Open University of Cyprus

Faculty of Economics and Management

Postgraduate Programme of

Master in Business Administration

Master's Dissertation

Measuring the Effects of Environmental Tax Policy on Construction Sector's GHG Emissions: Empirical Evidence from EU Countries

Maria Iona

Word count: 14939

Supervisor

Dr Konstantinos Chatzimichael

May 2022

Open University of Cyprus

Faculty of Economics and Management

Postgraduate Programme of

Master in Business Administration

Master Thesis

Measuring the Effects of Environmental Tax Policy on Construction Sector's GHG Emissions: Empirical Evidence from EU Countries

Maria Iona

Supervisor

Dr Konstantinos Chatzimichael

This Master's Dissertation was submitted in partial fulfillment of the requirements for the award of the postgraduate degree

on Master in Business Administration

by the Faculty of Economics and Management

of the Open University of Cyprus.

September 2022

[BLANK PAGE]

Abstract

EU Member States are engaged in understanding the mechanisms that create opportunities and threats for the market in order to be in a position to adjust their behavior towards the environmental challenges. Several policy instruments have been used over the last decades, amongst which taxation, with the prospect of obtaining rapid and effective outcomes in response to environmental degradation. Within the context of policy intervention and monitoring that needs to be performed in order to assess the response of the market, the present study aims to examine whether the environmental tax policy of the construction sector in European countries can be deployed as an effective tool towards mitigating GHG emissions. Despite the extent of literature on the effects of environmental intervention models applied in the European area, mainly through the implementation of the environmental tax reform (ETR), surprisingly limited analysis is performed focusing on the construction sector. By adopting econometric techniques, this study concentrates on the specific sector and aims to investigate and quantify the regulatory impact of taxation on GHG emissions within the EU area. The study also addresses the issue of endogeneity of variables, through the use of the Control Function (CF) approach. Overall, the evidence of the study indicates that the decrease caused by taxation on GHG emissions is valid, however, there is variation across categories of countries. The study also suggests considerations for policymakers, specifically towards environmental taxation policy, exploring how taxation can be used as an intervention instrument to provide the market the essential time to adjust to the need for mitigating the environmental degradation, while at the same time, ensure revenues and maintain environmental goals.

Περίληψη

Τα Κράτη Μέλη της ΕΕ επιδίδονται στην κατανόηση των μηχανισμών που δημιουργούν ευκαιρίες και απειλές για την αγορά, έτσι ώστε να καταστεί δυνατή η προσαρμογή της συμπεριφορά της στις περιβαλλοντικές προκλήσεις. Τις τελευταίες δεκαετίες έχουν χρησιμοποιηθεί διάφορα μέσα άσκησης πολιτικής, μεταξύ των οποίων η φορολογία, με την προσδοκία της εξασφάλισης γρήγορων και δραστικών αποτελεσμάτων ως απάντηση στην υποβάθμιση του περιβάλλοντος. Μέσα στο πλαίσιο της πολιτικής παρέμβασης και παρακολούθησης που χρειάζεται να εφαρμοστεί προκειμένου να αξιολογηθεί η ανταπόκριση της αγοράς, η παρούσα μελέτη στοχεύει να εξετάσει εάν η περιβαλλοντική φορολογική πολιτική που εφαρμόζεται στον κατασκευαστικό τομέα στις ευρωπαϊκές χώρες, μπορεί να χρησιμοποιηθεί ως αποτελεσματικό εργαλείο για τον μετριασμό των εκπομπών αερίων του θερμοκηπίου. Παρά την έκταση της βιβλιογραφίας για τις επιδράσεις των μοντέλων πολιτικής παρέμβασης που έχουν ενεργοποιηθεί στον ευρωπαϊκό χώρο μέσω της μεταρρύθμισης της περιβαλλοντικής φορολογίας (ETR), έχει πραγματοποιηθεί εκπληκτικά περιορισμένη ανάλυση με επίκεντρο τον κατασκευαστικό τομέα. Με την υιοθέτηση οικονομετρικών τεχνικών, η μελέτη αυτή επικεντρώνεται στον κατασκευαστικό τομέα και στοχεύει στη διερεύνηση και ποσοτικοποίηση των ρυθμιστικών επιπτώσεων της φορολόγησης στις εκπομπές αερίων του θερμοκηπίου στον ευρωπαϊκό χώρο. Η μελέτη αντιμετωπίζει επίσης το ζήτημα της ενδογένειας των μεταβλητών, με τη χρήση της προσέγγισης της συνάρτησης ελέγχου (CF). Συνοπτικά, η μελέτη δείχνει ότι η μείωση που προκαλείται από τη φορολόγηση των εκπομπών αερίων του θερμοκηπίου είναι ουσιαστική, υπάρχει ωστόσο διακύμανση μεταξύ των διαφόρων κατηγοριών χωρών. Η μελέτη διατυπώνει επίσης συστάσεις προς τους υπεύθυνους χάραξης πολιτικής όσον αφορά στην εφαρμογή της περιβαλλοντικής φορολογικής πολιτικής, διερευνώντας πώς η φορολόγηση μπορεί να χρησιμοποιηθεί ως μέσο παρέμβασης για να παράσχει στην αγορά τον απαραίτητο χρόνο προσαρμογής στην ανάγκη μετριασμού των δυσμενών επιδράσεων στο περιβάλλον, εξασφαλίζοντας ταυτόχρονα, τα απαραίτητα έσοδα και τη διατήρηση των περιβαλλοντικών στόχων.

Acknowledgements

Special thanks to my supervisor Konstantinos Chatzimichael for the advice on the selection of a most interesting topic. His guidance on the thesis work throughout the data retrieval and processing as well the writing formulation and his inputs towards the econometric analysis have been of great value.

Further, I would like to thank my dear colleague Antonis Koutsoullis for his encouragement and informative suggestions along the way.

Lastly, my thanks to my family for the support during the time of writing this master thesis.

Keywords

Environmental Tax Reform (ETR); Greenhouse Gas Emissions (GHG); Determinants of GHG emissions; Construction sector; Gross Domestic Product per capita (GDP); European Union (EU); Cyprus; Regression Approach; Control Function (CF) approach

Contents

Chapter 1 11
Introduction 11
1.1 Objectives of Master Thesis 12
1.2 Research Question 13
Chapter 2 15
Literature Review 15
2.1 Development and Principles of European Environmental Policy 15
2.2 Overview of EU Environmental Policy and Tax Reforms 19
2.3 Review of Scientific Studies 22
Chapter 3 26
Methodology 26
3.1 Research Objectives 26
3.2 Regression Model 27
3.3 Limitations 30
Chapter 4 32
Data 32
4.1 Data Sources 32
4.2 Group Classifications 34
4.3 Defining Variables 35
4.4 Descriptive Statistics 38
Chapter 5 48
Results 48
5.1 Regression Analysis Results 48
5.1.1 First Stage Regression Outcomes 48
5.1.2 Second Stage Regression Outcomes 51
Chapter 6 57
Conclusions and Recommendations 57
6.1 Research Conclusion 57
6.2 Recommendations 59
Appendices 62
Appendix A- Dataset used 62
References 81

List of tables

Table 1-Variable list and definitions 36
Table 2- Emitted GHG per capita in 2012-2018 40
Table 3- Descriptive Statistics-geographic cluster 41
Table 4. Descriptive Statistics-economic cluster 45
Table 5-Results of Regression Model stage 1-Dependent Variable T_{it} 50
Table 6- Results of Regression Model stage 2- Dependent Variable E_{it} 51
Table a -List of dataset used 62
Table b- Descriptive Statistics for variables used in analysis 67

List of figures

Figure 1: GHG emissions per capita. 33

List of abbreviations

2SLS	Two stage least squares
ANOVA	Analysis of Variance
β	Unstandardized coefficient
CF	Control Function approach
CGE	Computable General Equilibrium
CO_2	Carbon Dioxide
COP21	21st Conference of the Parties
COP26	26th Conference of the Parties
EEA	European Economic Area
EFTA	European Free Trade Area
EKC	Environmental Kuznets Curve
ESA	European System of Accounts, 2010
ESS	European Statistical System
ETR	Environmental Tax Reform
EU	European Union
EU ETS	European Union Emissions Trading Scheme
EUROSTAT	Statistical Office of the European Union
G10	Group of Ten
GHG	Green House Gas
IBM SPSS	Statistical Package for the Social Science, statistical software programme

IMF	International Monetary Fund
IV	Instrumental Variable
NACE	Nomenclature of Economic Activities
NDCs	Nationally Determined Contributions
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
R^2	R-squared, coefficient of multiple determination for multiple regression
SEEA CF 2012	System of Environmental-Economic Accounting Central Framework 2012
SMEs	Small and medium-sized enterprises
SO_2	Sulphur Dioxide
UNCCC	United Nations Climate Change Conference
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change

Chapter 1

Introduction

Persistent challenges in the fields of resource depletion and pollution, as well as uneven distribution and use of the raw resources are linked to both economic and environmental development. The non-convergence of those two key elements, impacts climate change, causes contamination of water, soil and air, generates environmental and health risks and affects the well-being of the inhabitants of the planet. Large-scale processes due to the advancing of global industrialization, expand the environmental puzzle, where at the same time the speed of technological advances and changes these bring along, contain new risks and uncertainties.

Since the beginning of the 21st century, global greenhouse gas (GHG) emissions have grown in comparison to the three previous decades, whereas in 2019, the world's largest CO_2 emitters released into the atmosphere 67.0% of total global fossil CO_2 (Crippa et al., 2020). At the same period, GHG emissions increased in 3 out of the top-5 emission countries and decreased in the European Union, United States and Japan (Olivier & Peters, 2002).

The Construction Industry, which uses and processes a significant portion of planet's raw materials and resources, is "accounted for 36% of final energy use and 39% of energy- and process-related emissions" (Global Alliance for Buildings and Construction, 2019). European Union's data confirm the global findings, since buildings alone are responsible for approximately 40% of energy consumption and 36% of CO_2 emissions in the EU which puts the construction sector into the focus in order to mitigate the problems caused by GHG emissions (European Commission, 2019).

The downsizing of the environmental deterioration while balancing the impact to the economic growth, is an issue that is dealt by policymakers with the deployment of instruments ranging from delivering informative and educational programs to implementing regulations, drafting incentives schemes and imposing regulatory measures. The emphasis of present thesis is on the latter, which stands as a tool that facilitates the effective intervention at those areas that market fails to adjust, and enables citizens/ consumers and the industry to choose, in a more adaptable way, the approaches to use in order to reduce their environmental footprint (OECD, 2011); as such environmental taxation may have a role in mitigating emission challenges.

1.1 Objectives of Master Thesis

The topic of the thesis is about the effects, specifically in the construction sector, of the harmonization and implementation of the environmental policy of the EU, which through the introduction of the “common market” has aimed in economic integration and cooperation between its member states. Given the long term, intense, preceded establishment of a European monetary and economic union, along with the acknowledgment of the environmental challenges since the 1970s, the strategic importance of the protection of the environment in relation to EU and/ or global regulation has been widely studied; nonetheless, the measurement of the effects of EU Environmental Regulation in the specific sector of the construction, has received little attention.

This study attempts to bridge this gap by adopting a model aiming to explore the determinants of GHG emissions due to the construction industry and measure the impact of the environmental taxation framework on the environmental performance of said industry in EU.

Unlike, other areas of economic activity, the dependence on the “free market” (ie no government involvement; individuals and firms voluntarily acquire information and voluntarily and altruistically internalize these) or on “information provision” for environmental protection purposes, is highly unlikely to deliver satisfactory outcomes mainly due to the fact that “the market” has little to inadequate incentives to proceed

to necessary measures to mitigate environmental risks without government intervention (Hepburn, 2010). Consequently, above notion implies a role for the state to intervene and apply policies that focus on effective measures towards the target on protecting the environments and minimizing emissions. More often than not, pricing, and/ or similarly taxing, is considered to be the right coordinating and implementation device, because it can convey the messages, information and scope of the states' goals, effectively and efficiently. The global collaboration among public leaders and private stakeholders has a role in realizing even a well-designed concept. However, when states fail, it is important to consider whether the magnitudes of the failure will be for better or worse compared to the "do nothing" option of having no state intervention.

Features of the environmental challenges such as detachment from direct-firsthand experience, slow changes of extreme climate events, diffused causality, and complexity of the causes and effects of the climate change, along with the fact that environmental challenges are "long-run" and "global" policy issues, cause environmental issues to be inherently difficult to understand and promptly act (Millner & Olivier, 2016). Therefore, in evaluating the necessity of intervention and the effectiveness of it, an appropriate approach would need to be followed by states. The understanding of the limitations of the states and the markets to appropriately, efficiently and timely act in a balanced way, is likely to be an important factor for the successful addressing of the global environmental challenges.

1.2 Research Question

This thesis aims at assessing whether the environmental tax policy implemented by EU27/EEA and UK countries is effective in reducing GHG emissions in the countries under investigation. More specifically, the analysis focuses on the effects of environmental taxation on the GHG emissions produced by the construction sector. The following three research questions are addressed:

- Is there a significant variation in the effect of the Environmental tax policies as these are controlled and managed by the EU27/EEA and UK countries?
- Do environmental taxation policies have a significant impact on the GHG emissions produced by the EU construction sector?
- Does the impact of environmental tax policies on GHG emissions vary across different groups of EU countries? How Cyprus performs compared to other EU member states?

Chapter 2

Literature Review

In Chapter 2 the contextual foundations of the environmental policy and the European environmental tax reform are introduced. The policy background is then presented about the roadmap of the EU environmental policy; the development and implementation of environmental tax reform, followed by a literature review on the issues of the effect of carbon tax; the impact of environmental taxing on the levels of pollution; the assessment of the adoption of environmental taxes by EU countries; the verification and critique of the environmental Kuznets curve (EKC); the identification of the possible determinants of emissions. The objective will be to identify the factors that affect emissions for the core area of the construction industry.

2.1 Development and Principles of European Environmental Policy

The international community has recognized that the impact which accompanies the economic development in the industrialized countries on the environment, along with the rapidly growing world population is an issue which knows no boundaries. As such the United Nations assembled the first international environmental conference in Stockholm in 1972, launching the era of global environmental protection.

In the aftermath of the UN conference, EU declared in Paris the need for a Community environment policy, next to the economic expansion. Through this EU has largely shifted environmental protection to the supranational level, due not only to the fact that, environmental pollution crosses national borders, but also because of the request of

the Member States to harmonize national environmental legislation for fear of competitive disadvantages.

While the 1970s is regarded as the decade when the beginning of environmental policy in the EU took place with the aim to eliminate health hazards, it was first during the 1980s, that there has been a change in strategy, and policymakers began to understand that environmental degradation is a crucial issue that needs to be handled by prevention measures. As the number of environmental protection laws increased significantly, in 1987, environmental protection was ensured for the first time in a separate article in the Single European Act, through the introduction of a new 'Environment Title', which provided the initial legal basis for a joint environment policy targeting at preservation of the quality of the environment, the protection of health, and the rational use of natural resources. The Treaty of Maastricht (1992) introduced the environment in the official policy arena whereas the Treaty of Amsterdam (1997) recognized the responsibility to assimilate the environmental protection into EU policies so as to stimulate sustainable development (Treaty of Amsterdam, 1997).

According to the Nice Treaty (2001), it is the task of the EU to promote a "*high level of environmental protection and improvement of the quality of the environment*" (Article 2), while in Article 174(1) it is further specified that the protection of the environment, the protection of human health, the rational use of natural resources and the endorsement of measures at international level to confront regional or global environmental problems should be followed (Treaty of Nice, 2001). Moreover, in 2007, the Lisbon Treaty sets that the EU "*shall work for the sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment*" (Treaty of Lisbon, 2007). Furthermore, EU environment policy is based on the principles of "*precaution, prevention and rectifying pollution at source",* and on "*the polluter pays principle*" which are used as a means to mitigate risks due to pollution, prevent environmental damages or provide remedies for these (European Parliament, 2021).

In addition to the policies designed at a European level, EU and its member countries participate in the United Nations Framework Convention on Climate Change

(UNFCCC), which since its inception in 1992 embraces a nearly universal membership of 197 countries and aims to stabilize GHG's concentrations "*at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system*." (UN General Assembly, 1994).

In 2015, EU participated at the 21st Conference of the Parties (COP-21) of the UNFCCC in Paris, in the first universal agreement to combat climate change (the Paris Agreement), where at a global level, the commitment to reduce GHG emissions, was taken by the members of the agreement. The Paris Agreement, targets to reduce GHG emissions in order to limit the rise in global average temperature to below 2ºC above pre-industrial levels, with an effort to limit the increase to 1.5ºC. Through measures set by each country – Nationally Determined Contributions (NDCs)- the parties of the Paris Agreement, are set to review their collective efforts to reach their goals regularly.

Since the 1st Conference of the Parties (COP-1) concluded that the aim of the parties engaged in stabilizing emissions at 1990 levels by the year 2000 was considered as "not adequate", following discussions at later conferences led to the Kyoto Protocol in 1997 (United Nations UNFCCC,1998, revised by the Doha Amendment in 2012), which established legally binding obligations for developed countries to reduce GHG emissions and instituted flexible market mechanisms, based on a trade of emissions permits (Depledge, 2000).

Responding to the targets set by the Kyoto Protocol, the EU established in 2003 a scheme for GHG emissions allowance within the European Community (the European Union Emissions Trading Scheme-EU ETS), "*in order to promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner, recognizing that, in the longer-term, global emissions of greenhouse gases will need to be reduced by approximately 70% compared to 1990 levels*." (European Commission, 2004). The scheme is based on the principle of "cap and trade" where a maximum is set on the total amount of GHGs that can be emitted by all participating installations, and allowances are then auctioned off and traded; the objective of the EU ETS is to comply to the commitments to reduce anthropogenic GHG emissions under the Kyoto Protocol which was approved by Council Decision 2002/358/EC.

Critics of the effectiveness of the EU ETS, (Bayer and Aklin, 2020) suggest that EU ETS reduced CO_2 emissions between 2008 and 2016 by 3.8% relative to total emissions over said period for a world without carbon markets, "*or almost half of what EU governments promised to reduce under their Kyoto Protocol commitments."*

In line with climate scientists who are asking for a more specific definition of the Paris climate target (Schurer et al., 2018) and scholars that have highlighted that Paris Agreement may be insufficient to adequately mitigate emissions (Kemp, 2018), environmental protection is anchored in EU law. In recent years, the EU environmental policy integrates issues of energy, as referred to in the EU's climate and energy package, with the ultimate goal of entering into a competitive low-carbon economy by 2050, by which EU aims to be climate-neutral i.e., become an economy with net-zero GHG's emissions (European Green Deal). To this end, on 14 July 2021, the EU, through a series of legislative proposals, has set the roadmap on the way to climate neutrality by 2050, which includes measures to reach the intermediate target of at least 55% reduction in GHG's by 2030, compared to 1990 levels (European Commission, 2020a). Achieving the targets of the European Green Deal is critical to Europe becoming the world's first climate-neutral continent by 2050. In order to do so, a series of EU Environmental regulations have been designed so as to enable the required deceleration of GHG emissions, which consists of application of trading emissions to new sectors; intensification of the existing EU Emissions Trading System; multiplication of the use of renewable energy; building up of greater energy efficiency; operation of low emission transport modes including the development and construction of necessary infrastructure and fuels to support these; an alignment of taxation policies throughout EU within the European Green Deal objectives (Fetting, 2020).

