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THE EFFECTIVENESS OF EUROPEAN UNION EMISSION TRADING SCHEME IN INCENTIVIZING THE INNOVATION AND ADOPTION OF ENVIRONMENTALLY FRIENDLY TECHNOLOGIES.

A qualitative study on energy intensive industries in Europe.

Satu-Maria Kristiina Nuorva

International Business
Bachelor's Thesis
Supervisor: Mika Sillanpää
Date of approval: 9 April 2018

Aalto University
School of Business
Bachelor´s Program in International Business
Mikkeli Campus

AALTO UNIVERSITY
SCHOOL OF BUSINESS
Mikkeli Campus

ABSTRACT OF
BACHELOR'S THESIS

Author: Satu-Maria Kristiina Nuorva

Title of thesis: The effectiveness of European Union Emission Trading Scheme in incentivizing innovation and adoption of environmentally friendly technologies.

Date: 13 April 2018

Degree: Bachelor of Science in Economics and Business Administration

Supervisor: Mika SIllanpää

Objectives
The main objective of this study is to explore the innovation effect of EU ETS in investment and adoption of energy efficient and less polluting technologies, and the adoption of organizational attitudes and perceptions towards the program. The results will be analyzed in the light of Porter Hypothesis.

Summary
Evidence from two first phases of EU ETS showed evidence of innovation effect on some energy intensive industries. However, the results were scattered and no general conclusions could be made, as some industries face higher costs of emission abatement and are dependent on other heavily polluting industries. There was no distinct support for either "weak" or "strong" versions of Porter Hypothesis. The data was collected from existing literature on EU ETS, its effectiveness and Porter Hypothesis.

Conclusions
Even though EU ETS has caused energy intensive industries to invest in RD&D actions and new technologies, even the industry-wide results differed, as some agents had adopted emission reduction and objectives of EU ETS from technological to organizational level, whereas there were organizations that had no interest in RD&D investments of less emitting technologies.
Also, the role of EU ETS as instigator of technological change cannot be confirmed, and empirical evidence from managerial level discussions showed that perceptions towards the program and its innovation effect were rather negative.

Key words: *EMISSION TRADING, AIR POLLUTION, ENVIRONMENTAL POLICY*
Language: English

Grade:

AALTO UNIVERSITY SCHOOL OF BUSINESS
Bachelor´s Program in International Business
Mikkeli Campus

OUTLINE
Bachelor's Thesis

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1. INTRODUCTION

The aim of this study is to examine European Union's cap-and-trade scheme, emission trading scheme (EU ETS), and its effectiveness on increasing and encouraging the innovation of less polluting and environmentally friendly technologies. The effectiveness on increasing the innovation will be discussed in the light of Porter Hypothesis. Firstly, EU ETS and its methods will be introduced. Then, existing literature and research on cap-and-trade programs and Porter Hypothesis will be examined and a theoretical framework created. Furthermore, EU emission trading scheme and its innovation effect will be discussed and analyzed in the light of Porter Hypothesis. Finally, the findings of this study will be relayed on further research of the topic.

1.1. Background

Climate change and its effects on our environment have been recognized widely during the past decades. The problem of man-made greenhouse gas emissions has been tackled on national and international level with different legislations and international treaties in order to reduce the greenhouse gases and to stop the global warming. One of the most famous international treaties is Kyoto Protocol, targeted to United Nations Member States, which created GHG emission targets that member states were not allowed to exceed (UNFCCC, 1997). In November 2016, the continuum of Kyoto Protocol spirit was confirmed, as Paris Agreement was put into force, EU being the first major economy to contribute and ratify the agreement (Liobkiené & Butkus, 2017).

1.1.1. European Union Emission Trading Scheme

To cut the greenhouse gas emissions from year 1990's levels by 40% before year 2030 (Liobkiené & Butkus, 2017), EU needs to create binding instruments that help to achieve the goals. In 2005, a new cap-and-trade program, EU ETS, was introduced and it has been called the "cornerstone of the European Union's drive to reduce its emissions of manmade greenhouse gases" (European Commission, 2016). It is regulated with Directive 2003/87/EC, which states that the European Community and member states together aim

to fulfill the Kyoto Protocol goals by reducing the GHG emissions in “a cost-effective and economically efficient matter” (European Commission, 2003).

EU ETS is the largest cap-and-trade program in the whole world, which covers all European Union Members States, Iceland, Liechtenstein and Norway, and total of approximately 45 per cent of greenhouse gases (GHG) produced in the EU area (EC, 2016). In cap-and-trade programs a cap is put on the allowed amount of emissions from significant emitters, such as major power plants and factories. Based on the defined cap, allowances are distributed to emitters and they have a possibility to either use their allowances or sell them to other emitters (Bergek & Berggren, 2014). The program has been criticized for causing too high costs for energy intensive industries and affecting their competitiveness but also burdening different industries in different ways and creating indirect costs for industries that are not regulated with EU ETS (Lund, 2007).

As emission trading scheme sets a cap for greenhouse gas emissions, and therefore forces companies and manufacturers to find a way to reduce their emission levels every year (European Commission, 2016). When the program was launched, expectation was that the companies would face higher costs for high emission levels, and therefore they would create technologies that increase their abatement costs but enable them to avoid increased emission costs (Calel & Dechezleprêtre, 2014). Also, stringent environmental legislation and its connection to innovation has been noted by Porter (1991, 1995), who claims that environmental legislation might have effects on innovation. However, the nature of EU ETS as a cap-and-trade program still leaves space for different interpretations and therefore the topic can be examined on more detailed level.

Originally EU ETS was regulated with Directive 2003/87/EC and later amended with Directive 2009/29/EC, which added the possibility to auction allowances between the member states. Use of directive as an instrument means that Member States are obliged to certain kinds of actions and the directive needs to be transposed into the national law (Krämer, 2016). The nature of this instrument also requires Member States to achieve the included objectives, yet the method of implementation has not clearly been defined (ibid).

