European Centralisation and CO_2 Emissions

The Impact of the Levels of EU and National Centralisation on the European Union Emissions Trading Scheme

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Abstract

Today, our world faces a big threat, the climate change, which has been proved to be related with Greenhouse Gases (GHG) emissions, produced by human activities. Therefore, it is our responsibility as citizens to find fast and efficient solutions to fight this reality before it is too late. In this sense, the European Union (EU) has engaged in the first regional emission trading scheme.

This thesis focuses on the EU Emissions Trading Scheme (EU ETS) and investigates the impact of European and National levels of political centralisation on the effectiveness of this policy. Scholars have found evidence connecting, not only the EU centralisation, but also the national levels of centralisation with policy effectiveness. Similarly, the EU ETS has been proved to show a better performance when implemented at the EU level, due to two sets of arguments, namely economic and political.

Therefore, this research carries a quantitative investigation, more specifically a panel data analysis, assessing the 28 EU Member States for a period of 12 years. To do so, it provides an approach including three levels of centralisation: the national level, the EU level and the specific case of the EU ETS centralisation level. Also, it measures their impact on the EU ETS effectiveness, which consists of our dependent variable.

The results of this study show that our expectations were partially verified. Firstly, the national centralisation is not proved to be significant, secondly, the EU policy centralisation is only relevant under certain conditions, such as the exclusion of the year of 2008, while, the EU ETS specific centralisation is shown to be central for the implementation of the scheme and it is in line with the theoretical assumptions further discussed.

Acknowledgments

In 2004, the European Union saw one of its most important moments, namely its biggest integration event when ten more countries became part of the Union. Back then, I was a child but I still remember watching it on the TV with my mother and telling her that one day I would like to work in the EU. What explains this passion is that I have always believed in the values that the EU represents. These are mostly that everyone deserves to have the same opportunities and that the key to success is to work together rather than separately. Moreover, I come from the south of Portugal, where the environment and weather constitute one of our main sources of sustainability. Without it, there would be no tourism, there would be no agriculture and the economy would have to adapt dramatically. Because of this, my family and I have always been very conscientious about how much water we use, the amount of trash we produce and how much we pollute. This leads us to choose more ecological options such as having solar panels at home.

Keeping this in mind and the fact that our world is facing an environmental crisis, with 2016 being the warmest year recorded in history, I decided to focus my research in an EU environmental policy. Therefore, when I found about the EU ETS, I saw a great opportunity to learn and to have a thorough understanding of how such complex policy works.

Indeed, this was the right decision due to the fact that I have accomplished my personal goals and improved many skills throughout the process. First, I have learnt how to carry a complex and detailed research, more specifically by using a quantitative method. The reason for this choice is related with the fact that I have studied Economics and I feel comfortable working with data and numbers. Second, I have learnt, mostly alone, how to work with a new statistical software, Stata/MP 14.1, in which I was successful. Third, I found that being a very developed country does not mean to have a great environmental performance, such as Luxembourg or Germany, meaning that every country can learn from the other Member States' expertise. Last but not least, I discovered that I want to pursue a career path related with environmental issues and policies.

All these lessons led me to believe that the process of writing this thesis was a very important period of my life. However, this process would not have been the same without the help and support of certain people. To those people I would like to show my gratitude. In first place, to my family, especially my mother, Ana, my father, Joaquim and my brother, Tiago, who have always supported my ambitions. Secondly, I want to thank my boyfriend, Coen, for accompanying me in this tough process, for being critical and showing emotional support. Thirdly, a big thanks to my thesis circle and my thesis supervisor, Dr. Asya Zhelyazkova for guiding us in the best way we could have asked. Also, I want to thank my roommates, for being my home support in the Netherlands, and to my classmates. Finally, to my closest friends who eased this period of time by doing it together with me, such as Marine, Neli, Ilse, Daniela and Jessica.

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1. Introduction

The Impact of the Levels of EU and National Centralisation on the European Union Emissions Trading Scheme is the name that carries the purpose of this thesis. Throughout this first Chapter the reader will have the chance to understand what is the problem being studied, the aim of this research and its contribution to the academia and the society.

1.1 Problem Statement

Climate change is a current reality that has been progressing at a worrying speed in the past few decades. The human kind has seen its actions damage the environment in a way that no one could predict in the past, affecting millions of lives every year. For instance, between 2008 and 2014, 22.5 million of people were forced to be displaced due to natural catastrophes (Yonetani, 2016). According the World Meteorological Organisation (WMO), 2015, 2016 and 2017 were the three warmest years reported in history. This is aligned with the evidence found by research suggesting that long-term concentration of greenhouse gases (GHG) in the atmosphere caused by pollution leads to the increase of the global temperature (WMO, 2018).

Certainly, pollution is an urgent matter that needs to be slowed down and the European Union (EU) leaders share the same concern. With this problem in mind, the EU has decided to increase its commitment in reducing GHG emissions by developing the first regional emissions trading scheme. Following the rationale behind the emissions trading scheme present in the Kyoto Protocol, an international environmental treaty, the European Emissions Trading Scheme (EU ETS) was signed in 2003 and it is contributing for the reduction of CO_2 emissions (Ellerman, Convery, and De Perthuis, 2010).

This being said, the problem that this thesis focuses on is the need to guarantee the effectiveness of the EU ETS and to find the best way to achieve its goals. As it will be further explained in this thesis, the EU ETS is designed to be implemented in phases. In 2007, the scheme started to be implemented and most of the decisions were undertaken by the national authorities. This means that the system was decentralised because the power to decide targets and implement them belonged to the states. This decentralisation in terms of the EU ETS execution has negatively affected the scheme's effectiveness, by not assuring the targets achievement. At that time, change in the system was in important step to take (Ellerman et al., 2010). To study if this change after 2012 has contributed positively for the EU ETS effectiveness, this thesis proposes to understand the differences across Member States and across time.

1.2 Research Aim and Research Question

In the previous section, we were shown that the pollution is a major problem that can be fixed if time and financial resources are invested effectively. Therefore, the main aim of this thesis is to understand if a decentralised EU ETS execution can affect the policy effectiveness. Moreover, other two important objectives are taken into consideration in this thesis, consisting in the verification of whether centralisation of the Environmental policies at the EU level and the levels of national decentralisation have an impact on the policy effectiveness of the EU ETS.

Arising from these goals, it is possible to indicate the research question of this thesis:

> How do the national and EU political centralisation levels influence the EU ETS effectiveness?

From this research question we can already identify the dependent variable, namely "the EU ETS effectiveness". The chapter 3 will be dedicated to clarify the concept of policy effectiveness and to conceptualise the independent variables namely the EU and national centralisation levels, to be analysed according to what has been supported by different scholars.

1.3 Social and Academic Relevance

After presenting the research question, it is important to understand its relevance. According to Lehnert, Miller and Wonka (2007) relevance is the foundation of a research and it can be divided in two dimensions: academic and social. This section briefly discusses these two types of relevance and shows in which way this research accomplishes them.

1.3.1 Social Relevance

When talking about social relevance, we often refer to whether the research is important for the general public or not. Being important means that the studied phenomenon affects the society and that it is better than an alternative topic (Lehnert et al., 2007). Similarly, this thesis focuses in a very important EU mechanism that aims to reduce the CO_2 emissions. Nevertheless, as every policy, the EU ETS comprises downfalls that can undermine the effort produced by the stakeholders involved such as companies, states and tax payers.

Therefore, this thesis follows the two criteria for providing social relevance as, first, it wants to assess the effectiveness of the policy that can affect the interests of certain actors (Lehnert et al., 2007). For instance, companies are investing together with national authorities in the installations to measure and monitor the reduction of the GHG emissions. If the implementation of the policy is not done in an effective way, these efforts will be lost and useless. Second, this thesis questions the best way of implementing the policy: through a national and local decentralisation or through the centralisation at the EU level. Answering this question will solve the problem of wasting resources in an ineffective system that is consuming millions of euros.

Lastly, researching the effectiveness of the EU ETS is important for everyone due to the climate change hazards, since it is a subject that does not take geographical barriers into account.

1.3.2 Academic Relevance

In order to assure relevance, a research must also provide an academic contribution. Lehnert et al. (2007) define academic relevance as the analytical foundation of a study that enable us to better comprehend the political phenomenon that is being studied. Furthermore, these authors present a set of eight alternative criteria that can guarantee academic relevance, which comprise finding empirical cases that theories cannot explain or presenting substitute explanations that integrated certain theories.

In this thesis, the main purpose is to verify if the expectation that a centralised system would increase the EU ETS effectiveness, by looking at three levels of centralisation. With this, we are testing an existing hypothesis coming from the theory on the EU ETS, by developing a new dependent variable and looking at empirical data from all the periods of the EU ETS implementation. For reaching these conclusions, we have analysed several studies on the EU ETS design that are further referred in this thesis, such as the one of Wråke, Burtraw, Löfgren, and Zetterberg (2012) or the one of Bausch, Görlach and Mehling, (2017). These studies looked at the first periods of the EU ETS, but in these thesis we are not only to the preliminary phases, but also at the more recent data which will help us to verify or not the past predictions. Also, we have tested the theories that connect policy effectiveness with centralisation, such as the principal-agent framework by applying it to the specific case of the EU ETS, which means this study is applying an existing theory to a different domain. These are two of the eight criteria mentioned above, formulated by Lehnert et al. (2007).

Nonetheless, this thesis is different than other researches about the influence of centralisation because it focuses on a specific topic of the EU policy. Also, it differentiates itself from the studies on the EU ETS since it tries to understand not only the effectiveness of the scheme before its change, but also in evaluating its evolution after the change in its execution.

In this sense, this research question holds both social and academic relevance.

1.4 Thesis Outline

In the present Chapter the introduction to the thesis was set in place, by stating the main problem, defining the research question according to the aims of this study and by presenting its academic and social relevance. There will follow seven Chapters divided in sections and subsections that will allow the reader an easier understanding of the information presented.

The Chapter two is crucial since it presents the most important characteristics of this thesis' main focus, namely about the EU ETS, such as the way it is implemented, which industries are included or the used key concepts. Following, the Chapter three sets the conditions to understand the central concepts of this thesis, including the dependent and independent variables, by addressing the existing literature on the studied topics. In this Chapter, other influencing factors of the EU ETS effectiveness will be identified and, further in the thesis, they will be referred as control variables.

Furthermore, the Chapter four is dedicated to present the theoretical explanations that describe the relationships between the dependent and the independent variables. From those theories, the three hypotheses of this research will be presented. Then, the fifth Chapter focuses on a detailed presentation of the research design and methodology. The purpose of this section is to present the way our hypotheses are going to be tested in a very clear and logic manner. Also, it includes the choice of design, the presentation of the indicators that measure each variable, the statistical model that will be used and the reliability and validity assurance. Next, the sixth Chapter constitutes the analysis of the data that was collected and it comprises five main subsections: the descriptive statistics; the testing of the OLS assumptions; the estimation models choice; the presentation of the regression models results; and the results interpretation, where the hypotheses are tested. The Chapter seven is the step that allows us to answer the research question and address interesting findings, by discussing the results presented in the previous section and looking at additional models (present in the Appendix). Finally, the Chapter eight concludes this research by introducing the limitations and future implications.

2. The European Union Emissions Trading Scheme (EU ETS)

Key Concepts:

Emission allowances: consist in the emissions tradable rights that determine how much can be polluted in terms of GHG emissions.

Free-allowances: the allowances that are allocated to each company without the need of paying any cost.

Decentralisation of the EU ETS: refers to the fact that the Member States held most of the authority to implement the system in phases I and II, such as defining their targets.

The 13th of October 2003 marks a very important moment for the climate change contributions of the European Union, when the European Trading Directive was formally signed by the European Parliament and Council. The European Emissions Trading Scheme officially started operating in 2005 as the first and largest CO_2 emissions trading system in the world with the first objective to complement the Kyoto protocol by helping reaching the targets in terms of carbon emission reductions (Ellerman et al., 2010). Furthermore, the scheme aims to limit the total amount of emissions produced in Europe by dividing its implementation in several stages. The first phase was a preliminary period between 2005 and 2007 aiming to prepare the Member States and businesses for great carbon emission reductions. Then, the second phase proceeded between 2008 and 2012, overlapping the first period of the Kyoto protocol and the current and third stage started in 2013 and will run until 2020, coinciding with the second period of the Kyoto protocol (European Commission, 2015).

The basic idea of this emissions trading scheme is to set a maximum (cap) of emissions that each country's industries can produce. In case, these limits are not met, companies can search to increase their emissions by purchasing allowances (to cover the surplus of pollution) that has a price. The determination of how much each industry can pollute has differences that will be discussed in the next paragraphs.

During the phases I and II, the authority regulating the scheme was more decentralised than it is becoming in the present phase, meaning that most of the decisions regarding implementation of the scheme were in the hands of the 25 Member States, at that time. Originally, most of the authority was held by the EU Member States. The European Commission only determined the global cap on total emissions, equivalent to the target defined by the Kyoto Protocol for the EU, which meant that the Member States defined their own caps. Also, the Commission specified the affected sectors, or in other words "trading sectors", which started to be iron and steel, certain mineral industries, energy production and the pulp and paper industries (Kruger, Oates and Pizer, 2007). In 2012, the aviation sector was also added to the scheme and from the beginning of the third phase the sectors of "aluminium, carbon capture and storage, petrochemicals and other chemicals" are also included (European Commission, 2015, p.20).

In the first two periods, each Member State had to meet national emissions targets that were aligned with the EU Burden Sharing Agreement (BSA). The BSA stated how much each Member State wanted to reduce in terms of carbon emissions for that period, without discriminating annual emissions. Then, the decisions regarding the annual national implementations and internal emission targets were embodied in the National Allocation Plans (NAPs). In these plans, the Member States defined the total amount of intended allowances per year and how the free-allowances would be allocated at the national level. Hence, the annual targets regarding the EU ETS emissions were set by each Member State separately and embedded in the NAPs. During three months after being issued, the NAPs could be rejected by the Commission which would have to state the reasons for rejection (Ellerman, et al., 2010). This meant that throughout the first two phases, companies were allocated with free-allowances and only in case they didn't meet the established free-allowances, they would purchase (trade) extra allowances in the EU emissions market to cover their emissions. Thus, the scheme implementation was a "cap-and-trade" programme that set a maximum of emissions covering approximately 45% of the total Green House Gases (GHG) emissions produced in the EU (European Commission, 2016).

Moreover, the decentralised design of the EU ETS left other three important set of decisions on the hands of the Member States. Firstly, even though the free-allocation was the default mechanism of distributing permits nationally, Member States could opt for allocating 5% and 10% of the allowances through the auctioning mechanism during the first and second phases, respectively. Secondly, despite the fact that the banking requirement is set from 2012 onwards, during the first two phases, the national authorities could have decided to allow companies to have a banking option. In the EU ETS, the term "banking" refers to the possibility of postponing emissions to the next implementation phase. In other words, if firms did not produce the total amount of emissions they were allowed according to their allocated permits, they could "bank" those emissions to the next phase and produce more emissions (Kruger et al., 2007).

Thirdly, Member States had the full discretion to verify compliance internally, by defining the mechanisms for monitoring and reporting. Nonetheless, the European Commission is responsible for applying noncompliance penalties after assessing the states' reports on the progress of the targets achievement (Kruger et al., 2007).

This degree of decentralisation of the scheme reflects that the EU is composed by sovereign states which do not want to give away their power to the European institutions (Ellerman et al, 2010). It also reflects the political limits that a centralised system would entail or, in other words, it enabled a consensus between the different actors affected by the policy, namely the EU governments and institutions, the involved industrial sectors and Non-governmental Organisations (NGOs). Indeed, the rather flexible trial period (2005-2007) and the free allowances allocated by national authorities were crucial for the agreement to be fast (Ellerman et al., 2010).

Key Concepts:

Auctioning: is the alternative method (to the free-allocation) of allocating allowances, in which companies auction the total amount of emissions allowances available to reach the national targets.

Banking: is the action of keeping emission allowances to use in the following years, when the total emissions is not reached in the present year.

After the phase II was completed, many conclusions about the decentralised allocation were issued and a reform was approved. The main changes of the EU ETS in the third phase include the definition of an overall EU Cap declining at 1.74% per year, replacing national caps. Additionally, the default allocation mechanism changed from the allocation of free-allowances to auctioning, indicating that the majority of the allowances will not be given for free, but rather through an auctioning process. This auctioning mechanism will be covering the entire electric sector by 2013. Regarding the remaining non-electric industries, the auctioning mechanism will be gradually implemented until 2027 (Ellerman, Marcantonini and Zaklan, 2015). The main reason for this is the fact that non-electric sectors participate in an international markets, and an abrupt change to the auctioning mechanism could have a huge negative effect on the industries competitiveness. The gradual decrease of free allocation started at 80% of the allowances in 2013; then, in 2020 they will decrease to 30% and in 2027 free-allowances will be no longer provided. However, in case of a competitive hazard, the industry affected can be given free-allowances, to prevent EU companies to reduce their economic stability (Ellerman et al, 2015).

Adding to the auctioning process, the Member States are asked to prepare National Implementation Measures (NIMs) instead of the NAPs, which have to be approved by the Commission. The main objective of these changes is to guarantee harmonisation of the EU policy, transparency and that all actors involved have access to understandable plans, avoiding unfavourable competition in certain Member States (European Commission, 2015). These do not define the annual targets of carbon emissions as the NAPs used to do. Instead, the annual national targets are decided jointly and signed through the Effort Sharing Decision (ESD), which was an agreement between the EU Member States, to accomplish the main goal of reducing 40% of the emissions comparing to the 1990 level, by 2030 (European Commission, 2015, European Commission, 2018).

