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Determinant Factors of Public Environmental Protection Investments in Europe

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October, 2023

CIÊNCIAS SOCIAIS
E HUMANAS

Department of Political Economy

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ACKNOWLEDGMENTS

I would like to express my heartfelt attitude to my parents and grandparents for supporting me throughout my academic career and allowing me to pursuit my studies in this area. During this time, they always motivated me to not give up and always try to do my best.

I’m also deeply thankful to my sister and my brother for always believing in me and João Nunes Amorim for his unconditional support.

Last but not least, I wanted to extend my sincere thanks to my supervisor for his availability and guidance. Without him this thesis would not have been possible.

RESUMO

A necessidade de preservar o meio ambiente devido às mudanças climáticas tem manifestado a importância de compreender por que certos países investem mais na proteção ambiental do que outros. Assim sendo, este artigo apresenta um estudo empírico sobre os impulsionadores dos investimentos públicos em proteção ambiental, usando dados em painel para 27 países europeus de 2014 a 2019. Esta investigação segue uma perspetiva não tradicional em relação aos investimentos em proteção ambiental, uma vez que se concentra na importância do investimento público na preservação do meio ambiente. Foi implementada a abordagem *Least-Squares Dummy Variable Bias-Corrected* (LSDVBC) nesta pesquisa empírica, e o resultado mostra que os Investimentos Passados contribuem positivamente para os Investimentos em Proteção Ambiental, enquanto a Regulamentação Ambiental e a Inovação Ambiental demonstram uma relação negativa com a variável de interesse. As outras variáveis refletem insignificância em relação aos investimentos na proteção do ambiente.

Palavras-chave: investimentos em proteção ambiental, investimento público, investimentos verdes, dados em painel, estimador *least-squares dummy variable bias-corrected*

ABSTRACT

The necessity of preserving the environment due to climate change has manifested the importance of understanding why certain countries invest more in environmental protection than others. Hence, this paper showcases an empirical study on the drivers of the environmental protection public investments, using a panel data for 27 European countries from 2014 to 2019. This investigation follows a nontraditional perspective regarding the investments on environmental protection since it focuses on the significance of public investment in safeguarding the environment. A Least-Squares Dummy Variable Bias-Corrected (LSDVBC) approach was employed on this empirical research and the outcome illustrates that the Previous Investments contribute positively to the Environmental Protection Investments whereas the Environmental Regulation and Environmental Innovation demonstrate a negative relationship with the variable of interest. The other variables reflect insignificance towards the investments in protecting the environment.

Keywords: environmental protection investments, public investment, green investments, panel data, least-squares dummy variable bias-corrected estimator

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Abbreviations

A

AMG: Augmented Mean Group · 19

C

CCEMG: Common Correlated Effects Mean Group · 19
CD: Credit Supply · 2
CEPA: Classification of Environmental Protection Activities · 26
CS-ARDL: Cross Sectional Autoregressive Distributed Lag · 19

E

EEA: European Economic Area · 17
EGD: Europe Green Deal · 17
EI: Environmental Innovation · 2
EKC: Environmental Kuznets Curve · 9
ER: Environmental Regulation · 2
ESDN: European Sustainable Development Network · 17
EU: European Union · 1

G

GDP: Gross Domestic Product · 2
GDPPC: Gross Domestic Product Per Capita · 9

I

i.i.d.: be independent and identically distributed · 21
IR: Interest Rates · 2

L

LSDVBC: Least-Squares Dummy Variable Bias-Corrected · 2

M

MMQR: Method of Moments Quantile Regression · 9

O

OECD: Organisation for Economic Co-operation and Development · 5
OLS: Ordinary Least Squares · 22

P

PEPI: Past Environmental Protection Investments · 2

R

R&D: Research & Development · 11
ROI: Return on Investment · 12

S

SEM: Structural Equation Modelling · 19

Introduction

It is common knowledge that environmental concerns have been considered a pressing matter in recent years. Akomea-Frimpong *et al*. (2022) discuss the urgency for environmental protection, for dealing with climate change and to achieve a sustainable development. It is a concern that has been argued by multiple scholars and has helped continue the conversation about green finance.

The new agenda 2019-2024 in European Union (EU) sets as one of the top priorities "Building a climate-neutral, green, fair and social Europe". One way of reaching this goal is by investing in green projects that aim at preserving the environment, the quality of the air and water and even develop an agriculture that is sustainable. Therefore, this research has the purpose to question "*What are the determinants that influence the environmental protection investments in Europe?".*

In order to comprehend the big picture of the issue of this research, we can ask five sub questions:

1st *How do past environmental protection investments influence current ones?*

2nd *How do environmental regulations contribute to the investment in environmental protection?*

3rd *How does the gross domestic product of a country influence the amount invested in protecting the environment?*

4th *How does environmental innovation affect environmental protection investments?*

5th *How do determinant variables of investment in general impact environmental protection investments?*

Concerning investments in environmental protection, the member states of EU have displayed a significant attention towards environmental issues, on an international level, by creating global policies and holding conventions about this topic (Dogaru, 2013). For instance, the Sustainable Development Goals and the Paris Agreement illustrate the global dedication towards fighting the repercussions of climate change and human actions on the environment.

In Europe the initiatives and sectorial guidelines, for example, Europe 2020, aim to align environmental regulations and encourage efforts to improve water quality, reduce waste production and energy savings, many others (Ercolano and Romano, 2018). Nevertheless, harmonized policies that meet regulatory requirements are limited which remains a challenge. Therefore, there is a need to explore the common factors that influence investments in environmental protection in Europe. Furthermore, investigating whether variables that impact general investments also affect green investments would also be of interest.

Therefore, this research has the purpose to investigate which factors are determinant to stimulate the investment in environmental protection in Europe and possibly explain why some countries choose to invest more in this matter than others.

This dissertation resorts to a panel data econometric model of twenty-four countries, that is, twenty-one countries from the EU and three countries from Europe (Norway, Iceland and Switzerland) in order to try to answer the research question. These last countries have special agreements with the EU and therefore are also interesting to analyse.

Magalhães (2021) presents two schools of thoughts regarding green investment: the neoclassical, which prioritizes market mechanisms as a way of controlling the levels of consumption, investment and production whereas the heterodox concentrates on the intervention of the government and public investment. This investigation will focus on the investments regarding the protection of the environment from a public perspective.

The variable of interest used is the environmental protection investments (EPI) which consists of annual data from environmental protection investments of general government.

As for the explanatory variables, it was chosen the following six variables: the past environmental protection investments (PEPI), the environmental regulation (ER), the gross domestic product (GDP) of each country, the environmental innovation (EI), the interest rates (IR) and the credit supply (CD). These variables were chosen due to their relevance on green investments and in investment in general, as shown in the literature (Stiglitz and Weiss, 1981; Heineman, 2006; Borri and Boccaletti, 1995; Eyraud *et al*. (2011, 2013)).

The interest and explanatory variables show different periods of availability. Therefore, in order to consider all of these variables in the research, the period of study will be from 2014 to 2019.

The data from the seven variables of the twenty-four European countries will be utilized to create an unbalanced, dynamic and macro panel data set.

This study employed a dynamic model with the Least-Squares Dummy Variable Bias-Corrected (LSDVBC) Estimator developed by Nickell (1981), Bun and Kiviet (2003), and Bruno (2005a, 2005b). This decision was made due to the data's properties, specifically, the presence of missing observations, a lagged explanatory variable and a low number of cross-sectional individuals. These traits call for a dynamic model that will determine whether or not the six dependent variables have any influence on the disparity in environmental investment levels between nations.

Overall, this research contributes to the literature by performing a macroeconomic analysis to understand the key factors that drive public environmental protection investments in Europe through time. Furthermore, it seeks to discover if there is a relationship among EI and investments in environmental protection.

Our results shows that it is expected the following behaviours: previous investments in environmental protection will impact positively the current investments (Borri and Boccaletti; 1995), ER will show a positive relationship in green investments (Eyraud *et al*., 2011, 2013) and it will be tested if the increase on EI itself results on a boost in environmental protection investments, given that there is a negative relationship between EI and CO_2 emissions (Yuan *et al*., 2022a, 2022b; Liu *et al*., 2022; Meng *et al*., 2022; Umar and Safi, 2023) which leads to a sustainable environmental (Wang *et al*., 2023). Additionally, it is predicted that GDP per capita will affect positively the environmental protection investments or will showcase different results for the numerous countries (Badulescu *et al*., 2016). Finally, the IR will negatively influence the environmental investments and the CS will determine a positive relationship with the variable of interest. Both these variables will demonstrate these results due to financial constraints that limit the amount invested (Gaiotti, 2013; Marinescu *et al*., 2019).

The dissertation is organized as follows. The research question and its pertinence are discussed in Section 1. The literature on green investments and the contributing aspects to investments in environmental protection is compiled in Section 2. A context of the reality is shown in Section 3. The empirical model and methodology are described in Section 4. The study's findings are presented in Section 5, and final thoughts are discussed in Section 6.

Chapter 1 – Theoretical Framework & Literature Review

This section will provide a theoretical framework for understanding where the concept of environmental protection investment first appeared and the importance of this topic nowadays. Subsequently, with the goal of answering the five sub questions presented in the previous section, it will be demonstrated the relationships between the explanatory factors and the variable of interest. Lastly, this section will answer the question of the dissertation: "*What are the determinants that influence the environmental protection investments in Europe?"*.

Environmental investments have become a hotly debated topic in literature regarding green finance. To analyse the different perspectives of what contributes to investing in environmental protection, it is fundamental to first understand what green finance is.

UNEP (2016, referenced in Migliorelli, M., & Dessertine, P., 2019) present numerous definitions of Green Finance made by different organizations with distinct motivations. According to the Organisation for Economic Co-operation and Development (OECD), Green Finance is the type of finance that promotes economic growth and, at the same time, decreases pollution and greenhouse gas emissions, reduces waste and assures that the natural resources are used efficiently.

Fleming (2020) wrote that Green Finance consists of loans, investments and any kind of debt mechanisms that help develop green projects or reduce the effect of climate in other projects. To sum up, it corresponds to activities with a financial structure that guarantee improvement in environmental issues.

This investigation will focus on the green investment component of green finance. As described by Eyraud *et al*. (2011, cited in Inderst *et al*., 2012) green investment is, in a macroeconomic perspective, all the investments - public and private - needed to decrease air pollutant emissions and greenhouse gas. However, the investment cannot influence substantially the level of consumption and production of non-energy products.

Magalhães (2021) states that, regarding the topic of green investment, there are two main schools of thoughts: neoclassical and heterodox. The former focuses on changing the levels of consumption, investment and production by pricing the carbon, since the climate is seen as an externality that negatively impacts the market and it is not controlled by it. The latter draws the attention to the urgency of public investment and intervention.

Furthermore, Baker and Eckerberg (2014) highlight the importance of the state in addressing environmental issues. It is concluded that the creation and management of strategic plans by the state are crucial for promoting sustainable development. In this article the involvement of the state is seen as a necessity for the sustainable development and market-based approaches tend to work more successfully with the participation of the state.

For this reason, this dissertation will assess the contribution of the state in preserving the environment given that it will study the determinant factors of the public investment in the environmental protection.

As written above, Green Investment is a broad concept. Therefore, Environmental Protection Investments will be used as a proxy for Green Investments.

1.1 – Environmental Protection Investments

United Nations (1997: 30) defined Environmental Protection as:
any activity to maintain or restore the quality of environmental media through preventing the emission of pollutants or reducing the presence of polluting substances in environmental media. It may consist of: (a) changes in characteristics of goods and services, (b) changes in consumption patterns, (c) changes in production techniques, (d) treatment or disposal of residuals in separate environmental protection facilities, (e) recycling and (f) prevention of degradation of the landscape and ecosystems. See also protection against natural hazards and classification of environmental protection activities.

The concept of environmental protection is one that presents two distinct points of view: the free-market perspective and the government intervention one (Hepburn, 2010).

From the “free-market” perspective, Hepburn (2010) states that there are two options concerning the possibility of firms contributing to environmental protection without the help of the government: the first is the willingness of the consumers to pay the additional environmental costs of the products since environmental issues are important to them. If the first option is not viable, the second one is to reduce the profits of shareholders in order to serve the public interest.

