Does the price of carbon emissions within the EU ETS affect the level of exports from trading to non-trading countries?

Pricing carbon emissions within the EU ETS and its effects on export levels from trading to non-trading countries

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Abstract

In recent years, the issue of the climate has aroused exponentially increasing interest and it is a common priority on the political agenda worldwide. The European Union Emissions Trading System (EU ETS) is the first and largest international system of trading with carbon emissions and it is sometimes described as the cornerstone in EU climate policy to combat climate change with its main objective to reduce carbon emissions. However, there are reasons to concern about topics related to competitiveness of firms included by the ETS. This thesis aims to examine the effects of the spot prices of EU allowances (EUAs) on the level of exports from trading countries to non-trading countries with the intention of drawing conclusions on the effects on competitiveness induced by the EU ETS. The research question is answered based on earlier research combined with an empirical analysis. My empirical analysis finds that the spot price levels of EUAs do have an impact on the level of exports from trading countries to non-trading countries.
Keywords: EU ETS, competitiveness, emissions trading, pricing carbon emissions, export.

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Abbreviations

GHGs Greenhouse gases

EUAs EU allowances

CO_2 Carbon dioxide

N_2O Nitrous oxide

PFC Perfluorocarbons

NAPs National Allocation Plans

KP Kyoto Protocol

1. Introduction

The introduction of this paper will present a background containing the history and design features of the European Union Emissions Trading System (EU ETS). Moreover, the purpose of this paper will be given alongside a disposition of this study.

1.1 Background

1.1.1 History of the European Union Emissions Trading System (EU ETS)

In a joint effort to avoid dangerous levels of global warming, 180 countries signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and in 1997 the Kyoto Protocol, specifying actions in agreement with UNFCCC objectives, was agreed upon by numerous industrialised countries (Convery, de Perthuis & Ellerman, 2010; European Union, 2015). The Kyoto Protocol which amongst other stated legally binding greenhouse gases (GHGs) reduction targets thus evoked the need for policy instruments in order to reach these (European Union, 2015). Hence, in 2000 the European Commission launched a green paper, "Greenhouse gas emissions trading within the European Union", including some fundamental design ideas for the European Union Emissions Trading System (EU ETS) (Ellerman, Marcantonini & Zaklan, 2014; Eur-Lex, 2000). The Emissions Trading System (ETS) directive was adopted in 2003 and the system was implemented in 2005 including all EU member states (Eur-Lex, 2003). EU ETS is intended to be a cost effective and economically efficient instrument to reduce GHG emissions, reaching immediate and long-term environmental objectives (Eur-Lex, 2003).

1.1.2 Design Features of the EU ETS

The EU ETS is a cap and trade system, the largest in its kind, whereas a cap on certain greenhouse gases is set, applying for all installations covered by the system (Eur-Lex, 2003; European Union, 2015). Since 2013, the cap has been reduced in a linear manner on an annual basis in order for the total amount of emissions to decline (Ellerman et.al. 2014; Eur-Lex, 2008). Within the system, included firms must possess European Union Allowances (EUAs) whereas one EUA gives its holder the right to emit one tonne of CO_2 (equivalents) and each firm must, by the end of each year, hand in the number of allowances subject to its emitted amount of emissions covered by the system during that year (Eur-Lex, 2003). Allowances can be bought on auction or received for free, and in addition be sold and bought between companies (European Union, 2015). It is the cap on emissions that decides the number of allowances to be released thus ensuring their market value (European Union, 2015). Moreover, there also exists a possibility of buying a limited amount of international emission reduction units, thus only if they are recognised as bringing real emission reductions under the Kyoto Protocol's Joint Implementation mechanism or Clean Development Mechanism (Eur-Lex, 2004; Mistra Indigo, 2014).

The proportion of allowances that are given away for free are amongst other purposes intended to prevent the risk for pollution heavy industries to move their production to regions with low or no costs related to environmental policies (European Union, 2015). Installations which do not receive allowances for free can buy allowances at auctions, hence in 2013 around 40 percent of the total number of allowances were auctioned (Mistra Indigo, 2014). Any authorised bidder is allowed to place any number of bids stating a given price they want to pay for a certain number of allowances (European Union, 2015). Thereafter the auction platform determines and publishes a clearing price according to the demand and supply of allowances whereas only bidders who placed a bid equal or higher than the clearing price will be able to buy the allowances (European Commission, n.d.). Moreover, all successful bidders will pay the same price for allowances regardless of their original bids (European Commission, n.d.). There also exists a secret minimum clearing price, a reserve price, which is set before the bidding takes place to ensure a minimum value of the allowances (European Union, 2015).

The majority of the auctioned allowances are sold on the common European platform, the European Energy Exchange in Leipzig, moreover, allowances available for auctions are distributed among member states based on trading sectors' emissions for each country during phase I of the EU ETS (Eur-Lex, 2009; Mistra Indigo, 2014). Poorer EU-countries, alongside countries fulfilling the achievement of reducing emissions by 20 percent relative to 1990, receive an additional number of allowances intended for auctions (Mistra Indigo, 2014). Although the aim is to allocate 100 percent of the allowances through auctions, a more recent framework from the commission declares that energy-intensive industries shall continue the reception of free allowances based on the need for ensuring competitiveness (Eur-Lex, 2014).

1.1.3 Development of the EU ETS

Since the EU ETS was implemented it has undergone numerous changes which can be located to the separate trading periods of the system. The implementation of the EU ETS is divided into separate trading periods (European Union, 2015), commonly known as phases, which will be discussed below. On the notion that this study will only focus on phase I, II and III, phase IV starting in 2021 will be left out of this discussion.

Phase I and II

The first phase of the EU ETS, starting in 2005 and ending in 2007, was a pilot period with the main objectives of getting experience of emissions trading as well as testing the infrastructure of the system in order to ensure the functioning of the system when entering the KP's first commitment period which also coincided with the second phase of the EU ETS (2008-2012) (Environmental Defense Fund, 2012; European Commission, n.d.). Only CO_2 emissions were covered by the system during phase I and II, alongside voluntary inclusion of N_2O emissions during phase II (European Union, 2015). The common goal during phase II was to reduce emissions EU-wide by 8 percent relative to 1990 years levels (European Union, 2015).