The ETS program was created to force EU member countries to achieve the goals set by the Kyoto Protocol and it was based on the directive 2003/87/EC, which aimed to make the

reductions efficiently in economic terms (Segura et al., 2017). During the two first phases, European Commission implemented a decentralized approach in which the emission caps were regulated on national basis and distributed based on National Allocation Plan that was supervised by European Commission (Meleo, 2014), but the decentralized approach and too long trading periods for allowances were seen inefficient (Betz & Sato, 2006). Also, national regulators were accused for being too largesse in allocation of emission allowances, as surplus of allocations was one of the major problems throughout the first trading period of the program (Ericsson et. al, 2011). However, this was not a case in all Member states and, for example, industries in Italy suffered from allowance deficit that was a consequence of local "political commitment", stricter implementation of emission trading scheme and local policies (Meleo, 2014).

1.2. Research Problem

The topic of EU ETS and its effectiveness is timely, as the third trading period of emission allowances is about to end at 2020 and the fourth phase will be implemented in 2021 (EC, 2016). Even though EU ETS was adopted in 2005 and it has gone through two full phases, harsh critique towards the program has been expressed, and the program still faces problems with its effectiveness in reducing the greenhouse gas emissions. Therefore, better understanding and knowledge about different aspects of emission trading should be gained in order to develop EU ETS and other cap-and-trade programs to service the combat against climate change.

As technological change has a key role in emission reduction, the innovation effect of climate policies should be examined. Production on energy intensive industries requires versatile use of different energy sources, which creates significant amount of greenhouse gas emissions, as the use of fossil fuels is often considered the most cost-effective option. After the adoption of EU ETS, the companies among regulated industries are pressured to cut down their emission levels, and make decisions to either cut their actual emissions or buy allowances to compensate the lack of reduction in their production. Therefore, this study seeks to gain a better understanding of the trade-offs between innovation and adoption of cleaner technologies, and holding on with existing technologies.

1.3. Research Questions

This thesis will seek to find answers to following questions:

- Does European Union's emission trading scheme incentivize innovation of environmentally friendly technologies in energy intense industries?
- Does EU ETS support both, weak and strong versions of Porter Hypothesis?

1.4. Research Objectives

I) To investigate the innovation effect of EU ETS

II) To examine whether the empirical evidence found from EU ETS supports or opposes the Porter Hypothesis

1.5. Definitions

1.5.1. Innovation

The definition of innovation has been widely discussed and there are several ways to define the term. For example, Oxford Dictionary (2018), defines innovation: 'make changes in something established, especially by introducing new methods, ideas, or products'. Porter and van der Linde (1991), describe that companies becoming smarter in their approaches to handle pollution in reducing the emission levels and handling the secondary treatment, is a form of innovation. However, these definitions are broad and not very detailed.

Research on emission trading's innovation effect prefers to use number of patents as a measurement of innovation even though not all environmental innovations are patented and therefore cannot be detected (Kemp & Pontoglio, 2011). Also, the organizational level innovation has been included in the study, as it has shown significant effects on the decision-making related to innovation-related investments (Gulbrandsen & Stenqvist, 2013).

1.5.2. Porter Hypothesis

In his article, Michael Porter (1991), states that strict environmental regulation that has been well constructed, could incentivize companies to re-engineer their technologies and not only to pollute less, but to lower their emission-related costs and increase their competitiveness.

Three dimensions of Porter Hypothesis (PH) have been extracted, and they are narrow, weak and strong (Jaffe & Palmer, 1997). However, the nature of narrow version is that "certain" kinds of regulations could incentivize innovation and mentions both, goals and processes, important in achieving these goals (ibid.), and therefore it cannot be applied to the case of EU ETS, which offers polluters a possibility to choose their methods to achieve the goals (EC, 2016).

Two other dimensions, strong and weak, are discussed in this study, as weak states that certain kind of regulation could stimulate innovation, and strong adds that regulation might increase the abatement costs but the adopted methods might lead to increase in profits (Jaffe & Palmer, 1995, Porter & van der Linde, 1997).

2. LITERATURE REVIEW

2.1. Introduction

The purpose is to investigate the European Union's emission regulation and its effectiveness in terms of innovation in environmentally friendly technologies. The public policy chosen to this study is EU emission trading scheme (ETS), which is a market-based instrument to combat climate change. The EU ETS has been implemented in 2005, and it has been described as the cornerstone of European greenhouse gas emission control (EC, 2016).

The theoretic background for this study is based on Porter Theory, which suggests that innovation can be promoted with environmental regulation that has been constructed well (Porter, 1991). Both "weak" and "strong" versions of Porter Hypothesis will be analyzed, as they suggest slightly different end-results for innovation and economic performance. In their article, Porter and van der Linder (1995) suggest, based on empirical testing, that waste of

resources comes in a form of pollution, and if the amount of pollution is reduced, bigger efficiency and improvement in production can be attained. Therefore, environmental regulation that controls emission levels might cause more innovation of environmentally friendly technologies. As Porter Hypothesis is originally based on flexible, market-based environmental policies, such as CTP, European Union Emission Trading Scheme can be used as a case study to examine support for the theory.

Existing research shows that the innovation effect of cap-and-trade programs in the United States has not been as successful as expected, as the adoption of the programs has not managed to increase the number of patent applications (Taylor, 2012). However, evidence conducted from one economy might not apply to others, and therefore specific research on EU ETS is necessary in order to draw conclusions on innovation effects of the program.