To keep in mind:

Kyoto Protocol: The EU ETS was designed to help the Member States to comply with the Kyoto Protocol target for the EU as a whole;
Coverage: 45% of the total of the EU emissions;
Target: reduce by 2030, 40% of the CO_2 emissions (compared to 1990);
Implementation: 3 phases (2005-2007, 2008-2012 and 2013-2020);
Differences between the phases:
Phase I and II:
Implementation: decentralised by each National authority;
The BSA: signed to set the overall targets for the phase II (without annual discrimination);
Yearly targets: defined in each country's NAPs, by each Member State;
Allowances Allocation Mechanism: free-allowances were distributed to the firms, defined in the NAPs;
Optional per Member State: auctioning and banking options, even though they were rarely chosen;
Industries: certain mineral industries, energy production and pulp and paper ceramics; plus, from 2012, the aviation sector.
Phase III:
Implementation: centralised at the EU level;
Yearly targets: defined at the EU level through the ESD (there are no NAPs, but there are NIMs to harmonise the monitoring and reporting);
Allowances Allocation Mechanism: there are very little or almost none free-allowances and the default allowances

Figure 1 – EU ETS Summary

3. Literature Review

The present Chapter is dedicated to explain the most interesting findings about the dependent variable and to define the concepts that will mostly be used in this thesis. This variable consists of the policy effectiveness, crucial to understand if policies are solving actual problems. After defining the general concept of policy effectiveness and identifying the one which will be used throughout the paper, a section is provided to make the connection of policy effectiveness at the EU level. Then, the conclusions about which factors are normally considered to impact the effectiveness of environmental regimes are provided. Finally, the concepts related to the independent variables will be presented and clarified.

3.1 Policy Effectiveness

Policy effectiveness is a wide concept that cannot be separated from the type of policy that is being studied. Most scholars analyse specific cases to draw conclusions about effectiveness, such as in the healthcare systems, environmental regulations or even monetary policies. However, this concept can be generally defined as a result from the policy evaluation stage in the policy cycle approach. In the first stage of the policy cycle, "Problem Recognition", politicians identify priorities that are aimed to be solved (Howlett, Ramesh and Perl, 2009, p12). In this sense, policy effectiveness is translated in actually resolving those problems.

Public policy theories also offer different perspectives to identify the quality of policy effectiveness concept. As regards to the first of its perspective, the rational approach associates policy effectiveness with the concept of achieving the benefits that are proposed to achieve, in addition to others that were not initially planned (Nagel, 1986). For rationalists, knowledge has a crucial role, therefore many scholars relate the concepts of effectiveness and efficiency to cost-benefit relations, meaning that a policy is evaluated in terms of transforming the economic resources in the desired outcomes (Bekkers, Fenger and Scholten, 2018). We should be aware that additional public policy approaches also define policy effectiveness, such as the political, the institutional and cultural perspectives (Bekkers et al., 2018).

The political perspective associates policy evaluation with the pursuit of the interest of each actor, in the way that it increases its powers and how the interests are connected through an interdependent network. To assess policy effectiveness, means to measure the support from the different stakeholders in the network and possessing information represents having power. It contrasts with the rational approach in the sense that knowledge is not used to achieve the best cost-benefit relation, but instead to attract public support. So, the greater the support politicians get from other stakeholders, the higher the effectiveness achieved by a certain policy (Bekkers et al., 2018).

Furthermore, the institutional perspective highly focuses in the role of institutions in the policy process and normally states that the set of formal and informal rules are the ones guiding policy rather than rational actors. This theory follows two main logics: the logic of appropriateness and the logic of consequence. The first one evaluates policy outcomes in terms of fixed and defined actions that were already thought of. Policy effectiveness consists of following the pre-defined rules, or taking the considered appropriate actions. Hence, the policies are effective when their implementation follows the standard way of doing things, which was already established and that entails actions considered to be appropriate. The logic of consequence resembles the rational theory, because it often assesses the outcomes by measuring whether rational actions were taken to solve the existing problems. In the latter, policy effectiveness is defined not as the outcomes of the policy but whether the outputs are achieved by rational actions. In the institutional approach, rules are important since they enable the collection of knowledge throughout time. They guide the policy process and which of the information collected is available to whom, meaning that effectiveness does not focus on the evaluation of results but on the maintenance of rules and norms (Bekkers et al., 2018).

Finally, the cultural perspective defines policy effectiveness as how the political actors can intervene in the political process and how many social perspectives were used to shape the policy outcomes. This theory says that policy is socially constructed, by the interaction between the political actors, where symbols, language and processes are important. In that sense, policy effectiveness is very subjective and refers to the capacity of politicians to create those symbols and frames about a specific problem, associating it to its causes and solutions (Bekkers et al., 2018).

For the present study the definition of policy effectiveness that matters is provided by the rational approach. The reason for this choice is that this thesis focuses on effectiveness of the EU ETS which is a policy that defines clear material targets. Hence, our objective is to measure this specific effectiveness, by evaluating the achievement of the initially intended goals, which in the case of the EU ETS is limiting the maximum of CO_2 emissions. Given the structure of the EU ETS, using a political, institutional or cultural perspective would not allow this study to reach plausible conclusions of whether the scheme is producing effective results, since these theories follow a view that it is not materially quantifiable. For example, if we followed an institutional definition, we would be limited to accessing whether the targets were defined via rational steps, such as defining quotas. This is not enough to measure the effectiveness of the policy in changing pollution patterns and reducing CO_2 emissions. Therefore, the policy effectiveness concept that will be studied throughout this thesis is the achievement of the intended goals, defined at the beginning of the policy cycle.

The next subsection aims to find the necessary conditions for the EU policies to be effective. This will help us to move to the next Chapter of the theoretical framework and understand indeed what is crucial for EU policy effectiveness.

3.3 EU Policy Effectiveness

After defining the concept of policy effectiveness we move on to understanding the concept of EU policy effectiveness.

Since the EU comprises a very complex system where policy is decided at multiple levels, such as supranational, intergovernmental or national, defining policy effectiveness can be a tough task. Wallace and Wallace (1996) defined eight criteria for policy effectiveness in the European Union. From these eight requirements, the one which is important to highlight for the EU ETS case is the number one: "policy authority clearly established at the European level and not elsewhere such that no alternative is available, and effectiveness then has to be judged by results" (Wallace and Wallace, 1996, p.30). As referred in the Chapter 2, the EU ETS started as a decentralised mechanism with the purpose of emissions limitation, nevertheless the regional coordination of this policy is only possible through the European Union. Hence, we can judge the results of the policy and assess its effectiveness by observing the achievement of the established targets.

Other authors have different definitions of the EU policy effectiveness. For instance, Hix and Hoyland (2011) refer to two types of regulatory policy outcome: redistributive and pareto-efficient outcomes. These outcomes allow us to say if a policy is or not effective by observing if policy-makers are able to achieve, on the one hand, pareto-efficient results or, on the other hand, redistributive results. First, achieving pareto-efficient results means that all citizens are better off with the policy than without, which improves everyone's situation, for example building a school. Whereas, when the aim of policy makers is to achieve redistributive outcomes, only some citizens become better off at the expense of others, such as increasing the taxes for the wealthiest to increase pensions for the poorest citizens (Hix and Hoyland, 2011). In the present study, this distinction between redistributive and pareto-efficient results will not be taken into consideration. Instead, this thesis will focus primarily in the achievement of targets, without measuring if it improved everyone's situation or not, being the definition referred above by Wallace and Wallace (1996) the crucial one.

As well as the EU, there are other international environmental regimes, which leads us to talk about environmental effectiveness at the international regimes level. The next subsection will be focused on assessing what are the main influencing factors discussed in the international environment regimes literature.

3.4 Influencing factors of the Environmental Regimes Effectiveness

The objectives of this subsection is to provide a background of which factors explain the effectiveness of environmental regimes by considering specific studies.

Faure's (2012) study about the effectiveness of environmental law explains the empirical evidence of the existing correlation between national environmental regulation and the control of environmental harm. Indeed, empirical studies show that there is a positive relationship between regulation and environmental quality and this is visible in the reduction of emissions. In this way, environmental policies, such as pollution, transport or emission taxes are effective when reducing the hazards produced by negative externalities.

In his contribution, Faure (2012) stresses the importance of other factors that might explain the performance of the environmental regulation. The interest group theory, for example, has been highly used to explain that regulation might be misconducted to serve interests of smaller groups of society. Also, the author addresses the fact that interest groups will try to capture the policies and change it in accordance to their own preferences, since they acknowledge that such regulations cannot be avoided. It is very common to observe several environmental regimes exceptions for certain products or industries due to the pressure created by interest groups. The so called "grandfather clauses", for instance, exempt existing companies from being affected by the new environmental regulation due to their negotiation capacity (Faure, 2012, p.308), i.e. some firms that are already installed in the market do not need to follow the new regulations. This will be translated on a technological delay, since companies instead of investing on technology improvements, will keep old technologies because it is more favourable to them (Faure, 2012). This means that the policy effectiveness of environmental regulations is many times affected by the organisation of powerful interests.

Contrarily, Jordan (1998) presents a study on the implementation of the Montreal Protocol in the UK, another environmental regime. He infers that experts, mainly scientists, positively contributed to promote the ozone binding policies, while national policy networks have served as mediators in the negotiations and implementation phases of the studied regime. This means that organised groups are not always prejudicial to the environmental regulations.

Other studies assume that the implementation of binding targets under international environmental regimes actually reduce the harms of pollution and its negative impacts (Almer and Winkler, 2017). Almer and Winkler (2017) conducted a research to evaluate the Kyoto Protocol (KP) based on the evidence found by other scholars that binding targets increase the capacity of reducing emissions, when comparing to countries which do not have binding emission targets.

Adding to this, the economic development seems to play a preponderant role in the quality of the embedding of international regimes defended by many scholars, but this is not the only explanation (Ellerman et al., 2010). Besides, we can still recall the existence of external environmental factors, such as the specific climate characteristics, or the available natural resources. Reasons for that are related with the capacity of producing alternative energies, namely renewable energies that come from natural resources (Ringquist and Kostadinova, 2005). Countries where there is a lack of wind, sunlight or ocean have limited capacity in producing renewable energies, which means that international environmental regimes are less effective in those regions.

Additionally, Young (2011) talks about feelings of fairness and legitimacy or the problem structure. With this, the author refers that the way that a policy problem is framed and positioned in the national political agenda can also influence the effectiveness of a policy. In this way, if a country gives a high priority to environmental issues, the environmental regulations will have higher capacity to reduce pollution and its environmental hazards.

Last but not least, several studies concerning the EU ETS show that the level of EU decentralisation, in the beginning of its implementation, has proved to harm the effectiveness of the policy. For example, Grubb and Neuhoff (2006), have predicted the risks of the EU ETS design when it comes to the allocation processes. They focus in the decentralisation of the EU ETS when it comes to allocate the national targets, because defining targets at the national level instead of defining emission targets collectively, at the EU level, reduces the effectiveness of the scheme. These authors state that when Member States have the power to decide the allowances allocation, they will have incentives to increase the allowances, in order to increase or maintain their economic competitiveness. In this case, national authorities become easy targets for companies to lobby for higher levels of pollution and more CO_2 allowances, make it less likely to achieve the national targets (Grubb and Neuhoff, 2006). Aligned with this logic is the perspective of Grant, Matthews and Newell (2000) who affirm that decentralisation of the enforcement of EU environmental laws can undermine the results of the policy at hand, due to the fact that when the national governments implement them there is a lack of consistency between what was aimed with the EU policy, and what the national authorities perceive. Many times, the central governments are not the ones implementing the EU policies, but rather the local officials, who do not hold the necessary power to assure the EU demands (Grant et al., 2000). From here, we can deduce that not only the level of EU decentralisation, but also the national level, impact the effectiveness of the EU policies.

In sum, this subsection provides an overview of the different factors that influence the effectiveness of environmental policies. These are summarised in the next Table, according to their relevance for this thesis.

Factors	Studied on this thesis
Centralisation of the Policy Implementation	Yes – Independent Variable
Economic Development	Yes – Control Variable
National Environmental regulations	Yes – Control Variable
Climate Conditions	No
Binding Targets	No
Order of Policies in the Political Agenda	No

Table 1 – Summary of influencing factors

3.5 Political Centralisation

Previously, we have pointed out the most important factors influencing our dependent variable, one of them being the level of political centralisation. This thesis aims to focus on the impact of the levels of centralisation on the EU ETS policy effectiveness. For that purpose, three levels of centralisation have to been taken into account and, hence characterised: national level, European Union level and the EU ETS level of centralisation.

Often, centralisation is associated to having most of the authority concentrated at higher levels of hierarchy, whereas a decentralised system divides decision-making participation and authority between lower levels of the hierarchy (Andrews et al., 2009). In national terms, decentralisation means that the governments which provide public services and the social welfare are closer to the public who votes for them, and that the policies are implemented by local or regional authorities rather than the central authority (Ivanyna and Shah, 2012). Adding to this definition, authors, such as Tommasi and Weinschelbaum (2007), often associate decentralisation with the "principal-agent' theory, which is used to describe the relationship between a principal, who delegates specific executive tasks, and an agent, who carries those tasks. They assume that in a centralised state, there is only one agent which is the central government assigned by the voters of the election (the citizens). Whereas, in a decentralised state, we observe several agents, more specifically the local authorities which carry policy at the local level. In this way, the concept of national decentralisation will be defined as the central government delegating its functions to regional or local bodies, increasing their decision-making power.

Regarding the EU, centralisation of the decisions and their implementation are given to non-state institutions, such as the European Commission, which give less discretion to the Member States to shape the policies in accordance to national interests (D'Amato and Valentini, 2011). The more tasks and responsibilities delegated to the European Commission, the more centralised the EU policy is (Pollak and Sonja, 2008).

Finally, when referring to the EU ETS levels of centralisation, this thesis will be referring to how much power is delegated to the European Commission specifically. The reasons behind this are related to the implementation design of the scheme that leaves some of the authority at the EU level and some of the power on the hands of the Member States[1].

Moreover, throughout this thesis, when we talk about political centralisation we will be referring to the implementation phase of the decision-making process, when the policy is already agreed upon and is being practised either in local communities or, in EU terms, transposed to the Member States.

All in all, this subsection was important to establish the concepts of decentralisation that will be used in this research. At this stage, it is important to understand that this thesis adds to the existing literature by addressing the defined concepts and evaluating three different levels of centralisation and applying this to the specific case of the EU ETS. Moreover, the studies developed on the EU ETS effectiveness mostly reflect the economic effectiveness, while this research looks at the effectiveness in the CO_2 emissions constraint.

[1] See chapter 2 for the description of the division of the authority of the EU ETS.

4. Theoretical Framework

In the previous Chapter, there was the presentation of the results of the literature review which led this thesis to explore centralisation as an explanation for differences in the EU ETS policy effectiveness. In order to provide strong evidence, we need to understand how both concepts are connected. Thus, this Chapter will deliver the necessary theoretical framework in which this research will be based on and will present the three hypotheses that arise from this background.

4.1 Centralisation Theories and Policy Effectiveness

The EU ETS consists of the largest regional emissions trading scheme, so to verify the relation between its effectiveness and the level of centralisation we have to understand the causal mechanism behind it. There are several arguments why centralisation impacts the effectiveness of policies like the one we are studying. As mentioned before, this relation between the level of centralisation and policy effectiveness will be studied at three essential levels: the national centralisation, the EU centralisation and the more specific case of the EU ETS. For each of these levels one hypothesis is associated.

4.1.1 National Centralisation

Before looking at how the level of centralisation affects the EU policy effectiveness, this thesis will describe the general mechanisms of how centralisation levels influence policy effectiveness in a nation-state. The general argument in this subsection is that centralisation is positive when it comes to the policy effectiveness, especially when talking about environmental regulations.

Recalling the principal-agent theory, aforementioned, it is possible to see that central governments delegate several responsibilities to lower levels of government. Most of the principal-agent literature refers to the same problems of the delegation that can undermine the whole policy implementation (Franchino, 2007). The first of those problems is when implementing policies, the agents, namely the local administrations, have more discretion in a decentralised state to shift the policies towards their individual interests (Franchino, 2007). In this sense, the goals that were first developed by the central authorities, when being implemented, will be lost and, thus, not achieved especially if local authorities have different preferences. We will call this the problem of interest, since there is a difference between the interests of the principal and of the agent, leading to bad the performance of policies. There are numerous interests that can be distinguished, such as the fact that the local leaders want to be re-elected, want to increase their budget and/or want to increase the local competitiveness (Hix and Hoyland, 2011). In the cases in which the re-election of the agent is the main goal, what can happen is that the policy shifts in order to respond to the immediate priorities of the citizens, instead of maintaining a more continuous evolution. For instance, politicians could seek the support from firms covered by the EU ETS, by allocating them more allowances so that they could pollute more. Moreover, when increasing the budget is the preferred goal, the agent can undermine policy effectiveness by restructuring the budget and reducing the available resources for the achievement of the policy goals. Regarding the local competitiveness, local authorities might have interest in increasing their economic development, meaning that they will again shift the priorities towards assuring competitiveness. This is often associated with environmental policies, when local governments, to maintain or increase the companies' competitiveness, will develop the so called grandfather clauses in which they exempt companies from certain legislations (Faure, 2012). Consequently, because companies are exempt from many environmental regulations, the national targets will not be fully accomplished. In the EU ETS case, this can happen if local authorities have higher industrial priorities, due to the differences between regions in terms of economic activities or wealth, at the cost of environmental issues.