The respective cap on emissions for phase I and II was based on the sum of the so called National Allocation Plans (NAPs) (Ellerman et.al. 2014; Eur-Lex, 2003). Each member state were obliged to declare national allocation plans stating the total number of allowances to be allocated alongside a proposition of allowance allocation thus under the decision that 95 percent (in phase I), respectively 90 percent (in phase II) of the total amount of allowances should be allocated free of charge (Eur-Lex, 2003; European Commission, n.d.). The Commission had the authority to reject or approve the NAPs on the basis of the ETS directive criterias and the cap was set when all NAPs had been accepted (Ellerman et.al. 2014; Eur-Lex, 2003). The system of NAPs received criticism among two main standpoints regarding "windfall profits" induced by free allowance allocation and the unharmonized allowance allocation methods across member states which potentially caused uneven impact on competitiveness (through cost differences) (Ellerman et.al. 2014).

Firms that failed to surrender enough allowances subject to their emissions received fees of €40 in phase I respectively of €100 in phase II per tonne of CO_2 (equivalents) for which they failed to hand in a sufficient amount of allowances (European Commission, n.d.).

Beyond the usage of EUAs, businesses were only allowed to use emission reduction units under the KP's clean development mechanism during phase I and hence, during the second phase such units could also be generated under the joint implementation (Eur-Lex, 2004; European Union, 2015). The scope of the EU ETS was expanded to include aviation in 2012 and during phase II Norway, Iceland and Liechtenstein joined the system (Eur-Lex, 2008; European Union, 2015).

Phase III

The third phase, running from 2013 to 2020, coincided with the KP's second commitment period (European Union, 2015; UNFCCC n.d). During this phase CO_2 emissions alongside certain N_2O and PFC emissions were covered by the system and in addition the scope of included sectors increased (European Union, 2015). Phase three set the target of an overall 21 percent emissions reduction relative to 2005 levels (European Commission, n.d.).

After evaluating the functioning of the system in its first years an amended directive on the ETS was adopted in 2008 that would govern the system from 2013 and onwards (Ellerman et.al. 2014; Eur-Lex, 2008). Some of the most groundbreaking changes were the adoption of an 1,74 percent annually declining EU-wide cap on an indefinite basis (replacing the former decentralized system of caps based on NAPs), the adoption of auctioning as the fundamental principle of allowance allocation, the inclusion of aluminium and chemical industries and adoptions that greatly limited the possibility of possessing emission reduction units from projects outside the EU ETS thus the scope for linking the EU ETS with other cap-and-trade systems was expanded (Ellerman et.al. 2014).

Table 1: Main features of the EU ETS over time

	Phase I (2005-2007)	Phase II (2008-2012)	Phase III (2013-2020)
Countries	*EU27*	*EU27 + Norway, Iceland and Liechtenstein*	*EU27 + Norway, Iceland, Liechtenstein and Croatia*
Sectors	*Power stations and other combustion plants ≥ 20MW* *Oil refineries* *Coke ovens* *Iron and Steel plants* *Cement clinker* *Glass* *Lime* *Bricks* *Ceramics* *Pulp* *Paper and board*	*Power stations and other combustion plants ≥ 20MW* *Oil refineries* *Coke ovens* *Iron and Steel plants* *Cement clinker* *Glass* *Lime* *Bricks* *Ceramics* *Pulp* *Paper and board* *Aviation*	*Power stations and other combustion plants ≥ 20MW* *Oil refineries* *Coke ovens* *Iron and Steel plants* *Cement clinker* *Glass* *Lime* *Bricks* *Ceramics* *Pulp* *Paper and board* *Aviation* *Aluminium* *Petrochemicals*
GHGs	*CO2*	*CO2* *N2O voluntarily*	*CO2, N2O and PFC*
Cap	*2058 million tCO2*	*1859 million tCO2*	*2084 million tCO2 in 2013, decreasing in a linear manner by 38 million tCO2 per year*

Source: European Union, 2015, pp. 18-19; Eur-Lex, 2003

1.1.4 Pricing carbon emissions and related costs for affected companies

An installation covered by the EU ETS can either choose to buy allowances or reduce its emissions (European Union, 2015). Therefore emissions trading implies additional costs for affected companies, either as a direct cost through directly buying allowances or as an opportunity cost since allowances can be traded on the market meaning that even allowances which are received for free gives rise to a cost (Pihl, 2014). Moreover, companies deciding to reduce their emissions instead of buying allowances will experience costs related to this activity, so called abatement costs (Dechezleprêtre & Sato, 2017). Although, the system can be considered cost efficient since companies with high abatement costs can choose to buy allowances and companies with low abatement costs can choose to reduce its emissions (European Union, 2015; Pihl, 2014).

The additional costs created by the system might give rise to effects on companies' level of competitiveness. In competitive markets where firms are price takers it is hard to pass on additional costs induced by climate policy to the price of the final good without suffering a loss of market shares (Pihl, 2014). Although, if all competing firms would compete under identical conditions, in this case meaning that all competing firms were covered by the same level of climate policy stringency, there would be no climate policy induced effects on the relative competitiveness (Dechezleprêtre & Sato, 2017). This will be discussed further in chapter 2.

1.2 Purpose

The purpose of this paper is to examine whether the spot price of EUAs cause any effect on the level of exports in trading sectors[1] from countries covered by the EU ETS to countries not covered by the EU ETS. Since EU ETS is the first international carbon market in the world, hence the largest in its kind, it is interesting to examine the potential effects on export levels which can be linked to effects on competitiveness induced by the ETS. Several earlier studies have been performed examining the effects of unilateral climate policy stringency on competitiveness, and forward ETS induced effects on competitiveness but mostly in the sense of climate policy stringency as an index or by using imaginary prices of carbon emissions. This study will contribute to the field of research by examining whether the actual spot price of EU allowances gives rise to effects on the level of exports within trading sectors, thus indicating potential ETS induced effects on competitiveness.