Be that as it may, these two options rarely happen, which is why to protect the environment it is not possible to rely only on the free market.

Hepburn (2010) clarifies that relying only on the government intervention is not optimal as well since governments don’t have access to all the information and can be influenced by individual humans.

Finally, Hepburn (2010) concludes that the single use of one of the perspectives is not favourable, instead, it should be a combination of both perspective where the government would set relevant goals in the creation of policies, considering the fact that each intervention differs from the essence of the environmental problem.

Focusing on our research question, it is important to understand if the government spending with respect to the protection of the environment has been consistent throughout the years in the European countries.

Pearce and Palmer (2001) suggest that the need for protecting the environment is a public one, since spending in environmental protection helps the population to gain from its development at once.

Ferreiro *et al*. (2010) talks about the concern for environmental protection demonstrated in a study consisting of 12 countries but points out the lack of a fiscal policy that provides prosperity and competition while maximizing the welfare of the people.

Furthermore, a study conducted by Apergis *et al*. (2013) claimed that the countries from the EU have focussed on the main elements of environmental issues and its consequences. Nevertheless, it has not been enough to reach convergency and it is essential to coordinate the policies about public expenditure considering the general regulatory requisite.

Ercolano and Romano (2018) concluded that countries' choices regarding public expenditure in environmental protection differed from one to another but remain consistent throughout the years. Additionally, it was deducted that when countries spend more in environmental protection, it increases the environmental performance.

1.2 – Determinants of Environmental Protection Investments

The macroeconomic determinants of green investment have not received much attention in the economic literature around environmental issues.

Eyraud *et al*. (2011, 2013) provide a broad range of factors that influence green investment, including both public and private investment.

Among several determinants of green investment presented by Eyraud *et al*. (2011, 2013), the ones that stand out the most are the economic growth and income level, the technological progress and innovation, the interest rates and finally, the public policies to support green investment.

Therefore, these variables will be used in our research. In addition, it will be used for this investigation the variable CS in order to understand if it influences green investments as it does to the investments in general.

As mentioned by Stiglitz and Weiss (1981), both IR and the amount of credit shift significantly the economy at a given period.

1.2.1 – Past Environmental Protection Investments

Heineman (2006) reveals that the level of capital stock and previous investments both determine the current level of public investments. This is also a characteristic of investment in general.

In a microeconomic level, according to Borri and Boccaletti (1995), a firm that gains from minimizing environmental impact will always take that into account when planning for the future of the business. This means that past investments influence positively the future investments.

Additionally, Wozniak *et al*. (2021), also in a microeconomic level, concluded that for Poland, previous investments, in general, affect negatively changes in current investments spending by firms. Hence, it would be intriguing to see if a macroeconomic analysis produced the same results.

From a theoretical point of view, in response to the first sub question "*How do past environmental protection investments influence current ones?"* it is clear that past investments impact current investments. Hence, it will be intriguing to see if a macroeconomic analysis produced the same results.

1.2.2 – Environmental Regulation

Eyraud *et al*. (2011, 2013) asserted that environmental issues are externalities that require government action through policies that support green investment. In this article, they tested with dummy variables which nations have at least one of the four major policies instruments: feed-in-tariffs, renewable portfolio requirements, biofuel obligations and strategies for carbon pricing.

As shown by the hypothesis tested, Green Investment is higher in countries with cap-and trade or carbon taxes and feed-in-tariffs. As for the other two policies, green investment appears to be insensitive to them.

Furthermore, empirical results provided by Leiter *et al*. (2011) indicate that income generated through environmental taxation contributes favourably to numerous types of investment explicit to each nation and industry.

Xie and Jamaani (2022) highlighted a different relationship to take into consideration regarding the environmental performance. In their research in G-7 economies both green innovation and environmental taxes help to minimize notably CO2 emissions, thus, enhancing the performance of the environment.

Umar and Safi (2023) research evidences are aligned with this literature presented. Using a Method of Moments Quantile Regression (MMQR) analysis, they observed a negative relationship between environmental policy stringency and CO_2 emissions, for the OECD countries. These nations achieve this outcome by creating more efficient and environmentally friendly technologies. Overall, the OECD nations must enforce a fair ER and give special attention to the development of green finance and innovation.

Regarding the second sub question "*How do environmental regulations contribute to the investment in environmental protection?*", according to the literature provided, there is a clear positive relationship between these two variables.

1.2.3 – Gross Domestic Product

In the empirical results from the study conducted by Eyraud *et al*. (2011, 2013), the variable used to measure income levels, GDPPC, displays a positive relationship with green investment, more precisely, it encourages green technologies investments. The GDP growth, however, ends up being insignificant.

Focusing on the GDP variable, Badulescu *et al*. (2016) analysed the relationship between the GDP and Environmental Protection Expenditure. As doing so, numerous theories were shown.

The first theory is well recognized for generating conflicting viewpoints on its applicability. It is the Environmental Kuznets Curve (EKC), which Kuznets first proposed in 1955 and which Grosssman and Krueger later revised in 1991. The EKC depicts an inverted U-shape relationship between environmental quality and economic growth, wherein economic expansion initially degrades the environment but eventually reaches a critical threshold where it contributes to environmental improvement[1]. It is believed that this occurs as a result of the necessity of structural adjustments and the effective use of environmental funds.

[1] This research traces a linear relationship between GDP and the variable of interest. The reason for this unusual relationship is the fact that the framework in this study is small and, therefore, it is not expected a significant alteration concerning the income levels of the 27 countries overtime. Additionally, the stabilization of economic growth in some of the economies, during the 2014-2019 period in this study, may contribute to the appearance of a linear relationship between the two variables.

According to Everett *et al*. (2010), economic development starts to be essential to promote environmental conservation whereas constraining environmental regulations are unable to obtain the same result.

The EKC is criticized for not being suitable to all types of environmental hazards and economies, especially, emerging nations (Everett *et al*., 2010; Magnani, 2000). As a result, this theory is not the best option to determine how the environment would react.

The limits theory referred by Arrow *et al*. (1996) mentions that it is feasible to surpass the environmental constraint before achieving the ECK tipping point. There comes a moment when the environmental consequences impact the production levels, causing the economy to deteriorate (Everett *et al*., 2010; Meadows, Randers and Meadows 2004).

On the contrair, Stern (2004) defends that there are continuously new harmful contaminants that exacerbate the destruction of the environment, thus, disputing the reality of turning points. Global competitiveness amplifies environmental degradation, but wealthier countries can minimize this impact by creating green technology and exporting their pollution to poor nations. This can be an interesting theory to test in our study, that is, to see if richer nations have a positive relationship between GDP and environmental protection investments due to green technologies.

Badulescu *et al*. (2016) tested for 24 countries, from 1995 to 2011, the relationship of environmental protection spending and GDP using regression analysis. It was revealed that the European countries had divergent interactions with GDP, which might imply one of two things: either the countries are at different phases of development, but the theoretical model is relevant to all, or there are various explanations for multiple nations. Another discovery was the absence of a connection between the variable GDP and the majority of the studied countries. This may have been due to the lack of data or the fact that there is no relationship between GDP the environmental protection expenditure. At last, in most countries the EKC is not significant to the environmental protection investments.

Concerning the third sub question "*How does the gross domestic product of a country influence the amount invested in protecting the environment?*", ultimately it is anticipated a positive impact on the level of investment and that the numerous countries show different results.

1.2.4 – Environmental Innovation

There is a literature gap regarding the relationship between EI and Environmental Protection Investments. Nevertheless, there is literature concerning the relationship of Green Innovation, which it can be considered as a proxy of EI, and carbon emissions.

With respect to the effect of green finance and green innovation on CO_2 emissions for OECD economies, Umar and Safi (2023) conduct an informative study. Several authors, suggest a clear negative relationship between Green Innovation and carbon emissions (Yuan *et al*., 2022a, 2022b; Liu *et al*., 2022; Meng *et al*., 2022). The empirical evidences from the study of Umar and Safi (2023) also reach the same conclusion.

Sharif *et al*. (2022) complete this study by determining that the application of innovative eco-friendly technologies and environmentally conscious investments also assists in lowering carbon emissions. Additionally, Wang *et al*. (2023), draw the conclusion in their investigation, from 1990 to 2018, that technological innovation minimizes CO_2 emissions, supporting a sustainable environment.

Contrarily, a study by Weina *et al*. (2016) that was conducted in Italian provinces came to the conclusion that green technology has not yet had a considerable positive impact on the environment.

Khan *et al*. (2022), Khan *et al*. (2022) and Khan *et al*. (2022) revealed the importance of evolution of technology in order to obtain the goals regarding 100% transition.

Furthermore, Guerrieri *et al*. (2011) discuss how the progress in technics is related to the investment in new technologies. Hence, it is anticipated that there will be positive relationship among Green Investment and the Research & Development (R&D) expenditures. Regardless of the literature, the empirical findings show that the variable R&D was not relevant to green investment. This relation might depend on the type of green investment, whether or not if it is the standard one. Therefore, it will assess whether this evidence holds up.

Abbass *et al*. (2022) and Jin *et al*. (2022) believe that government expenditures in R&D investments and in green projects contribute to the decrease of pollution in the environment and Alam *et al*. (2021) stated in their research that, from 1996 to 2013, R&D investments were significant for a sustainable environmental protection in 30 OECD economies.

All in all, Green Innovation contributes to reducing carbon emissions. This reduction promotes a sustainable environment. However, there is not a clear direct relationship between Green Innovation and Environmental Protection Investments. In order to answer the fourth sub-question "*How does environmental innovation affect environmental protection investments?*"

it will be crucial to test if the increase of the amount of EI, by itself stimulates the investment in environmental protection.

1.2.5 – Interest Rates

To no surprise, Eyraud *et al*. (2011, 2013) claim that increasing IR causes investment to decline, thus, having a negative impact on green investment. As predicted, the outcome was that green investment reacts to shifts on IR, in particular, long-term rates. By contrast, short-term rates are irrelevant to the study.

Leão *et al*. (2009) offers three transmission mechanisms of how IR shifts affect investments.

The first mechanism demonstrates how, assuming corporations can get finance, a decline in IR reduces the financial cost of their investment projects and allows them to invest more. As a result, the volume of investment in an economy is influenced by changes in IR as well as corporate financing capabilities.

The second one takes aim at the rise in profits brought on by a fall in IR. Since the company's reputation improves, it can now acquire more capital from potential investors.

Finally, a decrease in IR boosts share values, which encourages investment for two reasons: first, corporations will have more collateral enabling them to borrow money from banks, and second, the issuance of these new shares will result in higher profits.

Albu (2010) outlines the impact of the growth ratios on the fluctuation of IR and on the level of investment. In other words, if the growth rate changes, the IR will change as well, increasing or decreasing the investment ratio. As a result, a negative connection among IR and investment is seen.

Marinescu *et al*. (2019) points out that the IR affect mainly the public investment since the restraint to finance dictates whether or not a country has the money to invest. Ultimately, the anticipated outcome for this study, conducted by the EU 28, is a detrimental influence in public investment by the IR. Moreover, all components were lagged one year since the implications of these variables are only visible after a year.

As expected by Marinescu *et al*. (2019), the empirical findings confirm that there is a negative correlation between these factors.

Additionally, Sharma *et al*. (2019) also verify that the existence of restrictions in finance related to capital expenses negatively impacts the investment. In this research, it was proven the hypothesis that raising IR decreases investment returns (ROI), which leads to the decline of these projects.

In reference to the fifth sub question – *How do determinant variables of investment in general impact environmental protection investments?* – it is obvious that IR defines both investments in general and green investments.

1.2.6 – Credit Supply

In a microeconomic analysis, there are two perspectives on how the availability of credit dictates the investment in green technologies:

From one point of view, CS has no bearing on green investments. According to Acemoglu *et al*. (2012, 2016), the government must step in order for companies to invest in clean technologies. Otherwise, companies will not induce in those type of investments.

Additionally, green investments aim to decrease the harmful impact on the environment caused by corporations rather than maximizing their profits, which is the goal of the company, as stated by Friedman (1970). Therefore, it is not a priority.