The latter aims at supporting the green transition and reducing the painful effects of energy tax competition, by creating the right tools and incentives in line to EU's environmental policies and securing revenues for Member States from green taxes, which are considered as less detrimental to growth than taxes on labor and which would likely boost employment rates (Schneider, 1997; Koskela et al., 1998).

Following the Paris Agreement, which has represented the global consensus on climate policy and works on a 5- year cycle "*of increasingly ambitious climate action*

carried out by countries", the 26th United Nations Climate Change Conference (UNCCC), that took place in Glasgow (COP26), from 31 October to 13 November 2021 (delayed for a year due to the COVID-19 pandemic), was the conference that parties anticipated in order to make commitments with respect to mitigating climate change.

The outcome of COP26 was the Glasgow Climate Pact in which:

i. The emergency was recognized, expressing "*utmost concern that human activities have caused around 1.1 °C of warming to date, impacts are already being felt in every region, and carbon budgets consistent with achieving the Paris Agreement temperature goal are now small and being rapidly depleted*." (UNFCCC, 2021)

ii. The actions that need to be taken should be accelerated along with the provision of technical assistance, knowledge and resources to address climate risks and to adapt to the impacts of climate change.

iii. The parties agreed to a provision to move away from fossil fuels and assured about delivering on the required climate finance

iv. Countries concluded to an agreement on the practical implementation of the Paris Agreement.

2.2 Overview of EU Environmental Policy and Tax Reforms

Balancing between the increasing emergence of liberal economic ideas and market-based approaches on the one hand and regulation on the other, the use of taxes, subsidies and emissions trading are deployed as instruments to ensure an efficient design of an environmental policy.

Considering that regulatory intervention is required in order to drive the market to act against the polluter, approaches such as limiting particular harmful substances, or requesting for specific technologies to be used in the production process, have been utilized; over the last decades the tool of imposing environmental taxes and tradable

emissions, has been widely implemented (OECD, 2011). Furthermore, Porter argues that environmental policies may encourage process-oriented innovation and improve competitiveness. In particular when the effects of innovation can expand in the international market, innovations can yield competitive advantage (Porter, 1990). At the same time, Pearce, has entered into the discussion the possible “double dividend” feature of environmental taxes, namely the environmental benefit from pricing the full cost of using environmental resources, and the economic benefit from the reduction caused in other taxes, that leads to social benefits that could emerge should taxation were to be shifted from “good” to “bad” elements e.g., from labour to carbon (David Pearce, 1991). As such, environmental taxes aim at rectifying market failure, and by the adoption of fiscally neutral measures that swap existing taxes for environmental taxes, an opportunity evolves to claim positive benefits as the results of higher employment rate, while at the same time providing an environmental dividend with long-term effects (Pearce, 1991).

By applying the “double dividend” principle, the main notion of Environmental tax is to discourage the processes that are environmentally damaging, turning them into more costly ones and at the same time the revenues gained from such increased environmental taxes can be used to the benefit of more positive economic or social outcomes (OECD, 2017). The advantages of environmental taxes were recognized and the United Nations Conference on Environment and Development (UNCED) Summit in 1992 concluded that for the purpose of allocating economic resources towards sustainable development, the full social and environmental costs should be part of the economic activities, and therefore environmental costs should be reflected therein. Pearce also suggests that the use of economic and fiscal instruments can be employed among the measures to achieve this (Pearce, 1991).

In line with above principle, institutions of EU adopt a shift in taxation and introduce environmental taxation. In December 1995 the European Council concludes that "*In order to exploit the job-creation potential of environmental protection, these policies should rely on market-based instruments, including fiscal ones. Public authorities should also promote long-term investment in environment friendly technologies in*

major sectors such as energy, transport and agriculture" (European Council, 1995). Above basis was expanded in an integrated way in a range of policies and legislation over the period of the following years. Since the 90's when the introduction of environmental taxes concept started to be used by a number of EU countries, environmental taxation has been used more frequently and by a greater number of countries (Ekins et al., 2011).

Environmental tax properties are defined by EU through the Community guidelines on State aid for environmental protection, as "*the taxable base of the levy has a clear negative effect on the environment*" (European Commission, 2001). Environmental taxation is widely used as an instrument by EU and its positive effects in terms of reducing environmental pollution, enhancing innovation, and generating additional public funding are documented (Withana et al., 2013).

The European Environment Agency (EEA) has undertaken and applied the concept of the environmental tax reform (ETR), defined, as "*reform of the national tax system where there is a shift of the burden of taxes, for example on labour, to environmentally damaging activities, such as resource use or pollution*". The ETR involves a number of interventions that may be integrated such as taxes, subsidies, and/ or incentives aiming at a "tax shift" from taxes that are considered as misrepresented to environmental ones, generating the so called "double dividend" (Cicatiello et al., 2020).

In particular, environmental regulation is a way for raising public revenue that can be used either for purposes of general public services offered or specifically for environmental protection. At the same time, there is a tendency for policymakers to consider the use of charges or taxes directly linked to an activity that generates environmental damage (Anil Markandya, 1993). The benefits of using environmental taxes may come into many assortments and provide more than two dividends: increased productivity and innovation, improved employment rate, better health of environment and people, a more efficient tax system and a better recycling of public resources to the benefit of an ageing population (Andersen et al., 2011).

Today ETR is commonly recognized as a set of measures linking the increase of taxes on energy or natural resources with a revenue-redistribution element, which can cause

a wide impact across society, ranging from affecting the price of the taxed goods or services, to broader economic impacts on revenue recycling, job creation and eco-innovation, as well as environmental effects.

The use of taxation instruments has been endorsed in the EU through the 6th Environment Action Program (European Commission, 2009) in the renewed EU Sustainable Development Strategy as well as in the Europe 2020 Strategy (European Commission, 2020b).

2.3 Review of Scientific Studies

Starting with Pigou, environmental taxes have been present in literature, as a primary tool for the mitigation of environmental challenges such as emissions and climate change (Pigou, 2024).

Lin and Li (2011) research outcomes on a group of north European countries (Denmark, Finland, Sweden, Netherlands and Norway), which were the first adopters of carbon tax, reveal that Finland's carbon tax has a significant and negative impact on the increase in its CO_2 emissions per capita, where, the effects on emissions in Sweden, Denmark and the Netherlands are negative yet not significant. The study also showed that the effects of carbon tax in these countries are reduced as a consequent of tax exemption policies applied in specific energy-intensive industries. In contrary to the above countries, in Norway, the environmental taxation coefficient obtained by the modal extracted to describe the relations between the parameters that impact CO_2 emissions, had failed the significance test, indicating that that the carbon tax in Norway did not have any significant impact on CO_2 emissions reduction (Lin and Li, 2011).

The question about the impact of environmental taxes on the levels of air pollution and of energy consumption within the EU has been investigated by Morley Bruce, in order to determining whether environmental taxes have any significant effect on the levels of air pollution and consumption of energy, by using econometric modelling, rather than by using simulation exercises. The results of the study suggest that the introduction of environmental taxes in the EU had a considerable negative effect on pollution, but at

the same time narrow effect on the use of energy resources, extrapolating that the reduction of pollution is due to the use of a cleaner technology rather than of reducing energy consumption. Moreover, the outcomes of the study confirmed that environmental taxes depend on the structure of other tax levels, since the index of environmental taxes relative to total taxes had the most significant effect. The study also suggested that further research is required on order to assess the impact of income on pollution and energy consumption, and to evaluate the effect to the goals of EU to reduce the levels of pollution, by applying policies of using environmental taxation (Morley, 2012).

The evaluation of the adoption of Environmental Taxes by European countries, by Arbolino, Romano, presented a multiple step approach for examining the ETR, by using methods of comparison and hierarchical cluster analysis, reaching to a quantitative SWOT analysis. The study revealed variations among countries before and after the introduction of the ETR on environment, employment and innovation, as well as differences between adopting and non-adopting countries, indicating the wide range of policy implementation methodologies and challenges faced by the policymakers to suggest policies within the framework of the ETR system. Although analysis presented positive effects of the ETR in the areas of emission reduction and innovation, further study is suggested towards examining the effects of the policies used (Arbolino, Romano, 2014).

Empirical literature on the environmental Kuznets curve (EKC) portrays how a country's environmental quality evolves throughout its economic development. EKC got acknowledged at first as the relationship between concentrations of Sulphur dioxide (SO_2) and per capita GDP, forming an inverted U-shape where per capita income and Sulphur dioxide concentration are positively correlated to a maximum point at which, should economic development translate into a sufficiently high one, the trend reverses and the opposite relationship is observed. The EKC was later applied to environmental degradation globally. By examining the EKC hypothesis, Grosmann & Kruger, suggested that economic growth implies increased pollution levels mainly due to increased output; by this an increased output involves increased input and thus since more raw materials and natural resources are used, pollution levels escalate

accordingly. It was further argued that pollution is expected to increase to scale with an increase of per capita GDP at low levels of national income, but decrease with GDP growth at higher levels of income. (Grossman and Krueger, 1991). Other researchers also attempted to establish the influence of income to emissions. Panayotou considered that at least in the case of SO_2 levels, policies have an impact on environmental pollution related to the income level of a country and used GDP per unit area as a metric to estimate the effects of production and income on emissions, verifying the inverted-U relationship (Panayotou, 1997).

Critics of the EKC concept (e.g., Stern, 1998) claim that there is weak empirical evidence to estimate the relationship about the dynamics as countries experience economic development, and EKC relationships have be relevant for only a subset of countries. Coondoo and Dinda in an effort to examine the effects of the possible determinants of income–emission relation, established that this varies from one region of countries to another and any important policy discussion for mitigating and controlling emissions should require an examination of the country's income dispersal patterns along with the corresponding emissions and the respective variations over time (Coondoo and Dinda, 2002). Despite the criticism of the EKC generalization, the hypothesis of an inverted U-shaped relationship between per capita income and environmental degradation lives on (Van Zanden,1995).

Environmental taxation is a key market-based mechanism for environmental regulation despite the fact that special interest politics and energy lobbies constrain green taxation levels and as a result, exceptions to taxation may lead to inefficiently low levels of taxes (Ward and Cao, 2012). Researchers also argue that low tax rates are observed in countries that are more tightly integrated into the globalized economy and suggest that future research should focus on sectors that use energy intensively.

EU over the recent past, has set goals for the reduction of emissions, which retain the use of environmental taxes in the frontline. To date the literature in regards to the elements that affect GHG emissions by the construction industry and in particular within the EU, is limited. Construction sector in some EU regions, was the core of the investigation of researchers in regards to the effect of environmental regulation on firms' competitive performance. The study of Francesco Testa, Fabio Iraldo, Marco

Frey, applied econometric modelling approach in order to test the sign of the relationship between environmental regulatory stringency, form of regulation and competitive performance and indicated that direct regulation has a significant effect on measures of competitiveness parameters such as innovation and the level and intensity of stringency foster the environmental performance of the construction industry. At the same time, economic tools were also found to have a negative effect in the sector's business performance (Testa et al., 2011).

The impact of carbon taxes on the environment and economy of China, focusing on the construction sector is studied, with the use of computable general equilibrium (CGE) models by Qingwei Shi, Hong Ren, Weiguang Cai, Jingxin Gao, aiming in analyzing the macroeconomic and energy demand of the effect of a carbon tax and exploring the appropriate carbon tax (Shi et al., 2019). In conclusion researchers consider that a carbon tax can effectively improve energy efficiency and reduce CO_2 emissions, nonetheless, modelling developed needs to expand further to overcome the limitations of the CGE model more accurately, and to realize a continuous link between the CGE models of the construction sector and of the macroeconomy.

While literature has gone a long way in resolving the effects of taxation in GHG emissions, far less is known about what the impacts are in each separate sector of the economy and which might be the reasons behind any possible differences. The present study aims at establishing of the factors that trigger GHG emissions concentrating on the construction industry, based on the approach suggested by Morley (Morley, 2012), by examining parameters of taxation, GDP, and demographics.

A description of the methodology and framework exercised in the analysis is outlined in Chapter 3 below along with the econometric model shaped by the environmental taxes imposed by the EU member states. The data used are detailed in Chapter 4. Results are discussed in Chapter 5, and the study ends in Chapter 6 with a number of concluding remarks.

Chapter 3

Methodology

This Chapter presents the research objectives of the study along with the analytical framework used in order to investigate the effects of environmental regulation (i.e., environmental taxation) on the GHG emissions produced by the construction sector in EU countries. This is achieved by adopting an econometric regression model which links emission levels with environmental taxation and other control variables. In addition, a control function approach is used to address potential endogeneity issues arising from the presence of reverse causality in the estimation of the regression model.

3.1 Research Objectives

Policy interventions aiming at reducing emissions are not by definition successful, raising questions about their appropriateness and effectiveness in safeguarding and protecting the environment. Among the various policy interventions, environmental taxation constitutes a common and direct tool used extensively by many EU member states to reduce emission levels generated during the production process of various products. This thesis attempts to explore whether and to which extent environmental taxation constitutes a powerful and effective policy tool towards reducing emissions generated by the construction sector in EU+ countries (EU+)[1].

In particular, the main research objectives of this thesis are:

[1] Under study countries include the EU27/EEA/EFTA and UK

- to explore whether there is a significant variation in the effect of environmental taxation on emissions across EU+ countries
- to measure the effect of environmental taxation on GHG emissions generated by the construction sector in EU+
- to investigate whether environmental tax policy vary across different groups of countries and to assess the position of Cyprus in comparison to other EU+ countries

To achieve the above-mentioned objectives, a consistent econometric model is developed aiming to identify the quantitative impact of taxation on the GHG emissions of the construction sector. The model allows for heterogenous effects across different groups of countries while at the same time deals with estimation problems arising from the presence of endogeneity.

3.2 Regression Model

In order to quantify and analyze the causal effects of environmental taxation on GHG emissions, a multiple regression model is applied, which is a widely used approach to properly test the relationship between a single dependent variable and a set of independent variables. In particular, the general aim of the regression approach is:

(i) To find a regression equation that best describes the relationship between the under-study variables,

(ii) To determine the coefficient estimates as a validation of the concept of the relationship between the variables,

(iii) To predict the dependent variable values and establish the impact of key variables,

(iv) To enable comparisons between countries (or more precisely between the selected group of countries).

For the estimation of the determinants of GHG emissions, the following regression model is considered:

$$E_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \boldsymbol{\beta_3 D_j} T_{it} + \boldsymbol{\beta_4 D_j} + u_{it} \qquad \textit{(eq.1)}$$

where subscripts i and j indicate the countries and the groups of countries, respectively, and t indicates time, E_{it} denotes GHG emissions of country i at time t, GDP_{it} denotes real GDP per capita, T_{it} is a proxy of environmental taxation level defined as the ratio of the total environmental taxes over the total receipts from taxes, $\boldsymbol{D_j}$ is a vector of dummy variables each of which takes a value equal to one for countries belonging in group j and zero otherwise, and u_{it} is a normally distributed error term. Finally, β's are parameters to be estimated and bolded letters denote vectors of parameters or variables. All variables in equation (1) are in natural logarithms.

As it is obvious in equation (1), a vector of dummy variables, $\boldsymbol{D_j}$, along with the intersection of this vector with environmental taxation, $\boldsymbol{D_j} T_{it}$, have been added as additional regressors in the estimation of the regression model. The intuition behind this choice is that unobserved characteristics across groups of countries (socio-economic characteristics) may affect emission levels and thus the effect of taxation on emissions may vary across groups of countries. Hence, the inclusion of these regressors in equation (1): (a) enables to control for unobserved heterogeneity across groups of countries and, (b) allows for heterogenous effects of taxation on emissions across groups of countries.

Intuition also suggests that environmental taxes should act adversely to emissions. Therefore, the sign of the coefficient related to the independent variable T_{it} is expected to be negative. Nevertheless, above perception did not hold true in the initial estimation of the regression model. This result might be attributed to the presence of endogeneity in the estimation model. Endogeneity may arise for one of the following reasons: important variables have been omitted from the analysis (i.e., omitted variable bias) or errors exist with respect to the measurement of the variables (i.e., measurement errors), or there is a reverse causality between the dependent variable and one or more independent variables (Wooldridge, 2010, pp 50-51). In this study, endogeneity, if present, arises due to reverse causality between emissions and taxation since a

greater amount of emissions is likely to lead policymakers to increase environmental tax rates, implying that taxation variable, T_{it}, in equation (1) is endogenous.

To account for the above-described endogeneity problem, a control function approach (CF) is endorsed with the goal to uncover the partial effects of reverse causality between emissions and taxation, through the use of instrumental variables (IVs) necessary for the control function to eliminate endogeneity. In particular, the control function approach involves a two-step estimation process. In the first step, the endogenous variable, T_{it}, is regressed on a set of exogenous instruments, namely the variables included on the right-hand side of equation (2). In the second stage, the residuals of the regression model described at stage 1, are included as an additional regressor in equation (1).

For the purpose of this thesis, the one-year lag of the GHG emissions, E_{it-1}, along with the number and size of enterprises operating in a given group of countries have been used as instruments. Those instruments are relevant to the taxation levels but do not depend on taxation, so they are largely considered as exogenous. Along these lines, the following model is estimated at stage 1:

$$T_{it} = a_0 + a_1 GDP_{it} + a_2 GDP_{it}^2 + \boldsymbol{a_3 D_j} + a_4 k_{1it} + a_5 k_{2it} + a_6 k_{3it} + a_7 E_{it-1} + v_{it} \quad \textit{(eq.2)}$$

where k_{1it}, k_{2it}, and k_{1it} refer to the number of small, medium and large size enterprises in country i at period t, respectively, and E_{it-1} refers to GHG emissions of country i at period $t-1$. The above-mentioned variables are the instrumental variables of the analysis. Finally, v_{it}, is a normally distributed error term (i.e., residuals) and a's are parameters to be estimated. The remaining variables are as defined earlier[2].

The estimated residuals of equation (2), $\hat{v}_{it}$, are then used as an addition regressor in the estimation of equation (1) at the second stage, as follows:

[2] In order to avoid multicollinearity issues, the use of m-1 dummy variables have been used in the model, where m is the number of dummy variables. Thus, the group 3 of countries has been omitted from the analysis and is used as the reference group.

$$E_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \boldsymbol{\beta_3 D_j} T_{it} + \boldsymbol{\beta_4 D_j} + \beta_5 \hat{v}_{it} + u_{it} \qquad \textit{(eq.3)}$$

The estimation of equation (3) provides now consistent and unbiased estimates for the parameters of interest. This is because, the independent variable (T_{it}) is free from the influence of the error term u.