The research question is as follows:

- Does the spot price of EU allowances cause effects on the level of exports from trading sectors within countries covered by the EU ETS to countries not covered by the EU ETS.

[1] Trading sectors refers to firms/companies/industries/sectors covered by the EU ETS which are trading with carbon emission allowances.

The research question will be answered with the help of findings in earlier research and an empirical panel data analysis.

1.3 Disposition

The theory of pricing carbon emissions, its related costs for affected firms and potential effects on firms' competitiveness will be presented in chapter two in order to get an understanding of the mechanisms behind the research question. Chapter three will present the data included in this study and chapter four will describe some manipulations on the data as well as presenting and describing the regression models that will be used. Chapter five presents the results of the regressions made and a discussion of the results is given in chapter six. Conclusions from this study are presented in chapter seven.

2. Theory

2.1 The socioeconomic perspective of pricing carbon emissions

Many goods and resources are protected by property rights, meaning that if a producer wants to use these assets in his production, he needs to compensate (pay) the ones owning the assets or the ones that suffer from the consequences of his consumption (Pihl, 2014). This will lead to an efficient way of handling our resources since the benefits of the production (the price consumers want to pay for the goods produced) is weighted against the disadvantages of the production (the compensation that the producer must pay for using the assets in his production) (Pihl, 2014). The quantity of the good will be produced in the equilibrium of the benefits and the disadvantages (Pihl, 2014). However, there are resources that are not protected by property rights, e.g. air, which means that a producer who wants to use this resource in his production must not pay for using it. There will be no private costs of polluting the air for the producer since air is a common good, although the pollution gives rise to disadvantages (i.e. negative external effects) for many people which is denoted a socioeconomic cost and is a concept that includes all welfare reduction effects (Pihl, 2014). Without some kind of property rights, the air will be used in the production for free thus meaning that the private cost of producing will be lower than the socioeconomic cost which is indeed not reflected in the price of the good (Pihl, 2014).

Putting a price on carbon emissions through initiating allowances follows the "polluter pays principle" which refers to the producers obligation to pay for the socioeconomic costs associated with his production (European Union, 2015). Moreover, from a socioeconomic standpoint, putting a price on carbon emissions will lead to a resource efficiency since all costs associated with the production will then be taken into account (Pihl, 2014). In conclusion, the obligation to possess allowances in order to be able to emit certain emissions implies additional costs for firms included by the EU ETS, the cost associated with the environmental damage is added to the former private cost when emitting emissions could be done for free (Pihl, 2014).

2.2 Environmental policy and competitiveness

Although the system generates costs for affected firms, it is a cost-efficient system in the sense that firms with high marginal costs of reducing emissions can choose to buy allowances instead of reducing emissions and firms with low abatement[2] costs can choose to reduce emissions instead of buying allowances (Pihl, 2014). If the price of an allowance is higher than the firms' marginal emissions-reduction cost, then the firm will choose to reduce emissions instead of buying allowances and vice versa (Pihl. 2014). The EU ETS may also generate increased relative production cost resulting from higher prices of inputs, e.g., higher prices of electricity due to electricity' manufacturers obligation to possess EU allowances (Dechezleprêtre & Sato, 2017).

The additional costs imposed by an environmental regulation gives rise to a comparative disadvantage which may result in losses of market shares for the affected industries/firms in favour of competitors not affected by regulations (Spinelli, 2016). As costs induced by environmental regulation becomes higher, the comparative disadvantage for affected firms/industries becomes larger, hence creating incentives to invest in green producers thus enhancing market transformation toward pollution-efficient production (Pihl, 2014). Indeed, it is not the regulation in itself that give rise to effects on competitiveness but

[2] Abatement costs refers to costs related to activities of reducing emissions (Dechezleprêtre & Sato, 2017)

rather the asymmetry or difference in policy stringency[3] that causes effects on competitiveness (Dechezleprêtre & Sato, 2017). China for example can be seen as having relatively weak environmental institutions meaning relatively low costs for pollution intensive industries and thus giving these industries in China a comparative advantage compared to corresponding industries in countries with strong environmental institutions (e.g. EU ETS) (Andersson, 2018).

Dechezleprêtre and Sato (2017) identifies first, second and third order effects on competitiveness induced by asymmetric environmental regulations[4]. The first order effect is regarding increases in relative production costs due to differences in environmental policy stringency, thus leading to second order effects whereas the producers affected by increasing costs may have to adjust output levels, investments in abatement and prices of the marketed goods. Moreover, these changes affect other aspects (third order effects) such as process innovation, total factor productivity, trade flows, investment location, and pollution levels and leakage.

Table 2: Effects on competitiveness due to differences in the stringency of environmental regulation

First-order effect	**Second-order effect**	**Third-order effects**			
Cost Impacts	**Firm responses**	**Economic outcomes**	**Technology outcomes**	**International outcomes**	**Environmental outcomes**
Changes to relative costs (direct and indirect costs)	-Production -volume -Product prices -Productive -investments -Investments in -abatement	-Profitability -Employment -Market share	-Product -innovation -Process -innovation -Input-saving -technologies -Total factor -productivity	-Trade flows -Investment -location -Foreign direct -investment	-Pollution -levels and -intensity -Pollution -leakage

Source: Dechezleprêtre & Sato (2017), p.186

[3] Policy stringency refers to a general level of policy ambition (Dechezleprêtre & Sato, 2017)
[4] The authors refer asymmetric environmental policies to differences in environmental policy stringency among competing firms or sectors (Dechezleprêtre and Sato, 2017)

2.1.1 The Porter Hypothesis

The Porter hypothesis argue that companies realize cost-cutting efficiency improvements in response to more stringent environmental policies resulting in reduced or offset regulatory costs, meaning that such polices foster new technologies and innovations which in turn may enhance firm's international technological leadership and enlarging of market shares (Porter & van der Linde, 1995). Without stringent environmental policies, firms would not have incentives to devote resources on innovation and improvement (Porter & van der Linde, 1995).