From a different angle, whether a corporation invests in green technologies depends on the CS.

As claimed by Bénabou and Tirole (2006), Hart and Zingales (2017), Oehmke and Opp (2020) and Pástor *et al*. (2021), investors and entrepreneurs have been paying more attention to social and environmental concerns when deciding what to invest in, contradicting previous statements about the priority of only maximizing profits.

Furthermore, Dechezleprêtre and Sato (2017) and Ramadorai and Zeni (2021) argue that corporations might invest in technologies that reduce pollution if it is anticipated that environmental policies will be implemented in the future.

Accetturo *et al*. (2022) showed in their empirical work, in a study conducted from 2015 to 2019 using company's financial statements and a text-based approaches, that there is a significantly positive relationship among CS and green investments. Moreover, it has been noted that green investments require a lot of capital and if there are environmental policies that promote green investments, such as subsidies and low rates of green loans, then there will be a rise in the amount of credit available for these types of investments.

Therefore, companies that prioritise environmental protection and have access to internally capital will invest more in green technologies.

Moreover, Gaiotti (2013) reveals that the amount of credit shapes the investment. The investment level of corporations is affected over time by the credit supplied through banks. This outcome is particularly noticeable in the early stages of recessions when other financial instruments scarce as well.

Hence, it is determined that this driver of investment in general impacts green investments equally.

CS and IR may not influence environmental protection public investment as strongly as intended. According to Mogues (2015), for the example of agriculture public investment, there are other incentives that control the investment, such as, vote-seeking, optimization of budget allocation, capacity for coordination, influence of group size and economic resources.

Overall, considering the literature gathered in this section, it is expected the following results for the six variables: firstly, on a microeconomic angle, any alteration in investment expenses, in the general sense, may prove to be challenging (Wozniak *et al*., 2021). Thus, it is believed that previous investments in environmental protection influence current investments continuously (Borri and Boccaletti; 1995). Secondly, it is anticipated that the presence of some type of ER will have a favourable impact on green investments (Eyraud *et al*., 2011, 2013). Thirdly, EI does not show a directly relationship with environmental investments. Nonetheless, it is evidenced a negative association with the emissions of C02 (Yuan *et al*., 2022a, 2022b; Liu *et al*., 2022; Meng *et al*., 2022; Umar and Safi, 2023). This decrease contributes to a sustainable environment (Wang *et al*., 2023). Hence, it is opportune to test if the rise on EI itself promotes environmental protection investments. Fourthly, GDPPC will be expected to exhibit a positive relationship with the environmental protection investments or different results for the numerous countries (Badulescu *et al*., 2016). Finally, the IR will culminate in a negative association with the environmental investments for the same reason that the CS is anticipated to demonstrate a positive relationship with the variable of interest – financial constraints restrict the amount invested (Gaiotti, 2013; Marinescu *et al*., 2019). Nonetheless, the impact of these two variables may not be as strong as anticipated, given that there are other incentives that affect public investment (Mogues, 2015).

Ultimately, this investigation two gaps in the literature on the determinants of investments in environmental protection in Europe:

Firstly, it offers a macroeconomic analysis that enables readers to comprehend the factors that affect public investment in protecting the environment for different European countries. Additionally, this panel data research also makes it possible to compare and contrast the drivers that encourage the environmental protection investments overtime in these various economies.

Secondly, it complements the literature by attempting to explore a relationship between EI and investments in environmental protection.

Chapter 2 – Context Description of the Economic Reality

The group of countries with data availability chosen for the following econometric study are: Belgium, Bulgaria, Czechia, Denmark, Germany, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden and Iceland.

There is only one country from EU that isn't going to be analysed which is Estonia due to lack of data. Even though, Iceland doesn't belong to the EU it is part of the European Economic Area (EEA) which means that it shares a single market with the other 26 countries for this analysis.

Europe has had an important role in the protection of the environment starting with the Europe Green Deal (EGD). This deal consisted of achieving a carbon neutral EU by 2050 and disassociating economic growth from the use of resources.

According to a report by the European Sustainable Development Network (ESDN), as highlighted by Fetting (2020), it is still crucial to address the climate crisis. Although the Covid-19 pandemic led to a decrease in carbon emissions, this decline is expected to be momentary as economies recover.

Wolf *et al*. (2022) introduce the Environmental Performance Index that categorizes 180 countries based on their sustainability efforts. It considers forty performance indicators between eleven sections of issues, and it evaluates countries' success in preserving ecosystems, diminishing climate change and working towards a heathier environment.

Considering this index (**Table 1 in the Appendix A**), it is fascinating to observe how certain countries in this research represent the top of the rank, for example, Denmark and Finland, while others do not hold a notable position, such as, Poland and Portugal. Nevertheless, this group of countries belong in the top 50 of the 180 countries considered in this index. From this scope of different performances regarding the environment it is essential to try to understand why are there always countries who go the extra mile regarding environmental protection and others lack attention to this problem. Therefore, it will be interesting to study the key factors that influence the differences in environmental protection investments.

Chapter 3 – Methodology & Data

3.1 – Methodology

In the literature showed in the previous section, there were so many methodologies used in the different studies conducted. Eyraud *et al*. (2011, 2013) used Fixed Effects in order to test if the determinants presented were significant to green investments. Similarly, Marinescu *et al*. (2019) conducted their research using a country fixed and time fixed effects as their methodology for examining economic factors that potentially impact the progression of public investment.

On the contrair, Badulescu *et al*. (2016) in their research regarding the association among GDP and environmental spending in EU nations, decided to adopt a country level regression mostly because of inter-country disparities.

Umar and Safi (2023) used a MMQR analysis to determine the relation among the numerous variables. This method stands out from the others for being suitable for non-normal data. Hence, it is more resilient since it is less susceptible to the effect of outliers.

Wang *et al*. (2023) also based their research on this method and employed three additional methods: Cross Sectional Autoregressive Distributed Lag (CS-ARDL), Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCEMG). These models were used for testing which variables are relevant for achieving a sustainable environment in African economies, such as green energy and technological innovation.

Murovec *et al*. (2012) applied a structural equation modelling (SEM) to analyse the effect of past environmental investments, among other variables, on current environmental investments. As stated in Murovec *et al*. (2012), this method allows the inclusion of various measures for the same notion (Hair *et al*., 2010), tests hypotheses and explores structural theories related to that notion (Byrne, 2006).

Lisowski *et al*. (2021) study four hypotheses, particularly the implications of IR and previous investments on the investments of polish enterprises, resulting in the usage of multiple statistical analyses: canonical analysis, linear and causality correlation, autocorrelation and cointegration tests.

Acceturo *et al*. (2022) implemented a text-based approach by using the observations and financial records of SMEs in Italy with the intuit of testing the significance of CS in green investments.

Lastly, Gaiotti (2013) utilized a production function to discover if the quantity of credit shapes significantly the amount of investment.

3.2 – Panel Data

According to Verbeek (2017), panel data uses numerous observations of units, which can be firms, individuals, households or, in a macroeconomic analysis, countries and industries. These observations are gathered overtime. Therefore, panel data is the combination of cross section and time series.

The equation of a linear regression of a panel data model is the following:

$$y_{it} = \beta_0 + x'_{it}\beta + \varepsilon_{it} \ , \qquad (i = 1, \dots, N) \ and \ t \ (t = 1, \dots, T) \qquad (3.2.1)$$

where x_{it} represents the independent variables and the intercept β_0 is equal to the coefficients in β across all units and time frames. In contrast, the error term (ε_{it}) differs from individuals and time intervals. Moreover, this term takes into account the influence of overlooked variables that impact y_{it} (Verbeek, 2017).

Conducting a panel data analysis presents both strengths and limitations. Among its advantages, the ability to study individual-level changes stands out. This not only enables researches to comprehend why certain variables behave distinctly for each individual but also sheds light on why a particular individual acts differently across multiple time periods. Consequently, panel data models are usually more reliable and sophisticated models than cross section or time series models on its own. (Verbeek, 2017).

Another advantage of panel data is that it decreases the identification issues, such as, variables interrelated or errors in measurement. Panel data helps address these limitations by showcasing how individuals change over time (Verbeek, 2017).

As dictated by Hsiao (2003), panel data offers greater flexibility compared to alternative methodologies since it diminished the collinearity among independent variables and enhances the diversity of the sample in contrast to cross-sectional data. Hence, it elevates the precision of econometric estimates.

The limitations associated with panel data possess a practical aspect. Giving that the same individuals are recurrently examined; it becomes uncertain whether the distinct observations can be considered independent. Nonlinear and dynamic models' investigations are more affected by this issue. Moreover, panel data usually encounter situations of incomplete observations. (Verbeek, 2017).

The panel data employed in this analysis is unbalanced due to missing observations and since one of the six explanatory variables is the dependent variable lagged (PEPI), it will be conducted an econometric investigation with a Dynamic Linear Model.

3.3 – Dynamic Linear Model & LSDVBC Estimator

Dynamic Linear Models include explanatory variables, but they differ from conventional panel data models by using a lagged variable of interest. Thus, dynamic models are known for illustrating the idea that contemporary acts depend on past ones (Verbeek, 2017).

The equation of a linear dynamic model is represented as:

$$y_{it} = x'_{it}\beta + \gamma y_{i,t-1} + \alpha_i + u_{it} \ , \qquad (i = 1, \dots, N) \ and \ t \ (t = 1, \dots, T) \qquad (3.2.2)$$

In this equation, there are three distinct terms from the previous linear regression equation: $y_{i,t-1}$, α_i and u_{it}. The first term ($y_{i,t-1}$) symbolizes the lagged dependent variable and α_i the fixed indeterminate constants computed together with β. It is crucial to understand that $y_{i,t-1}$ relies on α_i regardless of how α_i is handled. Finally, u_{it} is presumed to be independent and identically distributed (i.i.d.) throughout individuals and time (Verbeek, 2017).

The panel data model used in this investigation exhibits three distinct characteristics: it is an unbalanced, dynamic and macro panel data.

As mentioned previously, this panel data has missing observations since, for each country during the analysis period, there were certain variables for which data wasn't available. Additionally, the lagged explanatory variable urges for a dynamic model. Finally, the low number of cross-sectional individuals constitutes a macro analysis. Hence it will be used for this macroeconomic investigation a dynamic model with unbalanced panel data.

These three traits are the reasons behind the adoption of the LSDVBC Estimator. This estimator, proposed by Nickell (1981), Bun and Kiviet (2003), and Bruno (2005a, 2005b), will be crucial to identify the key factors of investing in the environmental protection.

Furthermore, the possibility of endogeneity also justifies the choice for this methodology. Endogeneity may be present due to simultaneity between the variables or because significant variables aren't being considered in this research, even though, were referenced in other papers (Acceturo *et al*., 2022; Eyraud *et al*., 2011, 2013; Umar and Safi, 2023).

LSDVBC estimator is more useful in this investigation than the typical panel data estimators, such as, pooled Ordinary Least Squares (OLS), fixed effects or random effects. These estimators produce biased and inaccurate because of correlation among the fixed effects in the error term and the lagged explanatory variable (Nickell 1981; Baltagi 2005).

In terms of dynamic panel data model, LSDVBC estimator continues to prevail over the common estimators, for example, Anderson and Hsiao (1982), Arrellano and Bond (1991), Arrellano and Bover (1995) and Blundell and Bond (1998). These estimators will show unreliable estimates as a result of the low cross-sectional dimension units presented in this model (Bruno 2005a, 2005b).

Lastly, the Monte Carlo Experience indicates that the LSDVBC estimator, in macro analysis, evidences estimator more coherent and effective than the estimators mentioned above (Kiviet, 1995; Judson and Owen, 1999; Bruno, 2005a, 2005b), even when endogeneity is in play (Behr 2003).

The LSDVBC estimator works by choosing one of the three reliable estimators available (Anderson and Hsiao, 1982; Arrelano and Bond, 1991; Blundell and Bond, 1998) and then starting the bias correction by running a number of replications selected to bootstrap the standard errors. In terms of significance, the estimates generated by the initial estimator and the number of replications chosen won't differ much (Bun and Kiviet, 2003; Bruno, 2005a; 2005b). In this research, it will be used the Anderson and Hsiao estimator as the initial matrix of values, followed by 50 and 250 replications.