Even though evidence from the United States has not been very encouraging, the development of carbon capture and storage technologies has significantly increased in European Union Member States after the EU ETS has been implemented (Rogget et. al, 2011, Calel & Dechezleprêtre, 2014). The literature has also showed that the empirical support for Porter Hypothesis, which states that stringent environmental regulation could increase innovation of environmentally friendly technologies, is mainly based on company case studies, and it cannot be used to generalize the emission reduction among whole industries or economic areas (Lanoie et. al, 2011). Therefore, this thesis seeks to examine whether the evidence found from the case of European Union emission trading scheme supports Porter Hypothesis.

2.2. Cap-and-trade programs

As greenhouse gas emissions and climate change have become a major global problem, solutions to combat the climate change have been looked for. The use of cap-and-trade programs (CTP) has often been reasoned by equality; all polluters will face the same marginal abatement costs regardless of their industry (Metcalf, 2009). Another justification for the use of CTPs is related to their lower emission reduction costs in comparison to the costs caused by the use of other policy instruments, such as technological performance standards (Goulder & Schein, 2013). Emission trading programs' design has also been

described simple; the regulators in charge of emission control set an acceptable level of emissions that should not be exceeded and the emitters are given two options; to reduce their emissions by adopting less polluting technologies or buy allowances for each ton of emissions that exceed the emission cap (Stranlund et. al, 2002). In a simple and well-functioning form, firms are able to avoid high technology-related abatement costs by buying the permits from companies with low abatement costs, and the price of emission allowances is determined by the supply and demand (ibid).

2.2.1 CTP and innovation

Innovation related to environmental regulation and CTP has been discussed widely in the literature. There are several different definitions to explain what is innovation, and for example Hanemann (2015), uses Schumpeter's famous three stages: invention, innovation and diffusion to explain the development of technological change. However, he mentions only invention and innovation as noteworthy in the case of climate change, as the development of the less polluting technologies is still on very experimental level. This explanation is supported by Arundel et. al (2003) who mention that the patents are not often commercialized and therefore diffusion is not as focal part of innovation compared to invention and innovation.

Despite the attention gained in academia, one superior opinion regarding the relationship between emission trading and innovation cannot be detected. Instead, several different opinions have been brought out. Taylor (2012) noted that cap-and-trade programs in the United States have caused a decline in number of patent applications during the trading of emissions and hence no sustained incentives in innovation can be detected. Also, Hanemann (2011) notes that U.S. Clean Air Act in 1990s managed to reduce SO2 emissions, and new, more efficient technologies were indeed adopted but again, an increase in number of patent applications was not detected. However, evidence of emerging patenting activities has been found from the adoption of the European Union's Emission Trading Scheme, which managed to increase the patenting applications of low-carbon technologies in comparison to other general patents between 2003 and 2005 (Kemp & Pontoglio, 2011). The case of European Union Emission Trading Scheme will be discussed in detail later.

Even though patenting is widely used to indicate the environmental innovation, differing opinions do exist, as Arundel et al. (2003), suggest that patenting cannot be used as an indicator but a proxy instead, as they are not commercialized and often the innovations do not end up patented. Jaffe and Palmer also mention (1997) that Pollution Abatement Cost Expenditures (PACE) data, which is also used to indicate environmental innovation, has not found a connection between expenditures on research and development of technologies and patent applications. However, the use of PACE data has also been criticized by Arundel et. al (2003) who mention that the data focuses on such limited range of innovation, that the financial indicators based on PACE are not accurate enough. However, this study will examine literature based on both, PACE and patenting activities, as they still are widely accepted and used.

When discussing the effectiveness of environmental regulation, it is important to remember that judging and ranking policy instruments based on their effectiveness on innovation is difficult, as the implementation of a policy in different situation might lead into different end-results and therefore they are not always comparable (Kemp & Pontoglio, 2011). This is why this study focuses on one specific market-based instrument on a specific case study.

2.2.2 CTP and consequences on economic performance

Even though cap-and-trade and other market-based instruments have been complimented for their ability to share abatement costs equally among the polluters, a negative connection between economic performance and stringency of environmental regulation has been detected (Lanoie et. al, 2011). As CTPs offer firms a possibility to find their own way to perform within the regulatory framework, they have been seen as the most efficient instrument to control greenhouse gas emissions without damaging the business (Ramanathan et. al, 2017). However, the superiority of market-based instruments has been questioned, as they have been studied in a broad range of different methods and industries, which does not give consistent results

Over the time, another problem with emission trading has been the pricing. Even though the market should be able to determine the right price for emission allowances, the ex post observation has noticed that the implementation of these programs has caused a problem with the allowance prices (de Perthuis & Trotignon, 2014). Huppes et. al (2016) also mention

that the inelasticity of carbon market makes it impossible to predict price signals in order to maintain price efficiency and that cap-and-trade programs are likely to lower the permit prices instead of emission levels.

Also, one should bear in mind a notion by Arundel et. al (2003), that the connection between economic performance and environmental innovation can be found only under favorable conditions.

2.3. Porter Hypothesis

2.3.1 Background

In their article, Porter and van der Linde (1995), noted that various studies have actually failed to prove that strict environmental regulation or legislation hurt industrial competitiveness. Porter had previously published an essay, which stated that stringent environmental regulation could enhance the competitiveness if they were constructed in a way that aimed to outcomes instead of methods (Porte**r**, 1991). Companies could be encouraged to create new technologies that, at first, increase short-term costs, but later reduce their product costs and pollute less than the old technologies. New technologies and innovations in pollution prevention would help companies to gain a competitive advantage (Porter & van der Linde, 1995).

Porter hypothesis has been supported and opposed widely, as it is very controversial (Lanoie et al., 2011), and the literature and research on the topic have had major problems in methodology and measurements (Franckx, 2015). Arguments against have mentioned that the hypothesis was built on an assumption that companies do sometimes ignore profit-increasing opportunities, and they questioned why there was a need for regulation that encourages companies to create innovations that aim for increase in profits (Ambec et. al, 2013).