Porter and van der Linde (1995) argues that the competitive advantage of a firm is enhanced by a firm's capability of innovating and improving rather than optimizing and seeking efficiency within fixed constraints. Thus, companies have limited attention, and it can be challenging to identify what to improve and where improvements can be sought (Porter & van der Linde, 1995). Hence, the Porter hypothesis partially builds on the assumption that ",.. the actual process of dynamic competition is characterized by changing technological opportunities coupled with highly incomplete information, organizational inertia and control problems reflecting the difficulty of aligning individual, group and corporate incentives" (Porter & van der Linde, 1995, p. 99). According to the authors, there are six channels to where well-designed environmental regulations can be advantageous:

They send important signals on where resource inefficiency is apparent and technological innovations can be sought. They raise corporate awareness by gathering information. They create pressure thus encouraging innovation. They send signals that environmental investments will be valuable thus reduces the uncertainty regarding these investments. They make sure that every regulated company addresses environmental investments since ensuring that no company can act opportunistically by not addressing this. They make sure that offsets are adequate in order to improve the environmental quality.

Although, not to be overlooked is that innovations do not always cover the full cost of abatement or compliance, especially in the short term when improvements generally have not yet covered expenses for innovative solutions (Porter & van der Linde, 1995).

2.1.2 The Pollution Haven Hypothesis

The trade theory-based pollution haven hypothesis suggests that stringent environmental policies cause policy-induced pollution leakage and pollution havens induced by increased compliance costs followed by production moving towards regions with low abatement costs, creating pollution havens (Levinson & Taylor, 2008). The theory can be traced back to McGuire (1982 cited in Dechezleprêtre & Sato, 2017) who argues that for two identical competing companies, only experiencing differences in asymmetric environmental regulations, the company that suffers from more stringent environmental regulations will lose competitiveness (McGuire, 1982). According to Mcguire (1982) uniform world commodity prices, created by competition among countries and free trade, and their link between identical cross-country factor prices, will be destroyed by uncoordinated or partial regulation.

Rather than encouraging innovations, environmental regulations and accompanying regulatory costs have the potential of disregarding investments in efficiency improvements or innovation thus slowing down the productivity growth (Dechezleprêtre & Sato, 2017). Regulatory costs that are passed on to product prices will result in a loss of companies' market shares for companies operating on fiercely competitive markets thus increasing market shares for companies in countries with less or absent environmental policies (Pihl, 2014). Companies expecting asymmetric environmental regulations to last will relocate their production facilities toward areas with weak environmental policies (McGuire, 1982).

2.1.3 Earlier research

Ederington and Minier (2003) finds evidence of rising net imports, when treating environmental regulations as an endogenous variable, for industries having higher abatement costs relative to other identical industries. When treating environmental regulations as an exogenous variable, the same evidence in line with comparative advantage theory can be found, although in a quite smaller magnitude (Ederington & Minier, 2003). In later research, Ederington, Levinson and Minier (2005) examine whether a pollution haven effect can be found on the notion that pollution intensive industries tend to be immobile. The findings of the authors suggest that the immobility of pollution intensive industry can explain the lack of support for the pollution haven effect (Ederington et.al., 2005). Branger, Quirion and Chevallier (2016) estimates effects of carbon pricing by the EU ETS on the cement and steel industry and finds no evidence of carbon leakage[5] within these sectors during phase I and II of the system. Moreover, it is found that increased environmental costs does not affect trade between countries having relatively similar environmental regulations, meanwhile net imports from countries with relatively low environmental costs increases (Ederington et.al., 2005).

3. Data

In order to examine whether the price of EUA:s have an effect on the level of exports from countries covered by the EU ETS to countries not covered by the EU ETS, there is a need for using more than one explanatory variable thus the choice of model is a multiple regression model. The general form of the multiple regression model is as follows:

$$Y_i = \beta_1 + \beta_2 x_{2i} + \beta_3 x_{3i} + \ldots + \beta_k x_{ki} + \varepsilon_i$$

Y is the dependent variable and $X_{2i}, X_{3i}, \ldots, X_{ki}$ are the explanatory variables, β_1 is the intercept and ε_i is the error term. The value of the coefficient β_k in front of the explanatory variable is the increase or decrease in the dependent variable when X_{ki} increases or decreases with one unit, under the condition that all other X-variables are held constant (Dougherty, 2011, pp. 153-155).

Moreover, the dataset includes data for twenty years, from twentyseven countries which evoke the need for treating the data as panel data in order to compare different countries over time. Panel data also address the problem of heterogeneity, which might exist due to individual differences between countries (Dougherty, 2011, pp. 514-517). The general panel data model can be described as following:

$$Y_{it} = \beta_{1it} + \beta_{2it} x_{2it} + \beta_{3it} x_{3it} + \ldots + \beta_{kit} x_{kit} + \varepsilon_{it}, \quad i = [1, N] \; and \; t = [1, T]$$

[5] Carbon leakage refers to firms deciding to move their production to countries with lower environmental policy-related costs (European Commission, n.d.).

Where N denotes observations (countries) and T denotes time (years). A detailed list of sources for all data included in this study can be seen in table 9 in the appendix.

3.1 Included Countries

This dataset consists of twentyseven countries whereas fifteen are the EU15 countries and the additional twelve are countries outside of the EU not included by the EU ETS. The reason for not including additional EU-countries is due to economic differences between the additional EU-countries and the EU-countries included which can generate complications when analyzing the data. Countries outside of the EU were dictated by data availability.

Table 3. List of countries included

EU15 - Countries included by the EU ETS		**Countries not included by the EU ETS**	
Austria	*Greece*	*Australia*	*Korea*
Belgium	*Ireland*	*Brazil*	*Mexico*
Germany	*Italy*	*Canada*	*Russia*
Denmark	*Luxembourg*	*China*	*Turkey*
Spain	*Netherlands*	*Indonesia*	*USA*
Finland	*Portugal*	*India*	
France	*Sweden*	*Japan*	
Great Britain			

3.2 Variables

Dependent Variable

The dependent variable is real 2015 US$ exports from EU15-country i, in time t, to non EU15-country j.