3.4 – Hypotheses

Various explanatory variables have been examined in the literature to understand the factors influencing investments in environmental protection. Economic growth has been discussed by Eyraud *et al*. (2011, 2013) and Badulescu *et al*. (2016). The role of policies, including environmental policies (Acceturo *et al*., 2022), public policies (Eyraud *et al*., 2011, 2013), and policy stringency in general (Umar and Safi, 2023), has been explored. Umar and Safi (2023) specifically investigated the impact of environmental taxes on investments in environmental protection.

Previous investments and past decisions have also been considered in relation to environmental protection (Marinescu *et al*., 2019; Lisowski *et al*., 2021; Murovec *et al*., 2012). IR have been widely discussed by multiple authors, including Eyraud *et al*. (2011, 2013), Lagoa *et al*. (2009), Marinescu *et al*. (2019), and Lisowski *et al*. (2021).

Technological progress and innovation have been highlighted as determinants by Eyraud *et al*. (2011, 2013) and Umar and Safi (2023). Lastly, Gaiotti (2013) and Acceturo *et al*. (2022) have emphasized the importance of credit availability as a crucial factor for investing in projects that contribute to environmental preservation.

For the scope of this research, the selected variables include:

- <u>Past Environmental Protection Investments</u>: previous investments are considered because they are believed to influence current investment decisions;

- Environmental Regulation: due to the extensive discussions surrounding environmental policies.
- Environmental Innovation: the level of significance in the context of EI is examined to determine its influence on investments.
- Gross Domestic Product Per Capita: it aims to analyse potential differences in investment patterns between rich and poor countries.
- Interest rates: as highlighted in the current literature, it is a crucial factor when it comes to investment decisions.
- Credit supply: significant variable that affects investment decisions in general. However, in this particular research focusing on public investment, the influence of CS may not be as pronounced or strong.

The six hypotheses that will be tested in this inquiry are the following:

Hypothesis 1 (H1): *Previous Environmental Protection Investments influence positively current ones*

At a microeconomic perspective, if a firm takes into consideration its impact on the environment when investing, it will certainly continue with that behaviour in future decisions. Hence, there will be a continuous investment in the protection of the environment with few changes.

Hypothesis 2 (H2): *Environmental Regulation contributes positively to Environmental Protection Investments*

As the number of policy instruments increases, so does the level of investment in environmental protection. The revenue generated from environmental taxation serves as an incentive for further investment.

Hypothesis 3 (H3): *Gross Domestic Product impacts positively the Environmental Protection Investments*

The level of wealth in a country determines its willingness to invest. Thus, countries with higher GDP will tend to allocate more resources towards environmental protection. There is also a possibility of the various nations presenting different results in this matter.

Hypothesis 4 (H4): *Environmental Innovation has a positive effect on Environmental Protection Investments*

It is known that EI contributes to the reduction of pollutants emissions, leading to a sustainable environment. There is no literature regarding a direct relationship between EI and

Environmental Protection Investments. Thus, it will be interesting to test if EI by itself stimulates the variable of interest.

Hypothesis 5 (H5): *Interest Rates negatively affect the Environmental Protection Investments*

An increase in IR leads to higher financial constraints that prevent investments in environmental protection. Conversely, a decrease in IR would have the opposite effect, facilitating greater investment in environmental preservation.

Hypothesis 6 (H6): *Credit Supply has a positive relationship with Environmental Protection Investments*

When the CS expands, it results in a higher level of investment as more resources become available for investing in environmental protection. Therefore, the amount of credit available shapes the investment.

The data from the seven variables of the 27 countries that belong to Europe will be used to build a panel data and estimate a model with the sole purpose of determining whether these variables are significant or not to the differences that exist between the European countries in term of investments in environmental protection.

3.5 – Characterization of Variables

The data collected from 2014 until 2019 to use in this investigation shows a time where countries were recovering from previous crisis.

Table 3. 1 - Sample Composition

Country	Period	Observations	Missing
Austria	2015-2019	5	1
Belgium	2015-2019	5	1
Bulgaria	2015-2019	5	1
Croatia	2015-2019	5	1
Cyprus	2015-2019	5	1
Czechia	2015-2019	5	1
Denmark	2015-2019	5	1
Finland	2015-2019	5	1
France	2015-2019	5	1
Germany	2015-2019	5	1
Greece	2015-2019	5	1
Hungary	2015-2019	5	1
Iceland	2015-2017/ 2019	4	2
Ireland	2015-2019	5	1
Italy	2015-2019	5	1
Latvia	2015/ 2017-2019	4	2
Lithuania	2015-2019	5	1
Luxembourg	2015-2019	5	1
Malta	2015-2019	5	1
Netherlands	2015-2019	5	1
Poland	2015-2019	5	1
Portugal	2015-2019	5	1
Romania	2015-2019	5	1
Slovakia	2015-2019	5	1
Slovenia	2015-2019	5	1
Spain	2015-2019	5	1
Sweden	2015-2019	5	1

Source: Author's elaboration.

The variables used in the empirical analysis differs from the theoretical concepts. It is possible to visualize the proxies that will be applied to discover the key factors of the EPI.

Table 3. 2 - The Proxies and Sources of Each Variable

Variable	Proxy	Source
Environmental Protection Investments	Environmental protection investments of general government by environmental protection activity	Eurostat
Past Environmental Protection Investments	Environmental protection investments of general government by environmental protection activity lagged	Eurostat
Environmental Regulation	Environmental Tax Revenues	Eurostat
Environmental Innovation	Patents in environment-related technologies	OECD. Stat
Gross Domestic Product Per Capita	Main GDP aggregated per capita	Eurostat
Interest Rate	Interest Rates Long Term Nominal	AMECO
Credit Supply	Domestic credit to private sector (% of GDP)	World Bank

Source: Author's elaboration.

The intention of these research was initially to study the twenty-seven member states from the Europe Union and additionally three countries that have important commercial relationships as well with the EU, such as, United Kingdom, which recently left the EU, and Iceland and Norway. Regardless of the intention, due to data limitation for some of these countries the conclusive group of countries are twenty-six member states from EU and Iceland.

In this unbalanced panel data research, the variable of interest is Environmental Protection Investments (EPI), more specifically, annual data from environmental protection investments of general government from the countries in analysis, since 2006 to 2020. These Investments are the sum of the environmental protection activities which have the purpose to diminish, curb and eradicate pollution or acts of degradation as well as rehabilitating the environment after being harmed.

According to Eurostat (2021: 6), there is a Classification of Environmental Protection Activities (CEPA) that classifies *"activities, products, expenditure and other transactions related to environmental protection"*. Therefore, the environmental protection activities used in our variable of interest are classified into nine sections:

Table 3. 3 - The Nine Classifications of Environmental Protection Activities

CEPA 1	PROTECTION OF AMBIENT AIR AND CLIMATE
CEPA 2	WASTEWATER MANAGEMENT
CEPA 3	WASTE MANAGEMENT
CEPA 4	PROTECTION AND REMEDIATION OF SOIL AND WATER
CEPA 5	NOISE AND VIBRATION ABATEMENT
CEPA 6	PROTECTION OF BIODIVERSITY AND LANDSCAPES
CEPA 7	PROTECTION AGAINST PARTICLE RADIATION (excluding external safety)
CEPA 8	RESEARCH AND DEVELOPMENT
CEPA 9	OTHER ENVIRONMENTAL PROTECTION ACTIVITES

Source: Eurostat.

Environmental Protection Investments, extracted from Eurostat, are reflected in millions of euros. This variable has been converted to a percentage of GDP in order to make it easier to understand the results. To accomplish this, it was first divided by GDP at market prices expressed in millions of euros at current prices, and then it was multiplied by 100.

$$EPI = \frac{Million\ of\ Euros\ of\ Environmental\ Protection\ Investments\ of\ General\ Government}{Million\ of\ Euros\ at\ current\ prices\ of\ GDP\ at\ market\ prices} \times 100$$

It is important to alert that it is specifically public investment which will result in different intensity of outcomes for some of the explanatory variables that strongly affect private investment.

There are six explanatory variables that will be used in this study. The first variable is PEPI which is none other than our variable of interest lagged. As a result, it provides the same characteristics in terms of measurement unit, data source, period, frequency and observation unit.

The second variable is ER, particularly, environmentally related tax revenues from the twenty-seven countries since 1995 until 2020. This variable is measured in millions of euros, with an annual periodicity and has been taken from Eurostat. For ease of interpretation, it was also changed to a percentage of GPD. Therefore, it is represented as:

$$ER = \frac{Million\ of\ Euros\ of\ Environmentally\ related\ tax\ revenues}{Million\ of\ Euros\ at\ current\ prices\ of\ GDP\ at\ market\ prices} \times 100$$

GDP is the third variable taken into consideration in this investigation. It is represented by annual real gross domestic product per capita at market prices of each country. This Eurostat data, from 2000 to 2022, uses as a unit of measurement chain linked volumes (2010) euros per capita. This will be computed into a growth rate.

The fourth variable is IR of the nations in examination, since 1961 to 2021. This data consists of long-term real interest rates, expressed in percentage, and was extracted from AMECO.

The fifth variable is EI, precisely, the number of patents in environmental related technologies per country of inventor. This annual data is from OECD. Stat and has the period of analysis of 1995 to 2019. To make the results easier to grasp, this variable was multiplied by 100 000 and divided by the population of each nation. In this manner, the number of patents can be proportionally compared to the size of each nation. Hence, it is described by the following equation:

$$EI = \frac{Number\ of\ patents\ in\ environmental\ related\ technologies}{Population} \times 100\ 000$$

Finally, the variable CS is represented by the annual domestic credit for private sector in these countries. This World Bank data is indicated in percentage of GDP, from 1960 until 2021.

Despite having long periods of analysis, in these databases, the majority of the twenty-seven countries only have data available in recent years. Therefore, in order to consider all the nations, the period of study will be from 2014 to 2019.

The descriptive Statistics of each variable can be viewed in **Table 2 in the Appendix A**, where the Mean, Median, Maximum, Minimum and Standard Deviation of each factor is calculated.

In terms of seasonality, it isn’t expected to be any since the variables are annual and will be analysed for a short period of time - six years.

The descriptive graphics showcased in **the Appendix B** of each variable present the trend of each variable during the years in analysis. Starting with **Graph 1**, it is possible to see that the EPI demonstrates a negative slope during this time. It is also seen that there are some outliers in the year of 2014 and 2015. The most visible ones belong to Bulgaria, which reaches values higher than 1%. As a result, **Graph 2**, which consist of the variable of interest lagged also replies that effect.

In **Graph 3**, the ER shows a decline trend but not too steep throughout these six years. Two distinctive outliers stand out in this graph: one in 2017 that is associated to Greece and represents a percentage higher than 4 whereas in 2019 Ireland displays a percentage lower than 1.5.

The GDPPC represented in **Graph 4** exhibits a slight increase but mostly constant during the time of this analysis. In this graph, there is a clear outlier that distinct itself from the other values since it surpasses the value of 0.23. This outlier is related to Ireland in 2015.

The **Graph 5** features the EI, and it is possible to notice a slight decrease in the trend of this variable, however, it is not a notable one, that is, the EI has mostly been constant during these years. As for outliers, Denmark and Germany present values higher than 5.

In **Graph 6**, the IR highlights a considerable negative slope between 2014 and 2019. Greece attained rates beyond 8% from 2014 to 2016, with the highest being 10%. By contrast, Ireland registered a rate of - 6.6% in 2015.

Lastly, the CS is demonstrated in **Graph 7**, where the slope is also negative. The outliers in this graph are owned by Cyprus from 2014 to 2017, where some percentages reached values among 200, and by Denmark where percentages higher than 150 were obtained.

The correlation matrix between the variables of this investigation, illustrated in the following table, indicates the magnitude and the direction of the linear relationship between the pair of variables under consideration.