2.3.2. Empirical evidence of Porter Hypothesis

The “weak” interpretation of the hypothesis suggests that environmental regulation that is constructed properly could encourage innovation in research and development of new

technologies (Ambec et. al, 2013). It has been widely accepted and usually the empirical testing of PH has its focus on the "weak" version (Rubashkina et. al, 2015). Jaffe and Palmer (1997) tested the Porter Hypothesis on all three dimensions and found a link between strictness of the regulation and innovations in research and development of new technologies. However, they note that it would have been surprising if no linkage had been found, as changes in environmental policies tend to increase the relative prices of environmental factors in production and firms usually want to identify and minimize their expenditures that are not profitable enough.

As the "weak" version of PH focuses on the policy design, different kinds of classifications have been made. A distinction between "flexible" or innovation-friendly and "inflexible" with more stringent regulatory requirements (Majumdar & Marcus, 2001). One of the most recent policies, European Union's Emission Trading Scheme (ETS), has been classified as "flexible", since it does not restrict companies in their production methods or technological requirements but defines the outcome that is desired or required (Ramanathan et. al, 2017). Instead, these kinds of cap-and-trade programs adjust a strict quantitative limit for emissions from specific producers and these producers have a possibility to trade their emission reductions. The expenditures in research and development of efficient technologies can be financed with trading their EU allowances to other producers (Segura et. al, 2018).

The precision of the term 'innovation' has been questioned by Lanoie et. al (2011) and Jaffe & Palmer (1997) who agree that there have not been linkages between patenting activities and the stringency of environmental regulation but instead in R&D expenditures. Empiciral results from Rubashkina et al. (2015) show quite the opposite; they found out that European environmental policies have positive impacts on patenting related to environmental issues and technologies. However, their study was conducted based on several different environmental policies and did not offer insights on the EU emission trading scheme. Difficulties in defining innovation indeed arise, and no clear definition has not been offered. Some have made a distinction between innovation and R&D (Ramanthan et. al, 2017), whereas some include both, patent applications and R&D expenditures in their definition of overall innovation (Rubashkina et. al, 2015 & Franckx, 2017). In this paper, a distinction between R&D and patent application is not made, and they both will be included in the definition of innovation.

Overall, the literature does find supporting empirical results for the “weak” version of Porter Hypothesis, even though some contradiction in results and definitions does exist. Also, an important note by Segura et. al (2018) was that European Union’s ETS program has indeed had positive effects on innovation of cleaner technologies that have made the carbon dioxide emission control more affordable and efficient.

While the weak version of Porter Hypothesis suggests innovation could be promoted through well-constructed regulation, the “strong” version makes an addition that the innovation induced from the regulation tends to offset the costs that result from the expenditures or regulation so well that companies are able to increase their competitiveness (Ambec et. al, 2013).

The literature regarding strong Porter Hypothesis does also lack the empirical evidence of linkage between the stringency of regulation and firms’ competitiveness (Segura et. al, 2015). Often an approach with focus on proxies of competitiveness and the environmental regulation has been adopted but the results for this version are more mixed and controversial (Rubashkina et. al, 2015). Also, one should note that the research and empirical evidence has been gathered for more than two decades, and during that time the environmental regulation has been revised and changed and new regulations and policy types have been created. This has also been noticed by Ambec et al. (2013) who note that more clear evidence on strong Porter Hypothesis has been found on more recent studies (e.g. Rexhäuser & Rammer, 2011), whereas Jaffe & Palmer (1997) did not find a link between innovation, firms’ competitiveness and environmental regulation.

2.3.3 European Union Emission Trading Scheme

2.3.3.1. Background

Emission Trading Scheme was introduced by European Union in 2005 with an aim to cut CO2 emissions within European Union, and it became the biggest cap-and-trade scheme in the World (Betz & Sato, 2006). The EU ETS has been described as “the cornerstone of the European Union’s drive to reduce its emissions of manmade greenhouse gases which are largely responsible for warming of the planet and causing climate change” (European Commission, 2016) and it covers up to 46% of CO2 emissions in Europe (Sanin et. al, 2015).

2.3.3.2. Critisicm: EU ETS and price volatility

Even though the ETS program has been appreciated and evidence of positive effects on innovation has been detected (Segura et. al, 2018), the use of cap-and-trade programs has been questioned, especially when they include long-term objectives for emission reduction, as there is a possibility for changes in regulatory framework and market for emission allowances (Koch et. al, 2015).

Evidence of price volatility was detected immediately after the implementation of EU ETS program, during the Phase 1 and the carbon market was caught showing features or emerging markets (Balietti, 2016). During the expiration of Phase 1, the prices dropped dramatically as the allowances for this phase could not be banked or stored they did expire after the expiration of the phase (Sanin et. al, 2015). Short-term price volatility has been detected after any European Parliament decisions that have increased the media attention regarding EU ETS (Betz & Sato, 2006, Sanin et. al, 2015). Same notion was made in a study by Koch et. al (2016), in which the price jumps were detected immediately after significant EU ETS announcements or leakages of decision-making drafts. Indeed, increase in media attention has increased the volatility and an interpretation has been made that information regarding the EP decisions related to allowance market should be shared more efficiently and before the decisions take place as the price jumps can be prevented or moderated by offering higher media coverage and information about upcoming decisions (Deeney et. al, 2016).

Even though problems with price volatility have been detected and several reasons for their appearance proposed, the significance of global financial crisis should not be forgotten (de Bruyn et. al, 2010). It has caused decrease in demand and reduced emissions from various energy intensive industries so that a surplus in allowances has appeared (de Bruyn et. al, 2010, Skovgaard, 2017). Another explanation for surplus and price volatility was detected from the shift from Phase 1 to 2, as the banking and borrowing of future allowances was permitted during the Phase 1 but prohibited between phases and after the end of Phase 1 (Crossland et. al, 2013).