The other often referred problem of the principal-agent relationship is the information asymmetry. Indeed, one of the reasons why the principal contracts the agent is because he/she lacks of specific information and expertise (Myerson, 1982). In national terms, this means that local administrators hold more information about the local population to implement national policies. What can make a difference to the policy effectiveness is that there is a gap between the two actors, limiting the control of the principal over the agent's actions. This indicates that having two different actors in the different policy cycles leads to less policy effectiveness, with different levels of expertise, which is aligned with the argument that is being defended. However, we should keep in mind that information asymmetry can also mean that if policies are implemented without the complete necessary knowledge, policies can be ineffective.

Moreover, when focusing in the environmental policies, the conclusions about centralisation or decentralisation are similar. Nonetheless, there has been literature defending both sides of the coin. Typically, decentralisation is thought to be beneficial to increase the environmental quality if the jurisdictions between regions are heterogeneous (Garcia-Valiñas, 2007). What explains this argument is that there are differences in local preferences that potentially leads to losses of efficiency in small jurisdictions that do not have the capacity to adapt to higher environmental standards (Garcia-Valiñas, 2007). However, these differences in jurisdiction are technically not beneficial to the environment, since they reduce environmental quality by not achieving higher standards. This is what most of scholars refer to as "race to the bottom", because local authorities are competing with lower standards (Garcia-Valiñas, 2007). It is clear this competition carries negative consequences in the environmental policies effectiveness, since the central authorities first goals will not be achieved. For example, the poorest regions tend to dedicate their resources to priorities that seem to affect more the populations, such as health expenditure, leaving the environment behind. The same can happen for the EU ETS, since it would be too costly for these smaller jurisdictions to restrict firms by establishing really high CO_2 reduction targets.

Following from the previous argument, there are the negative externalities produced by some lower standards. Oates (2002) states that centralisation is preferable because some jurisdictions affect others and, thus, there must be a central authority deciding which environmental policy is followed by each region, even if the policies are different. From here, we can see that even when environmental policies comprise lower standards in one region, they will affect the other regions' policies reducing its effectiveness, since they will be challenged to reach their initial environmental targets.

This subsection has allowed to identify the main arguments why national decentralisation undermines policy effectiveness. Certainly, the main reasons comprise the agency problem of having a delegated agent with different interests and information asymmetry. Also, connected to environmental policy, decentralisation produces negative impacts by lowering standards and reducing environmental quality. From these conclusions, it is possible to formulate the following hypothesis:

H1: Higher the level of national centralisation of the environmental policies, higher the effectiveness of those policies.

4.1.2 European Union Centralisation

In the previous section, we have seen the arguments behind why national centralisation is preferable to achieve policy effectiveness. The EU is no exception to this reality and in the following paragraphs we will look at the relationship between the policy effectiveness in the EU and the delegation of the tasks to the EU, meaning to centralise the policies at the EU level.

As similar to the national centralisation, the principal-agent theory has been used to describe the relationship between the EU institutions, such as the Commission or the Parliament, and the Member States (Hix and Hoyland, 2011). The main problems with this relationship are called the agency problems, as referred in the previous section. First, when delegating tasks to the European Commission, for instance, Member States face the threat that the actors implementing EU policies will change them to be closer to their interests. Second, the information asymmetry problem that does not allow the Member States to control the Commission, since they do not hold the expertise that the Directorate-Generals (DG) have (e.g. DG Environment) (Majone, 2001). In this sense, centralisation at the EU level seems to harm the policy effectiveness, contrasting to what happened in the national level.

Nonetheless, in practise the EU is a very complex system composed by multiple actors with divergent preferences, especially the EU States. Due to this heterogeneity in their interests, Member States have difficulty in adapting to EU legislation. This is what Majone (2001) refers as the commitment problem that can be divided in two issues. The first issue consists in the fact that politicians have a short-time vision according to their mandates, neglecting their long-term promises. Because national politicians have mandates and seek to be re-elected, they usually shift their priorities to the ones that are on the top of the policy agenda. Therefore, they cannot commit to policies that are considered to be less important at the time of the elections. This leads the politicians to neglect certain policies in favour of others, especially the ones that are focused in problems outside of the national scope. When it comes to the EU policies, national politicians will tend to do the same, as these seem less relevant to the majority of the citizens, resulting in less effective European policies due to the lack of domestic effort. Instead, if the EU institutions were the ones overseeing and implementing the policies that are neglected, this issue would be resolved. The same can happen in the EU ETS case, since if environmental issues are not a domestic priority, the efforts dedicated will not be enough to achieve the stipulated targets and a way of solving this issue is by making the countries and regions to commit to higher standards defined at the EU level.

The second commitment issue is the lack of political authority ownership. In other words, the authority does not belong to any person, thus we cannot impede other politicians with a different vision or strategy to take over in the future. Accordingly, national legislations are unstable and the more decentralised the system, the more rapid changes in the political systems will occur. A way of solving this issue is, again, by transferring the authority to supranational bodies, so that the EU policies can be carried out effectively, instead of being lost due to national instability. This is why the EU has established the principle of supremacy of the EU law over national legislations, obliging national governments to commit and abide with the European rules (Majone, 2001). By doing so, for the EU is able to be credible and achieve results, which wouldn't be possible if the countries would feel a disadvantage coming from the EU ETS, enhancing its effectiveness.

Another important problem of decentralising EU policies is also related with the heterogeneity of the Member States, more specifically related with environmental matters (Borzel, 2003). When deciding environmental issues in the Council, there is evidence that Member States have less capability of reaching consensus due to the disparities of environmental priorities or even capacity to adapt. Countries which have more advanced environmental technologies are more likely to lobby for higher standards, while countries with lower standards do not want to see their competitiveness reduced by higher production costs. This reflects the already mentioned "race to the bottom" when countries will try to compete with each other by reducing environmental regulations, since they are afraid of not being attractive to companies or even of increasing their production costs (Borzel, 2003). Correspondingly, the way of solving this problem is by centralising the EU environmental policies at the EU level. Giving more power of decision and execution to the EU bodies assures the achievement of the environmental targets that were established initially, allowing less room for free-riding behaviours.

Finally, Borzel (2003) refers that allowing the Member States to implement EU policies will enable their possibility to influence other States' domestic implementation. By doing so, Member States are "up-loading" their own legislations to the EU system, which can be positive or not to the environmental quality. If Member States, which are able to impact EU policy, have higher standards, then the EU policy will stricter. However, it can highly influence the EU policy effectiveness, because there is a shift of the policy towards the policies of the countries which are capable of influencing it. Consequently, keeping the EU policy in the hands of a neutral body, with no specific preferences, allows the formulation of policies that take into consideration the every Member State's conditions. Policies will then be adapted to the heterogeneity of the EU countries and, thus, more accomplishable and effective.

Concluding, the EU centralisation is crucial to solve the several problems that arise from the fact that the EU is composed by Member States with dissimilar systems and priorities. From this expectations we can formulate the second hypothesis:

H2: Higher the level of centralisation of the EU environmental policies, higher the effectiveness of those policies.

4.1.3 EU ETS: Decentralisation vs Centralisation

As mentioned already in this paper, the first two phases of the EU ETS were characterised by giving a high level of discretion to the Member States by decentralising the implementation of the scheme. This feature of the system is believed to create many challenges in reaching national targets and, thus, reducing carbon emissions effectively. In this section, two sets of arguments that relate the EU ETS effectiveness with its level of centralisation will be presented: economic arguments and political arguments.

Starting with the economic arguments, in the beginning, the EU ETS was decentralised and the participating states defined how many allowances they were willing to allocate in their industrial sectors. By looking at D'Amato and Valentini's (2011) article, we have found that because Member States have a high level of freedom to decide its own targets, they normally tend to "over-allocate permits with respect to the optimal allocation that would emerge under a centralized ETS" (D'Amato and Valentini, 2011, p.142). The main reason for this phenomenon is that national authorities want to protect their companies' competitiveness and, hence, over-allocate emissions so that they do not lose international comparative advantage. This will immediately reduce the purpose of the policy in reducing emissions.

Another problem with the decentralised system is that the EU cannot interfere in the establishment of the tradable allowances prices. Firms have to cover their emissions with allowances, meaning that when the pollution produced is higher than their allowances, they will have to acquire more allowances. In case industrial emissions are not covered by the allowances that were free-allocated, firms have to purchase more permits in the market. If the total amount of allowances is set at a very high level, it will generate very volatile prices of the tradable allowances, leading to very low prices (Rickels, Görlich and Oberst, 2010, Wråke et al., 2012). This happened in the first phase of the EU ETS, when the prices fell down almost reaching zero (Bausch et al., 2017). The mechanism that explains this effect comes from the economic theory, which states that the aggregate supply is set at a very high level and the aggregate demand at very low level, the equilibrium price decreases (Henderson, 1964). Subsequently, when the prices are lower, companies have more incentives to pollute more, since the cost of pollution is lower, leading to more carbon emissions (Ellerman et al., 2010). This is translated in more difficulties in achieving the national emission targets.

Furthermore, in a decentralised EU ETS, there is a lack of harmonisation in terms of reporting and information sharing, which creates negative externalities in terms of understanding and interpreting the information, leading to abrupt price variations which harm the whole purpose of the emissions scheme (Betz and Sato, 2006). According to González (2006, p.465), "this lack of information on scarcity makes it difficult to obtain a market price signal, creating market uncertainty and also affecting the dynamic efficiency of the scheme". Also, Kruger et al. (2007, p.116) mention that "it is difficult for any member state to predict the market price of allowances as they set their own NAP, since one would have to know all the other NAPs in advance". Because Member States could not have any information in advance about the market beforehand, the prices would fall, creating incentives for companies to pollute more.

Another economic argument is that the Member States were also free to choose under the decentralised scheme if they want to have a banking option in the first two periods. The Member States who chose to allow banking in the first periods would have less allowances during the third phase (2008-2012), since they would have to subtract the amount of banked (postponed) emissions from the ones they need to reach the Kyoto Protocol's targets (Kruger et al, 2007). Thus, Member States face a competitive disadvantage which reduced the incentive to recur to use the banking option. However, according to economic arguments, the banking is preferable to achieve economic efficiency. This is explained by Kruger et al. (2007, p.126) who argument: "the ability to bank allowances through any member state's banking provisions could have had a significant impact on Phase I prices by letting prices rise to reflect future expected prices". Hence, the problem related to the volatile prices would not exist if the implementation of the EU ETS was centralised and the reduction of emissions would be more effective since the Member States would have a lower cap in the following phases.

In sum, the economic arguments show that the decentralised allocation creates problems that challenge the effectiveness of an emission trading scheme, mainly due to the lack of information and clear understanding of the market, the over-allocation of allowances, and the non-use of the banking option, which lead to the prices volatility and to a limited reduction of emissions.

Following, there is the set of political arguments. Often, decentralised systems intend to protect the national interests and the maintenance of power (Bausch et al., 2017). This means that EU decentralisation will favour Member States with higher political power, at the expense of others. As we have seen with Borzel's (2003) contribution, Member States are able to "upload" their policies into the EU political system. This capability can be either beneficial or prejudicial for the effectiveness of the EU ETS. On the one hand, Member States with stronger political networks or with higher European political power are more able to influence the decision-making reached at the EU level even if indirectly, so more able to have their less ambitious NAPs not rejected by the

Commission[2] (John, 1996). On the other hand, Member States with stricter environmental policies can use their power by defining more ambitious targets and thus improve the policy results.

Another important argument is that the decentralisation of an emissions scheme allows decentralised measuring, reporting, and verification of the emission progress among the Member States, leading to different ways of enforcement and implementation (Bausch et al., 2017). In international terms, it is very hard to be sure that the states' monitoring capacity is the same. The EU also faces this, since the administrative and enforcement cultures differ among Member States, making the levels of effectiveness in reaching targets different. Nonetheless, this situation calls for a decentralised approach as a centralised one could harm the efficacy of reaching each national targets. This is aligned with one of the problems of the principal-agent theory at the EU level, when a policy is complex the choice of agent tends to be the national bureaucracies since they have more knowledge about national characteristics and capacities to better enforce the regulations (Franchino, 2007).

On the contrary, delegation of the tasks to a supranational institution can solve the environmental commitment issues. As pointed in the subsection 4.1.2, the fact that national regulations are less stable and that national elections tend to change the political course, having a supranational body implementing the EU policies enhances their credibility and makes Member States to stick with their initial commitments (Majone, 2001).

In sum, the main problems that emerged from the two first implementation periods of the EU ETS made the literature to question the viability of the decentralised design. It made us think that the freedom that Member States have in choosing the amount of allowances leads to an over-allocation, not only due to protect the private interests of the national companies, but also due to the lack of harmonisation of the information. Not having strict standards in developing national plans leaves plenty of discretion for national bureaucracies to show and exert its power against EU supranational institutions. Nonetheless, one should not forget that decentralisation also has its advantages, since Member States have different ways of governing due to their cultures, processes and norms which do not immediately fit in the EU regulations.

So, it is crucial that this phenomenon is studied in more depth and further research should try to find evidence of whether the new centralised allocation is producing effective results in reducing CO_2 and achieving the respective targets. From these expectations, the last hypothesis arises:

H3: Higher the level of centralisation of the EU ETS, higher the effectiveness of the EU ETS.

[2] The Commission could reject the NAPs within the three months of their submission (see chapter 2).

4.2. Causal Relationship

The following scheme summarises the representation of how the described factors affect the dependent variable and the way that this thesis aims to test this relationship.

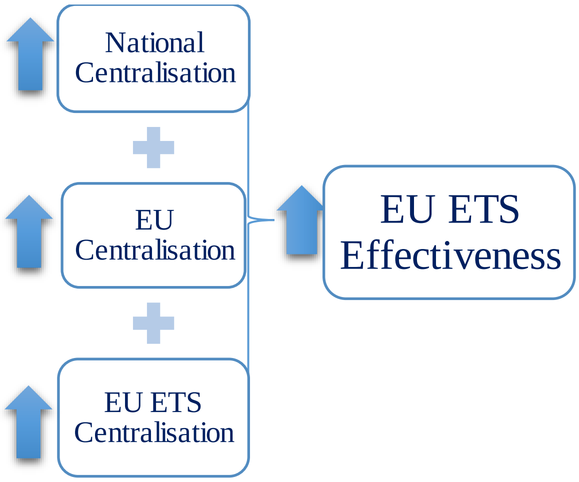

Figure 2: Causal Relationships between the independent and dependent variables.

5. Research Design

5.1 Panel Analysis Research Design

The choice of research design is highly influenced by the causal relationship between the dependent and independent variables. In order to prove if the theoretical explanations that demonstrate the relationship between the EU ETS effectiveness and the level of centralisation are correct, there are several paths that can be followed.

Political scientists use many methods of studying political problems, such as the experimental research designs. These allow researchers to control the values of the independent variables and, simultaneously, randomly assign those values to the individuals in the experiment (Kellstedt and Whitten, 2013). This type of design enables the studies to have a high level of internal validity, meaning that there is a high confidence in the causality mechanism behind the independent and dependent variables. Nonetheless, our population (to be discussed in the following section) is composed by the EU Member States, meaning that they cannot be randomly assigned values of the independent variable X. Because of this, the alternative is to recur to an observational method rather than an experimental one (Kellstedt and Whitten, 2013). In an observational study, the researchers look at the world as it is in reality and try to deduce causal links between the studied variables, which is the method that will be followed.

Additionally, there must be a choice between proceeding a quantitative or qualitative study. Due to the hypotheses of this study that relate to the policy effectiveness, its definition (chosen in the section 3.1) which is the achievement of the proposed targets on controlling and reducing GHG emissions and due to the availability of the quantitative data on the CO_2 emissions and on the multiple measurements of centralisation, the agreed method that will be followed is a quantitative study (Kellstedt and Whitten, 2013, Blatter and Haverland, 2012).

Moreover, the choice of method which is believed to be the most appropriate is a panel analysis, consisting of a combination of both cross-sectional and time-series (longitudinal) design (Hsiao, 2003). The reasons for this choice are associated not only with the characteristics of the research question, hypotheses and its variables, but also with the advantages that cross-sectional and time series can produce together.

First, it enables the increase of observations. As we are dealing with EU policy, if we have opted by following solely a cross-sectional approach, we would only have access to a comparison between the EU countries. Whereas with the combination of both methods, we will have access to many more cases due to the multiplication by number of years, since the beginning of the implementation of the EU ETS until the most recent data available (2016). Regarding the EU ETS policy effectiveness, meeting targets is a key feature, so observing variations throughout time enables the research to take relevant conclusions about changing patterns. Also, it allows us to see whether the change of targets has an influence or not in its results, instead of looking to one moment in time for different Member States.

Additionally, using a panel data research facilitates the inclusion of more variables. Indeed, one of the weaknesses of an observational study is controlling for other explanations of the same phenomenon. In this sense, the research will use control variables so that it can be more reliable since we are able to control alternative influencing factors (Hsiao, 2003).

5.2 Population and Sample

In the present moment, the EU has 28 Member States, however when the EU ETS came into force in 2005 only 25 countries were part of it. Three Member States were excluded in the implementation phase, namely Croatia, Bulgaria and Romania and one in the second implementation phase, Croatia which only formally accessed the EU in 2013. Moreover, the EU ETS was expanded to the European Economic Area (EEA) in the beginning of the second phase, including Iceland, Liechtenstein and Norway to the EU ETS participants. Hence, currently the EU ETS covers a total of 31 countries (European Commission, 2015).

Nonetheless, the sample that will be assessed in this research only includes the EU Member States, as we are studying the influence of the EU centralisation on the effectiveness of the policy. So that we can guarantee consistency of the data we will only look at the countries which have all the data available, not excluding the countries that entered the EU in 2007 and 2013. This makes a maximum amount of 28 countries, yet as referred above, Bulgaria and Romania will only be assessed from 2008 onwards and Croatia from 2013[3].