Table 3. 4 - The Correlation Matrix

	EPI	**PEPI**	**ER**	**GDPPC**	**EI**	**IR**	**CS**
EPI	1.0000						
PEPI	0.6792	1.0000					
ER	0.1245	0.1606	1.0000				
GDPPC	0.1250	0.0876	-0.1187	1.0000			
EI	-0.2761	-0.2628	0.0075	-0.3689	1.0000		
IR	0.1167	0.0816	0.3553	-0.2198	-0.2569	1.0000	
CS	-0.1916	-0.2113	0.1928	-0.3178	0.4466	0.3183	1.0000

Source: Author’s elaboration.

These conclusions can be drawn from these correlation coefficients:

- The variable EPI has a positive correlation with ER, GDPPC, IR and PEPI. The latter variable shows a strong linear relationship with EPI. By contrast, EPI demonstrates a negative correlation with EI and CS;
- PEPI showcases the expected direction of the correlation, that is, a positive linear association with ER, GDPPC and IR and a negative correlation with EI and CS;
- The variable ER reveals a negative correlation with GDPPC whereas with EI, IR and CS reflects a positive linear relationship;
- GDPPC displays a negative correlation with EI, IR and CS.
- The variable EI suggests a negative linear association with IR and a positive correlation with CS.

- IR outlines a positive correlation with CS.

Chapter 4 – Presentation & Analysis of Results

In this analysis, it will be considered all the five explanatory variables, including the variable of interest lagged with the purpose of studying if previous investments are also significant to the environmental protection investment in 27 European countries.

Anderson and Hsiao (1982) will be used as the initial estimator, and it will be examined in various combinations with bias 1, 2 and 3 and repetitions of 50 and 250.

To determine if a variable is significant or not, it is essential to take this hypothesis into consideration:

$H_0: The\ variable\ is\ not\ statistically\ significant$

$H_a: The\ variable\ is\ statistically\ significant$

$$y_{it} = x_{it}'\beta + \gamma y_{i,t-1} + \alpha_i + u_{it} \tag{4.1}$$

For the estimates with bias of 1 and of 2, whether the vcov is 50 or 250, (**view table 3 in Appendix A**) the outcomes were the same: all variables, except PEPI, have a p-value higher than the significance level of 1%, 5% and 10%. As a result, the alternative hypothesis is rejected meaning these variables are statistically insignificant. As for the PEPI, the null hypothesis is rejected stating that this variable is statistically significant for Environmental Protection Investments, since it's p-value is under the significance levels (1%, 5% and 10%).

By contrast for the estimate produced by using the Anderson and Hsiao 1982 estimator, bias of 3 and vcov of 50 or 250 (**view table 3 in Appendix A**) there is a different result. ER presents a p-value lower than the significance level of 5% and 10%. Hence, the null hypothesis is rejected indicating that this variable is statistically significant. PEPI continues to show a p-value inferior to 1%, 5% and 10%.

Moreover, for the Anderson and Hsiao 1982 estimator, bias of 3 and vcov 250 (**view table 3 in Appendix A**), EI can also be considered statistically significant to Environmental Protection Investments given that it displays a p-value equal to the significant level of 10%. As for the other four variables, they continue to display p-values greater than the significant levels (1%, 5% and 10%). Thus, they are not statistically significant to the variable of interest.

The dynamic model with the Anderson and Hsiao 1982 estimator featuring a bias of 3 and a vcov of 250 will be considered the ultimate model, since there are three significant variables: PEPI, ER and EI.

As far as the literature shown in the beginning of this dissertation, the results do not align exactly with the initial predictions.

4.1 – Past Environmental Protection Investments

As seen in section 2, Heineman (2006) presented past investments as a determinant factor in the current level of public investments. Additionally, Borri and Boccaletti (1995), in a microeconomic perspective, dictated that past investments influence positively the future investments.

Based on the outputs generated in this section, it is evident that, from 2014 to 2019, for this specific scope of countries, hypothesis 1, which states that *previous environmental protection investments influence positively current ones* is verified. Therefore, the literature supports the empirical investigation concerning this variable.

More specifically, the interpretation of this result is that if previous environmental protection investments increase by 1%, current environmental protection investments will rise by 1.22%. Thus, PEPI is statistically significant and impacts positively the EPI.

4.2 – Environmental Regulation

Leiter *et al*. (2011) demonstrate revenues from environmental taxes benefit numerous types of investment according to each country and industry.

Unexpectedly, the outcomes of this empirical study showcased a negative relationship between the ER and Environmental Protection Investments. As a result, Hypothesis 2 (*environmental regulation contributes positively to environmental protection investments*) is invalid. This finding can be justified by environmental tax revenues not being used explicitly for environmental investments under this framework, which ran from 2014 to 2019.

The implication of this output is that if ER grows by 1%, the investment in the protection of the environment falls by 0.42%. Hence, the ER is statistically significant and contributes negatively to EPI.

4.3 – Gross Domestic Product Per Capita

Concerning GDPPC, there were different perspectives of how this variable affects the variable of interest. Some authors believed that GDPPC contributed positively to green investments (Eyraud *et al*. (2011, 2013)). Kuznets even proposed in 1955 an inverted U-shape relationship between environmental quality and economic growth, which was highly criticized by other authors (Everett *et al*., 2010; Magnani, 2000).

Nevertheless, the findings in this section propose that the variable GDPPC is statistically insignificant to the Environmental Protection Investments. Hence, Hypothesis 3 (*gross domestic product impacts positively the environmental protection investments*) is not correct.

This behaviour is consistent with the conclusions of Badulescu *et al*. (2016)'s research, as stated in section 2. That is, most European countries showed no correlation with the variable GDP. This could be a possible cause for this variable's results.

4.4 – Environmental Innovation

Numerous researches suggested a negative relationship between Green Innovation and carbon emissions (Yuan *et al*., 2022a, 2022b; Liu *et al*., 2022; Meng *et al*., 2022; Umar and Safi, 2023; Wang *et al*., 2023).

Guerrieri *et al*. (2011) declared that the progress in technics is associated to the investment in new technologies. Nevertheless, the empirical findings showed an insignificant relationship between R&D and green investment. It was concluded that the type of green investments influenced the relation.

EI is a variable that does not show a direct relationship with Environmental Protection Investments, in terms of literature. However, in this section it was tested if the amount of innovation in the environment positively affects the environmental protection investments.

The empirical results from this section about EI were surprising. EI exhibits a negative impact on the variable of interest. Therefore, Hypothesis 4 (*environmental innovation has a positive effect on environmental protection investments*) does not hold up.

The improvements in environmental related technologies enhancing the efficiency of protecting the environment can be a possible explanation, given that, a decrease in the environmental protection investments can be due to the reduction in the expenses of environmental protection. Furthermore, this negative relationship can show the delayed impacts of EI on the variable of interest, as new technologies and technics need time to be employed on bigger grounds. This would result in a seemingly fall on the investments when, in reality, these investments have the purpose to obtain long term goals.

The outcome of this variable reflects a statistically significant negative relationship between EI and environmental protection investments. When EI rises 1%, the investment in the protection of the environment decreases by 0.11%.

4.5 – Interest Rates

Lagoa *et al*. (2009) and Albu (2010) demonstrate that the fluctuation of IR determines the level of investment. Eyraud *et al*. (2011, 2013) displayed a negative impact of the rise of IR in green investments. Furthermore, Marinescu *et al*. (2019) points out the detrimental influence in public investment by the increase of IR.

Contrarily to what the literature presented; this variable was considered insignificant to the environmental protection investments. A possible reason for this outcome is related with the transmission lags of monetary policy theory. In a simplified manner, this theory consists of the time it takes for the effects of monetary policy to become visible. According to Friedman, (1972), Batini and Nelson (2001) and Goodhart (2001), these impacts have a great duration and unpredictable lags. Mojon and Peersman (2001) specified that in European nations, these transmissions take about 16 to 20 quarters after the change. Another justification for this outcome might be that there are other motivations for the public investment, for instance, vote-seeking, optimization of budget allocation, capacity for coordination, pressure of group size and economic resources (Mogues, 2015), neglecting the effect of the IR

As presented in the literature section, Marinescu *et al*. (2019) used variables lagged one year in their investigation due to the consequences of these variables only being clear after a year. Thus, it is possible that the insignificant result of the IR is caused by this delay, making hypothesis 5 (*Interest Rates negatively affect the Environmental Protection Investments*) invalid.

4.6 – Credit Supply

There are two school of thoughts, regarding the impact of CS in green investments, from a microeconomic perspective. The first views CS has irrelevant to green investments (Acemoglu *et al*., 2012, 2016), since lowering the harmful effect on the environment of company is not important - maximizing profits is the goal (Friedman, 1970). There is a need for the government to incentivize companies to invest in clean technologies.

By contrast, there are other authors that believe in the importance of CS as a driver of green investment. Bénabou and Tirole, 2006; Hart and Zingales, 2017; Oehmke and Opp, 2020; Pástor *et al*., 2021, affirmed that social and environmental concerns have been taken into account when investing, contradicting the priority of only maximizing profits. Moreover, Dechezleprêtre and Sato, 2017; Ramadorai and Zeni, 2021 also appeal to the investment in technologies that decrease pollution when it is expected the execution of environmental policies. Accetturo *et al*. (2022) also demonstrated in their empirical evidences, a significantly positive relationship among CS and green investments.

From a macroeconomic perspective, it was tested the hypothesis 6 which claimed that *credit supply has a positive relationship with environmental protection investments*. This hypothesis turned out to be invalid since CS was considered statistically insignificant to environmental protection investments. A potential justification is that, from a macroeconomic angle, CS is also not relevant to green investments. It might be crucial the intervention of the government in terms of stimulating economies to invest in the protection of the environment, as it was for the investments of corporations, proclaimed by Acemoglu *et al*. (2012, 2016). Furthermore, there might be other incentives that influence more the public investment than the CS, such as, vote-seeking, optimization of budget allocation, capacity for coordination, influence of group size and economic resources (Mogues, 2015).

Overall, the empirical results did not support five of the six hypotheses stated in the previous section. One reasonable explanation for these findings is that environmental issues are a recent critical concern in our society, which explains the lack of data on this subject. As a result, the duration for this research is short (2014-2019), resulting in insignificant outcomes. It was also tested numerous dynamic models:

- Dynamic model with all variables lagged one;
- Dynamic model with time dummies;
- Dynamic model with an extra year of the time period in analysis (2013 – 2019) but with more missing observations;

- Dynamic model with logarithmic variables;

Nevertheless, all of these different models did not obtain robust results.

Conclusion

This dissertation aimed to identify the determinant factors for environmental protection investments in Europe in order to understand why some countries tend to invest more in the protection of the environment than others.

Reviewing the literature, it was discovered that investing in environmental protection benefits society as a whole and that European countries have continually made investments in this area. Although there is an absence of coordinated policies to meet regulatory standards.

This report also looked at the drivers of investing in environmental protection, such as PEPI, ER, EI, GDPPC and determinants of investment in general, namely, IR and CS.

It was expected that these six explanatory variables would have the following result: past investments in environmental protection would continuously affect current investments and the existence of ER would influence positively the environmental protection investments. Furthermore, GDPPC would impact positively the variable of interest, however the results might differ from countries. Moreover, the variable EI did not show a direct relationship with environmental protection investments. Nonetheless, since EI results in the decrease of CO_2 emissions and this fall of emissions leads to a sustainable environment, it was predicted that EI by itself would stimulate the investments in environmental protection. Finally, due to restrictions of finance, it was anticipated that the IR would have a negative impact in environmental protection investments whereas the CS would demonstrate a positive relationship with the investments to protect the environment.

Nevertheless, the outcomes were surprisingly different from what had been foreseen. The LSDVBC Model computed stated that only three of the six explanatory variables were statistically significant to the variable of interest.

Starting with ER, this variable showed a negative association with environmental protection investments which can be assumed that the revenue from the environmental taxation isn't being allocated necessarily toward the protection of the environment.

Secondly, EI also displayed a negative relationship with the variable of interest leading to the presumption that the overall expenses with the protection of the environment have reduced or that these innovations are for long-term investments, not affecting immediately the environmental protection investments. The decrease in the variable of interest can be associated with the low investments on short term.

Finally, the PEPI proof to contribute positively the current ones.

In conclusion, we can address the research question "*What are the determinants that influence the environmental protection investments in Europe?"*. These determinants include PEPI, ER and EI.