2.3.3.3. Development of EU ETS: from grandfathering to auctioning

The first Phase of EU ETS, which was a three-year pilot phase, included grandfathering, free allocation of emission allowances as the emission reduction method (Vlachous & Pantelias, 2017). The Member States were to explain in their National Allocation Plan (NAP), how many allowances were needed and how they would be distributed within the country (Meleo, 2014).

To discuss the innovation effect of EU ETS, it is important to understand the development and history of the program. The operating mechanism for emission allowance allocation has also been mentioned as one of the main research topics in the studies of emission trading scheme (Zhang & Wei, 2010), as surplus in allocations was detected during the Phase 1 (Crossland et. al, 2013).

The first phase of EU ETS resulted in outcomes that did not satisfy the European community, as there was no specific goal for CO2 emission reduction and Member states adjusted their emission caps based on their individual goals stated in Kyoto Protocol (Vlachou & Pantelias, 2017). The method of grandfathering, national regulators giving allowances for agents for free and based on their previous emission levels has been widely used among cap-and-trade programs but it has been seen inefficient and not as cost-efficient than auctioning of allowances (Álvarez & André, 2015). This argument has been supported by Betz & Sato (2006), who also mention that allowance allocation by grandfathering supported trading and price strategies in certain industries in a way that affected companies' competitiveness.

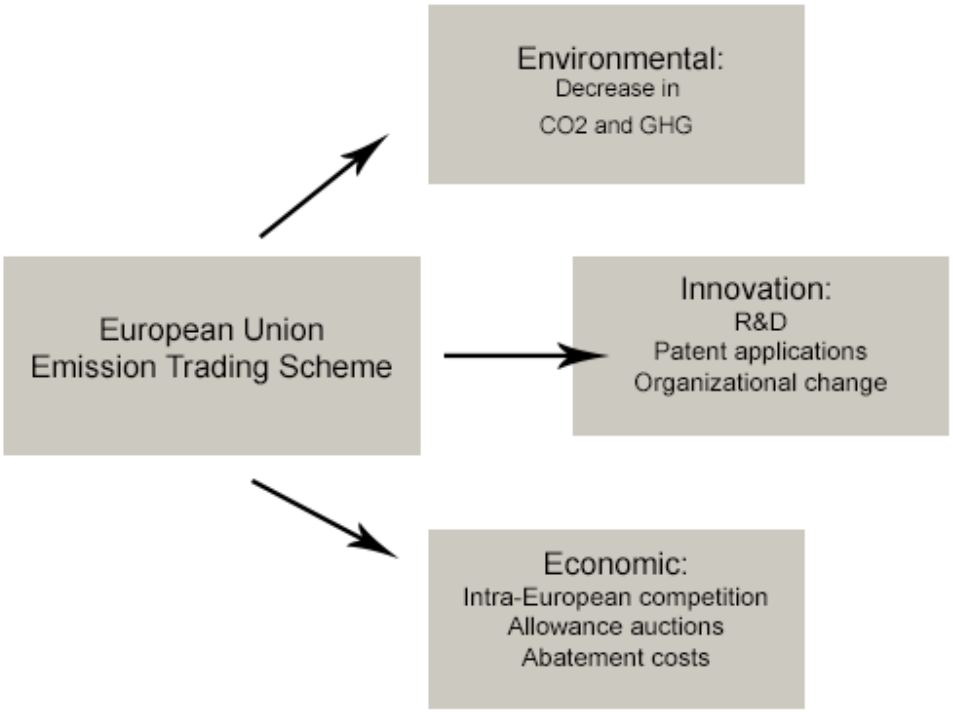
Despite the fact that free allocation of allowances was criticized throughout the first Phase 1, the same approach was adopted in second phase of EU ETS (EC, 2016). Even though the emission caps were re-evaluated and new ones installed, the emission levels in Europe decreased as a consequence of the global financial crisis, and the binding caps were no more as binding as they were meant to be (de Bruyn et. al, 2010). However, the implementation of Phase 3 brought the auctioning of allocations in the spotlight, as they are replacing the free allocation of allowances in order to increase the efficiency and transparency of EU ETS (Álvarez & André, 2015) and for instance, whole power generation sector has been subject to 100% auctioning from 2013 (EC, 2015).

It has been argued that auctioning might weaken the competitiveness of energy intensive industries within Europe if they are imposed to major part of the CO2 costs, as they already have suffered from increase in energy prices and abatement costs (Frondel et. al, 2012). However, support for auctioning has been reasoned by its cost-efficiency and transparency in distribution of allocations (Stenqvist & Åhman, 2014). The cost-efficiency has still been criticized, as auctioning costs have tended to increase over the costs that grandfathering caused (Álvarez & André, 2015).

Another auction-critiquing argument has been the problem with surplus of allowances, which has caused the decrease in allowance prices (de Bruyn et. al, 2010). As the price of allowances has been determined by the demand and supply, low demand in situation of allowance surplus has caused a problem of low-or even zero level prices and as a solution for this problem, a price floor for auctions or an additional emission fee have been introduced (Brink et. al, 2016).

3.0. CONCEPTUAL FRAMEWORK

Figure 1.0: Conceptual Framework



The conceptual framework, illustrated in Figure 1.0 shows the three represented effects of emission trading scheme. First, it affects the CO2 and greenhouse gas emissions within European Union Member states by placing a quantitative cap on emission levels and tightening the cap every year. Secondly, it has been said to affect the innovation of environmentally efficient technologies, especially among R&D, patents and organizational change. Thirdly, it has economic consequences, such as increase in Intra-European competition, auctioning of emission allowances and increased abatement costs.