3.3 Limitations

A limitation of this paper is the use of GHG emissions as sole indicator of environmental quality. In regards to the construction sector, other factors may have detrimental effects on the environment such as resource depletion, land-use, deforestation, contamination of water and soil. Consequently, the inclusion of these determinants needs to be further researched in order to verify whether the results of present study would still hold. Furthermore, this study relies on data from EUROSTAT, which are available for the total number of countries selected, for period 2012-2018. As environmental regulation needs time to be applied and produce meaningful results, measures taken throughout a larger timeframe would enable a broader evaluation of the policy measures implemented. This becomes more prominent from the fact that both GDP and GHG emissions, which are used as variables in the model, are variables that have a slow rate of change and any possible modification of those parameters would need a greater time period to evolve.

Testing for different time periods would also require a dynamic modelling, which was not within the scope of this thesis study. Moreover, the model was very sensitive to the inclusion of variables such as the population as well as backdrop emissions, which altered the coefficients and statistical significance of the model drastically. The segregation of the countries included in the model were based on theoretical arguments (geographical/ economical) which could be further explored and/ or modified.

In addition to the above, the purpose of the study was to evaluate the effects of EU environmental taxation regulations on the construction sector. However, the air pollution is an international problem, which needs global coordination and cooperation,

in order to overcome the challenges. The non-uniform policies applied worldwide, through the number of governments to the number of markets, as well as emissions produced outside the boarders of Europe, undoubtfully, affect the quality of the environment and the emissions in Europe.

Chapter 4

Data

The present Chapter provides a thorough description and explanation of the variables used in the regression model. The variables have been constructed using secondary data obtained from Eurostat. Descriptive statistics of the variables of interest are also presented in this Chapter. The analysis was performed in IBM SPSS.

4.1 Data Sources

Annual data were sourced from Eurostat, as per NACE Rev. 2 classification for the production activity of the Construction (Code F), which refers to data related to the economic activities conducted in the specific sector. Datasets from several European countries are used. This European-wide standardized data provides a comparable base which enables the consistent and harmonized evaluation and analysis, a transnational comparison of data, and an intra-country comparison, if one takes into account the variation of time, which would not be possible without a standardized collection and representation of data. Based on the above, it can be accepted that the internationally documented definitions of the datasets used to describe the environmental indicators, the demographic records and economic indices describing the pillars of the study, can be adequately utilized to describe the effects of the environmental taxation on emissions for the countries and sector of interest.

Due to the availability of statistical data, 30 countries that form part of the EU27 member states plus the EEA/EFTA and UK countries were included in the study. However, limitations due to the availability of data from Eurostat for the time span in which the particular countries belong to the EU, as well as the inconsistent availability

of data for particular countries, restricted the time horizon of the present study; consequently, only data from the timeseries of 2012 to 2018 are used in the analysis.

The examination of GHG emissions shows that there are significant differences between emissions amongst the EU+ countries. Figure 1 indicates the GHG emissions per capita for the period 2012-2018, where emission levels are at the lowest level in Spain, while in Norway GHG emissions are on mean values 3,282% higher.

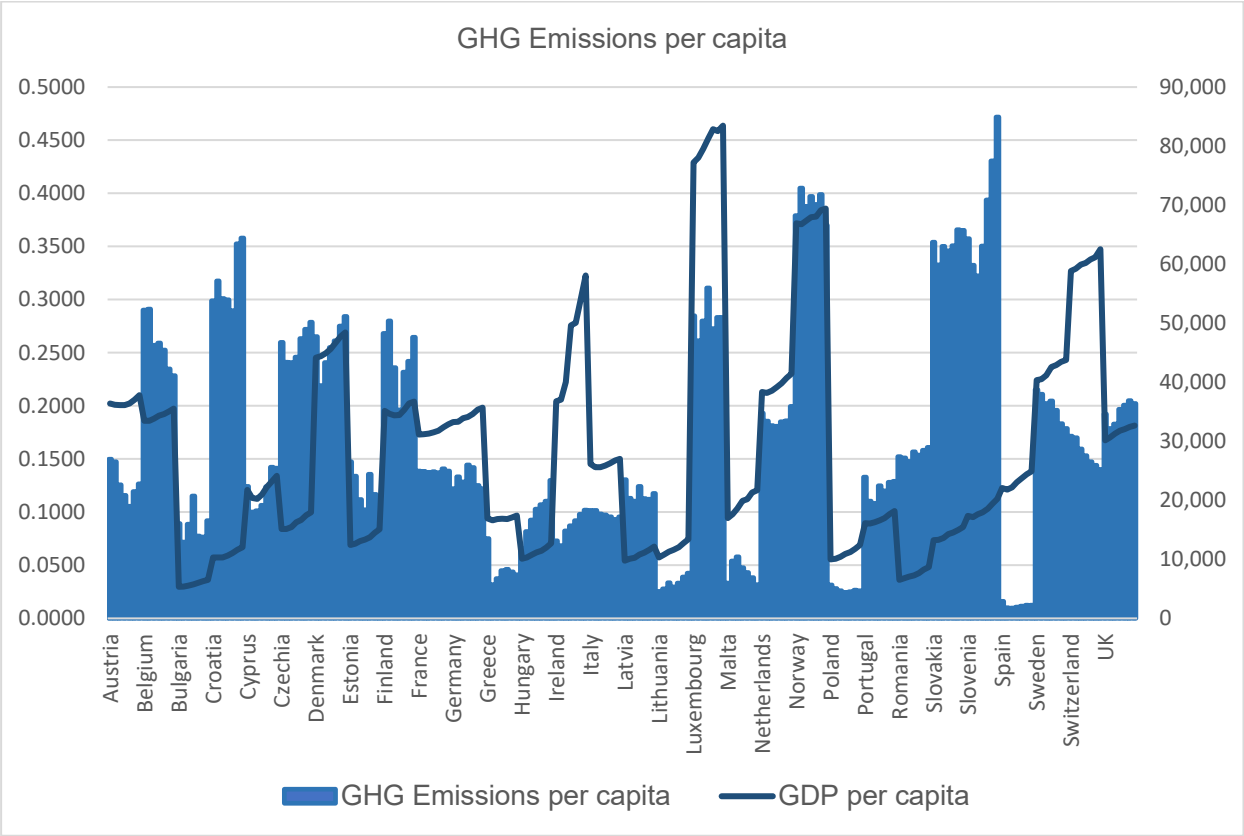

Figure 1: GHG emissions per capita (in tonnes)- GDP per capita

These differences appear not only across the countries, but also vary within the timeframe examined. For example, Slovenia having the greatest, within studied term, variation, has increased its GHG emissions by 46% in 2018 compared to 2012.

4.2 Group Classifications

As described in Chapter 3., in order to explore the behavior of different group of countries and the variations caused by the different demographic and economic data, considering policies implemented in the period examined, two distinct regression models have been produced, based on geographical and economic criteria, as these are described below:

a) Geographical segregation

b) Economic Development segregation

The classification of countries was done on geographical terms, as a first pass, and four geographic regions have been identified and have been entered into the model in order to assess the average differences in policy effects of the several categories of countries in GHG emissions and dummy variables were introduced for each distinct group:

D1-Central and West Europe (Austria-Belgium-Germany-Ireland-Luxembourg-Netherlands-Switzerland-UK)

D2- Mediterranean Region (France-Greece-Italy-Malta-Portugal-Spain-Cyprus)

D3- Eastern Europe (Bulgaria-Croatia-Czechia-Estonia-Hungary-Latvia-Lithouania-Poland-Romania-Slovakia-Slovenia)

D4-Scandinavian Region (Denmark-Finland-Norway-Sweden)

The characteristics of one region over another vary in time in cultural and economic terms, as well as technological advancements, behavioral and political views towards mitigation of pollution measures. In this way, changes in technology, transport and communications render some regions to operate having a better quality of political and economic institutions, while the long-standing advantages of other regions may have been undermined. As such, geography is just one among other factors that may contribute to the impact of environmental policies in pollution.

As indicated in literature, considering that the economic performance is an important factor which should not be neglected when distinguishing categorization of countries,

one more segregation of countries is introduced and economic indicators were used for the categorization of countries into 4 groups based on their economic development.

The membership in groups of the International Monetary Fund (IMF), is considered as a main pillar of the economic development of a country, and as such the participation of a country in the G-10 group was used for the analysis in order to form the first group of countries (Group 1). The countries with the highest real GDP per capita amongst the European countries, have formed a distinct group (Group 3) amongst the remaining countries not included in group 1. Cyprus was also chosen as an individual group for comparison purposes (Group 4). The remaining countries form the second group (Group 2).

D1- Countries included in the Group of Ten (G10)[3] (Belgium- France- Germany- Italy- Netherlands- Sweden- Switzerland -UK)

D2- Countries not included in G10 excluding Norway, Luxembourg and Cyprus (Bulgaria-Croatia-Czechia-Estonia- Denmark- Finland -Greece- Hungary- Latvia- Lithuania -Malta- -Poland -Portugal- Romania-Slovakia-Slovenia -Spain- Austria -Ireland)

D3-Norway and Luxembourg

D4-Cyprus

4.3 Defining Variables

In the following section the dependent and independent variables are included in the variables' list and their definitions are given in Table 1. Definitions and information needed in order to be able to apply and interpret the dataset used, are retrieved from Eurostat.

[3] The Group of Ten is made up of eleven industrial countries (Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States) which consult and co-operate on economic, monetary and financial matter (OECD, 2013)

Table 1-Variable list and definitions

Variable Code	Variable Name	Variable Definition	Source
E_{it}	Greenhouse Gas Emissions for year t	Greenhouse Gas Emissions measured in tonnes for year t	Eurostat
E_{it-1}	Greenhouse Gas Emissions for year t-1	Greenhouse Gas Emissions measured in tonnes for year t-1	Eurostat
GDP_{it}	GDP per capita	real GDP per capita Chain linked volumes (2010) in EUR and % change on previous year.	Eurostat
T_{it}	Percentage of Total Environmental Taxes over Total Receipts from Taxes;	The Ratio of Total Environmental Taxes as a percentage of Total Receipts from Taxes;	Eurostat
k_{1it}	Nr small enterprises	Number of small enterprises (0-49 employees)	Eurostat
k_{2it}	Nr medium enterprises	Number of medium enterprises (50-249 employees)	Eurostat
k_{3it}	Nr large enterprises	Number of large enterprises (over 250 employees)	Eurostat
D_j	Category of countries Dummy variable	Dummies used to control the variances between discrete categories of countries-subscripts i = 1, 2…, N, where N is the number of dummy categories used	Eurostat
$\hat{v}_{it}$	Estimated Residuals	Estimated Residuals produced in the first stage regression of CF approach	Regression Analysis

GHG Emissions

Eurostat dataset regarding air emissions reports the emissions of greenhouse gases and air pollutants by 64 industries (classified by NACE Rev. 2). Greenhouse gases and air pollutants emitted by all national economies are covered, however natural flows of gases and particulate materials such as those emitted by volcanos, forest fires, as well as any indirect emissions, are excluded. The concepts and definitions used in the Air Emissions Accounts are set out on the SEEA CF 2012.

GDP per capita

The GDP indicator is calculated in Eurostat dataset, as *"the ratio of real GDP to the average population of a specific year and measures the value of total final output of goods and services produced by an economy within a certain period of time.*"

As retrieved by ESS, GDP per capita is a measure of economic activity that includes goods and services that are marketable as well as products of general government and non-profit institutions. Although commonly and often used as an indicator of the development in a country's living standards, it does not take account of any negative effects of economic activity, such as the environmental degradation. Source data are retrieved by ESS.

Total Environmental taxes

Eurostat collects data on environmental tax revenue (by tax category ie. energy, transport, pollution and resource taxes) separated by economic activity, using the NACE classification for production activities.

The environmental tax statistics are based on Eurostat's 2013 'Environmental taxes - a statistical guide' and Eurostat's guide follows the Regulation (EU) N° 691/2011 definition of an environmental tax as: "*A tax whose tax base is a physical unit (or a proxy of a physical unit) of something that has a proven, specific negative impact on the environment, and which is identified in ESA2010 as a tax*" (EUROSTAT, 2020).

According to Eurostat, "*only payments that are identified as taxes in the national accounts can be environmental taxes whereas other types of payments to government are not considered environmental taxes*." Data selected in present study are presented in euro.

Total Receipts from Taxes

Total Receipts from Taxes, referred to by Eurostat as Main national accounts tax aggregates, indicates the "*detailed tax and social contribution receipts by type of tax or social contribution and by sub-sector of general government, notified by national*

authorities in line with the ESA 2010", where data selected in present study are presented in euro.

Ratio of Total Environmental Taxes over Total Receipts from Taxes

For the purposes of present analysis, the ratio of Total Environmental Taxes over Total Receipts from Taxes has been used, as it is considered to denote a more representative indicator of the effects of taxation rather than the nominal values of the Total Environmental Taxes alone.

Number of Enterprises

Structural business statistics collected by Eurostat describe the structure, conduct and performance of economic activities, while the main characteristics of which such as the Business Demographic variables ie. the Number of enterprises, have been used in present study.

According to Eurostat Guide, the detail level and breakdowns required is defined in Commission Regulation N° 251/2009 and number of enterprises is defined as *"a count of the number of enterprises active during at least a part of the reference period.*" (Eurostat, 2021).

For the classification of enterprises, the definition of SMEs of EUROSTAT was used on the basis of European Commission Recommendation 2003/361/EC, adopted on 1 January 2005, incorporating relevant thresholds depending on the number of persons employed. Groups of micro enterprises with 0-9 persons employed have been incorporated along with those of small enterprises with 10- 49 persons, forming the category of "small enterprises"; medium enterprises are characterized as those of 50-249 persons employed; and large enterprises are described as those which employ over 250 persons.

4.4 Descriptive Statistics

In order to avoid any potential implications of missing data for the analysis, the dataset has been checked for missing data. In the case of a country (UK), where missing data

have been detected for two of the variables for the year 2018, the data of the previous year have been used. Baseline characteristics of the datasets used are presented in Table a of Appendix A.

The dataset was analyzed with descriptive statistics in IBM SPSS exported in excel file and relevant results of the analysis appears in Table b of Appendix A. The outcomes of the analysis contain the variables of interest for the Mean, Minimum, Maximum and Standard Deviation for each of the countries examined, in order to provide more detailed information regarding the dataset used.

Table 2 provides the GHG emissions per capita of the countries for the under-study period, highlighting in bold the ten richest countries in terms of GDP per capita, illustrating that in general, there exist large differences between the emissions of richer countries such as Norway, Luxembourg, Belgium, Denmark, Finland, Sweden, in comparison with the less rich countries. Considering the impact that the construction sector has in the infrastructure development in rich counties, the large amounts of emissions of the rich countries are not surprising.

Specifically, in regards to Cyprus, GHG emissions, are 28.60% lower than the average of the under-study countries, on par with countries such as Portugal, Estonia and Latvia. All four countries have a lower than average GDP per capita level.

Geographically the Scandinavian countries show a similarity in the emission outcomes.

Likewise, with the possible exception of France, the Mediterranean countries follow an analogous pattern in GHG emissions.

In general, the similarities observed in the behavior between the various group of countries, have stipulated the selection of grouping/ segregation of the countries in order to proceed with the regression analysis.

Table 2- Emitted GHG per capita in 2012-2018

Country	GHG emissions per capita (in Kg)	Real Gross Domestic Product per capita (in Euro per capita)
Norway	**390**	**67,949**
Slovenia	380	18,333
Slovakia	352	14,203
Croatia	317	10,899
Luxembourg	**282**	**80,709**
Belgium	**259**	**34,341**
Czechia	257	16,321
Denmark	**257**	**46,001**
Finland	**245**	**35,300**
Sweden	**198**	**42,109**
UK	194	31,579
Netherlands	**187**	**39,466**
Switzerland	**155**	**60,380**
Romania	154	7,464
France	138	31,747
Germany	131	34,339
Austria	127	**36,580**
Estonia	123	13,531
Portugal	122	16,841
Cyprus	120	21,863
Latvia	117	10,837
Hungary	98	11,221
Italy	98	26,181
Bulgaria	87	5,854
Ireland	**86**	**46,507**
Greece	46	16,940
Malta	43	19,486
Lithuania	33	11,753
Poland	27	10,980
Spain	12	23,187
Average values	168	28,097

4.4.1 Geographical Segregation

The descriptive statistics shown in Table 3, indicate that emission levels per capita are much higher in Scandinavian countries, followed by the Central- West European ones, indicating that the first group of countries consist of the major emitters in absolute terms. There is also a significant gap between these two groups and the group of countries of the Mediterranean Region. A similar gap exists also when comparing the GDP per capita between same groups; as expected, the descriptive statistics indicate that for high GDP countries, emissions are higher on average than the emissions of the countries of the lower end GDP group.