This dissertation fills in literature gaps by offering a macroeconomic analysis that displays the factors that affect the investments in environmental protection for the numerous European nations. This is made by comparing and contrasting key factors that encourage these investments over time. Furthermore, this report explores the indirect relationship between EI and environmental protection investments. In contrast, the limitations of this dissertation are the insufficient data available for the twenty-seven countries in this investigation. Due to missing observations, the timeframe of analysis considered in this study prevents the research from attaining more substantial empirical results.

The implications regarding this research are the following:

- The government must be more transparent about how environmental tax revenues are allocated. It should be employed in investments concerning the perseverance of the environment.
- It is crucial to continue investing in the technical progress and environmental-related technologies since it contributes to the reduction of the costs of protecting the environment. Long-term investments are also encouraged.

Further research should focus on the determinants that impact the environmental protection private investments for the 27 countries presented.

Bibliographic References

Abbass, K., Song, H., Khan, F., Begum, H., & Asif, M. (2022). Fresh insight through the VAR approach to investigate the effects of fiscal policy on environmental pollution in Pakistan. *Environmental science and pollution research*, 1-14.

Accetturo, A., Barboni, G., Cascarano, M., Garcia-Appendini, E., & Tomasi, M. (2022). Credit supply and green investments. *Available at SSRN 4217890*.

Acemoglu, D., Aghion, P., Bursztyn, L., and Hemous, D. (2012). The environment and directed technical change. *American Economic Review, 102*(1):131–66.

Acemoglu, D., Akcigit, U., Hanley, D., and Kerr, W. (2016). Transition to clean technology. *Journal of Political Economy, 124*(1):52–104.

Akomea-Frimpong, I., Adeabah, D., Ofosu, D., & Tenakwah, E. J. (2022). A review of studies on green finance of banks, research gaps and future directions. *Journal of Sustainable Finance & Investment*, *12*(4), 1241-1264.

Alam, M. S., Apergis, N., Paramati, S. R., & Fang, J. (2021). The impacts of R&D investment and stock markets on clean-energy consumption and CO2 emissions in OECD economies. *International Journal of Finance & Economics*, *26*(4), 4979-4992.

Albu, L. L. (2010). Scenarios for post-crisis period based on a set of presumed changes in the interest rate–investment–GDP growth relationship; MPRA Paper 32753, *University Library of Munich*, Germany.

Anderson, Theodore W., and Cheng Hsiao. 1982. Formulation and estimation of dynamic models using panel data. *Journal of Econometrics* 18 (1): 570–606.

Apergis, N., Christou, C., & Hassapis, C. (2013). Convergence in public expenditures across EU countries: Evidence from club convergence. *Economics and Finance Research: An Open Access Journal, 1*(1), 45–59

Arrellano, Manuel, and Olympia Bover. 1995. Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics* 68: 29–51.

Arrellano, Manuel, and Stephen Bond. 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies* 58 (2): 277–97.

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., ... & Pimentel, D. (1996). Economic growth, carrying capacity, and the environment. *Environment and Development Economics*, *1*(1), 104-110

Badulescu, Daniel & Badulescu, Alina & Rangone, Adalberto & Sipos-Gug, Sebastian. (2016). Different or Alike? Investigating the Impact of GDP on Environmental Protection Expenditure in Selected European States. Global & Local Economic Review. 20. 55-75.

Baltagi, Badi. 2005. *Econometric Analysis of Panel Data*, 3rd edition. New York: John Wiley & Sons, Ltd.

Batini, N., & Nelson, E. (2001). The lag from monetary policy actions to inflation: Friedman revisited. *International Finance*, *4*(3), 381-400.

Behr, Andreas. 2003. *A Comparison of Dynamic Panel Data Estimators: Monte Carlo Evidence and an Application to the Investment Function*. Discussion Paper no. 05/03. Frankfurt am Main: Economic Research Centre of the Deutsche Bundesbank. Accessed at: https://www.bundesbank.de/resource/blob/618268/7f17b1ac928092106e235a8edcfa0fcb/mL/2003-04-23-dkp-05-data.pdf.

Bénabou, R., & Tirole, J. (2006). Incentives and prosocial behavior. *American economic review*, *96*(5), 1652-1678.

Blundell, Richard, and Stephen Bond. 1998. Initial conditions and moment restrictions in dynamic panel-data models. *Journal of Econometrics* 87: 115–4.

Borri, F., & Boccaletti, G. (1995). From total quality management to total quality environmental management. *The TQM Magazine*, *7*(5), 38-42.

Bruno, Giovanni S. F. 2005a. Approximating the bias of the LSDV estimator for dynamic unbalanced panel data models. *Economic Letters 87* (3): 361–66.

Bruno, Giovanni S. F. 2005b. Estimation and inference in dynamic unbalanced panel-data models with a small number of individuals. *The Stata Journal 5* (4): 473–500.

Bun, Maurice J. G., and Jan F. Kiviet. 2003. On the diminishing returns of higher orders terms in asymptotic expansions of bias. *Economic Letters 79* (2): 145–52.

Dechezleprêtre, A. and Sato, M. (2017). The impacts of environmental regulations on competitiveness. *Review of Environmental Economics and Policy*, *11*(2):183-206.

Dogaru, L. (2013). The importance of environmental protection and sustainable development. *Procedia-Social and Behavioral Sciences*, *93*, 1344-1348.

Environmental Performance Index (2022) 2022 EPI Results. Retrieved from *Environmental Performance Index*.

Ercolano, S., & Romano, O. (2018). Spending for the environment: General government expenditure trends in Europe. Social indicators research, 138(3), 1145-1169.

European Union (n.d.). European Union priorities 2019-2024. Retrieved from *European Union*. *67*. 30.

Eurostat (2021). *Classification of Environmental Protection Activities and Expenditure (CEPA) and Classification of Resource Management Activities (CReMA) – Explanatory notes*, Luxemburg: System of Environmental Economic Accounting.

Everett, T., Ishwaran, M., Ansaloni, G., & Rubin, A. (2010). Economic Growth and the environment. Defra evidence and analysis series, Paper 2, 1-52.

Eyraud, L., Clements, B., & Wane, A. (2013). Green investment: Trends and determinants. Energy Policy, 60, 852-865.

Eyraud, L., Wane, M. A., Zhang, M. C., & Clements, M. B. J. (2011). *Who's going green and why? Trends and determinants of green investment*. International Monetary Fund.

Ferreiro, J., García-del-Valle, M. T., & Gómez, C. (2010). Social preferences and fiscal policies: An analysis of the composition of public expenditures in the European Union. *Journal of Post Keynesian Economics, 32*(3), 347–370.

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

Fleming S. (2020) *What is green finance and why is it important?* Retrieved from https://www.weforum.org/agenda/2020/11/what-is-green-finance/. Accessed in April 30, 2023.

Friedman, M. (1972). Have monetary policies failed?. *The American Economic Review*, *62*(1/2), 11-18.

Gaiotti, E. (2013). Credit availability and investment: Lessons from the "great recession". *European Economic Review*, *59*, 212-227.

Goodhart, C. A. (2001). Monetary transmission lags and the formulation of the policy decision on interest rates. In *Challenges for Central Banking* (pp. 205-228). Boston, MA: Springer US.

Guerrieri, P., Luciani, M., & Meliciani, V. (2011). The determinants of investment in information and communication technologies. *Economics of Innovation and new Technology*, *20*(4), 387-403.

Hart, O. and Zingales, L. (2017). Companies should maximize shareholder welfare not market value. *Journal of Law, Finance, and Accounting, 2*(2):247–275.

Heinemann, F. (2006). Factor mobility, government debt and the decline in public investment. *International Economics and Economic Policy*, *3*(1), 11-26.

Hepburn, C. (2010). Environmental policy, government, and the market. Oxford review of economic policy, 26(2), 117-136.

Hsiao, C. (2003). Analysis of Panel Data. *Journal of Chemical Information and Modeling*, 53(9).

Inderst, G., Kaminker, C., & Stewart, F. (2012). Defining and measuring green investments. 10.

Jin, Y., Tang, Y. M., Chau, K. Y., & Abbas, M. (2022). How government expenditure mitigates emissions: a step towards sustainable green economy in belt and road initiatives project. *Journal of environmental management*, *303*, 113967.

Judson, Ruth A., and Ann L. Owen. 1999. Estimating dynamic panel data models: A guide for macroeconomists. *Economic Letters* 65 (1): 9–15.

Khan, I., Tan, D., Hassan, S. T., & Bilal. (2022). Role of alternative and nuclear energy in stimulating environmental sustainability: impact of government expenditures. *Environmental Science and Pollution Research*, *29*(25), 37894-37905.

Khan, K., Su, C. W., Rehman, A. U., & Ullah, R. (2022). Is technological innovation a driver of renewable energy?. *Technology in Society*, *70*, 102044.

Khan, S. A. R., Ibrahim, R. L., Al-Amin, A. Q., & Yu, Z. (2022). An ideology of sustainability under technological revolution: striving towards sustainable development. *Sustainability*, *14*(8), 4415.

Kiviet, Jan F. 1995. On bias, inconsistency, and efficiency of various estimators in dynamic panel data models. *Journal of Econometrics* 68 (1): 53–78.

Leão, E. R., Leão, P. R., & Lagoa, S. C. (2009). Política Monetária e Mercados Financeiros. *Edições Sílabo, Lisboa*.

Leiter, A. M., Parolini, A., & Winner, H. (2011). Environmental regulation and investment: Evidence from European industry data. *Ecological Economics*, *70*(4), 759-770.

Lisowski, R., Woźniak, M., Jastrzębski, P., Karafolas, S., & Matejun, M. (2021). Determinants of Investments in Energy Sector in Poland. *Energies*, *14*(15), 4526.

Liu, J., Duan, Y., & Zhong, S. (2022). Does green innovation suppress carbon emission intensity? New evidence from China. *Environmental Science and Pollution Research*, *29*(57), 86722-86743.

Magalhães, N. (2021). The green investment paradigm: Another headlong rush. Ecological Economics, 190, 107209.

Magnani, E. (2000). The Environmental Kuznets Curve, environmental protection policy and income distribution. *Ecological economics*, *32*(3), 431-443.

Marinescu, A. C., Spanulescu, G. A., Craiu, M. A., & Noica, R. (2019). Determinants of Public Investment in Europe Union Countries. *Economic Computation & Economic Cybernetics Studies & Research*, *53*(4).

Meadows, D., Randers, J., & Meadows, D. (2004). A synopsis: Limits to growth: The 30-year update. *Estados Unidos: Chelsea Green Publishing Company, 381*.

Meng, Y., Wu, H., Wang, Y., & Duan, Y. (2022). International trade diversification, green innovation, and consumption-based carbon emissions: The role of renewable energy for sustainable development in BRICST countries. *Renewable Energy*, *198*, 1243-1253.

Migliorelli, M., & Dessertine, P. (2019). The rise of green finance in Europe. Opportunities and challenges for issuers, investors and marketplaces. Cham: Palgrave Macmillan, 2, 35.

Mogues, T. (2015). Political economy determinants of public spending allocations: A review of theories, and implications for agricultural public investment. *The European Journal of Development Research*, *27*, 452-473.

Mojon, B., & Peersman, G. (2001). A VAR description of the effects of monetary policy in the individual countries of the euro area. *Available at SSRN 303801*.

Murovec, N., Erker, R. S., & Prodan, I. (2012). Determinants of environmental investments: testing the structural model. *Journal of Cleaner Production*, *37*, 265-277.

Nickell, Stephen. 1981. Biases in dynamic models with fixed effects. Econometrica 49 (6): 1417–26. Onaran, Özlem, and Thomas Obst. 2016. Wage-led growth in the EU15 member-states: The effects of income distribution on growth, investment, trade balance and inflation. *Cambridge Journal of Economics 40* (6): 1517–51.

Oehmke, M. and Opp, M. M. (2020). A theory of socially responsible investment. *Swedish House of Finance Research Paper 20-2*.

Pástor, L., Stambaugh, R. F., and Taylor, L. A. (2021). Sustainable investing in equilibrium. *Journal of Financial Economics*, *142*(2):550–571.