4.0. METHODOLOGY

The main source of data for this study was based on already existing literature, as research on the topic already exists. The topic of this study involves numerous sectors of business and European Union institutions, and therefore use of secondary sources for data collection offered a broader perspective for the topic, as extensive qualitative and quantitative studies would have been necessary in order to gather data for the use of this study.

Primary data used in this study was mainly conducted from European Union's and European Commission's material and regulations, such as Directive EC 2003/87/EC, that offer official information related to the regulation of EU ETS.

4.1. Data Collection

In order to find topic-related secondary data, existing literature was searched with keywords, such as, "European Union Emission Trading Scheme" "Innovation and EU ETS" "EU ETS and Porter Hypothesis", using the databases for data collection. The emphasis was on qualitative research and empirical evidence on the effects of EU ETS.

5.0. FINDINGS

The purpose of this section is to present the findings of the primary and secondary data on EU ETS and its innovation effects and evidence on Porter Hypothesis.

5.1. Technological innovation and development.

5.1.1. Technological change in paper and pulp industry

In Italy, the technological change has been significant since the introduction of Combined Heat Power (CHP), as the technology enables to decrease emission levels and lower the energy costs of production (Meleo, 2014). Also, the use of traditional petrol fuel has been shown to decrease, which is a consequence of converting paper plants from oil to gas. However, no significant evidence on adoption of renewable energy sources has been detected and industry has shown no interest towards the change (ibid). Swedish paper industry, which is the second largest in Europe, has been specialized in process-integrated energy production and major investments in, for example, steam turbine technology has been made and several producers have showed their interest in adoption of wind power (Meleo, 2015, Ericsson et al., 2011).

In Germany, paper and pulp industry showed increase in research, development, demonstration (RD&D) investments between years 2000 and 2009 but only 20% of producers experienced increase in investments after the introduction of EU ETS (Rogge et al., 2011). Investment volume in new plants was dispersed, as 40% of producers increased and 50% decreased their investments (ibid). However, a study by Gullbrandsen & Stenqvist (2013) shows that a Swedish paper company and its external partner have made massive investments in Germany to build a CHP plant in order to outsource the electricity and heat production of a German paper mill to CHP plant and phase out the use of old technologies.

Also in Norwegian and Swedish paper and pulp industries the amount of investments in GHG reduction are expected to raise during the 3rd trading period of EU ETS, as the adoption of cleaner technologies has enabled the companies to gain revenues from trading their excess allowances (Gullbrandsen & Stenqvist, 2013).

5.1.2. Technological change in other energy intensive industries

At the same time, German energy production has showed significant increase in their RD&D investments, even though GHG emission reduction has not been the only reason for increase in RD&D budgets (Rogge et al., 2010). The same point was made out by Borghesi et al. (2011), who interviewed representatives from European energy industry and stated that legislation targeted to CO2 reduction did not affect the technological innovation.

Evidence on patenting activities among businesses from ETS-regulated industries was detected by Calel and Dechezleprêtre (2014). They made a finding that emission trading scheme indeed has positive effects on as the innovation of low-carbon technologies and the patenting among ETS-regulated companies. Also, research and development of carbon capture and storage technologies (CCS) has not only increased but also attracted private funding, as the development of these technologies have been seen as a significant player in decarbonisation of Europe (Rogge et al., 2011).

Innovation of cleaner technologies has also been discussed as one of the drivers of better economic performance among German manufacturing industries (Löschel et al., 2018). Even though the results regarding economic performance and production efficiency were heterogeneous, supportive evidence for better economic performance during the first Phase of EU ETS could be detected. This was explained with the incentives to invest in capital stock and technologies, which gives the companies a better possibility to increase their production levels with smaller levels of inputs (ibid).

5.1.3. Corporate climate and environment

Even though innovation is often associated with technological change, also change within organizations and their corporate culture and strategies have been under examination. When EU ETS was introduced and under planning, a Swedish paper and pulp company decided to make a company-wide commitment to reduce their emission levels and as a consequence, their corporate strategy on emission reduction has remained and developed alongside EU ETS (Gullbrandsen & Stenqvist, 2013). In Germany, evidence of attitudes towards climate change and emission reduction have been changed and can be connected to the adoption of EU ETS (Rogge & Hoffman, 2010). Especially top management in German

companies has changed their way of thinking, as emission trading scheme has possible future effects on organizational strategies (ibid). This is supported by Borghesi et al. (2011), who add that environmental monitoring and implementation of EU ETS and other environmental standards has been moved to specialized, purposefully invented business units.

Change of attitudes and the role of perception happens to carry a strong role in RD&D investments. Companies' positive attitudes towards increased electricity prices, which are consequence of stringent regulation, have been connected to increase in total and RD&D-related investments (Schmidt et al., 2012). For example, the overall perception towards use of coal has decreased and companies who use non-coal technologies consider the phenomena as a driver for demand. Therefore, technologies are improved with the increased investments in RD&D (ibid).

Even though not all companies among heavily regulated industries support EU ETS, stringency of the regulation and lowered emission caps has forced them to participate in technological change. Exxon, World's largest oil refinery company has improved their energy efficiency three times faster than the industry average, even though at 2000 the company stated that climate change was not human-induced (Skjærseth, 2013). EU ETS has not particularly incentivized the introduction of new technologies, but the development of existing ones and therefore the company has managed to reach their reduction goals without buying extra allowances (ibid).

Schmidt et al. (2012) also found out that even though the overall perception towards EU ETS was positive, not all companies did invest in less emitting technologies. Instead, those with positive perception still invested in emitting technologies, but this could be explained with the low stringency and generous caps of the two first phases, as the price for excess CO2 emissions was relatively low (ibid). Also, European ceramics industry has noted that legislation is not the only reason for eco-innovation, and a common belief among coke industry is that innovations are carried out as a consequence of overall demand and cost-efficiency in production (Borghesi et al., 2015).