The other three participating countries of the EEA, namely Liechtenstein, Iceland and Norway, could be included, however the targets measuring the GHG emissions for these countries are not available. The reason is that these countries are not EU Member States and did not have to issue a National Allocation Plan, and for the last period (2013-2020) setting targets for the EU States was done through the approval of the Effort Sharing Decision (ESD) which these three countries are not part of.

As mentioned before, the EU ETS implementation is divided in phases and until the present moment, three phases can be observed: 2005-2007; 2008-2012; and 2013-2020. So, the time period which will be studied starts in the first year of implementation, 2005, and ends in 2016, which is the last year with complete and available data for the dependent variable. This makes a total of 12 years of observations.

[3] The data for Bulgaria and Romania will only be available from 2008 onwards and for Croatia from 2013 since these are the respective years of their adoption of the EU ETS, due to their later EU integration (European Commission, 2015).

Moreover, because this research has a mixed design of longitudinal and cross-sectional approaches, the maximum total of observations that will be incorporated are 322 observations (3 years multiplying by 25, 5 years multiplying by 27 and 4 years multiplying by 28 Member States).

5.3 Identification of the Variables

5.3.1 Dependent Variable

The dependent variable is the EU ETS policy effectiveness. According to the discussion of the definition of policy effectiveness in the section 3.1, the concept that will be studied consists in the observation of differences between the participating countries of achieving the formulated goals in the CO_2 maximum emission values. Since this thesis focuses on the EU ETS and each Member State has their own target (defined goal) for the EU ETS maximum of carbon emission, this variable will be measured by the difference between the targets that were initially defined for the EU ETS and the historical verified emissions[4].

In this sense, higher the value of this indicator, closer are the countries of achieving their emission targets. Additionally, the EU ETS was firstly designed to help the Member States in achieving the Kyoto Protocol target decided for the European Community as a whole (European Commission, 2015). In order to achieve that EU targets, the Member States have to share the emission reductions between them.

Firstly, the Kyoto Protocol only started to be implemented in 2008, whereas the first EU ETS period proceeded earlier (2005-2007). Thus, the targets relative to the first implementation period will be the ones set by the NAPs, which are embodied in the allowances allocation from the national authorities to the national firms (European Commission, 2017).

From 2008 to 2012, the national targets are measured in accordance to the ones established in the Kyoto Protocol, more specifically in the Burden Sharing Agreement (BSA). This agreement, adopted by the EU and its Member States, defined how the EU target under the Kyoto Protocol was going to be shared between the EU Member States. Nevertheless, the targets defined by the Member States in the BSA are set for each period as a whole, not detailing what will be done in each year to achieve them. Instead, each year's targets for each Member State are defined in their NAPs.

This being said, the data regarding the national targets for the EU ETS emission reductions of the two first periods (2005-2007 and 2008-2012) are collected from each Member State's NAPs of each year of those implementation phases.

Then, from 2013 until 2020, the targets are set through a collective EU decision. This decision is called Effort Sharing Decision (ESD) and defines the Annual Emission Allocation (AEA) that are needed in order to comply with the Kyoto Protocol goals. So, the targets for the most recent

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[4] All the GHG emissions are measured in tonnes of CO_2 equivalent.

implementation period will be the ones set in this agreement, which was first signed in 2009 and then amended to include Croatia, in 2013 (European Commission, 2017a).

In terms of historical emissions, the data related to this part of the indicator will be retrieved from the European Environment Agency (EEA) which provides the extracted data at the EU level, aggregated at the national level, by year (EEA, 2017) in addition to the data retrieved from the Eurostat (Eurostat, 2018a). As said before, for the first two periods, the targets only cover the emissions set in the NAPs, which are the emissions for the EU ETS sectors, whereas for the last period (2013-2020) the targets set in the ESA, also cover emissions present in the sectors of agriculture, waste, buildings, transports and land use, land use change and forestry (LULUCF) (European Commission, 2018). In this way, the historical emissions are collected differently for the last implementation phase. For the first two phases, the data covers the EU ETS verified emissions and for the last phase the data covers the ESD sectors' emissions.

In order to it understand better, the next Table summarises the data collection of this variable and which source is used for each component that composes this indicator.

Component / Phase	**2005-2007**		**2008-2012**		**2013-2020** [5]	
National Target (NTG)	Data from the National Allocation Plans (NAPs)	EU ETS website	Data from the NAPs	EU ETS website	Data from the Effort Sharing Agreement (ESD)	EU ETS website
Historical Emissions (HEM)	EU ETS verified emissions	EEA database	EU ETS verified emissions	EEA database	ESD Sectors Emissions	Eurostat database

Table 2 - Summary of the Data Collection for the Dependent Variable

Finally, this indicator will be a ratio of the national targets, in order to allow credible comparisons across countries and throughout the years, since it will reflect the achievement of the target regardless of the size of the industry, showing the actual policy effectiveness in the different Member States. The following formula expresses how this indicator is calculated:

$$EEF_{it} = \frac{NTG_{it} - HEM_{it}}{NTG_{it}}$$

Where,

- EEF is the EU ETS effectiveness;
- NTG is the national CO_2 emissions target;
- HEM stands for the historical CO_2 emissions;
- *i* represents one Member State and *t* one year.

[5] Note that the time span studied only goes until 2016 due to the data availability.

Here it is possible to observe an example of how the EEF was calculated for Austria in 2005 and in 2016:

$$\text{EEF}_{AUT,2015} = \frac{32\ 412\ 654 - 33\ 373\ 155}{32\ 412\ 654}\text{; EEF}_{AUT,2016} = \frac{51\ 899\ 864 - 50\ 160\ 000}{51\ 899\ 864}\text{;}$$

Variable	2005	2016
NTG	32 412 654	51 899 864,0
HEM	33 373 155,0	50 160 000,0
EEF	-3%	3%

Table 3 - Austria's EEF calculation, in tonnes of CO_2 equivalent.

5.3.2 Independent Variables

Previously, the theoretical framework presented the justification that relates the level of centralisation of the decision-making process and the effectiveness of a policy. We have looked at decentralisation levels from three different perspectives, first, from the national level, second, from the EU level and, third, from the EU ETS level. Because of this distinction, it is important to measure those concepts through separate variables and indicators.

5.3.2.1 Decentralisation at the National level

The first independent variable of our study is the national decentralisation level, which consists in delegating the implementation of the national policies to the regional or local authorities, meaning that the more power a local authority has, the more decentralised the political system is. The World Bank defines different ways in which decentralisation can be measured, either by the fiscal, political or administrative arrangements (The World Bank Group, 2013). In this thesis, the best way of measuring decentralisation is to use an indicator that reflects the political centralisation level because we are treating the influence of decentralisation on the implementation of an EU policy. Because we want to measure the evolution of the policy effectiveness throughout a total of 12 years, it is crucial to include an indicator that can also reflect the progression of time. Hence, a well suited indicator consists in the Regional Authority Index (RAI) which measures the capacity of regional and local authorities to have a saying in the functioning of the national laws, legislations and their execution. It is a composite index and the higher its level, the more decentralised a country is, reflecting the regional authority in terms of: institutional depth; policy scope; executive control; fiscal autonomy and control; executive control; borrowing autonomy and control; constitutional reform; and representation (Marks, Hooghe and Schakel, 2015). In this way, it reflects all types of powers that a regional authority can possess and thus is a good representation of what we want to measure and the highest the value, the more decentralised the political system is. Alternatively, we could have looked at the type of government, federal or unitary state, however, these definitions lack of the time-evolution component, which is essential in this research.

As regards the data provided by the RAI which was collected from 81 democracies, on annual basis between 1950 and 2010, it is an index that does not offer substantial variations. Our research proceeds between 2005 and 2016, therefore the data of 2010 will be assumed to be constant until 2016, because of the existence of very sporadic or non-existent variations. Nonetheless, between the years 2005 and 2010, inclusive, we will consider the variations available in data since there must be as much accuracy as possible. An example of how the dataset looks like is provided as follows:

Country/Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Czech Republic	9,00	9,00	9,00	9,00	9,00	9,00	9,00	9,00	9,00	9,00	9,00	9,00
Denmark	12,25	12,25	7,34	7,34	7,34	7,34	7,34	7,34	7,34	7,34	7,34	7,34

Figure 3: Example of the RAI Dataset (2005-2016) for Czech Republic.

The years 2011-2016 assume the same value of 2010. As we can see with the example of Czech Republic, the values never vary between 2005 and 2010, representing the majority of the cases. This is the condition that allows the assumption of assuming constant values between 2011 and 2016.

5.3.2.2 Centralisation at the EU level

The concept of centralisation of the EU policies was already discussed in the section 3.5, and it is defined as the delegation of the decision-making responsibilities to the supranational bodies of the EU. To measure this variable, it is important to include data that shows annual evolution of the delegation of functions regarding the implementation of the EU policy. To operationalise the delegation of tasks to the EU institutions we will use the number of environmental legal acts adopted and implemented by the European Commission as a percentage of the total number of legal acts implemented and adopted (including the European Commission, European Parliament and the Council of Ministers) for the issues related with "Environment".

The necessary data to form this component is believed to be reliable and valid since it will be retrieved from the EUR-Lex, the official database of the EU law and the most comprehensive source, providing authentic and daily updated documents and resources (EUR-Lex, 2018). This data was collected by counting the numbers of the Decisions; Regulations; Directives; Recommendations; Implementing Regulations; and Implementing Decisions issued by the European Commission, European Parliament and the Council of the European Union for each year of analysis (between 2005-2016). All the legal acts that are included are legislation in force (including binding and non-binding acts) as the objective is to have a proxy for the delegation of tasks to the EU institutions which represents the Member States waiving certain national powers and authority to the EU. The choice of the Commission specifically was due to the fact that we focus on the centralisation levels at the implementation phase and, as the executive body of the EU, the delegation of the tasks to the Commissions is believed to be the best proxy of EU centralisation level.

Then, the total of acts are a sum of the ones approved and implemented by the Commission, by the Parliament and by the Council of the EU. In this sense the formula to calculate our data is:

$$\mathrm{ECL}_{t} = \frac{\mathrm{LA\ EC}_{it}}{\mathrm{LA\ EC}_{it} + \mathrm{LA\ EP}_{it} + \mathrm{LA\ Council}_{it}}$$

Where

- ECL is the European Centralisation Level;
- LA EC stands for the Legal Acts approved by the European Commission;
- LA EP stands for the Legal Acts approved by the European Parliament;
- LA Council stands for the Legal Acts approved by the Council;
- The *t* represents the year and the *i* the Member State.

We can see that there is no variation across Member State because this is a variable that is constant per country as it belongs to the EU, however due to having a panel data analysis the same values will be applicable to every Member State, varying per year.

5.3.2.3 Centralisation of the EU ETS

Because the focus of this study is the EU ETS, the level of centralisation of this policy has to be measured separately. Yet, the evolution of the delegation of the tasks regarding this scheme, already presented in previous sections, leads the operationalisation of this variable to be done through a binary variable, assuming only two different values: 0 or 1. If the EU ETS implementation is decentralised, meaning that the Member States will be the ones implementing the policy and defining the targets allocation, this indicator will assume the value 0. While, if the implementation of the scheme is centralised at the EU level, the value for the indicator will be 1.

Throughout the first and second implementation phases, the policy execution was decentralised and implemented by each Member State, whereas since the beginning of the third phase, the targets setting shifts towards the EU institutions. Therefore, this variable we will be operationalised through the attribution of the value 0 to the years that belong to the first two phases (2005-2007 and 2008-2012) and the value 1 to the years of the last period (2013-2020).

5.3.3 Control Variables

As we have observed in the literature, environmental policies tend to be influenced by the economic growth. Also weather variations tend to influence but in a very complex manner that is not relevant for our analysis. Instead, we will consider to control the environmental taxes which can have an impact in the reduction of GHG emissions.

5.3.3.1 Economic Development

We have found evidence correlating the effectiveness of environmental policies and the level of economic growth, and the EU ETS is no exception to this rule. For example, Ellerman et al. (2010)

have shown that as the level of GDP grows, the capability of the Member States to decrease GHG emissions is higher, which leads us to believe that the GDP is the most appropriate indicator to operationalise this variable. According to the Eurostat (2017), the GDP is "the value of all goods and services produced less the value of any goods or services used in their creation". More specifically, the indicator that will represent this variable is the GDP per capita based on Purchasing Power Parity (PPP) in relation to the 2011 constant prices, converted to international dollars using PPP rates (one international dollar buys the same as one U.S. dollar buys in the US). By using this indicator, this thesis can eliminate the differences of purchasing power, allowing more realistic comparisons between Member States (World Bank, 2018). The data will be retrieved from the World Bank's International Comparison Program database, because of its complete and reliable information. In this thesis, the GDP per capita consists in the average GDP, since it divides the total GDP by the population dimension, measuring the differences of economic development rather than just economic growth.

5.3.3.2 Environmental Taxes

Regarding the national environmental conditions that may affect the volume of GHG emission, there must be considered the environmental taxes. These can affect the emissions in the way that companies or individuals that have to pollute during their economic activities will have to pay a tax depending on the amount of emissions released. In countries with higher taxes, the economic sectors have to adapt the type of energy chosen in terms of the tax that is applicable to that energy or emission. This research will consider three main types of environmental taxes, namely the energy, pollution and transport taxes. The choice of these three different taxes comes from the fact that they not only reflect the stringency of a Member State with environmental issues, but also they are related with the effectiveness of the EU ETS. First, the energy taxes cover the use of energy for transport and stationary purposes, fuel for transport and the GHG. Then, the transport taxes can influence the choices of vehicles which release emissions that have impact on the CO_2 emissions. Finally, the pollution taxes focus on all types of pollution which may reduce the amounts of pollution produced by the population and business in each Member State.

All the data will be collected from the Eurostat database which offers the three taxes revenues aggregated as a percentage of the GDP, enabling comparisons between Member States that have different economy sizes (Eurostat, 2018). The following formula summarises what has been described above (where *i* represents one Member State and *t* one year):

$$EVT_{it} = \frac{Pollution\,Tax_{it} + Energy\,Tax_{it} + Transport\,Tax_{it}}{GDP}$$

5.3.4 Variables Summary

The following Table summarises the variables together in order to allow a better and clearer understanding of them.

Dependent Variable	**Measurement**	**Source**
EU ETS Effectiveness	Difference between the national targets of maximum CO_2 emissions and the historical emissions for the EU ETS industrial sectors, as a percentage of the national targets of CO_2.	NAPs and ESD targets – EU ETS website; Verified emissions – EEA database; ESD emissions – Eurostat
Independent Variables	**Measurement**	**Source**
National Decentralisation Level	Regional Authority Index (RAI), as a proxy of national political decentralisation.	RAI developed by Arjan Schakel and retrieved from the project's website.
EU Centralisation Level	Percentage of the legal acts related with the Environment adopted and implemented by the European Commission (against the total legal acts).	Environment, Consumers and Health Protection Legal Acts - EUR-Lex
EU ETS Centralisation Level	Bivariate variable that assumes the values 0 or 1, in case the implementation is decentralised or centralised, respectively.	EU ETS factsheet – European Commission
Control Variables	**Measurement**	**Source**
Economic Development	GDP per capita, based on PPP, in relation to 2011 constant prices, in international dollars.	The World Bank – International Comparison Program Database
Environmental Taxes	Environmental taxes including pollution, energy and transport as a percentage of the GDP.	Environmental Taxes Revenues - Eurostat

Table 4 - Summary of the Variables Operationalisation

5.4 The Statistical Model

5.4.1 Linear Panel Regression Model

In this thesis we are dealing not only with time, but also with cross-country variations. An appropriate way of operationalising the present research is by using a multivariate regression model. Also, we have at hands a panel data analysis, which will demand the use of a complex regression that include time and cross-sectional variations. With a multivariate model we are able to have one dependent variable, represented by (Y) and different explanatory variables (X) which can be adapted for a panel data study. Furthermore, we can also control for multiple cofounding variables through this method.

To understand better how this method works, it is important to look at its general formula:

$$y_{it} = \beta_0 + X_{it}\beta_k + \varepsilon_{it}\,;\quad i = 1...; N;\ t = 1, ..., T$$

According to Graddy and Wang (2008):

- The y represents the dependent variable;
- The X represents the explanatory variables (independent and control variables);
- The *i* corresponds of the cross-sectional dimension, while the *t* represents time-series;
- The β is the intercept (the coefficient that measures the effect of the independent variables on the dependent one) and the β_0 is the value of dependent variable when the independent variables is 0;
- The ε consists of the error term, which are random effects on the dependent variable, and it can be specified as follows:
    - $\boldsymbol{\varepsilon_{it} = \mu_i + \nu_{it}}$ **,** in which μ_i - "the *unobservable* individual-specific effect" accounting for individual specific effects that are not included in the model equation; ν_{it} -"the remainder disturbance", or the idiosyncratic error varying in time and with the individuals (i.e. the EU Member States) (Baltagi, 2005, p.11).

The acronyms that will be attributed further on this thesis for the explanatory variables are:

- EEF – EU ETS Effectiveness;
- NDL – National Decentralisation Level;
- ECL – European Centralisation Level;
- EUT – EU ETS Centralisation Level;
- ECD – Economic Development;
- EVT – Environmental Taxes.

5.4.2 Estimation Methods

5.4.2.1 Ordinary Least Squares (OLS)

One of the ways of estimating the variables coefficients is through the estimation method of the Ordinary Least Squares (OLS). According to Graddy (1999, p.387) using the OLS "as the best estimation method for regression models is based on the regression model satisfying a set of assumptions" referring to a group of seven assumptions.