The calculation of exports from EU15-country i, in time t, to non EU15-country j will be given in the following example: The export from Austria in 1995 is calculated by taking the sum of 1995 Austrian' exports, but only within trading industries[6], to certain specified countries not covered by the EU ETS. The export from Austria in 1995 is then calculated into a weighted average based on export shares for Austria in 1995 to each non EU15 country. This data has been collected in nominal US$ from WIOD's input-output tables and hence converted into real 2015 US$. The same procedure has been done for every EU15-country during the years 1995 to 2014. The reason for not including further years is due to the lack of data. A list of trading sectors included in this study can be seen in table 10 in the appendix.

Explanatory variable

The explanatory variable is the yearly average spot price of EUAs in real 2015 US$ for each separate year (2005-2014). The spot prices of EUAs are gathered in euro, nominal values from European Environmental Agency (EEA) and European Energy Exchange (eea) and then calculated into yearly averages based on the data available. First off, the nominal spot prices have been converted to the nominal value of each EU15 country's currency by the same exchange rates as for WIOD's input-output tables. Thereafter, the nominal values have been converted into real 2015 US$ with exchange rates gathered from OECD. Higher prices of EUAs may imply increasing costs for affected firms and forward a decreasing competitive advantage for affected firms, thus it could be expected that higher prices of EUAs have a negative effect on the level of exports (for full discussion see chapter 2).

Control Variables

The control variables used in this study are variables which are known to have an impact on the level of exports (for a more detailed discussion see Burda & Wyplosz, 2017, p. 279). These can be seen below and are included in order to avoid or reduce the problem of missing variables.

Foreign real GDP

Components of GDP are private consumption (C), investments (I) and government consumption (G) (Burda & Wyplosz, 2017). When these components increase so does the GDP and moreover the level of spending (Burda & Wyplosz, 2017). Thus, foreign GDP can

[6] The categorised sectors in WIOD's input-output tables do not necessarily fit exactly with sectors covered by the EU ETS.

be seen as a determinant of foreign demand. When foreign demand increases, an increase in domestic export can be expected (Burda & Wyplosz, 2017).

In this study, foreign real GDP is a weighted average among non EU15-countries based on export shares for each EU15-country in each year (1995 to 2014). The variable is measured in real 2015 US$. Moreover, foreign refers to non EU15-countries and domestic refers to EU15 countries.

Foreign real effective exchange rate

An appreciation in foreign real effective exchange rate makes the domestic goods cheaper in the foreigner's perspective which stimulates domestic exports (Burda & Wyplosz, 2017). Conversely, a real depreciation in the foreign real effective exchange rate makes domestic goods more expensive and hence depresses domestic exports (Burda & Wyplosz, 2017). In this study, foreign refers to countries outside of the EU and domestic refers to EU15-countries. Hence, foreign real effective exchange rate (base year 2015) is a weighted average among non EU15-countries based on export shares within trading sectors for each EU15-country in each year (1995 to 2014). Foreign real effective exchange rate is calculated with the base year 2015.

A list of abbreviations of all the included variables can be seen in table 4, these will be used further on in this study.

Table 4: List of abbreviations for included variables

Variable	Variable Abbreviation
Real 2015 US$ exports	Export
Real 2015 US$ spot price of EUAs	SpotpriceEUAs
Foreign real GDP	GDP
Foreign real effective exchange rate	Eff.Ex.Rate

4. Method

4.1 Data and data manipulation

All mentioned variables will be included in the regression model by their logarithmic and first differences, meaning that the variables are calculated in logarithmic rates of change and the logarithmic values in the results can be seen as procentual change. One advantage of using logarithmic values is that it decreases the risk of spurious results and removes exponential trends (Dougherty, 2011). The first differences method ensures stationarity within the time series (Dougherty, 2011). Moreover, it is necessary to include lagged explanatory variables since macroeconomic variables have a tendency of not showing an immediate impact in the economy (see e.g. Andersson, 2018). Lagged explanatory variables will be included for up to four years and will account for the potential time lag of the explanatory variables' effect. The linear econometric model will therefore look accordingly:

$$\Delta(lnExport)_{ijt} = \beta_1 + \beta_2\Delta(lnGDP)_{j,t-1} + \beta_3\Delta(lnEff.Ex.Rate)_{j,t-1} + \beta_4\Delta(lnSpotPriceEUAs)_{i,t-1} + \varepsilon_{ij,t}$$

whereas β_1 is the intercept of the dependent variable, $\beta_2/\beta_3/\beta_4$ is the logarithmic rate of change of respective explanatory variable, $t-1$ denotes the lag of one year, and ε_{ijt} is the error term. Since lags for up to four years will be included, $t-1$ will be replaced by $t-2;\ t-3;\ t-4$.

Moreover, the study will consider one more model specification, a nonlinear model, in order to capture potential nonlinear relationships between the variables. This model is a replica of the one above with the exception of including the squared values of the explanatory variables. All variables are measured in logarithmic rate of change.

$$\Delta(lnExport)_{ijt} = \beta_1 + \beta_2\Delta(lnGDP)_{j,t-1} + \beta_3\Delta(lnEff.Ex.Rate)_{j,t-1} + \beta_4\Delta(lnSpotPriceEUAs)_{i,t-1}$$
$$+ \beta_5(\Delta(lnGDP))^2_{j,t-1} + \beta_6(\Delta(lnEff.Ex.Rate))^2_{j,t-1} + \beta_7(\Delta(lnSpotPriceEUAs))^2_{i,t-1} + \varepsilon_{ij,t}$$

4.1.1 The Hausman Test

The Hausman test is performed to see whether the model should include fixed or random effects. The null hypothesis (Ho) is that the individual-specific effects are random. If this is rejected, if the difference between the estimators is significantly different from zero, the alternative is to use the fixed effects estimator. In this analysis the p-value is less than 0,05 meaning the Ho is rejected and that the fixed effects estimator will be used.