Study among Belgian managers showed that there would be no incentives for future investments in innovation if the companies received excess number of allowances and achieved their reduction goals (Venmans, 2016).

6.0. DISCUSSION AND ANALYSIS

The purpose of this section is to analyze and discuss the findings from existing literature and evidence on EU ETS.

Firstly, it can be concluded that EU ETS indeed has driven technical change and innovation among regulated industries, however the reasons for adoption of new technologies cannot directly be associated with positive perceptions or free will to make technological changes in existing types of actions. Also, the findings from different sectors and geographical areas differed, and therefore simple conclusions on innovation effects cannot be made. The differences and their possible reasons will also be discussed in this section.

6.1. Analysis and Discussion

The innovation effect and effects on adoption of ecofriendly and less emitting technologies were one of the main issues discussed in the literature. Paper and pulp industry (PPI) did stand out in terms of technological change and commitment to GHG emission reduction. This can be connected to the use and adoption of CHP technologies, which allow companies to cut down their electricity and heat costs by producing the heat and electricity for their own needs (Meleo, 2014). This was noted in studies made in Italy, Sweden, Germany and Norway (Meleo, 2014; Ericsson et al., 2011; Gullbrandsen & Stenqvist, 2013). However, the possibility for self-sufficiency is also tied to ownership of raw materials; in their study, Gullbrandsen & Stenqvist (2013), compared Swedish SCA and Norwegian Norwegian Skog, from which SCA is the largest forest-owner in Europe and therefore has almost unlimited access to raw materials for self-sufficient energy and heat production. In comparison, Norwegian Skog does not own forest areas and is not capable to make as major investments

as SCA (ibid). However, the paper and pulp industry showed significant interest in environmentally friendly innovations, and companies among the industry have stated that they truly strive for sustainability and they are doing their best to create production methods that harm their environment as little as possible.

Another important observation regarding the paper industry is the heterogeneity of the adoption of new technologies. Whereas there was evidence on massive investments and adoption of CHP technologies and wind-turbines, the two first phases of EU ETS allowed some of the agents to remain investing in emitting technologies (Pontoglio, 2010). The stringency of EU ETS was still very loose and surplus of emission allowances enabled numerous agents to stick with their original methods and technologies. This observation could be described as supportive for Porter Hypothesis, as the stringency of regulation is described one of the significant factors in incentivizing technical innovations (Porter & van der Linde, 1997).

The reasons for not investing in energy-efficient technologies could be explained with various reasons. First of all, not all industries have the similar possibility for PPI sector's self-sufficiency in phasing out the use of fossil fuels. EU ETS has caused increase in energy prices, as power sector has faced significant costs, and this affects especially the most energy intensive sectors (Lund, 2007). Also, the regulatory uncertainty of EU ETS has caused the companies to postpone their plans in adoption of technologies and RD&D investments (Hoffmann et al., 2009). The first Phase of EU ETS was described as 'learning by doing' (EC, 2018), which caused ambivalence among agents on different sectors, as the program was still under development and there was no enough certainty on the implementation and future practices (Hoffmann et al., 2009).

Another interesting observation was made by Venmans (2015) in interviews with Belgian business managers. Even though companies had a possibility to invest in more advanced technologies, they did not perceive it necessary. Overall, the perceptions of EU ETS adoption and its effects on Belgian ETS-regulated industries were negative, and organizations did not consider reduction of GHG-emissions necessary and the policy was considered as forcing as command-and-control programs (ibid).

However, one should note that increase in research or patenting activities might not be a direct consequence of EU ETS, as fear of possible stringent command-and-control policies drives public authorities and companies to create better technologies as they are expected to become requisite (ibid). Innovation of carbon capture and storage technologies was also mentioned by Borghesi et. al (2015) who noted that policies targeted to reduction of CO2 emissions have not had major effects on innovation of technologies per se, but in switch of fuel and process innovations. Also, evidence from interviews with industry managers has shown that various agents consider the program as one obligatory environmental policy among others, and investment or innovation decisions are not connected to the incentives created by EU ETS (Borghesi et al., 2015; Venmans, 2015).

Based on the data collected from the literature in EU ETS, strong support for the Porter Hypothesis cannot be detected. Most of the empirical evidence did not support neither of the strong of weak versions of Porter Hypothesis, but the study by Löschel et al. (2018) supported the strong version, as their year-by-year analysis did show significant effect on economic performance during the first phase of EU ETS. Also, the weak version could be supported in the light of study by Lundgren et al. (2015) who highlighted the fact that the first phases were characterized by lack of stringency in the regulation, and therefore the regulated industries were not incentivized enough to invest in R&D or patenting activities for emission reduction. However, the opposing opinion was, that there is still not enough empirical evidence to support the Porter Hypothesis, even though both versions could somehow be supported in the light of modern environmental policies (Ambec et al., 2010).

Even though organizational culture and perceptions, and their effects on emission reduction are not included in the strict definition of innovation, they still appeared significantly in the discussion regarding technological change and innovation. In Germany, the adoption of EU ETS could be connected to change in overall attitudes towards climate change and emission reduction, as the companies among energy intensive industries were incentivized to create more efficient and less polluting technologies (Rogge & Hoffmann, 2010). One could draw a conclusion that the adoption of stringent environmental regulation might incentivize companies to reassess their organizational strategies and include emission reduction and environmental values as part of their operations model, and therefore increase innovation inputs in the future. As environmental policy instruments are already widely accepted and

implemented, organizations need to find ways to cope with the changes and be able to meet the objectives that they are regulated with.