The first assumption is that all values of the dependent, independent and control variables have to be metric, nonetheless a nominal variable can be measured through a dummy variable. In second place, the number of observations must be higher than the number of independent variables. The third assumption consists in the linearity requirement, meaning that the dependent variable (Y) is a linear function of the independent ones (X), and no irrelevant independent variables are included and all relevant independent ones are taken into account. In fourth place, the residuals, or error terms, cannot be correlated ($COV(\varepsilon_i;\varepsilon_m) = 0$). If we observe a violation of this assumption we are in the present of autocorrelation. The fifth assumption is the verification of homoscedasticity.

Homoscedasticity of the data consists in the fact that the variance of the residuals is constant ($VAR(\varepsilon_i) = \sigma^2$) or, conversely, when the variance of the residuals varies, this is called heteroscedasticity. In sixth place, there is the normality assumption that refers to the fact that the dependent variable and the error terms must follow a normal distribution. Last but not least, multicollinearity cannot be observed between the explanatory variables or, in other words, the independent and control variables should not be highly correlated between each other.

The fulfilment of these assumptions consists in complying with the *Gauss-Markov Theorem*, and, thus, the OLS is the best method of estimation because it is unbiased, namely the Best Linear Unbiased Estimate (BLUE) (Graddy, 1999, Best and Wolf, 2015) which is something to be assessed in the analysis section (6.2). Indeed, if that is the case, the method of estimation to be used will be the Pooled OLS, which is adapted to an analysis with panel data, such as the one we are performing in this research (Best and Wolf, 2015). On the contrary, in case these criteria are not fulfilled by our data, other methods of estimation that are commonly used in a panel data analysis, will be followed. These methods are the fixed effects estimation (FE) and the random effects estimation (RE), which will be discussed in the following subsection.

5.4.2.2 Fixed Effects (FE) and Random Effects (RE) Estimation

According to Baltagi (2005) when a research focuses on a specific group of observations, such as N countries which are not randomly selected, the fixed effects (FE) estimation model is an appropriate way of proceeding, which is the case of the sample collected in this thesis. Furthermore, the FE method is normally used in panel data analyses because it allows solving problems that other models do not, such as in case the OLS assumptions are not met by the data.

Going back to the general regression model: $y_{it} = \beta_0 + X_{it}\beta_k + \varepsilon_{it}$, (where $\varepsilon_{it} = \mu_i + v_{it}$). The FE method assumes the restriction $\sum_{i=1}^{N} \mu_i = 0$, which avoids the possibility of perfect multicollinearity[6] but at the same time reduces the degrees of freedom and does not allow us to assess the differences across individuals. Because of this and other disadvantages, such as the fact that the FE method includes too many parameters, there are other models often used in panel data analyses.

The other method that is relevant and typically used in a panel analysis, is the random effects (RE) estimation, which uses a Generalized Least-Squares (GLS) estimation. Contrarily to the FE, the RE is more adequate when the observations are randomly drawn from a large population. It is a good method when scholars are trying to reach conclusions from a large population and the studied sample is a representation of that population. In this way, the big difference between RE and FE, is that here

[6] The problem of "perfect multicollinearity" relates to the impossibility of taking any credible conclusions from the study, because if two variables have a perfect linear relationship, a change in one variable will lead to a predictable change in the other (Graddy, 1999).

the individual effect (μ_i) is assumed to be random instead of fixed, which means that unlike the FE, the RE allows not only changes across time, but also across the different individuals of the sample. The research question that is being studied focuses in both time and cross-sectional changes, so the RE seems to be more appropriate to this research. For instance, the independent variable NDL varies over countries and over time.

Even though the sample (not randomly) collected leads to a FE estimation, the research question points in the direction of the RE estimation. So, both of the methods will be tested, in case the OLS assumptions are not fulfilled, to guarantee the most stringency in the analysis of the data and, thus, the most accurate results. Then, in order to determine the best model of estimation there will be performed, a Hausman test to both of the estimation methods (Hoechle, 2007, Torres-Reyna, 2017). Once the model is chosen, the results coming from that method of estimation will be analysed and discussed.

5.5 Assuring Reliability and Validity

In order to assure the research quality, two important characteristics have to be observed and those are reliability and validity, which will be discussed in the next subsections.

5.5.1 Reliability

A crucial characteristic of a research is to be reliable, which means to have consistent results in case the research is done repeatedly. Johnson, Reynolds and Mycoff (2008, pp.95-97) present three methods of assuring reliable results and, in this thesis, one of them will be adopted. In first place, the "test-retest method" consists of applying the same test to the collected observations and afterwards compare the obtained outcomes. In second place, there is the "alternative-form method" which is to repeat a test over time and, simultaneously, to use different measurements, instead of just one, to look at the same variable. In third place, the "split-halves method" entails using two different measurements but for the same moment of time.

In the present research, the method to be used is the test-retest approach, due to the availability of data and the already discussed advantages of the research design, such as the fact that it is an observational analysis. Furthermore, the indicators chosen to study each variable were selected because of their advantages and for being the best option available. A great example is when the indicator the dependent variable relies in different sources of data that guarantee that we can make comparisons over time, due to the changes in the EU ETS.

5.5.2 Validity

In the previous subsections, the variables' operationalisation has been discussed, however to guarantee that this research makes sense, it must be valid. Ensuring validity means making sure that there is correspondence between the indicators that are being used and the concepts that are behind the variables of those indicators (Johnson et al., 2008). Normally, research design scholars differentiate two types of validity: internal validity and external validity.

The internal validity consists in assuring that the causal relationship between the dependent and independent variables is not generated due to other factors (Johnson et al., 2008, Kellstedt and Whitten, 2013). The authors Kellstedt and Whitten (2013) have summarised the conditions that need to be verified, in order to achieve internal validity, into what they call the four hurdles. Firstly, there has to be a mechanism proving the relation between the variable Y and X, which normally is found in theory. This process was done throughout the Chapter 4 in which the causal mechanisms were explained. Secondly, the dependent variable (Y) cannot cause X, meaning that X occurred first in time and there is no reverse causality. Because our Y is only observable after the policy implementation, this hurdle is verified, as there is no reason why policy effectiveness would affect centralisation levels. Thirdly, Y and X have to be correlated, which is a step that will be accomplish in the analysis of the data. Fourthly, the variables (Z) that might affect both Y and X have to be controlled. These variables were first identified in the section 3.4 and operationalised in the section 5.3.3.

Regarding the external validity, it entails the possibility of generalising the results produced by a research to the fields outside of its scope (Johnson et al., 2008, Kellstedt and Whitten, 2013). This thesis uses indicators that relate to (de)centralisation not only in terms of the EU, but also of the national levels, making it a different level approach that can provide a view on both of the aspects. The decision of approaching decentralisation in general terms was done to increase external validity so that we can make sure that the results can be brought to other policy areas and not only to the EU policy. Although focusing on a specific case such as the emissions trading can increase internal validity because of stronger causal relations found, it may decrease external validity and impose limits on generalisations to other policy areas outside of the environmental matters.

6. Analysis

After establishing the research design and collecting all the necessary data for each variable, we are ready to move forward into the analysis of the results obtained. This Chapter presents the information which allows answering the research question and verify the hypotheses. This thesis will recur to the statistical software STATA/MP, version 14.1 to proceed with the analysis and all necessary data manipulations.

6.1 Descriptive Statistics

The first step to take in this analysis is to present the descriptive statistics, giving us general information about each variable's data (Johnson et al., 2008), including the central tendencies, as the variation or mean. The next two Tables summarise the most important descriptive statistics for all the variables. The variable EUT is separated from the remaining because of its operationalisation. Since it consists of a nominal variable with only two values (0 or 1), it cannot be assessed the same way as the other ratio or scale variables (Johnson, et al., 2008).

Variable	Mean	Std. Dev.	Min	Max
EEF	8.32	12.46	-24.99	51.09
NDL	11.23	10.81	0	36.99
ECL	65.35	14.98	35.29	91.23
ECD	34,779.21	14,585.23	14,984.59	97,864.20
EVT	2.55	0.590	1.57	4.83

Table 5 – Descriptive Statistics for the EEF, ECL, NDL, ECD and EVT variables[7]

By looking at the Table 5, we can observe four main descriptive statistics which are the mean, the standard deviation, the minimum and the maximum. These values are presented in different units according to each variable measurement: the EEF, ECL and EVT are measured in percentages, the NDL is a numerical score of an index, whereas the ECD is measured in euros (€).

The remaining variable, EUT, is a nominal variable, so the way of describing it is different. For that, the Table 6 presents the percentages of observations in which the EU ETS is a decentralised or centralised scheme. We can see that there are 210 observations for which the system is decentralised, which represents the 8 years of the two first phases of the EU ETS, while 112 consists of 4 years (2008-2012) of a centralised scheme for the 28[8] Member States.

[7] For the variable names look at section 5.4.1.
[8] Taking into consideration that the data for three Member States is not available for the whole period of time, since Bulgaria, Romania entered the EU in 2007 and Croatia in 2013.

EUT	Frequency	Percent	Cumulative Percent
Decentralised	210	65.22	65.22
Centralised	112	34.78	100
Total	322	100	

Table 6 – Descriptive Statistics for the EUT variable

The next step of the descriptive analysis is to present the most crucial tendencies of our variables. Because the dependent variable is the focus of this thesis, it is important to look at its main characteristics. The subsequent graphs represent, respectively, the dependent variable averages per Member State and per year.

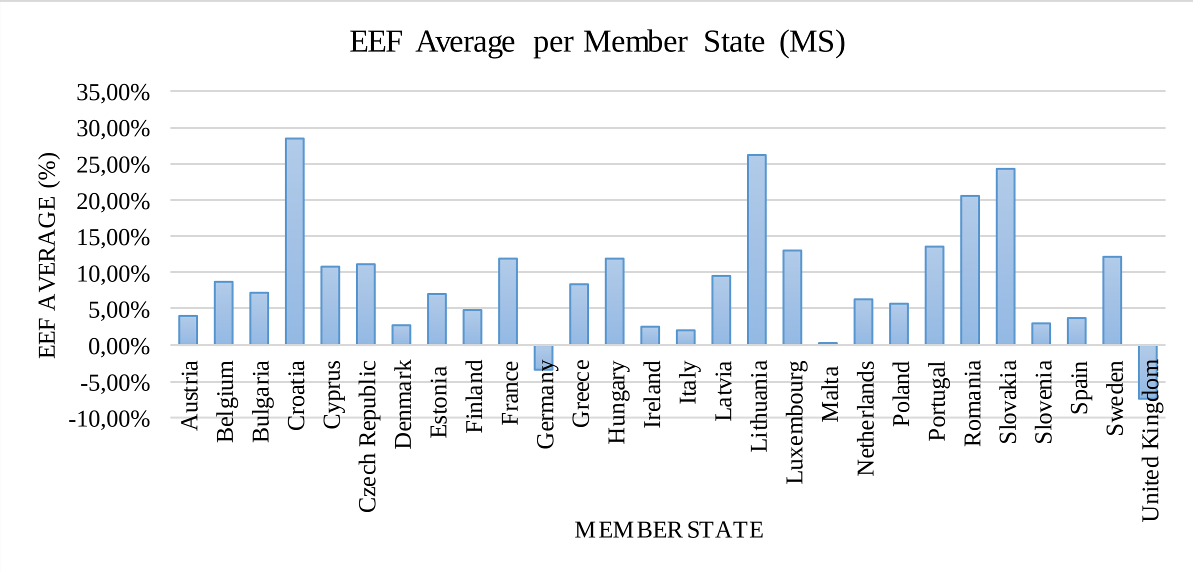

Figure 4: Bar chart of the EEF average per MS

This chart gives an overview of which Member States perform better or worse in achieving the EU ETS emission targets. Croatia, Lithuania and Slovenia are, in average, the most effective in reaching their targets. The case of Croatia can be related with the fact that it is the most recent EU Member State, nonetheless with a small number of observations is hard to make any inference about this country. This reality contrasts with the UK and Germany with a negative average of 7.40% and 3.40%, and with Malta with an average of 0.26%, showing that in terms of achieving their emission goals, these countries are the least effective.

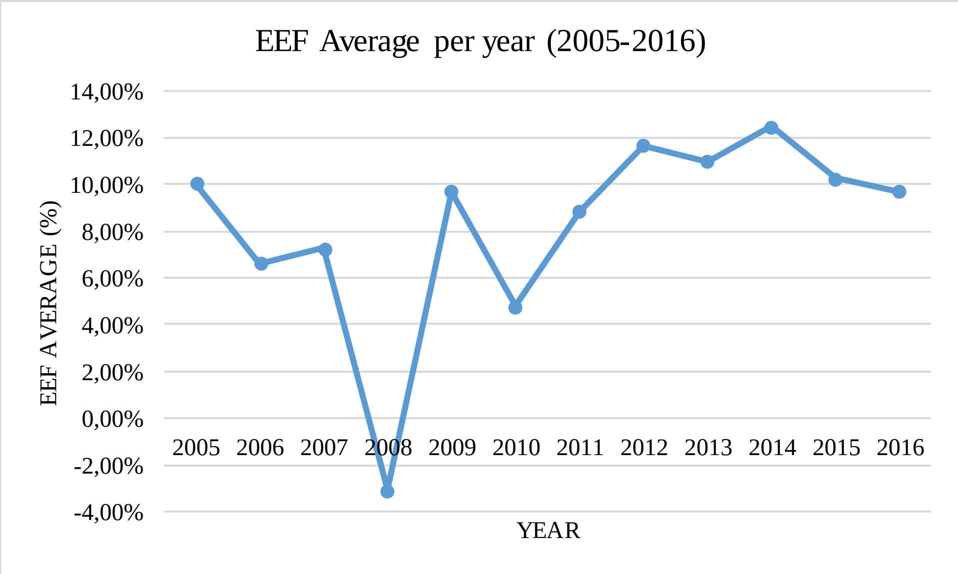

Figure 5: Line chart of the EEF average per Year.

Figure 5 enables the observation of the evolution of the variable EEF average over time. We can see that 2008 was the only year that, in average, the effectiveness of the EU ETS was negative and the highest scores were reached between 2012 and 2015. This can be related with several factors such as the international crisis of 2008. Nonetheless, by looking at these graphs, it is yet not possible to take conclusions about the impact of the independent variables on this evolution. In this sense, it would be relevant to assess the results of our analysis excluding the year of 2008. For that reason, the central models of this thesis will be performed without the year of 2008 for every Member State, presented in the Appendix IV and discussed in the Chapter 7.

Adding to the dependent variable, it is imperative to have a look at the independent and control variables. First, the NDL representing national decentralisation changes mostly over country, therefore it is relevant to look at its levels per Member State, rather than its time evolution. The next graph shows that the countries that score higher in terms of NDL and are more decentralised in terms of policy implementation are Germany and Belgium. These countries are federal states where most competences regarding decision-making are allocated to the regions. Also, Spain consists of an unitary state, but it presents a big division between thousands municipalities and 52 county councils (CEMR, 2016). Instead, the countries that have more centralised systems are Cyprus, Estonia and Luxembourg. This information will help us when analysing its influence on the dependent variable, further in this thesis.

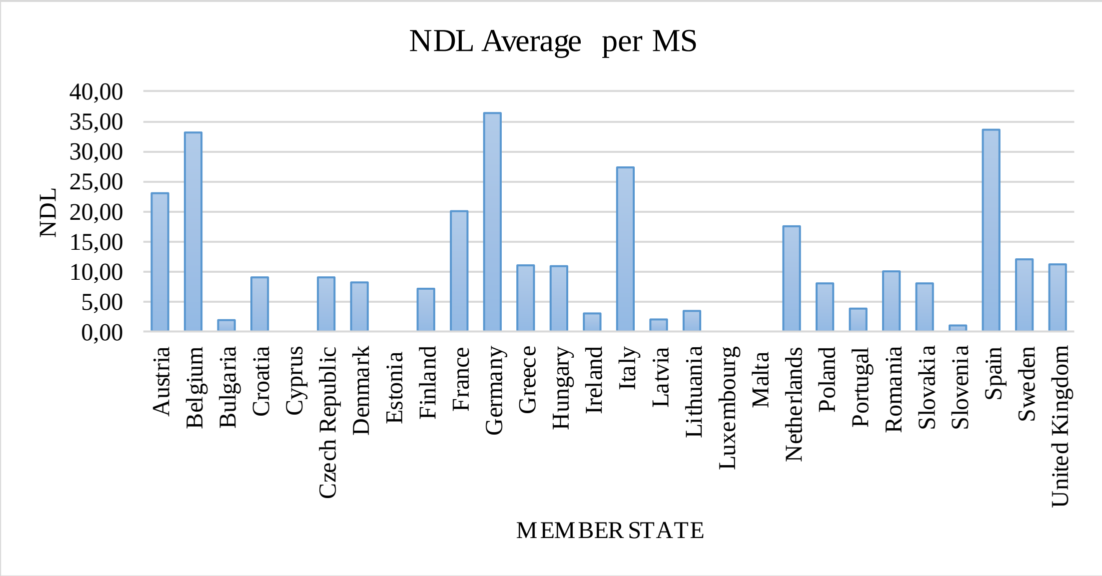

Figure 6: Bar chart of the NDL average per MS.

Second, the EU centralisation level, represented by the variable ECL, does not vary per Member State, therefore a good way of observing is by looking at its time evolution.