4.1.2 Fixed Effects

The country-specific fixed effects is used to control for over time constant unobserved heterogeneity across countries, this could be geographical distance between countries or other factors that are specific to each country and not already included as an explanatory variable (see e.g. Andersson 2018). By adding fixed effects to the model, each country will get an individual intercept since a dummy variable has been included. Moreover, a time specific effect will also be included as an additional dummy variable in order to capture for example economic shocks which affect all countries simultaneously (see e.g. Andersson 2018). The regression models with two-way fixed effects will look accordingly:

Model 1: Linear regression model with two-way fixed effects

$$\Delta(lnExport)_{ijt} = \beta_1 + a_i + \gamma_t + \beta_2\Delta(lnGDP)_{j,t-1} + \beta_3\Delta(lnEff.Ex.Rate)_{j,t-1} + \beta_4\Delta(lnSpotPriceEUAs)_{i,t-1} + \varepsilon_{ij,t}$$

Model 2: Nonlinear regression model with two-way fixed effects

$$\Delta(lnExport)_{ijt} = \beta_1 + \alpha_i + \gamma_t + \beta_2\Delta(lnGDP)_{j,t-1} + \beta_3\Delta(lnEff.Ex.Rate)_{j,t-1} + \beta_4\Delta(lnSpotPriceEUAs)_{i,t-1} + \beta_5(\Delta(lnGDP))^2_{j,t-1} + \beta_6(\Delta(lnEff.Ex.Rate))^2_{j,t-1} + \beta_7(\Delta(lnSpotPriceEUAs))^2_{i,t-1} + \varepsilon_{ij,t}$$

whereas α_i is a dummy variable accounting for individual-specific effects and γ_t is the dummy variable accounting for time specific effects. The downside of using the fixed effects estimator contrary to the random effects estimator is lower efficiency of the beta parameters due to the inclusion of several new variables (Dougherty, 2011).

4.1.3 Balanced and Unbalanced Data

There are no missing observations in this dataset meaning the data is a balanced panel data.

4.1.4 Multicollinearity

If the correlation between two explanatory variables in a regression model is high then the model suffers from multicollinearity which could lead to poor estimates of the coefficients and hence misleading results (Dougherty, 2011). To see whether there is multicollinearity the "collin" function in stata is used and conclusions can be drawn by looking at the VIF (variance inflation factor) values. A rule of thumb is that the VIF value should not exceed ten since that can be an indicator of multicollinearity issues (University of Utah, 2020). In the table presented below it can be seen that no variable has a VIF-value larger than ten thus there is no critical problem of multicollinearity.

Table 5: Collinearity Diagnostics

Variable ($ln\Delta$)	**VIF**	**Variable** ($ln\Delta$)	**VIF**
Export	1,25	Squared GDP	1,10
GDP	1,22	Squared Eff.Ex.Rate	1,28
Eff.Ex.Rate	1,19	Squared Spot price EUAs	1,08
Spot price EUAs	1,10		

4.1.5 Heteroscedasticity

When the variance of the error terms depends on changes in the explanatory variables. i.e., the variance if the error terms is not constant, there is a problem of heteroscedasticity (Dougherty, 2011). Heteroscedasticity can have an impact on the variance of the coefficients, making the variance larger than in the case of homoscedasticity thus resulting in less specific coefficients (Dougherty, 2011). Moreover, heteroscedastic data leads to incorrect standard errors of the coefficients which leads to an inaccurate p-value. In order to minimize the problem of heteroscedasticity robust standard errors will be used in all regressions. Robust standard errors do also minimize the problem of autocorrelation.

4.1.6 Endogeneity

Endogeneity is caused by a simultaneous problem meaning that the dependent variable is explaining the explanatory variable meanwhile the explanatory variable explains the dependent variable (Dougherty, 2011). Endogeneity can also arise when there is a correlation between the explanatory variables and the error terms which is a result of a missing important explanatory variable in the model (Dougherty, 2011). The existence of this problem can be examined with the help of instrumental variables, thus it is hard to find instrumental variables which meet the criteria of having a strong correlation with the supposed endogenous variable it is acting for. A weak instrumental variable can give a misleading effect (Dougherty, 2011). Therefore, this study will not use instrumental variables. However, the lagged explanatory variables will possibly counteract the problem of endogeneity (see e.g. Arellano & Bond, 1991).

4.1.7 Stationarity

The variables in the model may contain unit roots, meaning that they are not stationary which hence is an indicator of persistent effects of chocks in future time periods (Veerbek, 2012, p. 291). This can lead to overrated values of the determination coefficient and the variables respective t-statistic (Westerlund, 2005, p. 205). To test whether any of the variables have a unit root a Levin, Lin and Chu test is performed, allowing for up to four lags whereas the lag length is selected based on the Akaike information criterion (AIC).

Table 6: Levin-Lin-Chu unit-root test

Variable (in Δln)	Statistic
Export	-2,080***
GDP	-8.8049***
GDP squared	-7.9576***
Eff.Ex.Rate	-11.8670***
Eff.Ex.Rate squared	-20.4881***
Spot price EUAs	-18.0269***
Spot price EUAs squared	-9.7853***

**** p<0,01, **p<0,05, *p<0,1.*

The test result shows that none of the variables have a unit root, respectively at 10%, 5%, and 1% significance level, thus all variables are stationary.

4.2 Descriptive statistics

Figure 1 shows the price development of EUAs over the years 2005 to 2014. Since emissions data had not been a priority prior to 2005, many of the emissions forecasts included in the NAPs were based on estimates which would turn out to be rather overestimated (Anderson & Di Maria, 2011). Hence, it could be concluded that too many allowances had been allocated thus leading to a price fall of the EUAs shortly after the introduction of the system (Aldy & Stavins, 2011). This is visualized in figure 1 where a price fall can be seen from the introduction of the ETS in 2005. Moreover, during the end of phase I the price of EUAs dropped to zero which was partially a result of the non-existing possibility of banking allowances (European Union, 2015). Banking of allowances means that an operator of an installation can save unused allowances to the upcoming phase which can prevent a potential surplus of allowances to lose their value prior to an upcoming phase when they, without the possibility of banking, become invalid thus lose their value (European Union, 2015). The financial crisis of 2008 led to decreasing production levels and hence the level of emissions fell thus decreasing the demand for allowances and consequently there was a dramatic price fall of the EUAs (European Environmental Agency, 2011). The possibility of banking allowances from phase II to III might explain the increasing price level from 2007 to 2008 (European Environmental Agency, 2011). However, Koch, Fuss, Grossjean, and Edenhofer (2014) find that negative demand shocks are unlikely to have an impact on the price of EUAs and moreover evidence supporting that increasing solar electricity production and variations in economic activity have an impact on the price level. There are many theories regarding the price fall during 2011 and 2012 but there is still no certain nor unified explanation available (see e.g. Koch et.al. 2014).