Table 3- Descriptive Statistics-geographic cluster

Variable Abbreviation	Variable Description	N	Mean	Minimum	Maximum
D1-Central and West Europe (Austria-Belgium-Germany-Ireland-Luxembourg-Netherlands-Switzerland-UK)					
E_{it}	GHG emissions on year t (in Tonnes)	8	4,036,109	140,333	13,502,236
$E_{it\ pc}$	*GHG emissions on year t per capita (in Tonnes)*	*8*	*0.1642*		
T_{it}	Environmental Taxes on year t (in million Euro)	8	666	21	2,236
$T_{it\ pc}$ (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	8	*0.000027*		
GDP_{it}	Real Gross Domestic Product per capita (in Euro per capita)	8	45,488	30,190	83,470
Pop	Population (on 1 January - total)	8	24,575,578	524,853	82,792,351
Total tax rev	Main national accounts tax aggregates on year t (in million Euro)	8	360,922	17,586	1,387,630
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*		*0.014686*		
EnvTax/Total tax rev	Environmental Taxes / Main national accounts tax aggregates	8	0.001825	0.000599	0.002703
k_{1it}	Number of active enterprises (0-49)	8	123,055	3,206	355,102
k_{2it}	Number of active enterprises (50-249)	8	1,036	56	3,860
k_{3it}	Number of active enterprises (over 250)	8	114	9	361
D2- Mediterranean Region (France-Greece-Italy-Malta-Portugal-Spain-Cyprus)					
E_{it}	GHG emissions on year t (in Tonnes)	7	2,500,557	13,896	9,404,158
$E_{it\ pc}$	*GHG emissions on year t per capita (in Tonnes)*	*7*	*0.0894*		
T_{it}	Environmental Taxes on year t (in million Euro)	7	469	7	1,818

$T_{it\ pc}$ (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	*7*	*0.000017*		
GDP_{it}	Real Gross Domestic Product per capita (in Euro per capita)	7	22,321	16,050	32,890
Pop	Population (on 1 January - total)	7	27,970,297	417,546	67,026,224
Total tax rev	Main national accounts tax aggregates on year t (in million Euro)	7	327,710	2,413	1,137,450
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*		*0.011716*		
EnvTax/Total tax rev	Environmental Taxes / Main national accounts tax aggregates	7	0.002172	0.000792	0.005623
k_{1it}	Number of active enterprises (0-49)	7	221,907	3,605	574,017
k_{2it}	Number of active enterprises (50-249)	7	641	0	1,956
k_{3it}	Number of active enterprises (over 250)	7	74	0	325
D3- Eastern Europe (Bulgaria-Croatia-Czechia-Estonia-Hungary-Latvia-Lithouania-Poland-Romania-Slovakia-Slovenia)					
E_{it}	GHG emissions on year t (in Tonnes)	11	1,173,669	76,253	3,146,537
$E_{it\ pc}$	*GHG emissions on year t per capita (in Tonnes)*	*11*	*0.1249*		
T_{it}	Environmental Taxes on year t (in million Euro)	11	81	9	319
$T_{it\ pc}$ (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	11	*0.000009*		
GDP_{it}	Real Gross Domestic Product per capita (in Euro per capita)	11	11,945	5,350	20,220
Pop	Population (on 1 January - total)	11	9,395,769	1,314,870	38,063,792
Total tax rev	Main national accounts tax aggregates on year t (in million Euro)	11	35,828	5,715	179,268
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*		*0.003813*		
EnvTax/Total tax rev	Environmental Taxes / Main national accounts tax aggregates	11	0.002582	0.000529	0.005849
k_{1it}	Number of active enterprises (0-49)	11	66,711	7,775	324,261
k_{2it}	Number of active enterprises (50-249)	11	427	61	1,609
k_{3it}	Number of active enterprises (over 250)	11	42	8	175
D4-Scandinavian Region (Denmark-Finland-Norway-Sweden)					
E_{it}	GHG emissions on year t (in Tonnes)	4	1,686,942	1,074,165	2,097,657
$E_{it\ pc}$	*GHG emissions on year t per capita (in Tonnes)*	*4*	*0.2589*		
T_{it}	Environmental Taxes on year t (in million Euro)	4	367	170	547
$T_{it\ pc}$ (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	*4*	*0.000056*		
GDP_{it}	Real Gross Domestic Product per capita (in Euro per capita)	4	47,840	34,390	69,440

Pop	Population (on 1 January - total)	4	6,515,559	4,985,870	10,120,242
Total tax rev	Main national accounts tax aggregates on year t (in million Euro)	4	141,706	85,536	214,421
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*		*0.021749*		
EnvTax/Total tax rev	Environmental Taxes / Main national accounts tax aggregates	4	0.002546	0.001837	0.003315
k_{1it}	Number of active enterprises (0-49)	4	56,450	30,366	103,427
k_{2it}	Number of active enterprises (50-249)	4	405	220	804
k_{3it}	Number of active enterprises (over 250)	4	46	34	96

Descriptive Statistics per group of counties. N= Number of countries, mean=average of mean values per country, min=minimum value observed, max-maximum value observed

Considering that present study refers only to the construction sector, a possible explanation for the high emission levels of the Scandinavian and Central- West European groups of countries, would be that due to their higher GDP levels, the infrastructure development, which is the main force behind the construction industry, is expanding at greater rates compared to the low emission groups of countries. Another possible explanation concerning the Scandinavian countries, is that these have a high reliance on fossil fuels, since countries that enjoy large reservoirs of fossil fuels, such as Norway, have higher usage of fossil fuels compared to those that do not have these natural resources.

By using this geographic segregation of countries, in terms of GDP per capita, further observations are notable. The minimum and maximum GDP per capita for each group of countries shows significant variation, indicating that countries with heterogeneous characteristics are included in each of the groups, while the corresponding GDP per capita of each individual country is not representative of the mean value of said group of countries. In order to eliminate these variances, a re-group of the countries, based on economic criteria, has been examined and described in sub-section 4.4.2.

The pattern for the ratio of the Environmental Taxes over the Total Revenues of each country through taxation is diverse in each group of countries, with mean values of the Central and west European countries reaching 0.1825% while the other three groups

have fairly high numbers ranging from 0.2172% to 0.2582%. It is important to note however, that there is a heterogeneity within groups, as the maximum and minimum values within group observations range; between 33% and 148% for the first group of countries; 36% and 259% for the Mediterranean group of countries; between 20% and 227% for the central European group; and between 72% and 130% for the Scandinavian ones. This widespread range of values might be explained by the varied scale of industrialization and infrastructure development over the past years between the different European economies.

Furthermore, descriptive statistics, reveal that the ratio of the Environmental Taxes over the Total Revenues of each country through taxation, is higher amongst the Eastern European group of countries along with the Scandinavian ones. A more detailed reading of the statistics exposes that the Scandinavian countries apply the highest environmental taxation per capita compared to all other group of countries.

On the contrary, the high ratio the Environmental Taxes over the Total Revenues for the Eastern European Countries, which have the lowest environmental taxation per capita, is likely due to the significantly lower total revenues per capita through taxation (€ 3.81 compared to € 21.75 of the Scandinavian countries) and obviously not due to the level of environmental taxation.

4.4.2 Economic Development Segregation

Since researchers, as shown in literature review in Chapter 2, have developed theoretical explanations that relate GDP with emissions, a second segregation of the under-study countries is proposed, based on economic criteria, by which the counties have been grouped in accordance to their economic development, as explained in section 4.2 of present Chapter.

Table 4. Descriptive Statistics-economic cluster

Variable Abbreviation	Variable Description	N	Mean	Minimum	Maximum
D1- Belgium- France- Germany- Italy- Netherlands- Sweden- Switzerland -UK					
E_{it}	*GHG emissions on year t (in Tonnes)*	*8*	5,954,212	1,189,502	13,502,236
$E_{it\ pc}$	*GHG emissions on year t per capita (in Tonnes)*	*8*	*0.1493*		
T_{it}	*Environmental Taxes on year t (in million Euro)*	*8*	1,026	363	2,236
$T_{it\ pc}$ *(in millions)*	*Environmental Taxes on year t per capita (in million Euro)*	*8*	*0.000026*		
GDP_{it}	*Real Gross Domestic Product per capita (in Euro per capita)*	*8*	37,518	25,620	62,550
Pop	*Population (on 1 January - total)*	*8*	39,892,053	7,954,662	82,792,351
Total tax rev	*Main national accounts tax aggregates on year t (in million Euro)*	*8*	577,712	139,737	1,387,630
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	*8*	*0.014482*		
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	*8*	*0.002045*	*0.000792*	*0.002875*
k_{1it}	*Number of active enterprises (0-49)*	*8*	252,974	19,253	574,017
k_{2it}	*Number of active enterprises (50-249)*	*8*	1,341	400	3,860
k_{3it}	*Number of active enterprises (over 250)*	*8*	149	45	361
D2- Bulgaria-Croatia-Czechia-Estonia- Denmark- Finland -Greece- Hungary- Latvia-Lithuania -Malta -Poland -Portugal- Romania-Slovakia-Slovenia -Spain- Austria -Ireland					
E_{it}	*GHG emissions on year t (in Tonnes)*	*19*	1,028,807	13,896	3,146,537
$E_{it\ pc}$	*GHG emissions on year t per capita (in Tonnes)*	*19*	*0.0997*		
T_{it}	*Environmental Taxes on year t (in million Euro)*	*19*	120	7	421
$T_{it\ pc}$ *(in millions)*	*Environmental Taxes on year t per capita (in million Euro)*	*19*	*0.000012*		
GDP_{it}	*Real Gross Domestic Product per capita (in Euro per capita)*	*19*	19,592	5,350	58,100
Pop	*Population (on 1 January - total)*	*19*	10,321,142	417,546	46,818,219
Total tax rev	*Main national accounts tax aggregates on year t (in million Euro)*	*19*	70,962	2,413	426,149
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	*19*	*0.006875*		
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	*19*	*0.002319*	*0.000529*	*0.005849*
k_{1it}	*Number of active enterprises (0-49)*	*19*	74,057	3,605	378,358
k_{2it}	*Number of active enterprises (50-249)*	*19*	408	0	1,609
k_{3it}	*Number of active enterprises (over 250)*	*19*	43	0	175
D3-Norway and Luxembourg					
E_{it}	*GHG emissions on year t (in Tonnes)*	*2*	1,083,522	140,333	2,097,657
$E_{it\ pc}$	*GHG emissions on year t per capita (in Tonnes)*	*2*	*0.3790*		
T_{it}	*Environmental Taxes on year t (in million Euro)*	*2*	226	21	458
$T_{it\ pc}$ *(in millions)*	*Environmental Taxes on year t per capita (in million Euro)*	*2*	*0.000079*		

	Real Gross Domestic Product per capita (in				
GDP_{it}	*Euro per capita)*	*2*	74,329	66,780	83,470
Pop	*Population (on 1 January - total)*	*2*	2,858,551	524,853	5,295,619
	Main national accounts tax aggregates on year t				
Total tax rev	*(in million Euro)*	*2*	83,035	17,586	165,276
	Main national accounts tax aggregates on year t				
Total tax rev pc (in millions)	*per capita (in million Euro)*	*2*	*0.029048*		
	Environmental Taxes / Main national accounts				
EnvTax/Total tax rev	*tax aggregates*	*2*	*0.002419*	*0.001141*	*0.003315*
k_{1it}	*Number of active enterprises (0-49)*	*2*	29,400	3,206	57,447
k_{2it}	*Number of active enterprises (50-249)*	*2*	285	137	496
k_{3it}	*Number of active enterprises (over 250)*	*2*	32	15	63
D4-Cyprus					
E_{it}	*GHG emissions on year t (in Tonnes)*	*1*	102,823	86,604	122,275
$E_{it\ pc}$	*GHG emissions on year t per capita (in Tonnes)*	*1*	*0.1200*		
T_{it}	*Environmental Taxes on year t (in million Euro)*	*1*	20	16	23
	Environmental Taxes on year t per capita (in				
$T_{it\ pc}$ *(in millions)*	*million Euro)*	*1*	*0.000023*		
	Real Gross Domestic Product per capita (in Euro				
GDP_{it}	*per capita)*	*1*	21,863	20,250	24,120
Pop	*Population (on 1 January - total)*	*1*	857,179	847,008	865,878
	Main national accounts tax aggregates on year t				
Total tax rev	*(in million Euro)*	*1*	6,240	5,725	7,183
	Main national accounts tax aggregates on year t				
Total tax rev pc (in millions)	*per capita (in million Euro)*	*1*	*0.007280*		
	Environmental Taxes / Main national accounts				
EnvTax/Total tax rev	*tax aggregates*	*1*	*0.003140*	*0.002771*	*0.003452*
k_{1it}	*Number of active enterprises (0-49)*	*1*	7,746	7,160	8,589
k_{2it}	*Number of active enterprises (50-249)*	*1*	30	0	53
k_{3it}	*Number of active enterprises (over 250)*	*1*	1	0	4

Descriptive Statistics per group of counties. N= Number of countries, mean=average of mean values per country, min=minimum value observed, max=maximum value observed

The results of the descriptive statistics of the economic classification of countries shown in Table 4, show that emission levels per capita are 280% higher in the group 3 countries, which consists of the countries of Norway and Luxembourg compared to the lowest emitters, ie group 2, consisting of the least developed countries; 154% higher than the countries that belong to the G-10 group and; 216% higher than Cyprus emissions.

As anticipated, based on the analysis of the descriptive statistics of the sub-section 4.3.1, the higher-end GDP countries of the study ie those of groups 1 and 2, are causing higher emissions on average than the emissions of the countries of the lower end GDP group. This verifies the approach to pollution proposed by Grossman and Krueger (1995), and conforms to the principle that the process which accompanies early development leads to higher levels of pollution, following the track of the growth of the economy shifting from low to higher levels of development.

A further finding of the descriptive statistics analysis of the economic classification, is that the highest ratio of Environmental Taxes over the Total Revenues compared all the other group of countries is calculated in Cyprus. However, taking into consideration that the Environmental taxes per capita of Cyprus is only higher than those of group 2 countries (and 71.05% lower than the group 3 countries), the high level of the Environmental Taxes over the Total Revenues ratio, should be more attributable to the low level of Total Revenues of the country obtained through general taxation, rather than the level of environmental taxation. More specific and compared to the more similarly behaved in terms of environmental taxes per capita revenues, group 1 countries, the Environmental Taxes on year t per capita for Cyprus is only 10.85% lower, whereas the Total tax Revenues of the country is 49.73% lower.

It is also worth noting, that in terms of GDP per capita, descriptive statistics show that the mean values of the four groups are in line the classification of the countries. However, a closer look at the minimum and maximum values of the respective GDP figures, reveals that that the higher observation of a group 2 country, indicates that countries, or particular time periods of a country, are included in a lower economic development category, while their corresponding GDP per capita levels may be sufficiently high to be regarded as a high economically developed country. For these differences to be eliminated, one would have to perform other groupings of countries, or adjust the groupings for every year of the sample; this was outside the scope of present study.

Chapter 5

Results

This Chapter presents the estimation results of the regression models discussed in Chapter 3. First, the estimation results based on the geographical classification are presented and discussed. Next, the estimation results based on the economic classification are presented.

5.1 Regression Analysis Results

Due to the presence of endogeneity, a two-stage least squares estimation (2SLS), as a most common form of Instrumental Variable (IV) analysis (Crosby et al., 2010) was performed, in order to provide a general solution to the problem of an endogenous explanatory variable, for each classification of countries; in this way, the relationships between the IV and the GHG emission determinants were analyzed, and results were extracted. A logarithmic transformation of the variables was adopted. Therefore, all estimated coefficients are interpreted as elasticities rather than as marginal effects.

5.1.1 First Stage Regression Outcomes

In the first step of the regression analysis, which was run with the approach of establishing the Instrumental Variable, the demographic variables of the number of SME enterprises, the environmental backdrop (ie emissions of previous year), as well as economic factors that influence taxation, were used. Results displayed in Table 5, show the relationships between the IVs and the independent variables selected.

The R^2 for this analysis model for the geographic classification of countries is equal to 0.308 meaning that 30.8% of the variance in the model can be explained by the IV and independent variables, whereas the relevant R^2 for the economic classification of countries is 0.324.

Model suggests that the emissions of the previous year, affects positively the variable of taxation, as the coefficient of the previous year's emissions, indicated by α_7= 0.159 (p < .000), and α_7 = 0.123 (p =.003), for the geographic and economic classification respectively influences the taxation variable positively and passes the significance test. This can be explained, since an increased value of the pre-existing emissions would cause the indorsing by policymakers, of a rise in environmental taxation.

Moreover, the relationships between the demographic factors captured by the number of enterprises operating, reflect that the number of small enterprises is statistically significant indicated by α_4 = -0.199 (p < .000), and α_4= -0.201 (p < .000), for the geographic and economic classification respectively, suggesting that an increase in the number of small enterprises will affect negatively the taxation ratio. Interestingly, results show that every 1% rise on the number of small enterprises, shrinks the ratio of taxation by the same percentage of approximately 20% (19.9% and 20.1%) in the case of the geographic and economic classification respectively.

The strong decreasing relationship between environmental taxation and the number of small enterprises that operate in the groups of countries, and at the same time the absence of an effect caused by the medium and large sized enterprises, can be explained by the fact that the small enterprises, which are not expected to have the resources and means to implement policies and procedures to address environmental challenges, have a stronger influence on emissions and in turn environmental taxation.

Contrary to the impact of backdrop emissions and number of enterprises in operation, the effects of the variables of GDP per capita towards taxation are not statistically significant in any of the group classification used.

Table 5-Results of Regression Model stage 1-Dependent Variable T_{it}

Geographic classification of countries			Economic Development classification		
	Coefficient	Standard Error		Coefficient	Standard Error
(Constant)	5,949	8,377	(Constant)	4,011	9,759
GDP_{it}	-2,073	1,716	GDP_{it}	-1,495	2,033
$(GDP_{it})^2$	.088	.086	$(GDP_{it})^2$	.059	.103
D_1	.139	.163	D_1	.089	.167
D_2	.148	.112	D_2	-.342	.178 *
D_4	.491	.176 ***	D_{CY}	-.186	.261
k_{1it}	-.199	.055 ***	k_{1it}	-.201	.050 ***
k_{2it}	-.044	.063	k_{2it}	-.044	.063
k_{3it}	-.040	.078	k_{3it}	-.057	.081
E_{it-1}	.159	.041 ***	E_{it-1}	.123	.041 ***
R^2	0.308		R^2	0.324	

Notes: Variables D_1, D_2, D_4 are dummy variables representing group of countries in categories 1, 2 and 4 respectively; $D_{CY,}$ denotes category country D_4 for the economic development classification, as the specific category includes only Cyprus

*, ** and *** denote statistical significance at the 10%, 5% and 1% level respectively

5.1.2 Second Stage Regression Outcomes

The relationships established through the second stage regression, following the implementation of the IVs in the final model, are presented in Table 6 and the results in terms of the variables which influence GHG emissions are discussed below.

Table 6- Results of Regression Model stage 2- Dependent Variable E_{it}

Geographic classification			Economic Development classification		
	Coefficient	Standard Error		Coefficient	Standard Error
(Constant)	-29,011	19,234	(Constant)	63,204	19,256 ***
GDP_{it}	7,477	4,887*	GDP_{it}	-9,366	5,889**
$(GDP_{it})^2$	-.431	.2050*	$(GDP_{it})^2$	.435	.399**
D_1T_1	-.356	.4124	D_1T_1	-2,788	.421 ***
D_2T_2	-3,247	.3566***	D_2T_2	-2,049	.287 ***
D_3T_3	-1,701	.4231***	D_3T_3	-.047	.166
D_4T_4	.615	1,453	D_4T_4	-2,600	5,144
D_1	10,478	2,996***	D_1	-14,938	2,982 ***
D_2	-9,789	2,438***	D_2	-12,779	2,013 ***
D_4	16,463	9,102*	D_{CY}	-16,522	30,001
$\hat{v}_{it}$	1,781	.498***	$\hat{v}_{it}$	2,069	.302 ***
R^2	0.394		R^2	0.557	

Notes: Variables D_1, D_2, D_4 are dummy variables representing group of countries in categories 1, 2 and 4 respectively; $D_{CY,}$ denotes category country D_4 for the economic development classification, as the specific category includes only Cyprus

Product terms D_1T_1, D_2T_2, D_3T_3, D_4T_4 are interaction terms representing the effect of tax to the groups of countries in categories 1, 2, 3 and 4 respectively

*, ** and *** denote statistical significance at the 10%, 5% and 1% level respectively

5.1.2.1 Geographical classification results

In the geographic classification, GDP variable shares significantly positive relationships with GHG emissions, indicated by β_1 = 7,477 (p = .097).

The opposite signs of the coefficients β_1 and β_2 related to the independent variables of GDP and squared GDP indicate that, in respect of the geographical segregation, the GHG emissions increase along GDP per capita, followed by a decrease after a turning point. As per Grossman and Krueger (1995) often used assumption in literature, for an inverted U-shaped relationship of emissions and per capita GDP, the squared measure of GDP variable included in the model, results in a negative coefficient of β_2 = -0.431 (p = .054). Consequently, and since both respective coefficients β_1 and β_2, are statistically significant, the model for the geographic cluster, confirms the notion of EKC being supported.

A possible interpretation of the positive relationship between GHG emissions and GDP per capita, could be that due to the initial stage high growth of development, production in Constructions can be achieved through more intensive energy use production methods and existing technologies, up to a maximum point. Following that, the negative relationship between the GDP and GHG emissions, can be explained due to the development and use of new policies and energy-saving technologies that enable, in the long run, the production of the same output at lower GHG emissions.