Pearce, D., & Palmer, C. (2001). Public and private spending for environmental protection: A cross-country policy analysis. *Fiscal Studies*, *22*(4), 403–456.

Ramadorai, T. and Zeni, F. (2021). Climate regulation and emissions abatement: Theory and evidence from firms' disclosures. *ECGI Finance Working Paper 730*.

Sharif, A., Saqib, N., Dong, K., & Khan, S. A. R. (2022). Nexus between green technology innovation, green financing, and CO2 emissions in the G7 countries: the moderating role of social globalisation. *Sustainable Development*, *30*(6), 1934-1946.

Sharma, N., Smeets, B., & Tryggestad, C. (2019). The decoupling of GDP and energy growth: A CEO guide. *McKinsey Quarterly*, 1-11.

Stern, D. I. (2004). The rise and fall of the environmental Kuznets curve. *World development*, *32*(8), 1419-1439.

Stiglitz, J. E., & Weiss, A. (1981). Credit rationing in markets with imperfect information. *The American economic review*, *71*(3), 393-410.

Umar, M., & Safi, A. (2023). Do green finance and innovation matter for environmental protection? A case of OECD economies. *Energy Economics*, *119*, 106560.

United Nations Environment Programme (UNEP). (2016, September). Definitions and concepts. Background note (Inquiry working paper 16/13). New York.

United, N. (1997). Glossary of environment statistics, studies in methods. United Nations New York, NY.

Verbeek, M. (2017). *A guide to modern econometrics*. John Wiley & Sons.

Wang, Y., Ibrahim, R. L., Oke, D. M., & Al-Faryan, M. A. S. Investigating green energy–environment nexus in post-COP26 era: Can technological innovation, financial development and government expenditure deliver Africa's targets?. *International Journal of Finance & Economics*.

Weina, D., Gilli, M., Mazzanti, M., & Nicolli, F. (2016). Green inventions and greenhouse gas emission dynamics: A close examination of provincial Italian data. *Environmental Economics and Policy Studies*, *18*, 247-263.

Wolf, M. J., Emerson, J. W., Esty, D. C., de Sherbinin, A., Wendling, Z. A., et al. (2022). *2022 Environmental Performance Index*. New Haven, CT: Yale Center for Environmental Law & Policy. epi.yale.edu

Woźniak, M., Lisowski, R., & Dudek, M. (2021). Relationships between macroeconomics indicators and investments of enterprises: evidence from Poland.

Xie, P., & Jamaani, F. (2022). Does green innovation, energy productivity and environmental taxes limit carbon emissions in developed economies: Implications for sustainable development. *Structural Change and Economic Dynamics*, *63*, 66-78.

Yuan, B., Li, C., Yin, H., & Zeng, M. (2022). Green innovation and China's CO2 emissions–the moderating effect of institutional quality. *Journal of Environmental Planning and Management*, *65*(5), 877-906.

Yuan, X., Su, C. W., Umar, M., Shao, X., & LobonŢ, O. R. (2022). The race to zero emissions: Can renewable energy be the path to carbon neutrality?. *Journal of Environmental Management*, *308*, 114648.

Appendix A

Table A 1 - Country's Environmental Performance Index Score and Rank

Country	Rank	Environmental Performance Index Score
Denmark	1	77.90
Finland	3	76.50
Malta	4	75.20
Sweden	5	72.70
Luxembourg	6	72.30
Slovenia	7	67.30
Austria	8	66.50
Iceland	10	62.80
Netherlands	11	62.60
France	12	62.50
Germany	13	62.40
Latvia	15	61.10
Croatia	16	60.20
Slovakia	18	60.00
Czechia	19	59.90
Belgium	21	58.20
Cyprus	22	58.00
Italy	23	57.70
Ireland	24	57.40
Spain	27	56.60
Greece	28	56.20
Romania	30	56.00
Lithuania	31	55.90
Hungary	33	55.10
Bulgaria	41	51.90
Poland	46	50.60
Portugal	48	50.40

Source: Author's elaboration with data from Environmental Performance Index 2022.

Table A 2 - The Descriptive Statistics of Each Variable

Variable	Mean	Median	Maximum	Minimum	Standard Deviation
Environmental Protection Investments	0.192258	0.138287	1.596733	0.005379	0.201543
Past Environmental Protection Investments	0.201372	0.137333	1.596733	0.007310	0.216688
Environmental Regulation	2.627807	2.528928	4.029883	1.407445	0.648825
Environmental Innovation	1.574877	0.651836	7.479775	0.028927	1.821527
Gross Domestic Product Per Capita	0.027929	0.023396	0.233342	-0.008614	0.025218
Interest Rate	0.153086	-0.30	10.00	-6.60	2.34349
Credit Supply	81.67887	79.355284	251.8304	24.62327	40.20465

Source: Author's calculation.

Table A 3 - Results of the coefficients from the regression with Anderson and Hsiao 1982 estimator

Variables	bias 1 vcov 50	bias 1 vcov 250	bias 2 vcov 50	bias 2 vcov 250	bias 3 vcov 50	bias 3 vcov 250
PEPI	0.761***	0.761***	0.728***	0.728***	1.216***	1.216***
	(0.106)	(0.113)	(0.103)	(0.109)	(0.157)	(0.165)
ER	-0.200	-0.200	-0.183	-0.183	-0.424**	-0.424**
	(0.195)	(0.186)	(0.193)	(0.184)	(0.201)	(0.194)
GDPPC	0.880	0.880	0.860	0.860	1.142	1.142
	(1.078)	(1.022)	(1.069)	(1.017)	(1.036)	(0.970)
EI	-0.074	-0.074	-0.071	-0.071	-0.113	-0.113*
	(0.074)	(0.075)	(0.074)	(0.075)	(0.073)	(0.069)
IR	-0.005	-0.005	-0.004	-0.004	-0.018	-0.018
	(0.016)	(0.017)	(0.016)	(0.017)	(0.016)	(0.018)
CS	0.002	0.002	0.002	0.002	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)

*** p-value < 0.01

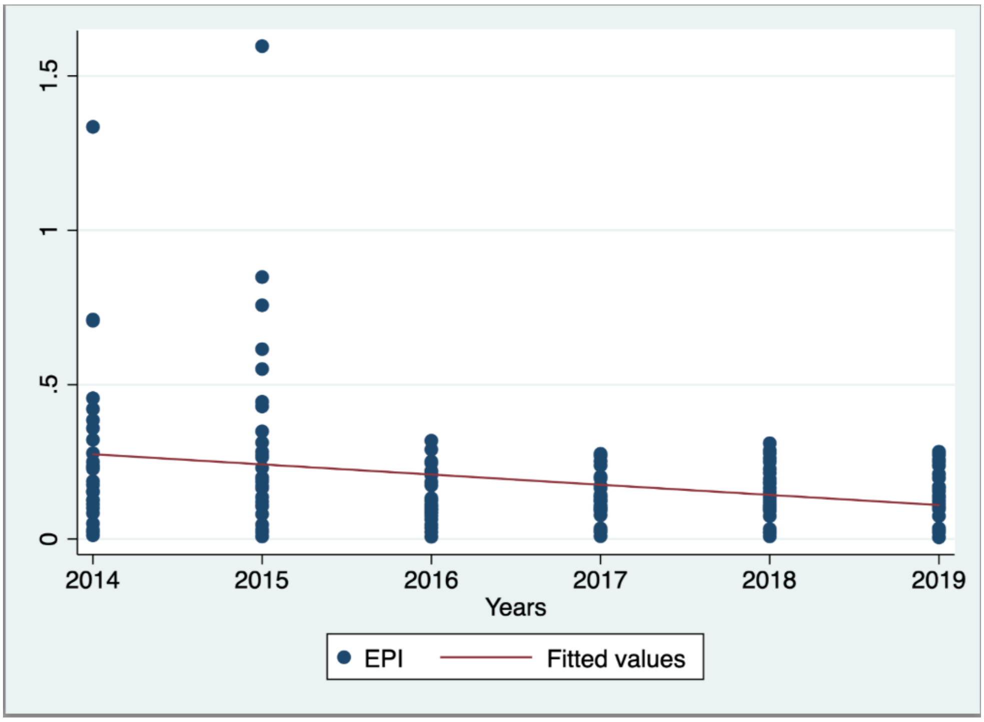
** p-value < 0.05

* p-value ≤ 0.1

Source: Author's elaboration.

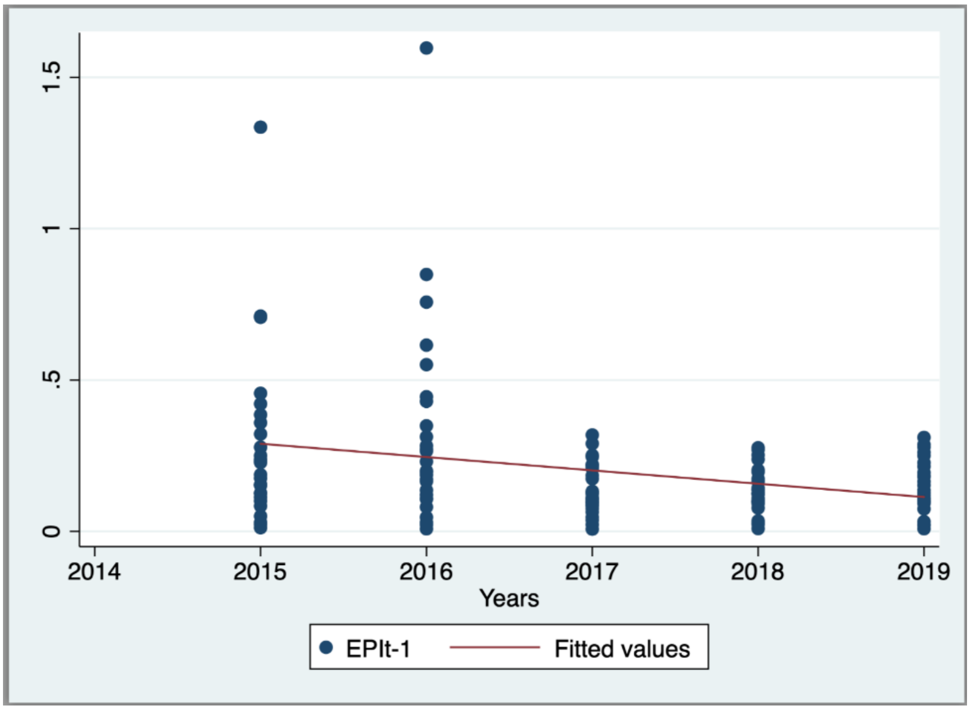
Appendix B

Graph B 1 - Descriptive graphic of the variable Environmental Protection Investments



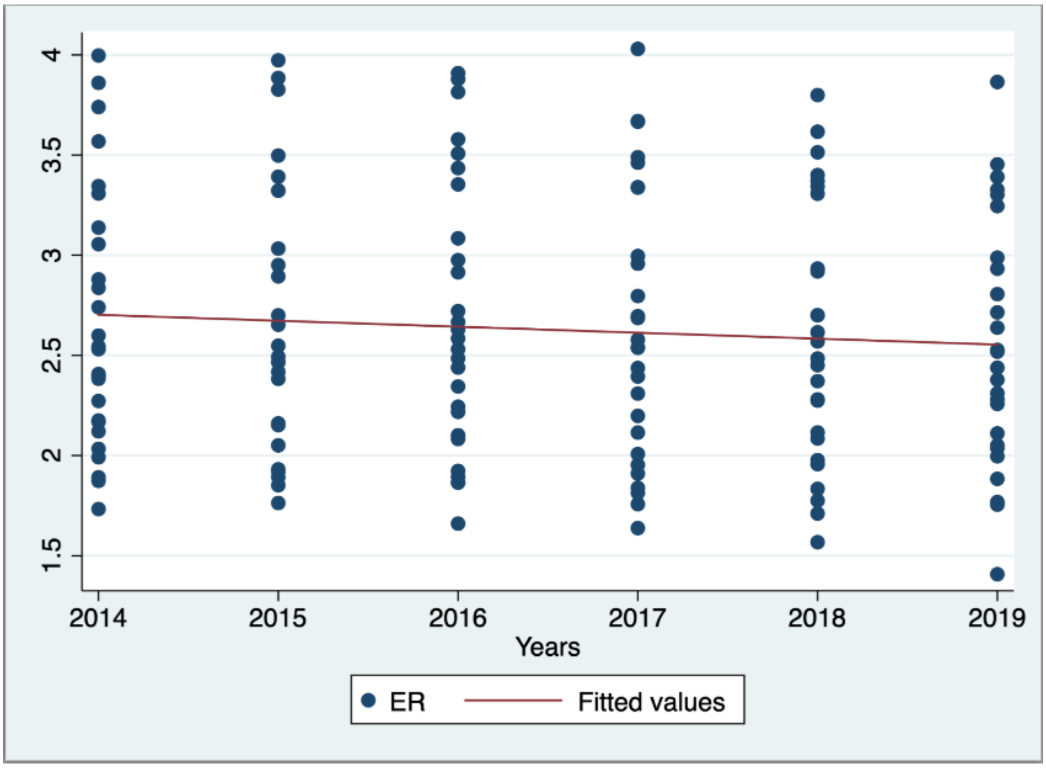
Source: Author's elaboration.