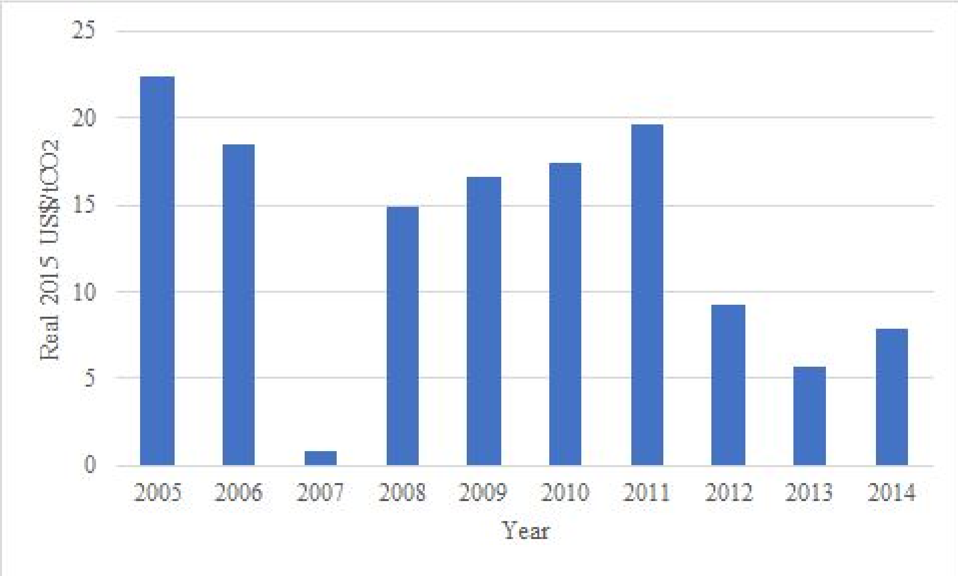

Figure 1: EUA average yearly spot price over time

Note: The graph is based on data gathered from European Environment Agency and European Energy Exchange.

5. Results

Table 7 presents the regression results of the linear model (model 1). The regression results of model one show that some of the explanatory variables have a significant linear effect on the level of exports. Since all included variables are in log and first differences the coefficients of the explanatory variables can be interpreted as the elasticity of the explanatory variable on the level of exports. GDP is the only variable that has a significant effect on the dependent variable over all four lags, that is on the 1 percent level when including one, two and three lags and on the 5 percent level when including four lags. The coefficient of GDP with one lag can be interpreted as following: if GDP increases with one percent, holding all other variables constant, the level of exports are estimated to decrease by approximately 0.3277 percent during the following year. The negative effect of GDP seems contradictory to the theory, however it can be that there is a time lag in the effect of variations in GDP which is why the coefficient of GDP only becomes positive (in line with theory) when including three and four lags.

The foreign real effective exchange rate only shows a significant effect on the level of exports when lagging it for two years, this on the 1 percent level. The coefficient of the real effective exchange rate with two lags also seems contradictory to the theory which dictates that an appreciation in the foreign real effective exchange rate should result in an increasing level of domestic exports. However, the time lag might also explain this result. The effect of the spot price of EUAs is only significant when lagging it for one year, this on the 5 percent level. Moreover, the effect of the spot price with one period lag is quite large according to the estimates, it suggests that a one percent increase in the (yearly average) spot price of EUAs, holding all other variables constant, decreases the level of exports by approximately 15 percent in the following year. Thus, noticable is that the robust standard error of the spot price with one lag is quite large. The spot price of EUAs does not show a significant effect on the level of exports when including two, three or four lags.

Table 7: Results from the estimations of model 1, dependent variable: Export

Explanatory variable	One lag	Two lags	Three lags	Four lags
GDP	-0.3277*** (0.0943)	-0.4992*** (0.1042)	0.4280*** (0.1024)	0.3925** (0.1539)
Eff.Ex.Rate	-0.3713 (0.3446)	-0.9378*** (0.2512)	1.4077 (0.9018)	-0.5846 (0.9592)
Spot price EUAs	-15.5540** (6.9575)	12.8980 (13.2126)	-1.5935 (21.7560)	-0.2411 (11.7008)

*** *p<0.01, **p<0.05, *p<0.1.*

Robust standard errors in parentheses.

Table 8 presents the regression results of the non-linear model (model 2). The coefficient of the log-diff GDP is now significant on the 5, respectively 1 percent level, when accounting for one, two and three lags, thus it is not significant when including four lags. However, the squared log-diff GDP is significant on all lag levels and the coefficient on each lag level suggests a more stringent effect thus suggesting that the squared value of log-diff GDP has a larger impact on the level of exports than the non-squared log-diff GDP. These results suggest a stronger non-linear relationship between GDP and exports relative to the linear relationship.

Noticeable is that the squared log-diff real effective exchange rate has a significant effect, on the 1 percent level, in all four lag lengths. The log-diff non-squared real effective exchange rate is still only significant, on the 1 percent level, when including two lags and the coefficient suggests a larger impact of the variable on the dependent variable compared to the same variable in regression model one. The spot price of EUAs still only shows a significant effect, on the 5 percent level, in a linear manner when one lag has been included. In line with the regression results of model one, the coefficient of the spot price suggests that when the spot price increases with 1 percent, holding all other variables constant, the level of exports will decrease by approximately 15 percent in the following year. The coefficient of the squared spot price is never significant.