The interaction terms of the group of countries dummy variables and the environmental taxation ratio, validate the presence of a negative relationship between taxation and GHG emissions. It is worth mentioning that the model was based on a short time frame and this did not allow for large scale time related effects to be produced, which would in turn enable the assessment and modelling of any technological or other policy changes that might be implemented, and consequently modify the environmental impact in countries at the various levels of economic growth. However, by having a closer look at the four groups of countries formed, one can observe that the β_3 tax coefficients of the groups 1 (central and west European countries) and group 4 (Scandinavian countries), are not statistically significant. This can be attributed to the

fact that countries that are considered as wealthy, have a slower economic rate of growth compared to the more rapidly growing low or middle wealth countries.

To the contrary, the statistically significant negative coefficients of the ratio of environmental taxation for the Mediterranean region countries and eastern European countries of groups 2 and 3 respectively, indicated by β_3 = -3,247 (p < .000) and β_3 = -1,701 (p = .002) respectively, confirm the hypothesized relationship between taxation and GHG emissions. The difference in the relationship regarding above countries, which are the low-middle level countries in terms of GDP per capita, shows that the impact of taxation has a strong negative effect on emissions and can have a time-related effect. As such it validates the expected policymakers' target for lower emission levels upon the implementation of environmental taxation measures.

As the model uses a double-log transformation, the coefficients measure the elasticity of the independent variables with respect to the dependent one. An elasticity coefficient greater than 1 is said to be elastic, and as such the interpretation of the difference on the results of the β_3 coefficient of the specific group of countries indicates that there are higher elasticities in group 2 countries compared to group 3 countries, and the variance in the magnitude of 90.9%, between the coefficients of the two groups of countries imply that the particular characteristics of the group 2 of countries have a proportionately greater effect on GHG emissions, compared to group 3 countries.

Finally, the R^2 for the model is 0.394 meaning that 39.4% of the variance in the model can be explained by the independent variables applied.

5.1.2.2 Economic classification results

An additional clustering of the under-study countries is performed based on the economic development of countries, as described in section 4.1.2 of Chapter 4.

The model indicates that the GDP variable shares a statistically significant relation with GHG emissions. Opposing relationships appear between GDP variables and GHG emissions in regards to the economic classification of countries; GDP variable has a negative relationship with GHG emissions, indicated by β_1 = -9,366 (p = .023), whereas

its squared variable reveals a positive coefficient β_2 = 0.435 (p = .035), suggesting again the existence of a curvature. In current classification, the function is convex, and therefore, GHG emissions are decreasing along with GDP per capita up to a minimum point, where GHG emissions begin to rise. This suggests the presence of a U-shaped relationship between emissions and GDP, rejecting the EKC theory of an inverted U. The purpose of this study was not to calculate the turning point levels; however, it should be noted that this might be required in order to establish whether both parts of the curve should be taken into consideration, or if a part can be ignored, as for example if the turning point is not within the period examined. This would then result in a monotonical relationship between GHG emission levels and GDP per capita. Moreover, a monotonically relationship might be reasonable considering the nature of some of the economies of the study; an increasing relationship might emerge in cases where GHG emissions are related to the presence of energy resources and possible subsidizing of prices; in addition, several industries are exempted from taxation as indicated in literature review which distorts the taxation policy goals. To the contrary, a decreasing relationship may be found in countries where the implementation of new policies and/ or energy-saving technologies result in lower GHG emissions.

To this point, and in an effort to explain the reverse relationship between the emissions and GDP per capita, it is important to note that the target of the policymakers through the introduction of taxes, is to stimulate GHG abatement. However, this may not always be the case, as due to concerns of possible loss of competitiveness, energy intensive industries, such as the construction industry or parts of it, are often exempted from paying environmental taxes (Ekins and Speck,1999), which may compromise the effectiveness of environmental taxes.

Having said that, and supporting the hypothesis of a relationship between taxation and emissions, the ratio of environmental taxation has a statistically significant coefficient of β_3 = -2,788 (p < 000) and β_3 = -2,049 (p < 000) for the countries of groups 1 and 2 respectively. The magnitude of the β_3 coefficients of group 1 and 2 countries, indicate again a high elasticity between the respective variables and the variation of 36.1% of

the coefficient of the two group of countries, suggests that the impact of taxation in group 1 is higher compared to group 2 countries.

Although the approach highlighted by Selden and Song (1994), indicates that environmental quality is valued higher with the presence of high economic development, which in turn increases the willingness to pay higher taxes for pollution reduction, the coefficient of group 3 countries, which have the greatest GDP per capita, is not-statistically significant.

Further to that, the use of dummy variables reveals that contrary to group 1 and 2 countries, the taxation coefficient that relates to Cyprus (Group 4) is not statistically significant, thus no linear dependence of the ratio of taxation on GHG emissions is detected in the specific sector. Despite the fact that environmental taxes provide an incentive to decrease the level of emissions, the absence of a relationship between environmental taxation and emissions for Cyprus, can be interpreted as an indication of a low level of environmental taxation, which cannot act as a motivator for the use of energy efficient or low emission technologies and processes. The collection of taxation requires regulatory, administrative and enforcement mechanisms, for which Cyprus might face challenges in applying. Issues of tax evasion, may also prohibit the correct representation of the taxes. In the case of environmental taxes, the precise definitions used and the control the taxing system also impose difficulties towards the collection of environmental taxes. Subsequently, the lack of proper administrative mechanisms and experience of the country may also pose a barrier in the application of environmental taxes.

In both classifications of group of countries used, stage 1 regression model implemented has produced statistically significant estimates of Residuals $\hat{v}_{it}$, representing the strong coefficient on the IV, and consequently satisfying the condition that the IV used must affect the probability of the independent variable. Because the estimated residuals from the first stage are used as a regressor in the second stage estimation, the standard errors in the second stage model have been corrected using bootstrapping techniques.

Moreover, the R^2 for the economic classification model is 0.557, which implies that, since R-squared is the percentage of the dependent variable variation that the model explains, the economic classification describes the model stronger compared to the geographic one.

Chapter 6

Conclusions and Recommendations

6.1 Research Conclusion

The awareness of the determinants of emissions, and their significance to influence the trends observed, could enable the converge of efforts to address the climate change challenges. Despite the intensified in recent years, range of policymakers' actions to reduce emissions, there is still a shortfall in the broad assessment of their overall results.

This study sets to investigate the effect of environmental taxation policy on emissions in the construction sector and to evaluate the extent of the policies implemented on combating emissions in the European area. By using data sets for 30 countries over the period 2012-2018, a regression model is estimated. The concurrent relationship between emissions and environmental taxation resulted in an endogeneity problem (reverse causality) that produced biased estimates, which was addressed by the use of a CF method approach. The outcomes indicate that the model established, which assumes a relationship between GHG emissions, GDP per capita and taxation, can produce valid results. Consequently, present study provides the estimation results of the regression model and the effect of each variable on GHG emissions, for two different classifications of the under-study countries.

As indicated in the introductory sections, environmental taxation is applied in European countries for many years and research explaining the impacts and effectiveness on

emissions has been conducted. Scientific analysis in the construction sector remains less comprehensive and, consequently, fewer clear conclusions have been drawn. This study has revealed that despite the differences in the institutional, economic and market conditions that prevail amongst countries, environmental taxes affect the environmental performance, and taxation influences negatively GHG emissions; the intensity of the impact varies depending on the categories of countries studied; variances also occur in the effectiveness of environmental taxation between the groups of countries formed; in particular, the study has indicated that the environmental taxation has no effect to the case of Cyprus; the amount of GHG emissions have an impact on the environmental taxes imposed (endogeneity problem). Therefore, the implementation of environmental taxes can be used as an instrument in order to promote the goal of mitigating the emission challenges.

The relationship between GHG emissions and ratio of environmental taxation differs between the various country groups. This can be explained due to the use of different fossil fuel consumption or of dissimilar pricing modelling or subsidizing of fossil fuels. In certain classification of countries, the GHG emissions decreases with increasing environmental taxation, whereas for other classifications this parameter remains not relevant. Cyprus being one of the latter category countries, should target its efforts at the implementation of policies that are geared towards an increase in the environmental taxation ratio, in order to increase the effect of said parameter on emissions.

The various groups of countries examined, show that an increase in environmental taxation decreases GHG emissions, in a different extent, as for example groups of countries that belong to high (Group 1) and low (Group 2) levels of economic development. Interestingly, this finding cannot support a hypothesis that highly developed countries, which are assumed to follow more stringent environmental standards and stricter monitoring and enforcement systems of environmental regulations compared with lower developed countries, produce lower emissions.

6.2 Recommendations

Accordingly, policymakers should consider that environmental regulation should address the environment degradation in all countries, however the heterogeneity that is observed should be treated in a more focused way. Taxation policies are assumed to be the ones that can contribute both in the long run, but also in the immediate future, with direct impact on emissions. In this section recommendations for policymakers are pulled together towards the design and implementation of environmentally effective environmental taxes. The variance observed, however, in different groups of countries causes the objectives of measures and their environmental impact to be less clear. As demonstrated in the study, taxation can have a significant role in addressing issues related with the GDP and GHG emissions; however, the successful application of policies in practice is often restricted in countries where environmental tax rates are too low, such as the case of Cyprus; or where the potential benefits cannot be appreciated or clearly evaluated or monetized. Subsequently, appropriate taxing interventions should be considered by policymakers; these can have a twofold purpose namely, to be effective in achieving the targets of reducing emissions and to act as a drive for economic growth at its own sake (OECD, 2010); at the same time, environmental taxation may aim directly on the pollutants in order to incorporate the environmental damage to the cost of the final product or service.

The readiness of politicians to impose higher taxes or to re-distribute the taxation coefficients, poses challenges when designing and implementing taxation instruments. In the light of this, there is a need to overcome opposition, and intervene through such policies which will meet the political acceptance so as to achieve the change required and to gain substantial environmental benefits without creating risks of market distortion. In countries where environmental taxation levels are still low, the introduction of a progressive tax rate increase can be considered, which can be combined in parallel with the introduction of compensation mechanisms, targeting at a greener transition, for instance by funding the acquisition of low-carbon, and/ or energy efficient technologies. Yet, the introduction of new taxation should take into

consideration the political will and monitoring mechanisms to reform the tax system, in a way so as to minimize risks for tax evasion.

Specific measures to improve the environmental degradation caused by the construction sector, can be implemented in the countries where the sector is exempted from taxation, or obtains subsidies. These measures should be shaped in a targeted, time-restricted way and be subject to monitoring and reevaluation so as to ensure the effectiveness of the environmental targets. Moreover, any possible exemptions or subsidies provided (in the form of low-cost loans or preferential interest rates for upgrading of machinery and equipment for use of green technologies, or for the use of renewable energy), have the meaning of incentives in order to minimize the risks and costs of the construction industry market; thus, these should be designed also with the aim of ensuring the presence of a framework with a direct relation to investments for the use of upgraded and low emission or low energy consumption technologies and processes.

The short time frame period examined obviously poses a limitation of the study, considering that the effects of policy interventions need time to produce results and to provide more observations to determine the validation of the results extracted by the data. This may be more crucial when picturing the heterogeneity of the countries examined, as well as the reverse causality observed between GHG emissions, and taxation. A recommendation for future research study should focus on the issues described in the limitation's sub-section of Chapter 3, which are assumed to have an effect in the regression estimation.

In the EU, for the period examined, the Construction sector accounts for 5-5.5% of EU's GDP (EUROSTAT, 2022). Yet, as mentioned above, the construction industry consumes over 40% of Europe's energy and is responsible for 36% of CO_2 emissions. Any possible improvement in the efficiency along infrastructure's life cycle can have a considerable positive impact in the environment. Moreover, the aftermath to the economy can emerge as distressing, should the implementation of environmental regulation rely on existing technologies alone. Therefore, the necessity for an environmentally friendly construction sector requires an innovative change in the way energy consumption and production methods, systems and technologies are

developed and implemented over time. What is equally important, is that innovation is vital in realizing the goals of minimizing GHG emissions at a reasonable cost. However, innovation in construction, may occur at slower steps compared to other industries, since construction is a high labour intensive and complex industry, which in general has low productivity levels compared for example to the manufacturing industry. As such a further study could focus on the role and effect of innovation in the reduction of emissions of the sector.

Concluding, policymakers should consider the role of environmental taxation, which has showed to be an effective instrument in combating emissions; this is of particular importance in economies which do not fully exploit the potential of environmental taxes and is therefore, essential for states to intervene and implement control mechanisms that allow the realization of the environmental objectives of the countries. Since any consequences of flawed-designed actions can be discouraging, an adjusted taxation design, (which could include the harmonization of taxing systems of the EU countries so as to enable the prevention of tax competition), may also allow for a more balanced approach between environmental effectiveness, fiscal goals and revenue distribution, development of private investments and innovation, that will be used as an efficient policy instrument for the environmental protection.

Appendices

Appendix A- Dataset used

Table a -List of dataset used

Year	Country	T_{it}	GDP_{it}	$(GDP_{it})^2$	Number of active enterprises (0-49) k_{1it}	Number of active enterprises (50 to 249) k_{3it}	Number of active enterprises (over 250) k_{2it}	E_{it}	E_{it-1}	First Stage Residuals $\hat{v}_{it}$
1	Austria	-6.56754	10.50205	110.29304	10.35755	6.41182	4.26268	14.04647	14.06416	-0.06072
2	Austria	-6.60413	10.49626	110.17151	10.40056	6.34564	4.24850	14.03618	14.04647	-0.08456
3	Austria	-6.61993	10.49488	110.14248	10.42115	6.39192	4.21951	13.88158	14.03618	-0.09954
4	Austria	-6.64043	10.49516	110.14829	10.43158	6.36647	4.21951	13.80848	13.88158	-0.06489
5	Austria	-6.61709	10.50205	110.29304	10.44622	6.38856	4.23411	13.73017	13.80848	-0.01509
6	Austria	-6.59906	10.51948	110.65954	10.47661	6.40688	4.31749	13.86085	13.73017	0.03790
7	Austria	-6.30527	10.54006	111.09296	10.46707	6.48311	4.36945	13.92657	13.86085	0.28690
1	Belgium	-5.97281	10.41900	108.55561	11.46168	6.19236	4.00733	14.98312	14.94802	0.11287
2	Belgium	-6.02559	10.41900	108.55561	11.47468	6.19032	4.00733	14.99187	14.98312	0.04953
3	Belgium	-6.11853	10.43028	108.79084	11.56619	6.16542	3.93183	14.87134	14.99187	-0.03896
4	Belgium	-6.26047	10.44465	109.09068	11.53453	6.13123	4.00733	14.88495	14.87134	-0.13501
5	Belgium	-6.13895	10.45219	109.24821	11.57045	6.15060	3.98898	14.86463	14.88495	-0.01602
6	Belgium	-6.15134	10.46453	109.50641	11.64490	6.16752	4.09434	14.79593	14.86463	-0.00830
7	Belgium	-6.14090	10.47757	109.77947	11.55967	5.99146	4.20469	14.77246	14.79593	0.03589
1	Bulgaria	-5.14152	8.58485	73.69968	9.82666	6.22059	3.78419	13.39178	13.29268	0.28882
2	Bulgaria	-5.15805	8.59415	73.85949	9.80863	6.21461	3.87120	13.16666	13.39178	0.24312
3	Bulgaria	-5.30372	8.61794	74.26894	9.81788	6.21060	3.93183	13.37299	13.16666	0.18118
4	Bulgaria	-5.25003	8.66389	75.06295	9.84315	6.19441	3.87120	13.62780	13.37299	0.17025
5	Bulgaria	-5.68980	8.70781	75.82602	9.85277	6.17379	3.55535	13.22712	13.62780	-0.36599
6	Bulgaria	-5.77683	8.74989	76.56059	9.87102	6.20051	3.55535	13.20547	13.22712	-0.31184
7	Bulgaria	-5.68201	8.78722	77.21524	9.89172	6.23637	3.55535	13.38381	13.20547	-0.20554
1	Croatia	-6.01608	9.24087	85.39367	9.89888	5.42495	3.55535	14.06106	14.12361	-0.03717
2	Croatia	-5.93738	9.23990	85.37574	9.85119	5.39816	3.52636	14.11864	14.06106	0.05823
3	Croatia	-5.87471	9.24087	85.39367	9.80461	5.36598	3.33220	14.06098	14.11864	0.08844
4	Croatia	-6.02531	9.27144	85.95952	9.76008	5.39816	3.25810	14.05231	14.06098	-0.04925
5	Croatia	-6.02827	9.31470	86.76364	9.76164	5.38907	3.17805	14.00886	14.05231	-0.04784
6	Croatia	-5.98966	9.35876	87.58640	9.78346	5.44242	3.21888	14.19716	14.00886	0.01171
7	Croatia	-5.96220	9.39599	88.28462	9.82871	5.49717	3.13549	14.20038	14.19716	-0.02411
1	Cyprus	-5.72173	9.98875	99.77507	9.05824	3.85015	1.38629	11.58116	11.79532	-0.04999