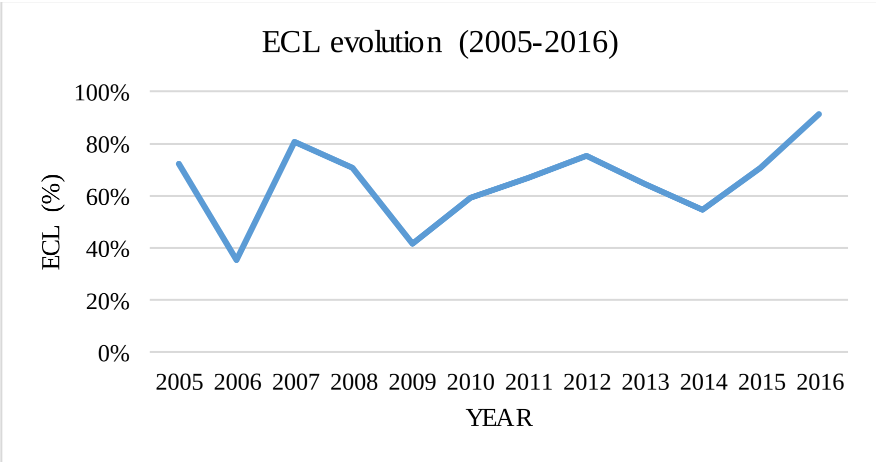

Figure 7: Line chart of the ECL evolution.

The Figure 7 shows that there is a general tendency for the EU legal acts regarding the environment to be more centralised at the EU level throughout time, however due to the volatile progress it is hard to see a specific trend. If we compare it with the evolution of the variable EEF, we can see some years in which they present a similar tendency, nonetheless, the year of 2008 the EEF decreases abruptly, whereas the ECL increases. Similarly, in 2014 the EEF increases while the ECL decreases, showing contradictory results to the other years.

Third, the variable EUT can only assume two values that represent the EU ETS level of centralisation. As mentioned before, this system was first decentralised, from 2005 until 2012 and then centralised, from 2013 onwards. This does not let us take further conclusions about this variable, allowing to proceed to the next variables.

Regarding the control variables ECD and EVT, it is more relevant to verify variations across countries. So, in this subsection we will only refer changes that are visible between the EU Member States. For that, the next two bar charts show us that: the wealthiest countries are Luxembourg, with a ECD average value of 92,397.70 euros per year, Ireland and the Netherlands, with a ECD average above 45,000 euros per year. the poorest countries in average are the last three countries to integrate the EU, namely Bulgaria, Romania and Croatia. Then, the most environmentally taxed countries are Denmark, Croatia and Slovenia; and, lastly, the countries with lower averages of environmental taxes as a percentage of their GDP are Spain, Slovakia and Lithuania.

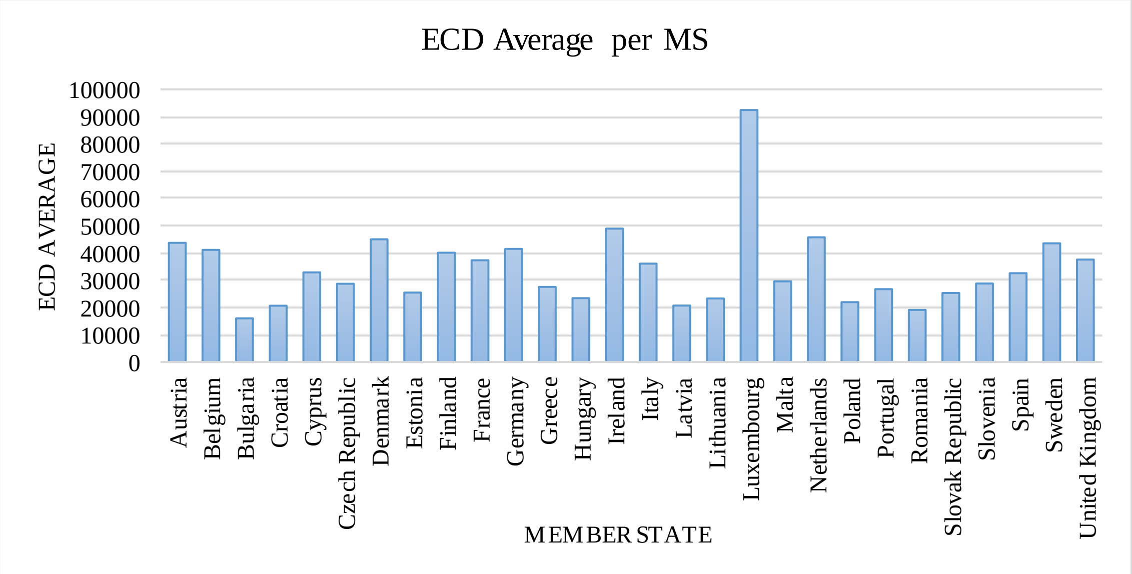

Figure 8: Bar chart of the ECD average per MS.

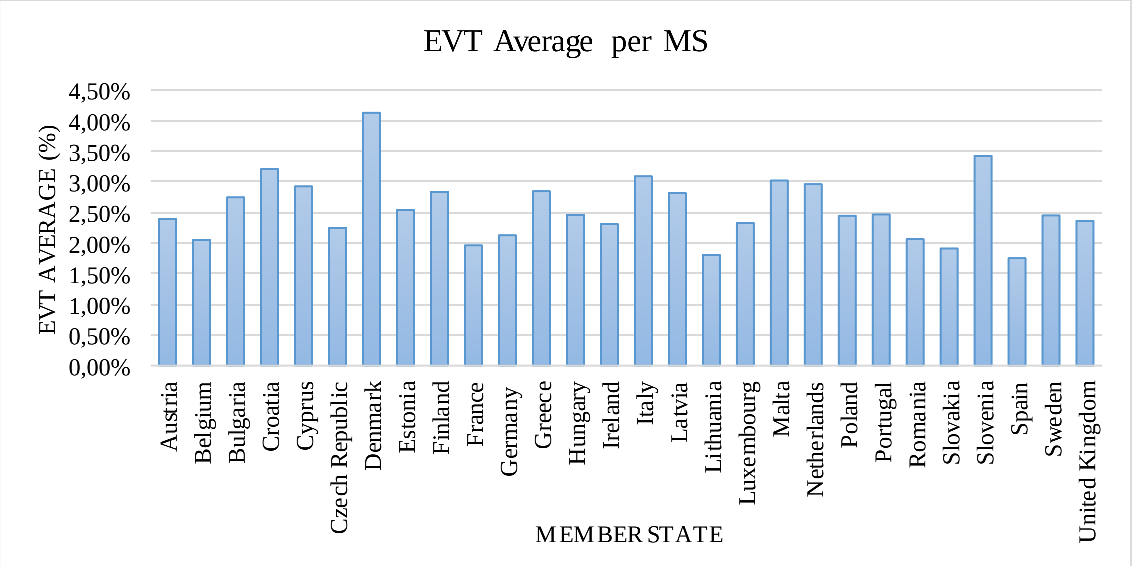

Figure 9: Bar chart of the EVT average per MS.

Even though this descriptive analysis highlights the main characteristics of the variables that are being studied, the central conclusions regarding the research question and hypothesis will be assessed in the discussion section, where all our expectations will be tested.

Before proceeding to the extensive analysis and results, the OLS assumptions will be tested in order to decide which estimation model will be used to analyse our data.

6.2 OLS Assumptions Testing

The present section is going to verify whether the pooled OLS is the Best Linear Unbiased Estimate (BLUE)[9], by testing the already mentioned seven assumptions (Graddy, 1999). The two first assumptions that were mentioned in the subsection 5.4.2.1 are indeed verified by the present model. First, according to Graddy (1999), the number of observations has to be higher than the number of independent variables. Certainly, in the present model, there are only three independent variables against a total of 322 observations. Therefore, this assumption is not violated and the number of observations is enough. Second, it is required that all the variables are metric. Despite the fact that the variable EUT is nominal, we are able to attribute a numerical value that allows its numerical measurement. The remaining ones are interval variables which leads to the verification of this assumption.

The other five assumptions require a more detailed analysis, therefore they are tested in the different following subsections.

6.2.1 Linearity

A simple way of understanding if the independent variables are linearly related with the dependent variable is by drawing the different scatter plots (Acock, 2006). For each independent and control variable a scatter plot was designed to see the association with the dependent variable, which can be found in the Appendix I. Linearity means that when looking at the plots we observe a linear relationship between an independent/control variable and the dependent one.

By looking at the different scatter plots, it is not possible to observe a clear linear relationship between the dependent variable and any independent or control variables. The variables NDL and ECL present an inconstant distribution of the observations, so we cannot say with certainty that when the EEF increases, there is an increase or decrease in these variables. In terms of the variable ECD, it assumes values that are very concentrated in a smaller interval of the EEF. Similar relationship is verified for the variable EVT, and both of them include outliers that do not allow us to infer a linear relationship. Hence, there is not enough evidence for us to say that the linearity assumption is verified and, thus, it is violated.

6.2.2 No Autocorrelation (Independence)

Autocorrelation occurs when there is a systematically correlation between the error term of an observation with the error term of another observation (Graddy, 1999), which often happens in time-

[9] See section 5.4.2.

series analysis. In a panel data model, this can also happen due to the time variation component and can undermine the efficiency of the results. To verify if we are in the presence of autocorrelation or not, this thesis performed a Wooldridge test in STATA. According to Drukker (2003), this test is appropriate to perform in a panel data analysis due to its flexibility and because it is not difficult to implement.

After executing the Wooldridge test to the EU ETS model with the studied data, we have obtained a P-value of 0.0021. Because the P-value is lower than 0.05, the null hypothesis (H0: No first-order autocorrelation) has to be rejected. We reject the possibility that no autocorrelation exists and this means that autocorrelation might exist. In this sense, the no autocorrelation assumptions is violated and the way to assure it is not going to affect the results will be explained in the model selection (subsection 6.3), by using a FE method of estimation with robust standard errors (Wooldridge, 2002).

6.2.3 Homoscedasticity

To guaranty the homoscedasticity assumption means that the variances of the residuals are homogenous, or constant. Alternatively, we can also search for evidence on heteroscedasticity and in case we find it, this assumption is violated. The different ways of testing this characteristic of the residuals include, first, performing a plot of the error terms against the predicted values. Second, performing a Breusch-Pagan test to the studied model or, third, performing a White's test which is a decomposition test providing an overview of the heteroscedasticity, skewness and kurtosis of the dataset (Torres-Reyna, 2017). This thesis will execute all of the three options to make sure that we run every possibility and guaranty trustworthy results.

By looking at the plot present in Appendix I of the residuals against the predicted (fitted) values, we do not observe any direct pattern of the residuals and the predicted values. This points that the assumption is verified and there is homoscedasticity of the data. The results of the Breusch-Pagan also show the same conclusions, since the consequent P-value is 0.5914 (> 0.05) which does not allow the rejection of the null hypothesis (H0: Constant variance) and enables us to consider that the variance of the residuals is constant. Contrarily, the White's test shows a different conclusion, due to a P-value of 0.0099 (<0.05). With the latter test, there is heteroscedasticity, meaning that the assumption of homoscedasticity is not verified. Even though the other two tests point to a different result, we will consider that this assumption is violated[10].

6.2.4 No Multicollinearity

One of the assumptions of the OLS is that there should not be a linear relation between any of the independent (and control) variables which means there should not be multicollinearity between the

[10] Because other assumptions were also violated, this thesis will not follow the pooled OLS as an estimation method. This will be explained in the subsection 6.3.

different variables. We can verify this assumption by calculating the correlation between the different pairs of explanatory variables (Acock, 2006). For this purpose STATA is again used and the Table II.1, shown in the Appendix II, summarises the results obtained.

Indeed, from the results of the correlation tests, it is possible to affirm that none of the pairs of variables presents a high level of correlation. Even though some of the values are higher than others, none of them is strong enough to say that there is a linear relationship between the variables, let alone to have perfect multicollinearity. The strongest correlation is between the variables NDL and EVT, which present a negative correlation of 0.2841, whereas the weakest is between the EUT and NDL that present a negative correlation of only 0.0085. Additionally, to see if these coefficients are significant, this thesis performed a significance test for each coefficient. The P-values for each correlation are represented in the Table II.1 (Appendix II) and show us that the only relevant correlations are, first, between the EUT and the ECL and between the EVT and the NDL, which means that these variables actually establish a relationship between each other. However, as referred above, the coefficients do not indicate a high level of correlations, which will not affect the result in a great extent.

Another method that could be used to test this assumption of no multicollinearity is to calculate the Variance Inflation Factor (VIF) for all the independent and control variables (IDRE, 2017). The Table II.2 in the Appendix II contains the values that were obtained.

When the VIF value is higher than 10, it requires further investigation about the collinearity of the variables. Thus, because all of the values are under 10 and approximately to 1, is in line with the conclusions referring to the correlation values. This means that this assumption is verified and there is no multicollinearity between the explanatory variables.

6.2.5 Normality

The normality assumption of a linear regression states that the dependent variable of the model and the residuals should follow a normal distribution. To test whether or not this is the case, there are different methods that can be followed and here both graphical and numerical methods are discussed. First, there is the graphical approach of drawing a histogram of the distribution of the different variables and visualising if they assemble a normal distribution (IDRE, 2017). The histograms of the different variables, which can be found in the Appendix III, tell us that the dependent variable and residuals present a distribution that assembles definitely a normal distribution. With this method we observe that the normality assumption is not violated.

Secondly, the numerical method adopted in this thesis is a Jarque-Bera test (Ghasemi and Zahediasl, 2012). After executing it, we can see that the dependent variable is truly normally distributed, since the resulting P-value is 0.288, higher than 0.05, meaning we cannot reject the null hypothesis (H0: normality). The residuals with a P-value of 0.0476, can still be considered normally distributed if we assume that the P-value is higher than 0.01, leading us to accept the null hypothesis.

Again, normality is followed by the residuals and dependent variable, meaning that both of the tests lead us to believe that the normality assumption is verified.

6.3 Estimation Model Choice

In the section 6.2, the OLS assumptions were tested and part of them were violated, including the linearity, no autocorrelation and homoscedasticity. In this way, other method of estimation has to be chosen instead of the pooled OLS for panel data[11]. The alternatives are indeed the fixed effects (FE) and the random effects (RE) estimation. As said before, a common procedure, to choose between these two approaches, is to perform a Hausman test. If the P-value resulting from the test is lower than 0.05, we have to reject the null hypothesis (H0: difference in coefficients not systematic). If the null hypothesis is rejected, it means that FE is preferable, otherwise RE is the most appropriate method (Park, 2011, Torres-Reyna, 2017).

After running the Hausman, the P-value obtained is 0.000, translating in the rejection of the null hypothesis. Hence, the FE is the most appropriate according to the test that was ran, and should be used in our analysis. Nevertheless, as mentioned in subsection 5.4.2.2, the FE method eliminates the influence of characteristics that vary due to non-time reasons. The research question that is aimed to be answered also focuses in differences across countries. In order to guarantee that we can observe the impact of characteristics of each country, this thesis will regress two main models, one with the FE and the other with the RE method[12].

Moreover, many authors suggest the use of the FE estimation recurring to the robust estimator for panel data, when we suspect that the assumptions of no autocorrelation and of heteroscedasticity are violated by the data that is being studying (Wooldridge, 2002). This method is performed through STATA, allowing us to obtain the robust standard errors and new P-values that are higher and the same estimated coefficients that we would obtain without the robust estimator (StataCorp LP, 2017). This being said, the methods of estimation being used are the fixed effects with a robust estimator and the random effects. The subsequent results of the regression will be presented in the next section.

6.4 Results

In the previous subsections, the steps to define the model that will be used to test the hypotheses and answer the research question were explained. After having all the variables, data and estimation methods, this thesis proceeds by presenting the models regressed. The following Table summarises the two regression models that were obtained when regressing the data with a FE and RE methods, respectively.

[11] Look at section 5.4.2.1 for the explanation.
[12] Look at section 5.4.2.2 for more detailed information on FE and RE methods.

Variable	Coefficient		Std. Error		P-value	
	FE (Robust) Model	RE Model	FE (Robust) Model	RE Model	FE (Robust) Model	RE Model
NDL	-0.0040	-0.0018	0.0170	0.0012	0.816	0.155
ECL	0.0397	-0.0187	0.0305	0.0391	0.205	0.632
EUT	0.0564	0.0384	0.0209	0.0124	0.012**	0.002*
ECD	-0.00002	-2.73e-06	5.13e-06	8.71e-07	0.001*	0.002*
EVT	-2.3281	-0.5941	3.6777	1.6408	0.532	0.717
Constant	0.8398	0.2139	0.2737	0.0612	0.005*	0.000*
	FE (Robust) Model			RE Model		
Sigma u (μ_i)	0.2906			0.0578		
Sigma e (ν_{it})	0.0942			0.0942		
R^2	0.1703			0.0701		
Adjusted R^2	0.1571			0.0554		
N	322			322		
F-Test	4.44 (P-value=0.0044*)			21.35 (P-Value=0.0007*)		
DF	27			-		

Table 7 – Multiple linear regression model, with FE (robust) and RE estimation (Significant at *P=0.01; **P=0.05).

In Table 7, it is possible to observe several important results that describe the multiple linear regression model. Before moving on to the discussion of the values obtained, it is important to clarify the meaning of each of them. First, the Table 7 comprises the estimated coefficients that can be interpreted as “for a given country, as X varies across time by one unit, Y increases or decreases by β units” for the case of the FE estimators (Bartels, 2009, p.9). For a RE estimation, the coefficients are harder to interpret because the effects between countries and within are the same, meaning “one-unit change in X across time has the same impact on Y as a one-unit change in the average of X between countries” (Bartels, 2009, p.9). In other words, the coefficients incorporate both yearly and cross-country differences.