Table 8: Results from the estimations of model 2, dependent variable: Export

Explanatory variable	One lag	Two lags	Three lags	Four lags
GDP	-0.2613** (0.1124)	-0.6555*** (0.1518)	0.3494*** (0.0710)	0.4518 (0.2231)
Eff.Ex.Rate	0.1203 (0.3601)	-2.0397*** (0.6035)	0.8017 (0.8278)	-0.1240 (0.8208)
Spot price EUAs	-15.4329** (5.9987)	13.9525 (8.3457)	-6.3217 (20.7477)	-1.3330 (10.564)
GDP squared	-0.8210** (0.2950)	-2.0341*** (0.3813)	-1.0457*** (0.1191)	2.1577*** (0.4038)
Eff.Ex.Rate squared	7.3597*** (1.5976)	-13.3903*** (2.6725)	-7.7174*** (1.3717)	5.3428*** (0.4918)
Spot price EUAs squared	1.9876 (6.4039)	-3.7599 (4.1496)	2.2389 (2.1917)	1.5890 (4.7512)

**** p<0.01, **p<0.05, *p<0.1.*

Robust standard errors in parentheses.

6. Discussion

The results of my empirical analysis shows a varying degree of unity with my original assumptions. The results support the original assumption that an increasing spot price of EUAs depresses the level of the trading sectors exports from countries included by the EU ETS to foreign countries not included by the EU ETS when lagging the variable “Spot price EUAs” for one year. However, the magnitude of the significant spot price coefficient does raise some suspicions, thus this result should be interpreted with caution. One of the reasons for treating the results with caution is due to the relatively small magnitude of data used to perform this study, generally estimations become better when there are large magnitudes of data included. I could have included more data in this study, although it has to be taken into account that the EU ETS has only existed for a certain number of years thus limiting the level of data availability.

Moreover, the impact that the spot price has on the level of exports, according to my results, suggest support to the theory of losing comparative advantage in favour of competitors with less stringent environmental policies (see e.g. Ederington et.al., 2005). Whether it is the variation in the price level of the spot price that causes additional costs for affected firms and hence potentially leading to decreasing market shares or whether it is the price signals that the spot price sends that potentially lead to a decreasing level of market shares cannot be concluded based on the findings in my study. I.e. the cost of carbon emissions through EUAs might still be unrecognizable for a multi-million dollar company. Thus it might be that it is not the actual spot price that causes the export levels to fall but rather the price signal, signalling to companies included by the EU ETS that the cost of carbon emissions will increase in the future, thus that it is favourable to invest in carbon-efficient solutions and undergo changes toward pollution-efficiency within the company. Such changes are costful and as pointed out by Porter & van der Linde (1995), innovative improvements can lead to a higher factor productivity hence increasing the market share but such improvements might not cover the full expenses of innovative solutions, especially in the short term. This could potentially mean that if companies adjust regarding to the price signal, they lose competitiveness today (which is seen in the decreasing level of exports) due to high costs of investments in innovative solutions that have not yet resulted in productive increases.

It is also unlikely that the decreasing levels of exports due to the cost of carbon emissions is due to the pollution haven effect since earlier studies find little evidence of carbon leakage for installations covered by the EU ETS (see e.g. Branger et.al. 2016).

7. Conclusion

This thesis has aimed to examine the potential effects of the spot prices of EUAs on the trading sectors export levels from countries included by the EU ETS to countries not included by the EU ETS. In doing so, a panel data regression was performed to measure the impact of certain variables which are known to have an impact on the level of export (see Burda & Wyplosz, 2017, p. 279) while also including the yearly average spot price of EUAs as an explanatory variable. The regression results presented a significant negative effect of increasing EUA price levels on the level of exports, thus the results supported the original assumption of higher price levels of EUAs leading to a decreasing level of exports from trading sectors to non-trading sectors. This effect could only be proven when including a time lag of one year. However, it remains uncertain whether it is the actual variation in the spot prices that cause effects on the export levels or whether it is the price signals of the EUAs that causes effects.

Moreover, this study focused on an overall effect, meaning the potential effect of EUA spot prices were estimated on the sum of all trading sectors exports within respective EU-country. There are reasons to believe that the effect of EUA spot prices on the level of exports might differ between trading sectors since they might be sensitive to competition or other factors to a varying degree. Therefore, a future field of research could account for differences between trading sectors when examining the effects of carbon-emission prices. Additionally, there is room for including prices of emission reduction units generated from projects other than the EU ETS when estimating the effects of carbon pricing in future research.

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Appendix

Table 9: List of variables and sources

Variable	Data source
Export	World Input-output database. Timmer, M.P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G.J. 2015. *An Illustrated User Guide to the World Input-Output Database: the Case of Global Automotive Production,* Review of International Economics, 23: 575-605.
European Union Allowance spot price	European Environment Agency (EEA). *EUA Future Prices 2005-2011.* Available at: https://www.eea.europa.eu/data-and-maps/figures/eua-future-prices-200520132011 European Energy Exchange (eex). *EEX EUA Primary Market Auction Report 2012/2013/2014.* Available at: https://www.eex.com/en/market-data/environmental-markets/eua-primary-auction-spot-download
Gross domestic product (GDP)	OECD. *Dataset: 1. Gross domestic product (GDP).* Available at: https://stats.oecd.org/
Real Effective Exchange Rate	OECD. *Dataset: Economic outlook no 107*. Available at: https://stats.oecd.org/

Table 10: Trading sectors

WIOD Release 2013	WIOD Release 2016
Years: 1995-1999	Years: 2000-2014
Wood and Products of Wood and Cork Pulp, Paper, Printing and Publishing Coke, Refined Petroleum and Nuclear Fuel Rubber and Plastics Other Non-Metallic Mineral Basic Metals and Fabricated Metals	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials Manufacture of paper and paper products Printing and reproduction of recorded media Manufacture of coke and refined petroleum products Manufacture of rubber and plastic products Manufacture of other non-metallic mineral products Manufacture of basic metals Manufacture of fabricated metal products, except machinery and equipment

Note: These are the sectors in WIOD's input output tables that the data on exports are gathered from.