2	Cyprus	-5.84870	9.92329	98.47169	8.93076	0.00000	0.00000	11.36910	11.58116	0.03947
3	Cyprus	-5.88863	9.91591	98.32527	8.87627	0.00000	0.00000	11.37207	11.36910	0.06557
4	Cyprus	-5.78175	9.95323	99.06678	8.90544	3.29584	0.00000	11.40986	11.37207	-0.02609
5	Cyprus	-5.70830	10.01100	100.22004	8.89494	3.55535	0.00000	11.56261	11.40986	0.02420
6	Cyprus	-5.66877	10.05191	101.04085	8.96687	3.85015	0.00000	11.70896	11.56261	0.00514
7	Cyprus	-5.74615	10.09080	101.82418	9.03658	3.97029	1.09861	11.71403	11.70896	-0.05829
1	Czechia	-5.80974	9.62708	92.68057	12.07324	6.41999	4.14313	14.81961	14.84729	-0.06918
2	Czechia	-5.86629	9.62642	92.66788	12.04274	6.36130	3.97029	14.74639	14.81961	-0.12509
3	Czechia	-5.64145	9.64730	93.07048	12.04476	6.30262	3.98898	14.74474	14.74639	0.13195
4	Czechia	-5.66520	9.69831	94.05715	12.05467	6.26149	4.00733	14.76766	14.74474	0.11926
5	Czechia	-5.77906	9.72137	94.50496	12.06888	6.21461	3.91202	14.83738	14.76766	-0.00063
6	Czechia	-5.78810	9.76938	95.44087	12.08303	6.19848	3.95124	14.87300	14.83738	-0.02323
7	Czechia	-5.79604	9.79757	95.99240	12.10678	6.20456	4.04305	14.90022	14.87300	-0.03308
1	Denmark	-5.86608	10.69580	114.40016	10.34013	5.74620	3.61092	14.20764	14.32746	-0.00702
2	Denmark	-5.97814	10.70122	114.51611	10.32108	5.71043	3.66356	14.01992	14.20764	-0.07444
3	Denmark	-6.02490	10.71197	114.74631	10.33854	5.82305	3.73767	14.11869	14.01992	-0.05743
4	Denmark	-5.91831	10.72832	115.09686	10.33472	5.91350	3.78419	14.18199	14.11869	0.01407
5	Denmark	-5.96201	10.75193	115.60395	10.36088	5.81711	3.63759	14.21524	14.18199	-0.04790
6	Denmark	-5.82502	10.77352	116.06884	10.38115	5.88332	3.63759	14.27365	14.21524	0.07813
7	Denmark	-5.78353	10.78829	116.38715	10.39986	6.02345	3.63759	14.31210	14.27365	0.09459
1	Estonia	-5.60442	9.41898	88.71717	9.02244	4.36945	2.30259	12.18280	11.73593	0.14619
2	Estonia	-5.64520	9.43668	89.05091	9.07966	4.45435	2.19722	12.08175	12.18280	-0.04995
3	Estonia	-5.68509	9.46962	89.67376	9.09919	4.26268	2.30259	11.90021	12.08175	-0.03213
4	Estonia	-5.87639	9.49024	90.06470	9.15070	4.24850	2.19722	11.80704	11.90021	-0.15929
5	Estonia	-5.72954	9.51929	90.61697	9.21910	4.26268	2.07944	12.09209	11.80704	0.02181
6	Estonia	-5.61374	9.57568	91.69360	9.29293	4.12713	2.07944	11.94166	12.09209	0.06278
7	Estonia	-5.73454	9.61380	92.42522	9.35158	4.11087	2.19722	11.92592	11.94166	0.01059
1	Finland	-6.13499	10.46710	109.56009	10.65726	5.49717	3.61092	14.18613	14.14932	0.06045
2	Finland	-6.08158	10.45334	109.27235	10.65937	5.39363	3.52636	14.23345	14.18613	0.10174
3	Finland	-6.19188	10.44552	109.10891	10.63388	5.60947	3.58352	14.06721	14.23345	-0.03826
4	Finland	-6.29960	10.44755	109.15140	10.62840	5.66643	3.58352	13.88705	14.06721	-0.09330
5	Finland	-6.25141	10.47249	109.67300	10.61022	5.70044	3.80666	14.05549	13.88705	0.02738
6	Finland	-6.25820	10.50177	110.28727	10.61474	5.80212	3.87120	14.10222	14.05549	-0.03557
7	Finland	-6.23242	10.51162	110.49418	10.60735	5.79301	3.91202	14.19272	14.10222	-0.02242
1	France	-6.82284	10.34689	107.05814	13.14334	7.57866	5.73010	16.01754	16.02201	0.17452
2	France	-6.90397	10.34721	107.06478	13.18884	7.49220	5.78383	16.02075	16.01754	0.10756
3	France	-7.00913	10.35201	107.16416	13.26041	7.30452	5.43372	16.02261	16.02075	0.00121
4	France	-7.08303	10.35901	107.30913	13.10708	7.28413	5.42053	16.03191	16.02261	-0.08650
5	France	-7.14043	10.36628	107.45971	13.13297	7.30452	5.43372	16.02907	16.03191	-0.14429
6	France	-7.05949	10.38468	107.84154	13.05464	7.32712	5.26786	16.05666	16.02907	-0.07811
7	France	-6.94697	10.39879	108.13490	13.06187	7.36455	5.27811	16.04550	16.05666	0.02561
1	Germany	-6.43499	10.41271	108.42457	12.50809	8.08703	5.45104	16.09899	16.12599	0.12152
2	Germany	-6.53194	10.41421	108.45584	12.48470	8.11313	5.51343	16.18888	16.09899	0.03349
3	Germany	-6.52601	10.43176	108.82162	12.72154	8.13652	5.45104	16.15417	16.18888	0.02854
4	Germany	-6.58368	10.43793	108.95043	12.70293	8.15133	5.44674	16.27642	16.15417	-0.01953
5	Germany	-6.51091	10.45190	109.24217	12.78016	8.17611	5.56834	16.27202	16.27642	0.02577

6	Germany	-6.62742	10.47475	109.72038	12.72006	8.24460	5.63121	16.15089	16.27202	-0.09309
7	Germany	-6.69146	10.48263	109.88544	12.77413	8.25842	5.88888	16.12782	16.15089	-0.09670
1	Greece	-6.70230	9.73743	94.81760	11.37005	5.16479	2.56495	13.63344	13.65690	-0.07090
2	Greece	-6.61311	9.71716	94.42316	11.34395	5.05625	2.48491	12.76248	13.63344	0.02377
3	Greece	-6.80175	9.73032	94.67920	11.37175	4.94164	2.89037	12.92070	12.76248	0.16454
4	Greece	-6.86580	9.73329	94.73698	11.21443	4.89035	2.39790	13.09760	12.92070	0.00845
5	Greece	-6.88620	9.73211	94.71389	11.25263	4.90527	2.48491	13.11614	13.09760	-0.06476
6	Greece	-6.81119	9.74683	95.00077	11.02978	4.91265	2.56495	13.06374	13.11614	-0.01154
7	Greece	-6.86584	9.76423	95.34010	10.99529	5.14749	2.83321	12.99987	13.06374	-0.04955
1	Hungary	-7.54506	9.21930	84.99549	11.00188	5.60212	3.25810	13.38102	13.46036	-1.44988
2	Hungary	-5.83290	9.24087	85.39367	10.91830	5.62402	2.83321	13.60278	13.38102	0.25930
3	Hungary	-5.83492	9.28452	86.20231	10.94139	5.63121	2.99573	13.72620	13.60278	0.19766
4	Hungary	-5.78312	9.32456	86.94745	11.00909	5.65948	2.77259	13.82970	13.72620	0.20472
5	Hungary	-5.76627	9.34836	87.39187	11.06004	5.62040	2.77259	13.86665	13.82970	0.19645
6	Hungary	-5.72418	9.39349	88.23775	11.14694	5.66988	2.83321	13.89460	13.86665	0.23977
7	Hungary	-5.62532	9.44778	89.26057	11.27557	5.78690	3.04452	14.05485	13.89460	0.35198
1	Ireland	-7.40576	10.51244	110.51134	10.80902	4.02535	2.19722	12.72033	12.45785	-0.05668
2	Ireland	-7.25508	10.52029	110.67658	10.78781	4.18965	2.19722	12.66182	12.72033	-0.00649
3	Ireland	-7.04182	10.59688	112.29397	10.76308	4.48864	2.77259	12.85352	12.66182	0.24615
4	Ireland	-7.15481	10.81215	116.90257	10.82838	4.61512	2.56495	12.91770	12.85352	0.08032
5	Ireland	-7.19466	10.82098	117.09356	10.84782	4.88280	2.63906	12.98394	12.91770	0.00897
6	Ireland	-7.24022	10.89544	118.71066	10.95226	5.04343	2.83321	13.05817	12.98394	-0.03983
7	Ireland	-7.41988	10.96992	120.33917	10.95827	5.18178	3.04452	13.10552	13.05817	-0.23244
1	Italy	-5.96093	10.17199	103.46932	13.25531	7.12044	4.36945	15.61233	15.67668	0.05749
2	Italy	-6.00809	10.15113	103.04541	13.21519	7.03174	4.36945	15.61764	15.61233	0.03145
3	Italy	-6.05082	10.15113	103.04541	13.17682	6.94794	4.36945	15.60348	15.61764	-0.01152
4	Italy	-6.06100	10.16045	103.23480	13.14272	6.94698	4.38203	15.59368	15.60348	-0.01828
5	Italy	-6.05914	10.17504	103.53144	13.13733	6.97915	4.38203	15.57417	15.59368	-0.01389
6	Italy	-6.07666	10.19354	103.90829	13.12550	7.02376	4.40672	15.54485	15.57417	-0.02515
7	Italy	-6.08372	10.20507	104.14351	13.10702	7.08423	4.52179	15.56999	15.54485	-0.02011
1	Latvia	-5.32405	9.18502	84.36464	8.95867	5.35659	2.48491	12.49435	12.47888	0.10018
2	Latvia	-5.47799	9.21831	84.97721	9.05357	5.31812	2.63906	12.33968	12.49435	-0.03530
3	Latvia	-5.46630	9.23893	85.35779	9.12750	5.31321	2.77259	12.30536	12.33968	0.04598
4	Latvia	-5.36898	9.28638	86.23676	9.29303	5.19850	2.63906	12.41579	12.30536	0.17608
5	Latvia	-5.51205	9.31919	86.84739	9.35721	5.05625	2.56495	12.31018	12.41579	0.01021
6	Latvia	-5.73976	9.36048	87.61864	9.34260	5.09987	2.48491	12.29472	12.31018	-0.18522
7	Latvia	-5.67279	9.40755	88.50201	9.34540	5.17615	2.48491	12.33362	12.29472	-0.11193
1	Lithuania	-6.87103	9.24281	85.42949	9.89848	5.73657	3.46574	11.24181	11.25710	-0.25471
2	Lithuania	-6.10386	9.28823	86.27116	10.01695	5.70711	3.46574	11.32175	11.24181	0.53606
3	Lithuania	-6.33950	9.33167	87.08011	10.21108	5.71703	3.58352	11.50120	11.32175	0.30259
4	Lithuania	-6.69259	9.36048	87.61864	10.26580	5.70044	3.55535	11.36876	11.50120	-0.10341
5	Lithuania	-6.74246	9.39848	88.33139	10.33624	5.66296	3.49651	11.47343	11.36876	-0.09802
6	Lithuania	-6.76759	9.45407	89.37945	10.35405	5.66988	3.52636	11.62016	11.47343	-0.14929
7	Lithuania	-6.81866	9.50226	90.29301	10.38056	5.60212	3.61092	11.68881	11.62016	-0.23322
1	Luxembourg	-6.54920	11.25467	126.66766	8.07278	4.96284	2.77259	11.91466	12.03779	-0.33919
2	Luxembourg	-6.77597	11.26485	126.89682	8.11791	4.96284	2.70805	11.85178	11.91466	-0.52216

3	Luxembourg	-6.18596	11.28339	127.31481	8.12770	4.91998	2.89037	11.94434	11.85178	0.10494
4	Luxembourg	-6.13537	11.30590	127.82340	8.15220	4.98361	2.83321	12.07319	11.94434	0.12197
5	Luxembourg	-6.12669	11.32515	128.25900	8.18813	4.95583	2.99573	11.96530	12.07319	0.10314
6	Luxembourg	-5.98059	11.32116	128.16865	8.22951	5.08140	2.94444	12.02809	11.96530	0.27875
7	Luxembourg	-6.00861	11.33224	128.41972	8.26848	5.03044	3.21888	12.04639	12.02809	0.25254
1	Malta	-5.86864	9.73920	94.85206	8.24670	0.00000	0.00000	9.53935	9.26662	-0.26160
2	Malta	-5.81636	9.77849	95.61889	8.19008	0.00000	0.00000	10.03616	9.53935	-0.30275
3	Malta	-5.48669	9.83145	96.65749	8.21257	0.00000	0.00000	10.11984	10.03616	-0.13355
4	Malta	-5.19532	9.89948	97.99969	8.19561	0.00000	0.00000	9.95049	10.11984	0.13577
5	Malta	-5.24663	9.91393	98.28606	8.27487	3.04452	1.38629	9.87251	9.95049	0.03782
6	Malta	-5.20631	9.99012	99.80257	8.26359	0.00000	0.00000	9.77506	9.87251	0.22593
7	Malta	-5.18085	10.01458	100.29184	8.37954	0.00000	0.00000	9.62354	9.77506	0.29839
1	Netherlands	-6.44429	10.55425	111.39217	11.80290	6.71780	4.80402	14.98820	15.03631	-0.18817
2	Netherlands	-6.46726	10.55007	111.30392	11.92923	6.64898	4.71850	14.95100	14.98820	-0.18369
3	Netherlands	-6.27332	10.56049	111.52393	11.94440	6.52649	4.72739	14.93111	14.95100	0.03365
4	Netherlands	-6.22096	10.57567	111.84472	11.98264	6.51619	4.58497	14.93203	14.93111	0.09104
5	Netherlands	-6.22600	10.59187	112.18778	12.02125	6.51619	4.56435	14.96096	14.93203	0.09013
6	Netherlands	-6.24167	10.61472	112.67228	12.06091	6.55393	4.56435	14.97114	14.96096	0.06873
7	Netherlands	-6.22615	10.63224	113.04459	12.13786	6.61070	4.59512	15.04728	14.97114	0.08831
1	Norway	-6.07997	11.11095	123.45330	10.86565	5.91889	3.78419	14.45223	14.32744	-0.15744
2	Norway	-5.95649	11.10916	123.41341	10.88986	5.96871	3.76120	14.53120	14.45223	-0.07863
3	Norway	-5.90865	11.11751	123.59902	10.90975	5.98896	3.78419	14.49895	14.53120	-0.05476
4	Norway	-5.82060	11.12667	123.80289	10.93676	6.00389	3.78419	14.53412	14.49895	0.04697
5	Norway	-5.80651	11.12859	123.84542	10.94912	6.06843	3.71357	14.52335	14.53412	0.04264
6	Norway	-5.70932	11.14374	124.18303	10.95862	6.15698	3.80666	14.55633	14.52335	0.14575
7	Norway	-5.80128	11.14822	124.28277	10.92768	6.20658	4.14313	14.48847	14.55633	0.05546
1	Poland	-5.99833	9.20834	84.79350	12.35426	7.38337	5.16479	13.99650	14.09004	0.25196
2	Poland	-6.19815	9.22029	85.01376	12.31152	7.24494	5.01728	13.87770	13.99650	0.08181
3	Poland	-6.39108	9.25340	85.62541	12.34149	7.20042	5.03695	13.80383	13.87770	-0.06017
4	Poland	-6.39376	9.29560	86.40818	12.40042	7.18690	4.90527	13.74618	13.80383	-0.03355
5	Poland	-6.43801	9.32723	86.99730	12.48001	7.14835	4.95583	13.76295	13.74618	-0.04179
6	Poland	-6.46819	9.37501	87.89076	12.54455	7.13250	4.93447	13.82650	13.76295	-0.06610
7	Poland	-6.53062	9.42706	88.86952	12.68930	7.14362	4.91265	13.80700	13.82650	-0.13216
1	Portugal	-6.03051	9.68720	93.84176	11.37405	6.22258	3.98898	14.15229	14.39071	0.00880
2	Portugal	-6.23325	9.68346	93.76948	11.30002	6.13123	3.95124	13.96173	14.15229	-0.11677
3	Portugal	-6.22118	9.69646	94.02140	11.25624	6.07074	3.91202	13.93632	13.96173	-0.04095
4	Portugal	-6.13605	9.71836	94.44656	11.25710	6.05912	3.91202	14.07311	13.93632	0.05619
5	Portugal	-6.10013	9.74156	94.89793	11.26902	6.12030	4.00733	14.03197	14.07311	0.05089
6	Portugal	-6.13558	9.77849	95.61889	11.30341	6.17794	3.89182	14.09401	14.03197	0.02714
7	Portugal	-6.12816	9.80863	96.20917	11.34719	6.28227	3.89182	14.09784	14.09401	0.01469
1	Romania	-6.50401	8.77956	77.08063	10.67782	7.00488	4.80402	14.93338	14.88167	-0.07731
2	Romania	-6.46779	8.82026	77.79692	10.69813	6.92756	4.48864	14.92173	14.93338	-0.06436
3	Romania	-6.33203	8.85936	78.48832	10.75300	6.86276	4.46591	14.89643	14.92173	0.08794
4	Romania	-6.35192	8.89426	79.10784	10.76291	6.91672	4.56435	14.95128	14.89643	0.08372
5	Romania	-6.29392	8.94507	80.01431	10.79208	6.89568	4.55388	14.92592	14.95128	0.13255
6	Romania	-6.48723	9.02160	81.38923	10.85507	6.82437	4.33073	14.95023	14.92592	-0.04492

7	Romania	-6.56430	9.07108	82.28446	10.91432	6.81674	4.34381	14.96181	14.95023	-0.11762
1	Slovakia	-6.26173	9.48949	90.05035	11.36461	5.18178	2.89037	14.46415	14.59459	-0.12507
2	Slovakia	-6.17588	9.49477	90.15060	11.31098	5.14166	2.83321	14.40308	14.46415	0.00002
3	Slovakia	-6.00336	9.52003	90.63094	11.35902	5.06260	2.63906	14.45515	14.40308	0.19512
4	Slovakia	-5.96219	9.56591	91.50672	11.34848	5.12396	2.48491	14.44385	14.45515	0.21076
5	Slovakia	-6.07347	9.58535	91.87886	11.37918	5.12990	2.70805	14.45914	14.44385	0.12034
6	Slovakia	-6.29069	9.61380	92.42522	11.46080	5.17615	2.77259	14.50278	14.45914	-0.09035
7	Slovakia	-6.51487	9.64795	93.08294	11.52896	5.09987	2.83321	14.50253	14.50278	-0.31083
1	Slovenia	-6.93193	9.76192	95.29516	9.81384	4.57471	2.30259	13.50711	13.52405	-0.09656
2	Slovenia	-6.79185	9.75034	95.06906	9.79635	4.47734	2.30259	13.43587	13.50711	0.05230
3	Slovenia	-6.78673	9.77679	95.58562	9.80029	4.43082	2.30259	13.40679	13.43587	0.08800
4	Slovenia	-6.77247	9.79757	95.99240	9.80868	4.46591	2.39790	13.49110	13.40679	0.11841
5	Slovenia	-6.77130	9.82823	96.59401	9.83162	4.40672	2.39790	13.60864	13.49110	0.10038
6	Slovenia	-6.91349	9.87509	97.51736	9.82914	4.51086	2.30259	13.69832	13.60864	-0.08815
7	Slovenia	-6.96813	9.91542	98.31548	9.84829	4.63473	2.30259	13.79068	13.69832	-0.17439
1	Spain	-7.07057	10.00243	100.04856	12.67490	7.00397	4.99043	13.53482	13.62398	-0.22401
2	Spain	-6.94432	9.99150	99.83004	12.67308	6.81783	4.85981	13.04824	13.53482	-0.06449
3	Spain	-6.99943	10.00830	100.16603	12.75364	6.79459	4.79579	13.03394	13.04824	0.05331
4	Spain	-6.96986	10.04672	100.93662	12.83906	6.93440	4.82028	13.10655	13.03394	0.09302
5	Spain	-6.97625	10.07576	101.52091	12.81147	6.98934	4.77912	13.19930	13.10655	0.05709
6	Spain	-6.97892	10.10357	102.08207	12.83460	7.03351	4.87520	13.26569	13.19930	0.03087
7	Spain	-6.91896	10.12302	102.47563	12.84360	7.33694	4.90527	13.27901	13.26569	0.05420
1	Sweden	-5.87953	10.60609	112.48914	11.44150	6.10032	3.80666	14.52808	14.55293	0.05052
2	Sweden	-5.85154	10.60930	112.55733	11.44952	6.13773	3.89182	14.51711	14.52808	0.09042
3	Sweden	-5.99236	10.62571	112.90567	11.47361	6.21661	3.87120	14.48345	14.51711	-0.04848
4	Sweden	-6.00169	10.65914	113.61726	11.49606	6.29895	3.97029	14.50619	14.48345	-0.04002
5	Sweden	-5.96503	10.66709	113.78688	11.52509	6.37843	4.00733	14.47274	14.50619	-0.01031
6	Sweden	-5.98810	10.67891	114.03903	11.54662	6.42487	3.97029	14.42095	14.47274	-0.02349
7	Sweden	-6.01285	10.68648	114.20076	11.49532	6.68960	4.56435	14.40734	14.42095	-0.01864
1	Switzerland	-5.94096	10.98224	120.60953	9.86542	6.63595	4.14313	14.12586	14.09343	0.00798
2	Switzerland	-5.95212	10.98868	120.75102	9.91551	6.63068	4.17439	14.12778	14.12586	-0.00667
3	Switzerland	-5.98295	11.00077	121.01684	9.94271	6.68211	4.14313	14.07646	14.12778	-0.03905
4	Switzerland	-5.96638	11.00576	121.12675	9.93707	6.71296	4.24850	14.04717	14.07646	-0.00115
5	Switzerland	-5.99478	11.01502	121.33058	9.92764	6.68586	4.30407	14.02042	14.04717	-0.01469
6	Switzerland	-5.97036	11.02141	121.47153	9.93003	6.69950	4.31749	14.00966	14.02042	0.01969
7	Switzerland	-5.96409	11.04292	121.94612	9.92584	6.69950	4.35671	13.98905	14.00966	0.03389
1	UK	-5.91338	10.31527	106.40471	12.44903	7.53476	5.75890	16.31817	16.25801	0.09658
2	UK	-6.03839	10.33071	106.72365	12.47013	7.51752	5.72031	16.25114	16.31817	-0.04609
3	UK	-6.02367	10.35105	107.14432	12.50106	7.51316	5.75257	16.28177	16.25114	-0.00123
4	UK	-6.00147	10.36659	107.46624	12.57335	7.54908	5.76205	16.36255	16.28177	0.01752
5	UK	-5.96321	10.37536	107.64819	12.65265	7.56216	5.73334	16.39017	16.36255	0.03450
6	UK	-6.06801	10.38684	107.88643	12.70147	7.60489	5.72359	16.41837	16.39017	-0.07689
7	UK	-6.16481	10.39329	108.02056	12.68285	7.60489	5.72359	16.41077	16.41837	-0.02440

