

Interviewer: en in hoeverre denk je dat het milieuvriendelijker maken van de producten de omzet van het bedrijf heeft beïnvloed?

Interviewee: Nou ja dan praat je misschien over een getal van 5%, maar er zijn wel echt bedrijven die aangeven dat wanneer wij het niet kunnen maken dat ze het dan niet kopen.

Interviewer: en als je dit in een cijfer uitdrukt van 1 tot 7 waarbij 1 geen effect is en 7 een zeer sterk effect?

Interviewee: een klein effect. 1.5. In heel veel landen wordt er totaal niet naar gevraagd. Het totaalplaatje is wel belangrijk. 80% van wat wij maken gaat naar het buitenland.

Interviewer: ja ja

Interviewee: De Amerikaanse markt is veel groter dan de Nederlandse en daar vragen ze er veel minder naar. Nog wel enigszins, maar in Australië of Afrika helemaal niet.

Interviewer: oké en als je kijkt naar kosten. Jullie hebben best wel geïnvesteerd in duurzame technologieën. Merk je dat dit effect heeft op de kosten?

Interviewee: Ja dit heeft wel effect op onze eigen kosten. Doordat wij besparen op energie merk je onder aan de streep wel dat je meer overhoudt.

Interviewer: en als je kijkt naar het algemene beeld. Is het lonend of niet voor jullie bedrijf om te investeren in duurzame technologieën en of producten?

Interviewee: nou daar zijn twee antwoorden mogelijk.

Interviewer: ja

Interviewee: het is zeker lonend en antwoord twee is, als we het niet zouden doen dan zijn we over vijf jaar dicht. Heel simpel.

Interviewer: en waarom zou dat dan zo zijn?

Interviewee: nou wij hebben ons ook te houden aan de Nederlandse wetgeving.

Interviewer: ja precies dat is dan vanwege de regels, maar

Interviewee: dat is dus de must vanwege de wet, aan de andere kant is het ook zo bij heel veel dingen. Stel dat wij over een jaar 10.000 m2 zonnepanelen hebben. Dat is wel een investering van ongeveer 1 miljoen, maar dan gaan we toch in elektriciteits- en gas kosten naar beneden.

Het zal wel even duren voordat het terug verdiend is, maar we denken wel dat dit echt effect gaat hebben.

Interviewer: Ja precies. Nou dank voor dit interview en de informatie.

Afsluiting

Appendix 4: Research Integrity Form

Name: Annelot van den Hurk	*Student number:* s4647238
RU e-mail address: annelot.vandenhurk@ru.nl	*Master specialisation:* Strategic management

Thesis title: Do sustainability investments pay off?
Brief description of the study: Research to the influence of sustainable process innovation in manufacturing firms in the Netherlands, on firms' total production costs.

It is my responsibility to follow the university's code of academic integrity and any relevant academic or professional guidelines in the conduct of my study. This includes:

- providing original work or proper use of references;
- providing appropriate information to all involved in my study;
- requesting informed consent from participants;
- transparency in the way data is processed and represented;
- ensuring confidentiality in the storage and use of data;

If there is any significant change in the question, design or conduct over the course of the research, I will complete another Research Integrity Form.

Breaches of the code of conduct with respect to academic integrity (as described / referred to in the thesis handbook) should and will be forwarded to the examination board. Acting contrary to the code of conduct can result in declaring the thesis invalid

Student's Signature: Digitally signed by Annelot van den Hurk on 31-08-2022 **Date: 30th of August 2022**

To be signed by supervisor

I have instructed the student about ethical issues related to their specific study. I hereby declare that I will challenge her on ethical aspects through their investigation and to act on any violations that I may encounter.

Supervisor's Signature: _____ Date: 30th of August 2022

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2. Wherever possible and allowed, make theses available to potential users inside and outside Radboud University.

This supports the process of creation, acquisition and sharing of knowledge in the educational setting.
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- neither the organization offering internship nor the client of the thesis has any objections against making the thesis publicly available in the thesis repository.
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Student number : s4647238

Student name : Annelot van den Hurk

Thesis title : Do sustainability investments pay off?

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Signature: Digitally signed by Annelot van den Hurk on 31-08-2022

Date: 30th of August 2022

Assessment Form for Master thesis

A digital form is available at the secretary office: secretariaatbedrijfskunde@fm.ru.nl.

Name of student: Annelot van den Hurk

Student ID no. s4647238 Date of defense: 30th of August 2022

CRITERIA	ASSESSMENT (circle your choice)	NOTES
1. Problem formulation	I – S – G - VG	
2. Theoretical background	I – S – G - VG	
3. Methodology (including research ethics)	I – S – G – VG	
4. Analyses	I – S – G – VG	
5. Discussion and conclusions	I – S – G – VG	

6. Practical implications, reflection, and recommendations	I – S – G – VG	
7. Style and structure	I – S – G – VG	
8. Consistency	I – S – G – VG	
9. Process	I – S – G – VG	
10. Defense	I – S – G – VG	

Student handed in a signed Research Integrity Form.	Yes / No
The thesis is checked for plagiarism or fraud	Yes / No

Motivation for final grade

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Name of supervisor: Tentative grade:

Name 2nd examiner: Tentative grade:

I = insufficient; S = sufficient; G = good; VG = very good

Final grade