Overall, the results indicated that the innovation and patenting activities after the adoption of EU ETS could not directly connected to the program itself. Increase in R&D investments, adoption of less polluting technologies was detected, especially among paper and pulp industry, but the true reason for adoption of the new technologies is difficult to detect, as there are there are several other reasons for companies among energy intensive industries to adopt new technologies. Also, there was evidence that companies with negative or neutral attitudes did take part in technological change, whereas companies with positive attitudes did very limited changes or reduction in their emission levels. Therefore, a clear connection between attitudes and performance or adoption of technologies could not be drawn. However, the research on this topic is still rather limited. The limitations will be discussed further.

7.0. CONCLUSION AND RECOMMENDATIONS

7.1. Main Findings

This thesis posed the question ‘Is European Union’s Emission Trading Scheme effective in incentivizing the innovation and adoption of environmentally friendly technologies in the light of Porter Hypothesis?’ in order to highlight the company- and sector-level consequences of the adoption of this international cap-and-trade program. First, the background and theoretical framework were introduced and existing literature analyzed in order to highlight the predominant comprehension of EU ETS and its effectiveness. This revealed that the program still undergoes its development, as the first trading period was a try out-phase, and two other following ones have given more information about the functions and possibilities of the program. It was also revealed that empirical evidence on third trading period’s effectiveness is still exiguous. However, there has been change in the nature of EU ETS after the method of grandfathering the emission allowances based on National Allowance

Plans has been developed and the method of auctioning has been adopted to complement the system in order to make it more efficient and increase the innovation effect.

When the innovation effect of EU ETS was examined, a new scope appeared. Even though statistics on adoption of new technologies and emission reductions could be analyzed by themselves, organizational attitudes and perceptions towards emission reduction and climate change did take an important role in the discussion. It became evident, that technological change has occurred among the participating industries, but it could not be connected to EU ETS only. Management-level discussion revealed that technological change was not necessary or a consequence of emission reduction objectives, but some industries found it necessary to update their technologies in order to create their business more efficient and cut costs. Adoption of Combined Heat and Power technology was seen almost mandatory in order to cut the costs or energy consumption, as the price volatility of EU ETS affects industries in which the production is heavily dependent on electricity, and therefore self-sufficiency offers a competitive advantage.

Even though studies with a scope in certain industries did exist, it was difficult to make a clear distinction between numerous industries and their differences. Also, differences inside industries did exist. Enterprises among did have different approaches towards climate change, innovation and technological change, and companies in different countries among same industry might have had contrary experiences during the economic crisis. Where paper and pulp industry in Italy was strongly affected by the economic crisis, Swedish PPI has managed to develop their business and capitalize the material from their woodland after adopting CHP in mills and production facilities.

To analyze the innovation effect in the light of Porter Hypothesis, two dimensions – weak and strong were detached and discussed. As the evidence showed, the results related to actual innovation effect of EU ETS were weak, there was hardly no evidence to support Porter Hypothesis, especially the strong version. One could talk about innovation effect, as there was evidence on patent applications and adoption of technologies, but no studies showed significant support for increase in competitiveness as a consequence of stringent regulation. The perceptions among participated industries was that EU ETS was not the primary reason for technological change, but the increased competition among technologically developed companies that strove towards self-sufficiency in order to create

a competitive advantage. Also, the increase in abatement costs was not connected to economic performance, and therefore the strong version of Porter Hypothesis could not be supported.

Even though a slight connection between EU ETS and Porter Hypothesis' weak version could be made, there was not enough evidence to support that patent applications and new technologies were a consequence of the stringency and policy model of EU ETS. Indeed, there was evidence of increased innovation and patenting activity among some industries, but the overall results regarding the innovation were slightly scattered and not consistent, and they varied depending on the phase of the program.

7.2. Implication for International Business

As European Union Emission Trading Scheme is a program that is implemented in overall 31 countries and among multiple energy intensive industries, it is the largest cap-and-trade program in the world. Not only does it affect the regulated industries and Member States of European Union, but also those who do trade with European companies from energy intensive industries. As the literature has shown, the EU ETS has had a secondary effect on industries that are not directly part of it, it could be described very effective and comprehensive. This study gives an outlook on EU ETS and how its implementation has affected companies across Europe. The research on topic also gives a better understanding on the nature of multinational cap-and-trade programs, as the research is often limited to national environmental policies. The information gained from this kind of research gives more information for those who might plan to enter the European market or who take part in business practices with European companies that are regulated with EU ETS.

7.3. Suggestions for further research

This study highlighted the innovation effects of European Union Emission Trading Scheme and how the literature perceives its effectiveness on the development of less polluting technologies.

There were several limitations in this study and existing research. First of all, the empirical evidence on Phase 3 of EU ETS was very limited, as the 3rd trading phase has only been adopted in 2012. Therefore, *ex post* research mainly focused on the first two phases and the influence of auctioning of allowances was discussed on general and prognostic level. Also, study in effectiveness of EU ETS did not cover all regulated industries. Therefore, it is difficult to make generalizations or compare data between different industries.

Even though the innovation effect of EU ETS was widely researched, literature on its innovation effects in the light of Porter Hypothesis was discussed only on a lesser extent. Conclusions regarding the PH could be drawn on a very general level. Overall, Porter Hypothesis is widely known and evidence in support and against it has been sought from different environmental policies. As the literature showed, innovation does not reach to technological level only, but organizational attitudes and strategies have been included into the research. Deeper understanding of perceptions and attitudes within the organization could be examined in order to understand the investment and business decisions that support or oppose Porter Hypothesis.

In the future, there are various opportunities to study the innovation effects of EU ETS, as the program is still developing, and the 4th trading priod will be implemented in 2021. As the time goes by, more empirical evidence on effects of allowance auctioning will be received, and better understanding of innovation effects of EU ETS can be gained. This could help decision-making and development of the program, which has been widely criticized among the industries affected by the regulation. As EU ETS is not the only policy targeted to combat climate change, program's effectiveness in cooperation with other national or multinational environmental policies could be studied in order to draw a more detailed picture of the effectiveness of environmental policies.

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