Source: EUROSTAT, Author's compilation

Table b- Descriptive Statistics for variables used in analysis

Variable Abbreviation	Variable Description	Mean	Minimum	Maximum	Standard Deviation
Austria					
Em	*GHG emissions on year t (in Tonnes)*	1,092,865	918,200	1,259,811	126,129
Empc	*GHG emissions on year t per capita (in Tonnes)*	0.1270			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	1,116,413	918,200	1,282,299	145,402
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	213	191	302	40
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000025			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	36,580	36,130	37,800	622
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	1,338,427,714	1,305,376,900	1,428,840,000	45,928,761
Pop	*Population (on 1 January - total)*	8,606,899	8,408,121	8,822,267	161,524
Total tax rev	*Main national accounts tax aggregates on year t (in million Euro)*	149,449	135,755	165,149	9,973
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.017364			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.001418	0.001306	0.001827	0.000183
k1	*Number of active enterprises (0-49)*	33,840	31,494	35,476	1,367
k2	*Number of active enterprises (50-249)*	602	570	654	27
k3	*Number of active enterprises (over 250)*	71	68	79	4
Belgium					
Em	*GHG emissions on year t (in Tonnes)*	2,909,914	2,603,754	3,242,542	245,288
Empc	*GHG emissions on year t per capita (in Tonnes)*	0.2588			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	2,981,298	2,665,581	3,242,542	211,757
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	440	377	471	33
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000039			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	34,341	33,490	35,510	776
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	1,179,850,529	1,121,580,100	1,260,960,100	53,470,032
Pop	*Population (on 1 January - total)*	11,241,916	11,075,889	11,398,589	117,979
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	199,236	184,753	217,084	11,075
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.017723			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002217	0.001910	0.002547	0.000207
k1	*Number of active enterprises (0-49)*	103,389	95,005	114,108	6,459
k2	*Number of active enterprises (50-249)*	466	400	489	31
k3	*Number of active enterprises (over 250)*	57	51	67	5

Bulgaria					
Em	*GHG emissions on year t (in Tonnes)*	628,067	522,645	828,852	104,307
Empc	*GHG emissions on year t per capita (in Tonnes)*	0.0873			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	619,986	522,645	828,852	104,570
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	60	48	70	9
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000008			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	5,854	5,350	6,550	465
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	34,458,371	28,622,500	42,902,500	5,517,301
Pop	*Population (on 1 January - total)*	7,195,047	7,050,034	7,327,224	99,592
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	13,578	11,228	16,811	2,015
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.001887			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.004530	0.003099	0.005849	0.001196
k1	*Number of active enterprises (0-49)*	18,862	18,190	19,766	564
k2	*Number of active enterprises (50-249)*	496	480	511	10
k3	*Number of active enterprises (over 250)*	42	35	51	7
Croatia					
Em	*GHG emissions on year t (in Tonnes)*	1,332,179	1,213,302	1,469,422	100,866
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,3165			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	1,316,667	1,213,302	1,464,700	83,011
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	44	39	51	4
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000010			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	10,899	10,300	12,040	702
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	119,201,529	106,090,000	144,961,600	15,594,024
Pop	*Population (on 1 January - total)*	4,208,661	4,105,493	4,275,984	61,991
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	17,235	15,849	19,917	1,543
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.004095			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002542	0.002410	0.002810	0.000146
k1	*Number of active enterprises (0-49)*	18,284	17,328	19,908	940
k2	*Number of active enterprises (50-249)*	225	214	244	10
k3	*Number of active enterprises (over 250)*	28	23	35	5
Cyprus					
Em	*GHG emissions on year t (in Tonnes)*	102,823	86,604	122,275	15,455
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,1200			

EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	104,302	86,604	132,630	17,926
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	20	16	23	3
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000023			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	21,863	20,250	24,120	1,444
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	479,771,229	410,062,500	581,774,400	63,847,115
Pop	*Population (on 1 January - total)*	857,179	847,008	865,878	7,495
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	6,240	5,725	7,183	514
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.007280			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.003140	0.002771	0.003452	0.000243
k1	*Number of active enterprises (0-49)*	7,746	7,160	8,589	559
k2	*Number of active enterprises (50-249)*	30	-	53	22
k3	*Number of active enterprises (over 250)*	1	-	4	2
Czechia					
Em	*GHG emissions on year t (in Tonnes)*	2,715,158	2,532,546	2,958,589	168,760
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,2575			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	2,693,366	2,532,546	2,879,138	139,378
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	193	158	231	25
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000018			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	16,321	15,160	17,990	1,130
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	267,482,586	229,825,600	323,640,100	37,263,570
Pop	*Population (on 1 January - total)*	10,544,997	10,505,445	10,610,055	38,642
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	61,570	53,914	75,968	8,103
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.005839			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.003148	0.002833	0.003548	0.000259
k1	*Number of active enterprises (0-49)*	174,199	169,862	181,095	3,989
k2	*Number of active enterprises (50-249)*	536	492	614	47
k3	*Number of active enterprises (over 250)*	55	50	63	4
Denmark					
Em	*GHG emissions on year t (in Tonnes)*	1,459,913	1,226,804	1,643,112	138,732
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,2574			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	1,463,546	1,226,804	1,668,545	144,541
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	354	310	420	42
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000062			

GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	46,001	44,170	48,450	1,673
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	2,118,530,643	1,950,988,900	2,347,402,500	154,803,166
Pop	*Population (on 1 January - total)*	5,672,472	5,580,516	5,781,190	75,712
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	129,839	119,328	137,182	6,809
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.022889			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002726	0.002418	0.003078	0.000239
k1	*Number of active enterprises (0-49)*	31,386	30,366	32,855	892
k2	*Number of active enterprises (50-249)*	347	302	413	37
k3	*Number of active enterprises (over 250)*	39	37	44	3
Estonia					
Em	*GHG emissions on year t (in Tonnes)*	162,375	134,193	195,399	21,518
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,1232			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	158,640	124,983	195,399	25,665
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	23	19	29	3
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000018			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	13,531	12,420	15,070	966
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	181,325,986	151,782,400	224,100,900	26,490,927
Pop	*Population (on 1 January - total)*	1,318,113	1,314,870	1,325,217	3,705
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	6,987	5,715	8,597	1,017
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.005301			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.003364	0.002805	0.003682	0.000304
k1	*Number of active enterprises (0-49)*	9,700	8,287	11,517	1,176
k2	*Number of active enterprises (50-249)*	71	61	86	9
k3	*Number of active enterprises (over 250)*	9	8	10	1
Finland					
Em	*GHG emissions on year t (in Tonnes)*	1,341,329	1,074,165	1,518,824	150,606
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,2454			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	1,332,481	1,074,165	1,518,824	144,283
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	187	170	203	10
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000034			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	35,300	34,390	36,740	932
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	1,246,834,257	1,182,672,100	1,349,827,600	66,260,172
Pop	*Population (on 1 January - total)*	5,464,957	5,401,267	5,513,130	40,918

Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	92,720	85,536	99,227	4,869
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.016966			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002020	0.001837	0.002285	0.000157
k1	*Number of active enterprises (0-49)*	41,373	40,431	42,590	891
k2	*Number of active enterprises (50-249)*	283	220	331	41
k3	*Number of active enterprises (over 250)*	41	34	50	7
France					
Em	*GHG emissions on year t (in Tonnes)*	9,175,923	9,043,362	9,404,158	131,647
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,1384			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	9,145,071	9,043,362	9,404,158	122,791
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	966	843	1,094	92
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000015			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	31,747	31,160	32,890	660
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	1,007,411,914	970,945,600	1,077,152,400	40,667,402
Pop	*Population (on 1 January - total)*	66,282,271	65,276,983	67,026,224	642,738
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	1,051,717	971,918	1,137,450	57,575
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.015867			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.000921	0.000792	0.001089	0.000103
k1	*Number of active enterprises (0-49)*	507,806	467,259	574,017	37,338
k2	*Number of active enterprises (50-249)*	1,612	1,457	1,956	190
k3	*Number of active enterprises (over 250)*	244	194	325	52
Germany					
Em	*GHG emissions on year t (in Tonnes)*	10,674,577	9,810,710	11,715,457	747,871
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,1310			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	10,671,949	9,810,710	11,715,457	750,264
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	1,733	1,632	1,889	82
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000021			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	34,339	33,280	35,720	951
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	1,179,909,557	1,107,558,400	1,273,776,100	65,433,011
Pop	*Population (on 1 January - total)*	81,472,333	80,327,900	82,792,351	1,009,961
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	1,224,652	1,091,212	1,387,630	109,972
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.015032			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.001423	0.001241	0.001604	0.000119

k1	*Number of active enterprises (0-49)*	320,119	264,263	355,102	37,369
k2	*Number of active enterprises (50-249)*	3,528	3,252	3,860	230
k3	*Number of active enterprises (over 250)*	264	232	361	46
Greece					
Em	*GHG emissions on year t (in Tonnes)*	498,523	348,877	833,545	156,368
Empc	*GHG emissions on year t per capita (in Tonnes)*	0.0458			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	557,233	348,877	853,326	202,200
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	82	73	94	8
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000008			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	16,940	16,600	17,400	252
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	287,017,914	275,560,000	302,760,000	8,568,088
Pop	*Population (on 1 January - total)*	10,881,136	10,741,165	11,086,406	130,121
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	72,681	69,661	76,716	2,798
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.006680			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.001127	0.001022	0.001343	0.000118
k1	*Number of active enterprises (0-49)*	75,789	59,593	86,834	11,411
k2	*Number of active enterprises (50-249)*	150	133	175	18
k3	*Number of active enterprises (over 250)*	14	11	18	3
Hungary					
Em	*GHG emissions on year t (in Tonnes)*	969,999	647,591	1,270,407	201,974
Empc	*GHG emissions on year t per capita (in Tonnes)*	0.0984			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	888,665	647,591	1,082,299	173,461
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	125	21	181	51
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000013			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	11,221	10,090	12,680	925
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	126,653,443	101,808,100	160,782,400	21,003,186
Pop	*Population (on 1 January - total)*	9,854,297	9,778,371	9,931,925	56,393
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	43,908	39,132	50,269	4,347
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.004456			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002781	0.000529	0.003605	0.001020
k1	*Number of active enterprises (0-49)*	63,407	55,177	78,871	8,277
k2	*Number of active enterprises (50-249)*	287	271	326	19
k3	*Number of active enterprises (over 250)*	19	16	26	4

Ireland					
Em	*GHG emissions on year t (in Tonnes)*	405,067	315,471	491,647	65,869
Empc	*GHG emissions on year t per capita (in Tonnes)*	0.0863			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	371,583	257,262	468,913	73,637
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	45	31	51	8
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000010			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	46,507	36,770	58,100	8,545
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	2,225,497,071	1,352,032,900	3,375,610,000	796,141,156
Pop	*Population (on 1 January - total)*	4,693,658	4,589,287	4,830,392	90,639
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	62,858	51,782	75,932	8,746
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.013392			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.000720	0.000599	0.000875	0.000097
k1	*Number of active enterprises (0-49)*	51,643	47,244	57,427	4,062
k2	*Number of active enterprises (50-249)*	111	56	178	46
k3	*Number of active enterprises (over 250)*	14	9	21	4
Italy					
Em	*GHG emissions on year t (in Tonnes)*	5,887,347	5,636,951	6,062,570	153,432
Empc	*GHG emissions on year t per capita (in Tonnes)*	0.0976			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	5,980,315	5,636,951	6,431,224	246,685
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	1,702	1,656	1,818	56
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000028			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	26,181	25,620	27,040	544
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	685,720,871	656,384,400	731,161,600	28,612,746
Pop	*Population (on 1 January - total)*	60,342,383	59,394,207	60,795,612	565,049
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	716,711	701,642	742,493	15,458
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.011877			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002377	0.002280	0.002578	0.000106
k1	*Number of active enterprises (0-49)*	522,786	492,389	571,096	28,260
k2	*Number of active enterprises (50-249)*	1,120	1,040	1,237	75
k3	*Number of active enterprises (over 250)*	82	79	92	5
Latvia					
Em	*GHG emissions on year t (in Tonnes)*	232,950	218,539	266,826	17,618
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,1172			

EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	238,024	218,539	266,826	20,559
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	31	27	34	2
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000015			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	10,837	9,750	12,180	873
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	118,096,629	95,062,500	148,352,400	19,127,487
Pop	*Population (on 1 January - total)*	1,987,093	1,934,379	2,044,813	39,504
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	7,598	6,470	9,144	961
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.003824			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.004090	0.003216	0.004873	0.000599
k1	*Number of active enterprises (0-49)*	10,119	7,775	11,582	1,577
k2	*Number of active enterprises (50-249)*	185	157	212	21
k3	*Number of active enterprises (over 250)*	13	12	16	1
Lithuania					
Em	*GHG emissions on year t (in Tonnes)*	95,848	76,253	119,230	15,495
Empc	*GHG emissions on year t per capita (in Tonnes)*	0.0329			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	89,877	76,253	111,320	12,804
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	15	9	21	4
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000005			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	11,753	10,330	13,390	1,076
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	139,121,157	106,708,900	179,292,100	25,551,472
Pop	*Population (on 1 January - total)*	2,912,235	2,808,901	3,003,641	68,738
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	11,110	9,109	13,795	1,689
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.003815			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.001386	0.001037	0.002234	0.000445
k1	*Number of active enterprises (0-49)*	27,526	19,900	32,227	4,723
k2	*Number of active enterprises (50-249)*	295	271	310	13
k3	*Number of active enterprises (over 250)*	34	32	37	2
Luxembourg					
Em	*GHG emissions on year t (in Tonnes)*	159,130	140,333	175,114	12,453
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,2825			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	158,921	140,333	175,114	12,241
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	41	21	60	15
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000074			

GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	80,709	77,240	83,470	2,476
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	6,519,126,629	5,966,017,600	6,967,240,900	397,938,945
Pop	*Population (on 1 January - total)*	563,350	524,853	602,005	28,190
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	20,351	17,586	24,582	2,379
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.036126			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.001995	0.001141	0.002527	0.000519
k1	*Number of active enterprises (0-49)*	3,524	3,206	3,899	241
k2	*Number of active enterprises (50-249)*	146	137	161	8
k3	*Number of active enterprises (over 250)*	19	15	25	3
Malta					
Em	*GHG emissions on year t (in Tonnes)*	19,232	13,896	24,831	3,989
Empc	*GHG emissions on year t per capita (in Tonnes)*	0.0435			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	18,584	10,579	24,831	5,008
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	15	7	23	6
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000034			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	19,486	16,970	21,690	1,803
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	389,469,229	287,980,900	499,522,500	79,784,723
Pop	*Population (on 1 January - total)*	442,226	417,546	475,701	21,144
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	3,138	2,413	4,030	590
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.007096			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.004551	0.002827	0.005623	0.001233
k1	*Number of active enterprises (0-49)*	3,842	3,605	4,357	259
k2	*Number of active enterprises (50-249)*	3	-	21	8
k3	*Number of active enterprises (over 250)*	1	-	4	2
Netherlands					
Em	*GHG emissions on year t (in Tonnes)*	3,170,876	3,051,403	3,427,282	129,967
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,1873			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	3,165,536	3,051,403	3,389,905	117,883
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	493	375	601	89
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000029			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	39,466	38,180	41,450	1,255
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	1,558,892,114	1,457,712,400	1,718,102,500	99,790,095
Pop	*Population (on 1 January - total)*	16,925,950	16,730,348	17,181,084	164,207

Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	265,402	235,912	303,988	25,137
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.015680			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.001845	0.001553	0.001987	0.000190
k1	*Number of active enterprises (0-49)*	160,746	133,640	186,812	16,950
k2	*Number of active enterprises (50-249)*	726	676	827	58
k3	*Number of active enterprises (over 250)*	105	96	122	10
Norway					
Em	*GHG emissions on year t (in Tonnes)*	2,007,914	1,890,270	2,097,657	69,192
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,3896			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	1,966,268	1,668,507	2,097,657	146,906
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	411	378	458	29
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000080			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	67,949	66,780	69,440	1,039
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	4,617,933,457	4,459,568,400	4,821,913,600	141,503,591
Pop	*Population (on 1 January - total)*	5,153,752	4,985,870	5,295,619	111,989
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	145,718	130,649	165,276	12,504
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.028274			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002844	0.002288	0.003315	0.000338
k1	*Number of active enterprises (0-49)*	55,277	52,347	57,447	1,826
k2	*Number of active enterprises (50-249)*	424	372	496	45
k3	*Number of active enterprises (over 250)*	46	41	63	7
Poland					
Em	*GHG emissions on year t (in Tonnes)*	1,019,335	933,020	1,198,404	89,723
Empc	*GHG emissions on year t per capita (in Tonnes)*	0.0268			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	1,065,676	933,020	1,315,917	141,690
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	257	227	319	31
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000007			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	10,980	9,980	12,420	901
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	121,256,314	99,600,400	154,256,400	20,110,861
Pop	*Population (on 1 January - total)*	38,009,522	37,967,209	38,063,792	40,917
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	146,703	128,499	179,268	18,747
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.003860			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.001782	0.001458	0.002483	0.000358

k1	*Number of active enterprises (0-49)*	256,278	222,242	324,261	36,355
k2	*Number of active enterprises (50-249)*	1,352	1,252	1,609	125
k3	*Number of active enterprises (over 250)*	147	135	175	14
Portugal					
Em	*GHG emissions on year t (in Tonnes)*	1,267,021	1,128,411	1,400,427	97,304
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,1219			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	1,331,488	1,128,411	1,777,482	217,862
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	144	124	165	15
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000014			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	16,841	16,050	18,190	822
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	284,212,186	257,602,500	330,876,100	28,058,482
Pop	*Population (on 1 January - total)*	10,396,249	10,291,027	10,542,398	93,694
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	66,742	57,831	75,856	5,886
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.006420			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002158	0.001963	0.002404	0.000150
k1	*Number of active enterprises (0-49)*	80,975	77,361	87,034	3,727
k2	*Number of active enterprises (50-249)*	471	428	535	39
k3	*Number of active enterprises (over 250)*	51	49	55	2
Romania					
Em	*GHG emissions on year t (in Tonnes)*	3,062,091	2,947,389	3,146,537	67,713
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,1543			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	3,027,471	2,904,197	3,113,561	78,443
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	72	55	84	10
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000004			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	7,464	6,500	8,700	802
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	56,266,557	42,250,000	75,690,000	12,213,083
Pop	*Population (on 1 January - total)*	19,838,863	19,533,481	20,095,996	203,758
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	44,488	37,024	54,865	6,001
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.002242			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.001622	0.001410	0.001848	0.000166
k1	*Number of active enterprises (0-49)*	48,150	43,383	54,958	4,090
k2	*Number of active enterprises (50-249)*	987	913	1,102	65
k3	*Number of active enterprises (over 250)*	92	76	122	15

Slovakia

Em	*GHG emissions on year t (in Tonnes)*	1,908,899	1,799,603	1,988,273	65,664
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,3520			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	1,936,280	1,799,603	2,179,456	120,831
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	54	40	67	10
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000010			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	14,203	13,220	15,490	866
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	202,363,686	174,768,400	239,940,100	24,740,201
Pop	*Population (on 1 January - total)*	5,422,453	5,404,322	5,443,120	13,632
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	25,873	21,175	30,603	3,270
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.004771			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002096	0.001481	0.002574	0.000384
k1	*Number of active enterprises (0-49)*	88,931	81,714	101,616	6,896
k2	*Number of active enterprises (50-249)*	169	158	178	7
k3	*Number of active enterprises (over 250)*	16	12	18	2

Slovenia

Em	*GHG emissions on year t (in Tonnes)*	783,456	664,499	975,478	114,779
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,3799			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	750,841	664,499	889,412	77,506
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	16	14	18	1
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000008			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	18,333	17,160	20,220	1,137
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	337,373,343	294,465,600	409,657,600	42,747,017
Pop	*Population (on 1 January - total)*	2,062,177	2,055,496	2,066,880	4,032
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	15,052	13,786	17,314	1,309
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.007299			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.001065	0.000941	0.001146	0.000090
k1	*Number of active enterprises (0-49)*	18,370	17,968	18,926	346
k2	*Number of active enterprises (50-249)*	90	82	103	7
k3	*Number of active enterprises (over 250)*	10	10	11	0

Spain

Em	*GHG emissions on year t (in Tonnes)*	553,030	457,685	755,261	102,735
Empc	*GHG emissions on year t per capita (in Tonnes)*	0.0119			

EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	587,445	457,685	825,695	146,272
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	352	292	421	41
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000008			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	23,187	21,840	24,910	1,214
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	538,907,586	476,985,600	620,508,100	56,663,511
Pop	*Population (on 1 January - total)*	46,590,635	46,440,099	46,818,219	145,983
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	376,741	343,512	426,149	29,993
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.008086			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.000931	0.000850	0.000989	0.000044
k1	*Number of active enterprises (0-49)*	354,406	319,043	378,358	26,360
k2	*Number of active enterprises (50-249)*	1,099	893	1,536	214
k3	*Number of active enterprises (over 250)*	129	119	147	10
Sweden					
Em	*GHG emissions on year t (in Tonnes)*	1,938,613	1,807,295	2,039,230	89,693
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,1984			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	1,979,075	1,832,062	2,090,525	84,303
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	514	468	547	29
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000053			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	42,109	40,380	43,760	1,400
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	1,774,811,743	1,630,544,400	1,914,937,600	117,597,706
Pop	*Population (on 1 January - total)*	9,771,054	9,482,855	10,120,242	232,517
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	198,547	183,516	214,421	12,093
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.020320			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002595	0.002447	0.002875	0.000170
k1	*Number of active enterprises (0-49)*	97,763	93,107	103,427	3,746
k2	*Number of active enterprises (50-249)*	566	446	804	122
k3	*Number of active enterprises (over 250)*	57	45	96	18
Switzerland					
Em	*GHG emissions on year t (in Tonnes)*	1,274,352	1,189,502	1,366,519	71,039
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,1549			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	1,293,047	1,214,278	1,366,519	61,578
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	402	363	437	35
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000049			

GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	60,380	58,820	62,550	1,262
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	3,646,216,357	3,459,792,400	3,906,250,000	151,302,291
Pop	*Population (on 1 January - total)*	8,228,832	7,954,662	8,484,130	195,972
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	156,939	139,737	171,013	14,858
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.019072			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002561	0.002492	0.002630	0.000046
k1	*Number of active enterprises (0-49)*	20,351	19,253	20,800	515
k2	*Number of active enterprises (50-249)*	795	758	823	25
k3	*Number of active enterprises (over 250)*	70	63	78	6
UK					
Em	*GHG emissions on year t (in Tonnes)*	12,602,091	11,422,968	13,502,236	813,360
Empc	*GHG emissions on year t per capita (in Tonnes)*	0,1943			
EmLagt-1	*GHG emissions on year t-1 (in Tonnes)*	12,330,899	11,422,968	13,502,236	819,406
Tax (in millions)	*Environmental Taxes on year t (in million Euro)*	1,957	1,713	2,236	191
Tax pc (in millions)	*Environmental Taxes on year t per capita (in million Euro)*	0.000030			
GDP	*Real Gross Domestic Product per capita (in Euro per capita)*	31,579	30,190	32,640	911
GDPsq	*Real Gross Domestic Product per capita Squared (in Euro per capita squared)*	997,917,471	911,436,100	1,065,369,600	57,254,495
Pop	*Population (on 1 January - total)*	64,871,684	63,495,088	66,273,576	1,022,127
Total tax rev (in millions)	*Main national accounts tax aggregates on year t (in million Euro)*	808,492	718,157	903,461	68,913
Total tax rev pc (in millions)	*Main national accounts tax aggregates on year t per capita (in million Euro)*	0.012463			
EnvTax/Total tax rev	*Environmental Taxes / Main national accounts tax aggregates*	0.002425	0.002102	0.002703	0.000191
k1	*Number of active enterprises (0-49)*	290,832	255,003	328,231	30,440
k2	*Number of active enterprises (50-249)*	1,912	1,832	2,008	73
k3	*Number of active enterprises (over 250)*	311	305	318	6

Source: SPSS, Author's compilation

Notes: In the table above (Table b), Em, EmLagt-1, EnvTax/Total tax rev, GDP, GDPsq, k1, k2, k3 correspond to variables E_{it}, E_{it-1}, T_{it}, GDP_{it}, $(GDP_{it})^2$, k_{1it}, k_{2it}, k_{3it}, respectively.

References

Andersen Mikael Skou, Speck Stefan and Mautone Orsola, (2011), *EEA, environmental fiscal reform, illustrative potential in Italy*, Prepared for the conference "Environmentally-related taxation and fiscal reform", Rome, 15 December 2011

Angrist Joshua, and Krueger Alan B., (2001), *Instrumental Variables and the Search for Identification: From Supply and Demand to Natural Experiments.,* Journal of Economic Perspectives, 15 (4): 69-85. DOI: 10.1257/jep.15.4.69

Bayer Patrick & Aklin Michaël, (2020), *The European Union Emissions Trading System reduced CO_2 emissions despite low prices*, Proceedings of the National Academy of Sciences. 117. 201918128. 10.1073/pnas.1918128117.

Becker Sascha, (2016), *Using instrumental variables to establish causality*, IZA World of Labor. 10.15185/izawol.250.

Cicatiello Lorenzo & Ercolano Salvatore & Gaeta Giuseppe & Pinto Mauro, (2020), *Willingness to pay for environmental protection and the importance of pollutant industries in the regional economy. Evidence from Italy*, Ecological Economics. 177. 106774. 10.1016/j.ecolecon.2020.106774.

Coondoo Dipankor, Dinda Soumyananda*, Causality between income and emission: a country group-specific econometric analysis*, (2002) Ecological Economics, Volume 40, Issue 3, Pages 351-367, ISSN 0921-8009, https://doi.org/10.1016/S0921-8009(01)00280-4.

Crippa M., Guizzardi D., Muntean M., Schaaf E., Solazzo E., Monforti-Ferrario F., Olivier J. and Vignati E., *(2020), Fossil CO_2 emissions of all world countries, Report*, EUR 30358 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-21514-1, doi:10.2760/56420, JRC121460.

Crosby, D. A., Dowsett, C. J., Gennetian, L. A., & Huston, A. C., (2010), *A tale of two methods: comparing regression and instrumental variables estimates of the effects of*

preschool child care type on the subsequent externalizing behavior of children in low-income families, Developmental psychology, *46*(5), 1030–1048. https://doi.org/10.1037/a0020384

Depledge, J., United Nations Framework Convention on Climate Change (UNFCCC) (2020), Technical paper: *Tracing the Origins of the Kyoto Protocol: An Article-by-Article Textual History* (PDF)

Ekins Paul & Speck Stefan, (1999),*Competitiveness and Exemptions From Environmental Taxes in Europe,"* Environmental & Resource Economics, Springer;European Association of Environmental and Resource Economists, vol. 13(4), pages 369-396, June.

Ekins Paul & Pollitt Hector & Summerton Philip & Chewpreecha Unnada, (2011), *Increasing carbon and material productivity through environmental tax reform*, Energy Policy. 42. 10.1016/j.enpol.2011.11.094.

European Commission, (2004), *Directive 2004/101/EC of the European Parliament*, Official Journal of the European Union L 338, 13 November 2004.

European Commission, (2019), *New Rules for Greener and Smarter Buildings Will Increase Quality of Life for All Europeans*, Available online: https://ec.europa.eu/info/news/new-rules-greener-and-smarter-buildings-will-increase-quality-lifealleuropeans- 2019-apr-15_en

European Commission, *Mainstreaming sustainable development into EU policies: (2009), Review of the European Union Strategy for Sustainable Development, Communication from the Commission. COM (2009) 400 final*

European Commission, (2020a), *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, stepping up Europe's 2030 climate ambition—investing in a climate-neutral future for the benefit of our people COM (2020) 562 final*, 17 September 2020

European Commission, (2020b), *Europe 2020. A strategy for smart, sustainable and inclusive growth. Communication from the Commission, COM (2010) 2020 final*

European Council in Madrid, (1995), *15-16 December 1995, Presidency Conclusions'*, SN 400/95.

European Commission, (2001), *Information from the Commission - Community guidelines on State aid for environmental protection*, 2001, Official Journal, C 37, 3-15. CELEX:https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32001Y0203(02)

European Parliament, (2021), *Fact sheets on the European union, October, 2021 Environment policy: general principles and basic framework*

European Union, (2001), *Treaty of Nice amending the Treaty on European Union, the Treaties establishing the European Communities and certain related acts*, OJ C 80

European Union, (2007), *Treaty of Lisbon Amending the Treaty on European Union and the Treaty Establishing the European Community*, O.J. (C 306)

Eurostat, (2020), Statistical Database European Union. Retrieved from https://ec.europa.eu/eurostat/cache/metadata/en/env_ac_taxind2_esms.htm

Eurostat, (2021), Statistical Database European Union. Retrieved from https://ec.europa.eu/eurostat/cache/metadata/en/sbs_esms.htm

Eurostat, (2022), Statistical Database European Union. Retrieved from https://ec.europa.eu/eurostat/cache/digpub/housing_2020/bloc-3a.html?lang=en

Fetting C., (2020), *"The European Green Deal", ESDN Report*, December 2020, ESDN Office, Vienna.

Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme, (2019), *2019 global status report for buildings and construction: Towards a zero-emission, efficient and resilient buildings and construction sector.*

Grossman Gene M. & Krueger Alan B., (1991), "*Environmental Impacts of a North American Free Trade Agreement,"* NBER Working Papers 3914, National Bureau of Economic Research, Inc.

Hepburn Cameron, (2011), *Environmental policy, government, and the market*, Oxford Review of Economic Policy. 26. 117-136.

Kemp Luke, (2018), *A Systems Critique of the 2015 Paris Agreement on Climate*,10.1007/978-3-319-67702-6_3.

Koskela E., Schöb R. & Sinn HW, (1998), *Pollution, Factor Taxation and Unemployment*, International Tax and Public Finance 5, 379–396. https://doi.org/10.1023/A:1008642512728

Markandya Anil, (1993), *Environmental Taxation: A Review of OECD Country Experience and Prospects for Economies in Transition*, Development Discussion Paper No. 471

Lin Boqiang, Li Xuehui, (2011), *The effect of carbon tax on per capita CO2 emissions*, Energy Policy, Volume 39, Issue 9, Pages 5137-5146, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2011.05.050.

Millner Antony and Olivier Helene, (2016), *Beliefs, politics, and environmental policy. Review of Environmental Economics and Policy*, 10 (2). pp. 226-244. ISSN 1750-6824

Morley Bruce, (2012), *Empirical evidence on the effectiveness of environmental taxes*, Applied Economics Letters, 19:18, 1817-1820

OECD, (2010), *Taxation, Innovation and the Environment* (Summary), OECD Publishing, Paris, https://doi.org/10.1787/9789264087637-sum-en.

OECD, (2011), *Environmental Taxation - A Guide for Policy Makers,* OECD Publishing, Paris, https://www.oecd.org/env/tools-evaluation/48164926.pdf.

OECD, (2013), *Glossary of Statistical Terms*, OECD Publishing, Paris, Retrieved from https://stats.oecd.org/glossary/detail.asp?ID=7022

OECD, (2017), *Environmental Fiscal Reform: Progress, Prospects and Pitfalls*, OECD Report for the G7 Environment Ministers, OECD Publishing, Paris, https://www.oecd.org/tax/tax-policy/environmental-fiscal-reform-G7-environment-ministerial-meeting-june-2017.pdf.

Olivier J., Peters J., (2020), *Trends in Global CO2 and Total Greenhouse Gas emissions; 2019 report-2020 Report*, En, 4068, PBL Netherlands Environmental Assessment Agency, The Hague

Omri Anis, Saida Daly & Rault Christophe & Chaibi Anissa, (2015), *Financial Development, Environmental Quality, Trade and Economic Growth: What Causes What in MENA Countries?* Energy Economics. 10.2139/ssrn.2573609.

Panayotou T., (1997), *Demystifying the environmental Kuznets curve: turning a black box into a policy tool*, Environment and Development Economics, *2*(4), 465–484. http://www.jstor.org/stable/44379189

Pearce David, (1991), *The Role of Carbon Taxes in Adjusting to Global Warming,* Economic Journal, 101, issue 407, p. 938-48, https://EconPapers.repec.org/RePEc:ecj:econjl:v:101:y:1991:i:407:p:938-48.

Pigou A. C., (1924), *The economics of welfare,* London: Macmillan,

Porter M. E., (1990), *The Competitive Advantage of Nations*, Harvard Business Review 68, no. 2 (March–April 1990): 73–93.

R. Arbolino, O. Romano, (2014), *A Methodological Approach for Assessing Policies: The Case of the Environmental Tax Reform at European Level*, Procedia Economics and Finance, Volume 17, Pages 202-210, ISSN 2212-5671, https://doi.org/10.1016/S2212-5671(14)00895-8.

Schneider Kerstin, (1997*), Involuntary Unemployment and Environmental Policy: The Double Dividend Hypothesis*, Scandinavian Journal of Economics, Wiley Blackwell, vol. 99(1), pages 45-59, March.

Schurer A. P., Cowtan K., Hawkins E., Mann M. E., Scott V. and Tett S., (2018), *Interpretations of the Paris climate target.* Nature Geoscience, 11. pp. 220-221. ISSN 1752-0894

Shi Q., Ren H., Cai W., &, Gao J., (2019), *How to set the proper level of carbon tax in the context of Chinese construction sector? A CGE analysis*. Journal of cleaner production, doi: 10.1016/j.jclepro.2019.117955

Selden T.M., & Song, D. (1994), *Environmental Quality and Development: Is There a Kuznets Curve for Air Pollution Emissions?* Journal of Environmental Economics and Management, 27, 147-162.

Stern David I., (1998), *Progress on the Environmental Kuznets Curve?* Environment and Development Economics, 3 173-96

Testa Francesco & Iraldo Fabio & Frey Marco, (2011), *The effect of environmental regulation on firms' competitive performance: The case of the building & construction sector in some EU regions,* Journal of environmental management. 92. 2136-44. 10.1016/j.jenvman.2011.03.039.

United Nations Framework Convention on Climate Change (UNFCCC), (1998), *Kyoto Protocol to the United Nations Framework Convention on Climate Change.*

United Nations Framework Convention on Climate Change (UNFCCC), (2021), *Draft CMA decision proposed by the President, DRAFT TEXT on 1/CMA.3,* Glasgow Climate Pact

UN General Assembly, United Nations Framework Convention on Climate Change (1994), *Resolution adopted by the General Assembly*, 20 January 1994, A/RES/48/189, available at: https://www.refworld.org/docid/3b00f2770.html [accessed 10 January 2022]

Van Zanden J. L. (1995), *Tracing the beginning of the Kuznets curve: western Europe during the early modern period*, The Economic History Review, 48: 643-664. https://doi.org/10.1111/j.1468-0289.1995.tb01437.x

Ward Hugh, Cao Xun, (2012), *Domestic and International Influences on Green Taxation*, Comparative Political Studies, 45(9): 1075–1103.

Withana S., ten Brink P., Kretschmer B., Mazza L., Hjerp P., Sauter R., (2013), *Evaluation of environmental tax reforms: International experiences*, A report by the Institute for European Environmental Policy (IEEP) for the State Secretariat for Economic Affairs (SECO) and the Federal Finance Administration (FFA) of Switzerland. Final Report. Brussels.

World Bank*, (2022), The World Bank Data, Data for Cyprus*, Retrieved from https://data.worldbank.org/?locations=CY-XD

Wooldridge, J. M. (2010), *Econometric analysis of cross section and panel data (2nd ed.)*. MIT Press.