Graph B 2 - Descriptive graphic of the variable Past Environmental Protection Investments



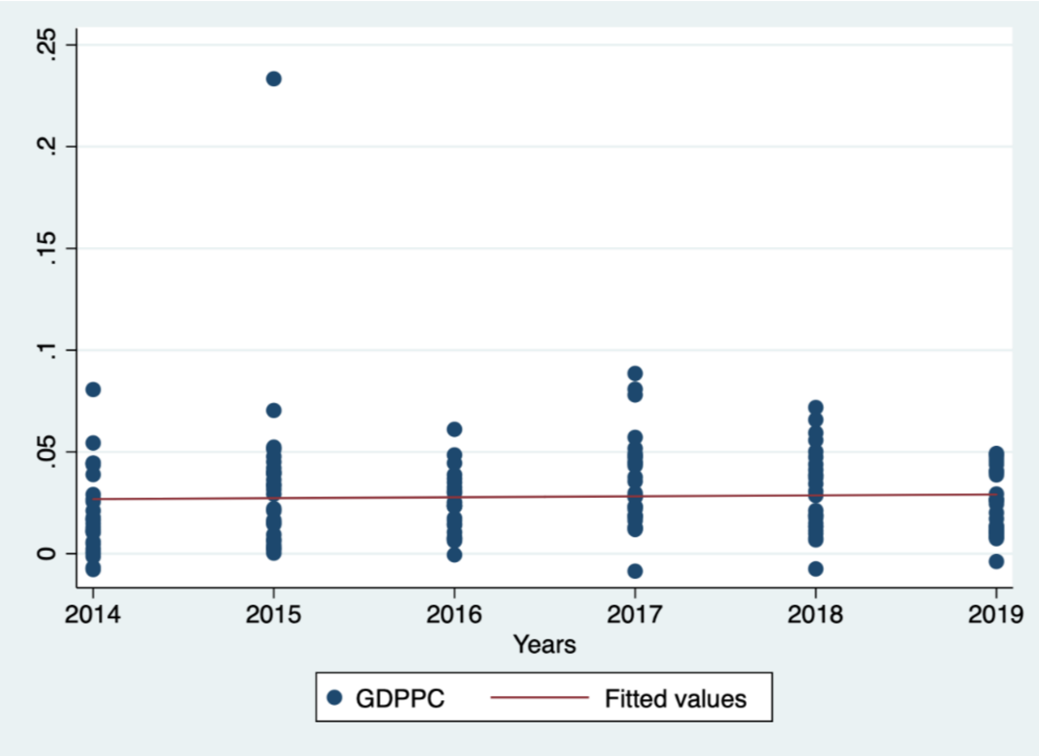
Source: Author's elaboration.

Graph B 3 - Descriptive graphic of the variable Environmental Regulation



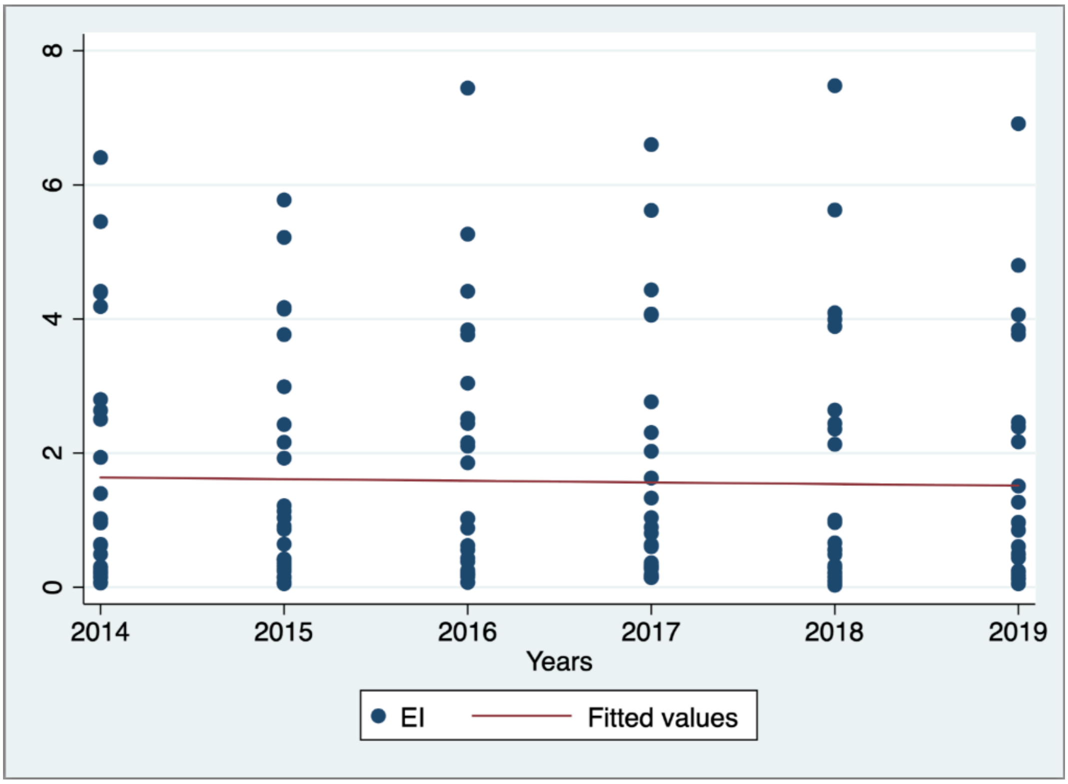
Source: Author’s elaboration.

Graph B 4 - Descriptive graphic of the variable Gross Domestic Product Per Capita



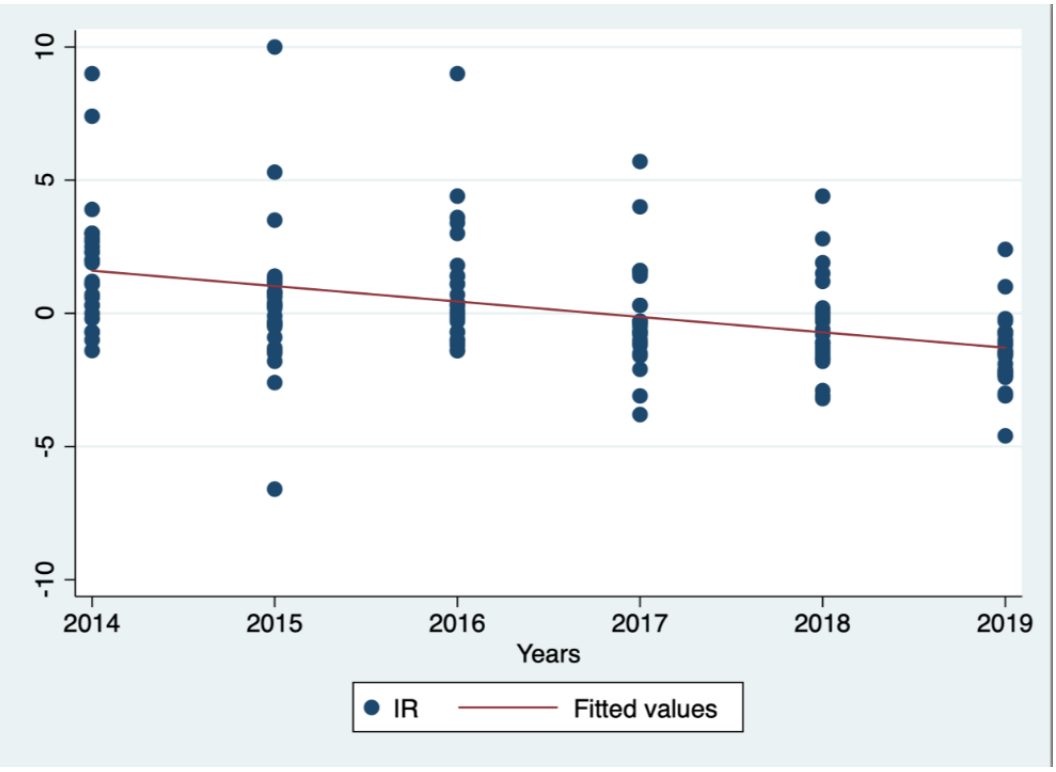
Source: Author’s elaboration.

Graph B 5 - Descriptive graphic of the variable Environmental Innovation



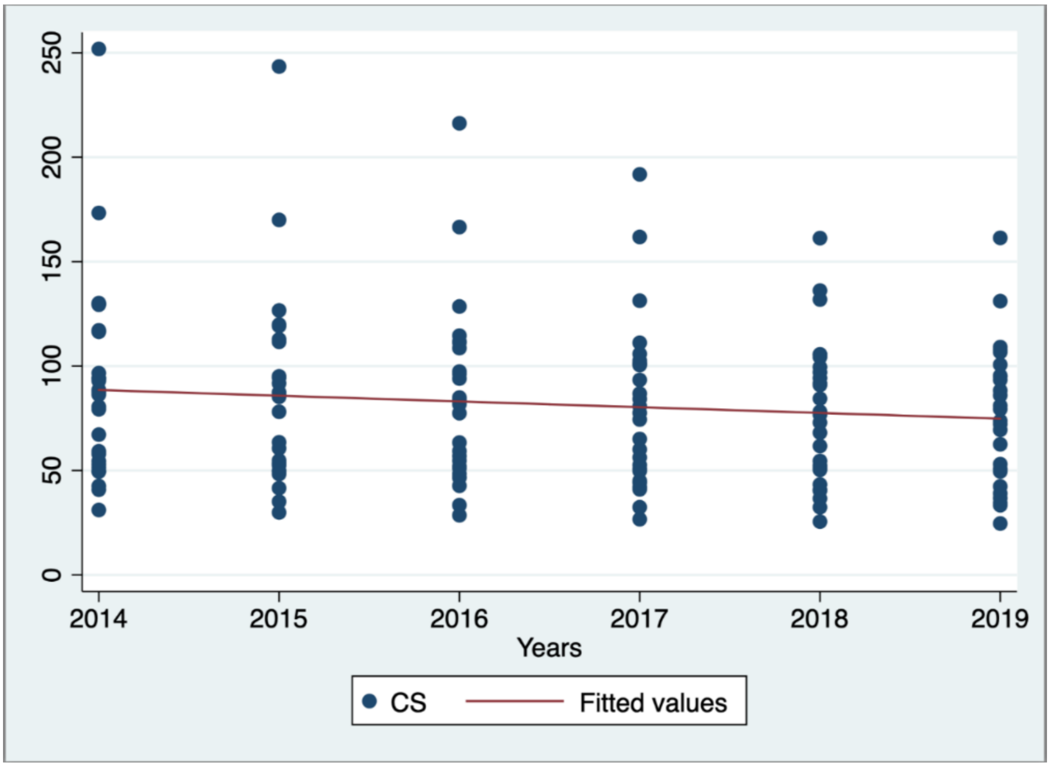
Source: Author's elaboration.

Graph B 6 - Descriptive graphic of the variable Interest Rates



Source: Author's elaboration.

Graph B 7 - Descriptive graphic of the variable Credit Supply



Source: Author's elaboration.