Then, the (robust[13]) standard errors and the P-value for each explanatory variable are presented. The former one tells us how far a sample observation is from the regressions model. If we have a very high standard error, we have high uncertainty about the estimates. The latter one consists in the level of significance that tests the null-hypothesis of zero correlation exists between the dependent and independent variable. In other words, if the P-value is higher than the significant level (0.01; 0.05 or 0.1), we cannot reject the null hypothesis and say that there is a significant relationship between the dependent and independent variables (Mohr, 1990).

Moreover, the sigma *u* and sigma *e* are the two components of the error term that were described in the section 5.4.1. Also, we can find other important characteristics including the R-

[13] For FE, robust standard errors were calculated (see section 6.3).

squared[14] and Adjusted R-squared, the number of observations (N), the F-test and the degrees of freedom (DF) of the F-test for the FE method, and the Wald test for the RE method. The R-squared is referred as of Goodness-of-fit that measures how much the model can predict the variability of the dependent variable (Bartlett, 2014). Normally, it is one of the most important statistics to understand the results of multiple regression model, however, in panel data the R-squared tends to be low due to the unobserved heterogeneity of the data across sections (Andy, 2013). The adjusted R-squared is a similar measure but assumes that the model matches better the sample data than the actual population, which makes it a better evaluation measure than the R-squared.

Alternatively, F-test and Wald test are important to verify if the model is significant or not in explaining the relationship between the variables. This are more relevant than the R-squared when it comes to interpret the results of a panel data analysis estimated with a FE or a RE method, respectively (StataCorp LP, 2007).

6.5. Results Interpretation

This section is crucial to understand if the statistical models presented above have contributed for the assessment of causality between the different types of centralisation and the EU ETS effectiveness. We will be able to look at the impact of each explanatory variable and infer if they match with the hypotheses proposed in the section 4.1. For this purpose, this section will be divided in the analysis of each independent and control variable separately and in the comparison between the two models (additional models are discussed in Chapter 7 and presented in the Appendixes IV and V).

6.5.1 National Decentralisation

The national level of decentralisation is supposed to be negatively related with the EU ETS effectiveness. Indeed, from both models, the obtained coefficients are negative, which means that when the NDL increases one point, the EEF decreases 0.4% and 0.18% respectively according with the FE and RE models. Nonetheless, these values are not only very small, showing a very low correlation, but also the variable NDL does not pass the significance test, since its P-values are 0.816 and 0.155, higher than either 0.01, 0.05 or 0.1. The RE model actually assumes a higher significance than the FE, but we still cannot reject the null hypothesis of zero relationship. So, we have to assume that the causality mechanism is not sufficient to accept the H1, meaning that the national level of decentralisation does not impact directly the EU ETS effectiveness.

[14] Note that the R-Squared (R^2) is calculated differently depending on the estimation method. For the FE method, the used R^2 is the value from the mean-deviated regression, namely R^2 “within”; while, for the RE method, the R^2 used is the “overall” value, since the RE estimator (GLS estimator) is a weighted average of the between and within estimators (Andy, 2013).

6.5.2 European Centralisation

In terms of the EU centralisation variable, the models show contradictory results. First, the FE model shows a positive coefficient of 0.0397, meaning that when the number of legal acts adopted and implemented by the European Commission increase in proportion to all legal acts one percent, the effectiveness of the policy for a Member State, at a certain year, increases 3.97%. With the RE estimation, one percent increase in the ECL variable leads to the decrease in 1.87% in the EU ETS effectiveness. Although these results are inconsistent, both models do not present a P-value that allows us to accept the correlation between the ECL and EEF. The P-values are 0.205 and 0.632, showing that this variable do not pass the significance test in either the models. The most accurate test would be the FE in this case, since it has the lowest P-value and because this variable only varies per year and not across country.

Nevertheless, we have to reject hypothesis number two (H2) that states that the European level of centralisation causes the EU environmental policies to be more effective.

6.5.3 EU ETS Centralisation

The focus of our thesis is the specific case of the EU emissions trading scheme and how its level of centralisation has influenced its effectiveness in the different Member States. Certainly, by looking at the significance levels obtained with both models, the RE is the method which can better regress the relationship between the variables EEF and EUT. The fact that the P-value in this method is 0.002, lower than 0.01 enables the rejection of the null hypothesis of zero correlation. The FE method also allows the rejection of the null hypothesis, but at a higher significance level (P=0.05) since the obtained P-value is 0.012.

The coefficients are slightly different: 0.0564 and 0.0384 for the FE and RE methods, respectively. This can be interpreted as when the EU ETS is implemented through centralisation at the EU level, the EU ETS effectiveness grows approximately 5.64% and 3.84% (with the FE and RE estimation). The FE is again the best method to interpret this variable due to the fact that it only changes per year and is constant across Member State.

This results are in line with the theory that was explained in the subsection 4.1.3. Therefore, the hypothesis three (H3) is accepted by both regression models, and we can positively say that centralising the EU emissions trading system leads to the increase of the effectiveness of the Member States in reaching targets.

6.5.4 Economic Development

The first control variable, economic development, shows very similar results in both of the models. Even though the theory presents evidence that economic development influences positively the impact of environmental measures and, in particular, emissions trading, the results of the present research show that the impact is close to zero in a negative direction. The coefficients attained with both models (FE and RE) are -0.00002 and -2.73e-06. Moreover, the P-values are similar (0.001 and 0.002) and allow us to reject the null hypothesis of non-correlation, meaning that this model explains the relationship between EEF and ECD. In this way our expectations towards the economic development were wrong since they do not represent a positive impact in the variance of the effectiveness of the EU ETS.

6.5.5 Environmental Taxes

The last variable to be studied is the EVT, representing the environmental taxes. Both models infer that the higher the environmental taxes revenue as a percentage of the GDP, the lower the effectiveness of the emissions scheme. First, the FE coefficient indicates that when the EVT increases one percent, the EEF decreases by 232.81%, whereas the RE says that the same value corresponds to 59.41%.

Despite this results, we cannot consider either of the models to be relevant in the explanation of the relationship between the EVT and the dependent variable since the significance levels found are too high. The P-values are 0.532 and 0.717, meaning that none of the models rejects the null hypothesis of zero correlation, not corresponding to the expectations based on the theory regarding environmental taxes playing an important role in the reduction of CO_2 emissions.

6.5.6 Comparison of the FE and RE Models

After looking at the variables' results and the models produced using the FE and RE estimation, some conclusions about the models were reached.

In first place, the R-squared and the adjusted R-squared are higher in the FE model, respectively 0.1703 and 0.1571 against the 0.0701 and 0.0554, resulting from the RE model, which goes in line with the Hausman test performed before[15]. These numbers are very low, but as referred before, R-squared and the adjusted R-squared are not the best measures to evaluate FE and RE models in panel data[16], due to the heterogeneity of the data. Because the adjusted R-squared is considered to be the best measure of these two values, we can say that by looking at the two models, the FE estimation predicts 15.71% of the variability of the EEF variable, while the RE only predicts around 5.54% of the same variability. From here, we can suppose that the FE is more efficient in predicting the variations in the dependent variable, making it more efficient and credible, which goes in favour of the Hausman test performed and discussed in the subsection 6.3.

[15] See subsection 6.3.
[16] See subsection 6.4.

Concerning the constant, the FE obtained a value of 0.8398, higher than the 0.2139 of the RE method. Also, both of the methods assume a significant constant at a P-value lower than 0.01. Hence, it fits the model and can be taken into consideration.

Finally, when it comes to the F-test and Wald-test, both of them have rejected the null hypothesis of that all coefficients are equal to zero with high confidence (P-values of 0.0044 and 0.0007, respectively). Both models explain some variation of the dependent variable, according to the independent and control variables used, being better than a null model with no use of independent variables.

7. Discussion

When interpreting the results obtained by the two models performed, this thesis has reached the conclusion that only one of the hypotheses formulated was not rejected. That hypothesis refers to the fact that the EU ETS is more effective for every Member State in case the system is centralised at the EU level. Nonetheless, the results indicate that the Levels of National Decentralisation of the policies and the EU level of centralisation are not relevant to explain the evolution of the EU ETS effectiveness.

In first place, the fact that national centralisation does not create a more effective emissions trading scheme can be related with many factors. The fixed effects model does not account for differences between sections, only considering the time evolutions. However, the Level of National Decentralisation is for the majority of the countries constant, since the Regional Authority Index (RAI)[17] does not vary much over the years. This explains the low significance level of this model. In alternative, the random effects almost explains the relationship between the national centralisation and the effectiveness of the scheme. Yet, the explanations behind this weak relationship are related with the fact that even in a highly decentralised state, the EU ETS decisions are perhaps decided at higher levels of government without consulting local authorities for the definition of targets and implementation. If this is true, the mechanisms behind the causal relationship described in section 4.1.1 would not have the opportunity to interfere with the EU ETS implementation. To verify this expectation, we would have to access the way every Member State implements the EU ETS internally.

Moreover, including or excluding the control variables does not change the results regarding the National Centralisation Level. The theory says that higher levels of centralisation do not facilitate the accomplishing of ambitious environmental policies. Nonetheless, decentralisation is preferred when there are there is a great heterogeneity in the legislations. The reasons for this argument lie in the fact that smaller jurisdictions, when confronted with stricter environmental standards, are not able to adapt due to the lack of resources or experts to achieve them, undermining the whole policy results (Garcia-Valiñas, 2007). This indicates that the EU Member States that are more centralised have more capacity in achieving the proposed results of the EU ETS, creating an interesting finding that could be worth investigating further.

In second place, the European Centralisation Level of environmental policies does not seem to play a role in the EU ETS effectiveness according to both of the central models regressed. The fixed effects method is the best one to understand this relationship, since the European Centralisation Level only varies in time. Even though the significance of the statistical results obtained is low, the direction of the relationship generated statistically is positive. The explanations behind this reduced significance are maybe related with external factors, such as values of the year 2008. In the section

[17] See section 4.1.1.

6.1, the Figure 4 shows that in 2008 the EEF average has reduced dramatically, which might be related with the financial crises that negatively affected the EU ETS (Ellerman et al., 2010). For this reason, we have decided to regress the same models, but excluding the year of 2008, to assess if there are any significant changes in the results.

When excluding the year of 2008, it is possible to see that the European Centralisation Level becomes statistically relevant. This suggests that when excluding the exceptional year of 2008, there is a positive relationship between the European centralisation and the achievement of environmental goals, as predicted by the principal-agent theory.

This is aligned with the economic expectations[18] stating that the level of economic development affects the EU ETS effectiveness. Correspondingly, if we look at the Figure 6 in the section 6.1, the European Centralisation Level time evolution follows a similar pattern to the one of the EU ETS Effectiveness averages follow, except the years of 2007 and 2008. Again, this can be related with the economic crisis of 2008, supporting the results of the new regression model. Although this thesis cannot account for all explanations behind this variation, an additional justification could be the integration of Bulgaria and Romania in 2007. These two eastern European countries have entered the EU ETS in 2008, and due to their lower capacity in adaptation to the EU policies, this could have destabilised the EU ETS effectiveness in 2008.

In addition, when considering the European Centralisation Level isolated[19] from the other two centralisation levels the results indicate a positive relation between the European centralisation and the accomplishment of the EU ETS targets. However, the results are not statistically significant if we exclude the Economic Development and the Environmental Taxes from the model. Another interesting finding is to see that the only significant factor is the Economic Development indicating that the centralisation impact will depend of the economic circumstances. This finding is aligned with the problem of interest mentioned by the principal-agent theory. The interests of the agent will vary according to the economic conditions faced at each moment in time, affecting its impact in the accomplishment of environmental goals.

In last place, the positive relationship between the EU ETS Effectiveness and its level of centralisation confirms the theory presented in this thesis. In this sense, the changes in the implementation of the scheme were justified by this thesis' results. By making the policy more centralised at the European level, the countries seem to be more capable to achieve their CO_2 targets. This supports that deciding the targets collectively and having the same monitoring and enforcement procedures is more effective. Also, it means that when the EU Member States decide the targets together with the Commission, the market price of the allowances is known beforehand, which reduces its unstable variations as referred in the literature (Ellerman et al., 2010).

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[18] See section 3.4.

[19] See appendix V.

Likewise, when focusing solely in the centralisation of the scheme[20], the results are mostly significant, despite when excluding the Economic Development and Environmental Taxes for the fixed effects model, which can be related with the calculation methods used.

In conclusion, after changing the scheme's implementation from decentralised to centralised, at the EU level, the results in its effectiveness are positive. The theoretical expectations[21] which stated that a decentralised EU ETS would lead to volatile prices of allowances, to the choice of Member States to not use the banking option and to the over-allocation of allowances which then would lead to a less effective EU ETS, have now more evidence to be further researched. However, the results about the impact of the European centralisation are not so strong, since it depends on certain conditions, such as the exclusion of the year of 2008 or the inclusion of the control variables. The National Decentralisation Level does not follow our initial theoretical expectations. This inference is in line with the competing theories that point out that the heterogeneity of the jurisdictions can reduce the capacity of certain regions and local governments of achieving higher environmental objectives.

With this, our discussion is finished and it has achieved some interesting findings for future investigations.

[20] See appendix V.

[21] See section 4.1.3

8. Conclusion

The previous section has allowed us to enter the discussion of the results which will allow us to answer of the research question. This Chapter concludes the thesis with the answer to the research question, the main limitations faced throughout the research process and it summarises future policy and theoretical implications.

8.1 Answer to the Research Question

According to the findings discussed in the previous Chapter, this thesis is ready to answer its central research question:

How do the national and EU political centralisation levels influence the EU ETS effectiveness?

It can be said that, in first place, the national political centralisation level does not impact the EU ETS in a positive way nor in a negative way. The findings show very little significance of the relationship between these two variables to say that there is a causal relationship. In second place, the EU level of centralisation of the environmental policies can only affect the EU ETS effectiveness under certain circumstances, according to the models regressed. Only when the control variables are taken into account and the other two independent variables are excluded, we can affirm that the EU environmental centralisation has a positive relationship with the EU ETS effectiveness. Lastly, the centralisation level of the EU ETS implementation has a positive relationship with its effectiveness. Indeed, the EU implementation of the EU ETS produces more effective results compared to the results of the scheme when implemented independently by each Member State. Our results support the economic and political arguments presented in 4.1.3, such as the fact that collectively defining targets allows the market to identify the price, not leading to its constant variations, which doesn't incentive firms to pollute more and, thus, increases the effectiveness of the scheme.

This findings are crucial for future investigation and for relevant political decisions, which will be discussed in the section 8.3.

8.2 Research Limitations

This research faces limitations related with different subjects, such as data collection, interpretation and generalisation of the results.

In first instance, the complexity of the EU ETS has led this thesis to choose a quantitative analysis without recurring to alternative methods, such as a qualitative study (e.g. interviews, surveys, etc.). Combining other methods could have let us to find empirical evidence regarding the design of the EU ETS and whether centralisation positively affects the effectiveness of this specific policy. Another limitation of the quantitative method lies in the fact that the data regarding the targets and the EU ETS emissions are collected from bodies of the EU, such as EUR-Lex, Eurostat or the

EEA. These can be biased sources of information, since the outcomes rely on the way that the EU collects information and presents it.

Additionally, in the subsection 5.5.2, it was referred that to assure external validity, this thesis would measure national levels of centralisation and their impact in the EU ETS effectiveness. Yet, this thesis did not prove that this variable influences the dependent variable, which can be related with the fact that we are studying the specific case of the EU ETS. This can mean that if the research was about a different international environment regime, or even a different kind of policy, the national centralisation could be significant to the policy effectiveness.

Also, this thesis uses panel data which takes into account both time and cross-sectional variations. This means that the data can present heterogeneity that we cannot control due to external effects, such as the economic crisis of 2008. For this event, an extra model was regressed and the results which slightly changed. Nonetheless, the thesis could not identify every single event that might have influenced the results of each individual Member State.

8.3 Future Implications

8.3.1 Research Implications

The results of this thesis provided an important insight of which level of centralisation actually influences the EU ETS effectiveness across the EU Member States. This allowed us to reach the conclusion that national decentralisation does not portrait as relevant. Yet, as referred in Chapter 7, more research should be dedicated to understand the different ways that each Member State used to implement the EU ETS in the phase I and II, by conducting a qualitative analysis rather than using solely a quantitative method. In this way, we could have a more detailed vision of how the different administrative processes, such as how many stakeholders are involved, or which actors have more power, impact the EU ETS outcomes.

Further, excluding the year of 2008 has influenced the results of the variable ECL, meaning that the impact of the EU level of centralisation was positive if we excluded a year of economic deficit. This suggests that the economic development might have an effect on the way that the EU centralisation increases EU policy effectiveness. Future research must be focused in understanding whether economic crisis require higher levels of EU centralisation or require increasing the EU institutions' powers to assure that the EU policies are not affected by the instabilities of the private markets, such as capital or financial markets.

Also, this thesis has focused on the EU environmental policy and more specifically the EU ETS implementation. Taking this and the results into account, more investigation should be performed to evaluate other environmental policies or even other EU policies, so that we can verify the theoretical expectations in which this thesis was based on.

Lastly, the results about the countries which are the most and least efficient in achieving the EU ETS targets are very interesting[22]. More research can be developed in trying to understand why countries such as Lithuania, Slovakia or even Romania have better results and the Member States of Germany, the UK or Luxembourg score low in this matter, since they are some of the most developed countries in the EU. The case of Croatia can be further studied when more years have passed. The data available will be more sufficient to draw stronger conclusions, for example through a case study analysis.

8.3.2 Policy Implications

After answering the research question, something has become clearer: the change in the implementation of the EU ETS from a decentralised system, in which the Member States held most of the authority, to a centralised scheme, where the European Commission has a bigger saying in defining targets, has indeed produced positive results. The EU ETS has seen its effectiveness being improved by the new centralised implementation and definition of targets which allows us to say that the increase of the powers of the EU institutions is beneficial in reaching EU targets. The sense of being European and making collective efforts is helping the countries in staying focused on the policy goals. Thus, this effort should be continued.

As regards to specific Member States that have presented lower levels of effectiveness, such as Germany, the UK and Luxembourg, it is important to develop stronger solutions. This could include developing better guidelines or a joint implementation with Member States which have more expertise in reducing CO_2 emissions. This implication is aligned with the fact the fact the EU should have more authority over the monitoring and implementation referred above, since a collective effort turns out to be better than the individual effort. This is supported by what led to the creation of the EU ETS in first place. Its main objective was to create a policy that would facilitate the implementation and the accomplishment the Kyoto Protocol's targets for the EU (Ellerman et al., 2010).

In terms of the conclusions about the EU environmental policy centralisation, these point out that, throughout periods of economic recession, tighter measures should be followed in order to prevent the loss of effectiveness of those policies. One suggestion can be the increase of the number of acts implemented by the Commission or the increase of the EU environmental proposals by the Commission.

All in all, the according to the results obtained, the EU should focus in increasing its functions in the implementation of the EU ETS, not only by delegating the tasks directly to the Commission, but also by promoting more cooperation between the Member State. Pollution does not respect physical borders and it affects everyone despite nationality.

[22] See section 6.1.

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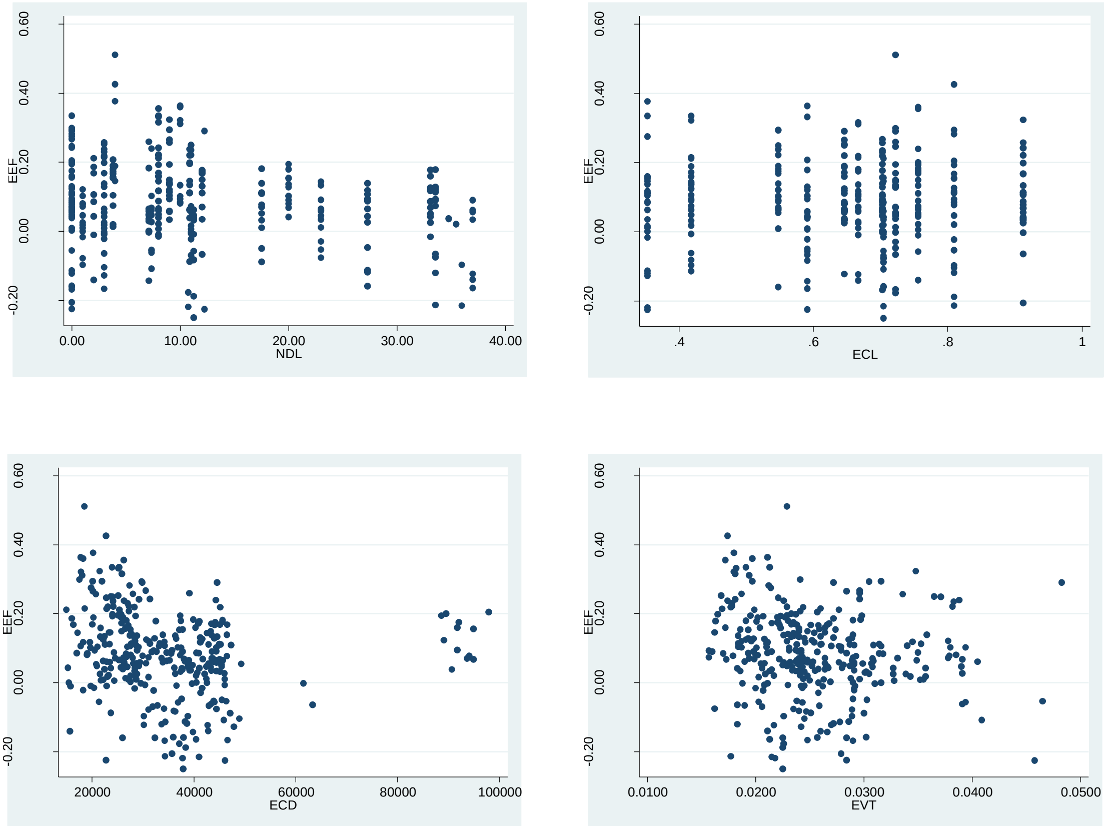
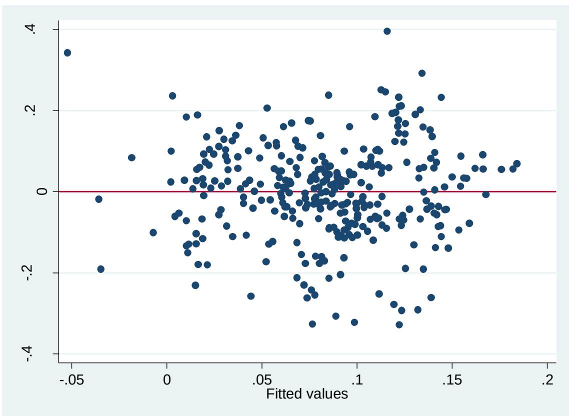
Appendix I – Scatter Plots

Graphical Test for Linearity



Graphical Test for Homoscedasticity



Appendix II – Multicollinearity Test

Variable	NDL	ECL	EUT	ECD	EVT
NDL	1.0000				
ECL	-0.0039 (0.9450)	1.0000			
EUT	-0.0085 (0.8797)	0.2372 (0.0000)*	1.0000		
ECD	0.1039 (0.0625)	0.0349 (0.5332)	0.0105 (0.8514)	1.0000	
EVT	-0.2841 (0.0000)*	0.0271 (0.62277)	0.0592 (0.2894)	-0.0099 (0.8591)	1.0000

Table II. 1 – Summary of the Independent and Control Variables Correlations (Significant at *P=0.01).

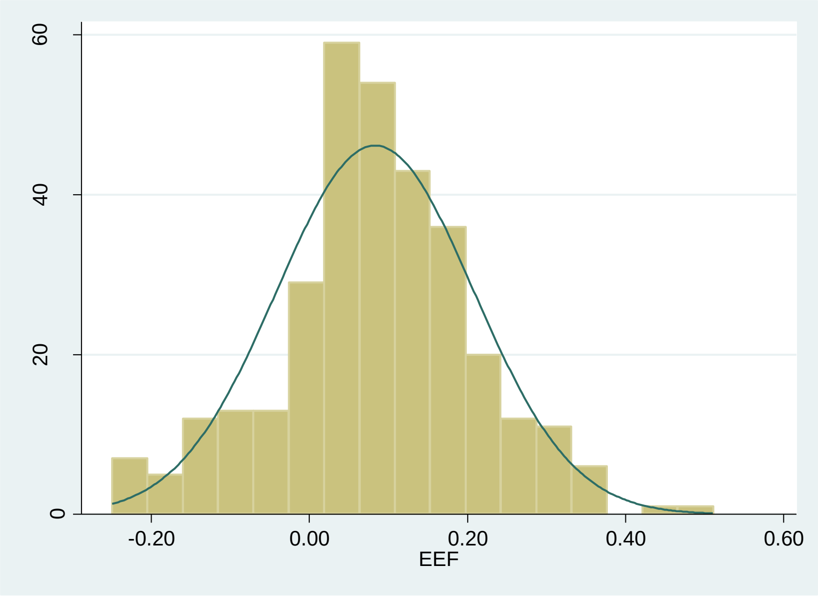
Variable	VIF
NDL	1.06
ECL	1.10
EUT	1.09
ECD	1.06
EVT	1.01

Table II. 2– Calculation of the VIF of the Independent and Control Variables

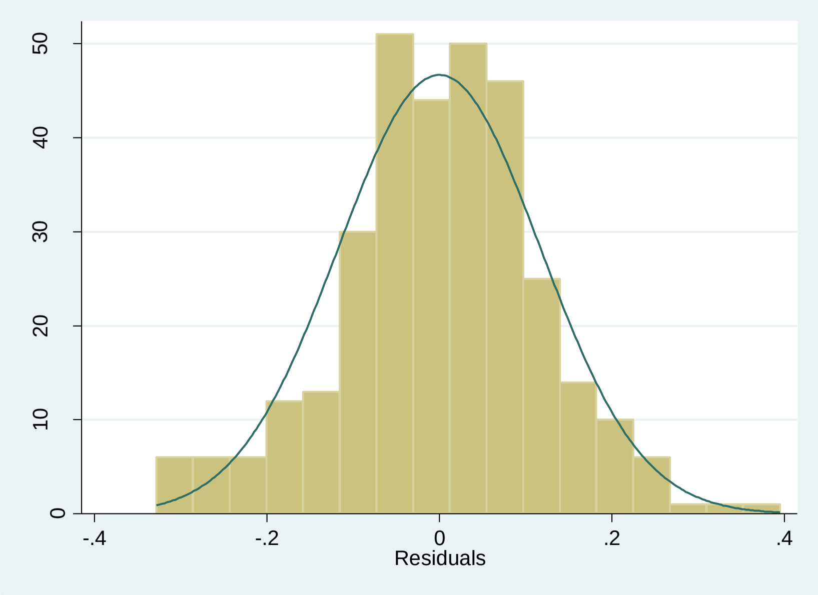
Appendix III – Distribution Histograms

Graphical Test for Normality

Dependent Variable EEF



Residuals



Appendix IV – Models without 2008

Variable	Coefficient	Robust Std. Error	P-value
NDL	-0.0079	0.0210	0.708
ECL	0.0674	0.0309	0.038**
EUT	0.0404	0.0209	0.064***
ECD	-0.00002	4.55e-06	0.000*
EVT	-3.8113	4.2114	0.373
Constant	0.8776	0.2942	0.006*
Sigma u (μ_i)	0.2811		
Sigma e (ν_{it})	0.0914		
R^2	0.1496[23]		
Adjusted R^2	0.1349		
N	322		
F-Test	4.47 (P-value=0.0031*)		
DF	27		

Table IV. 1 – Multiple linear regression model not including the year of 2008, with FE (robust) estimation (Significant at *P=0.01; **P=0.05; ***P=0.1).

Variable	Coefficient	Std. Error	P-value
NDL	-0.0019	0.0013	0.127
ECL	0.0180	0.0381	0.638
EUT	0.0213	0.0123	0.083***
ECD	-2.80e-06	8.78e-07	0.001*
EVT	-1.8315	1.6615	0.270
Constant	0.2417	0.0614	0.000*
Sigma u (μ_i)	0.0586		
Sigma e (ν_{it})	0.0914		
R^2	0.0822[24]		
Adjusted R^2	0.0677		
N	322		
Wald	16.37 (P-value=0.0059*)		

Table IV. 2 - Multiple linear regression model not including 2008, with RE estimation (Significant at *P=0.01; **P=0.05; ***P=0.1).

[23] Note that the R^2 for FE method is the "within" coming from the regressed model, calculated in Stata/MP 14.1.

[24] Note that the R^2 for the RE method is the "overall" coming from the regressed model, calculated in Stata/MP 14.1.

Appendix V – Additional Models

This appendix includes additional models for each independent variable, which will allow to visualise if there are relevant differences from when all the variables are included. Furthermore, for each independent variable, we will perform the Fixed Effects and Random Effects models with and without the control variables to assess the variations caused by those variables.

National Decentralisation Level (NDL)

Variable	Coefficient	Robust Std. Error	P-value
NDL	-0.0110	0.0160	0.496
Constant	0.2071	0.1797	0.259
Sigma u (μ_i)	0.1259		
Sigma e (ν_{it})	0.1025		
R^2	0.0030		
Adjusted R^2	-0.0001		
N	322		
F-Test	0.48 (P-value=0.4962)		
DF	27		

Table V. 1 - Multiple linear regression model for NDL, with FE (robust) estimation excluding the control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).

Variable	Coefficient	Robust Std. Error	P-value
NDL	-0.0088	0.0150	0.563
ECD	-0.00001	4.24e-06	0.003*
EVT	0.6239	3.7266	0.868
Constant	0.6574	0.2457	0.013**
Sigma u (μ_i)	0.2264		
Sigma e (ν_{it})	0.0978		
R^2	0.1006		
Adjusted R^2	0.0921		
N	322		
F-Test	3.97 (P-value=0.0183**)		
DF	27		

Table V. 2 – Multiple linear regression model for NDL, with FE (robust) estimation including the control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).

Variable	Coefficient	Std. Error	P-value
NDL	-0.0022	0.0014	0.131
Constant	0.1114	0.0222	0.000*
Sigma u (μ_i)	0.0757		
Sigma e (ν_{it})	0.1026		
R^2	0.0030		
Adjusted R^2	-0.0001		
N	322		
Wald	2.28 (P-value=0.1311)		

Table V. 3 - Multiple linear regression for NDL, with RE estimation, excluding control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).

Variable	Coefficient	Std. Error	P-value
NDL	-0.00164	0.00143	0.250
ECD	-2.94e-0.6	9.83e-07	0.003*
EVT	0.4146	1.7167	0.809
Constant	0.1958	0.0626	0.002*
Sigma u (μ_i)	0.0713		
Sigma e (ν_{it})	0.0978		
R^2	0.0394		
Adjusted R^2	0.0303		
N	322		
Wald	11.57 (P-value=0.0090*)		

Table V. 4 - Multiple linear regression model for NDL, with RE estimation, including control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).

European Centralisation Level (ECL)

Variable	Coefficient	Robust Std. Error	P-value
ECL	-0.0035	0.0287	0.904
Constant	0.0855	0.0188	0.000*
Sigma u (μ_i)	0.0833		
Sigma e (ν_{it})	0.1027		
R^2	0.0000		
Adjusted R^2	-0.0031		
N	322		
F-Test	0.01 (P-value=0.9043)		
DF	27		

Table V. 5 – Multiple linear regression model for ECL, with FE (robust) estimation excluding the control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).

Variable	Coefficient	Robust Std. Error	P-value
ECL	0.0636	0.0305	0.047**
ECD	-0.00001	4.76e-06	0.002*
EVT	-0.5713	3.8021	0.882
Constant	0.6156	0.2036	0.005*
Sigma u (μ_i)	0.2301		
Sigma e (ν_{it})	0.0974		
R^2	0.0265		
Adjusted R^2	0.0173		
N	322		
F-Test	4.05 (P-value=0.0169**)		
DF	27		

Table V. 6 – Multiple linear regression model for ECL, with FE (robust) estimation including the control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).

Variable	Coefficient	Std. Error	P-value
ECL	-0.0013	0.0386	0.974
Constant	0.0879	0.0289	0.002*
Sigma u (μ_i)	0.0671		
Sigma e (ν_{it})	0.1027		
R^2	0.0000		
Adjusted R^2	-0.0031		
N	322		
Wald	0.00 (P-value=0.9742)		

Table V. 7 - Multiple linear regression for ECL, with RE estimation, excluding control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).

Variable	Coefficient	Std. Error	P-value
ECL	0.0093	0.03844	0.808
ECD	-2.78e-06	9.08e-07	0.002*
EVT	0.3634	1.6543	0.826
Constant	0.1671	0.0598	0.005*
Sigma u (μ_i)	0.0628		
Sigma e (ν_{it})	0.0974		
R^2	0.0234		
Adjusted R^2	0.0142		
N	322		
Wald	9.66 (P-value=0.0217**)		

Table V. 8- Multiple linear regression model for ECL, with RE estimation, including control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).

EU ETS Centralisation Level (EUT)

Variable	Coefficient	Robust Std. Error	P-value
EUT	0.0310	0.0229	0.188
Constant	0.0724	0.0080	0.000
Sigma u (μ_i)	0.0814		
Sigma e (ν_{it})	0.1016		
R^2	0.0221		
Adjusted R^2	0.0190		
N	322		
F-Test	1.83 (P-value=0.1879)		
DF	27		

Table V. 9– Multiple linear regression model for EUT, with FE (robust) estimation excluding the control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).

Variable	Coefficient	Robust Std. Error	P-value
EUT	0.0583	0.0206	0.009*
ECD	-0.00001	484e-06	0.000*
EVT	-2.2767	3.8498	0.559
Constant	0.7956	0.2247	0.001*
Sigma u (μ_i)	0.2766		
Sigma e (ν_{it})	0.0941		
R^2	0.1665		
Adjusted R^2	0.1586		
N	322		
F-Test	6.62 (P-value=0.0017*)		
DF	27		

Table V. 10– Multiple linear regression model for EUT, with FE (robust) estimation including the control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).

Variable	Coefficient	Std. Error	P-value
EUT	0.0337	0.0121	0.005*
Constant	0.0750	0.0147	0.000*
Sigma u (μ_i)	0.0672		
Sigma e (ν_{it})	0.1016		
R^2	0.023		
Adjusted R^2	0.0199		
N	322		
Wald	7.76 (P-value=0.0052*)		

Table V. 11- Multiple linear regression for EUT, with RE estimation, excluding control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).

Variable	Coefficient	Std. Error	P-value
EUT	0.0369	0.0120	0.002*
ECD	-3.11e-06	9.19e-07	0.001*
EVT	0.0214	1.6518	0.990
Constant	0.1799	0.0567	0.002*
Sigma u (μ_i)	0.0633		
Sigma e (ν_{it})	0.0941		
R^2	0.0416		
Adjusted R^2	0.0326		
N	322		
Wald	19.55 (P-Value=0.0002*)		

Table V. 12- Multiple linear regression model for EUT, with RE estimation, including control variables (Significant at *P=0.01; **P=0.05; ***P=0.1).