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Master in Monetary and Financial Economics

Master Thesis Proposal

The impact of Economic development on climate change and Fiscal Policy as a measure of improving the environment quality

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Abstract

This research investigates the impact of economic development on climate change and how fiscal policies can be used as a tool to improve the environmental quality. The study examines the relationship between economic development and environmental degradation focusing on CO_2 emissions, utilizing the Environmental Kuznets Curve (EKC) hypothesis. For the investigation, data from 50 countries between 1990 and 2022 was used. The results, showed an inverted U-shaped relationship between economic development and carbon dioxide emissions, thus, the findings support the EKC hypothesis. The study also examined the effect of fiscal policies on the environmental sustainability; however, the results showed a non - statistically significant relationship, implying insufficient evidence to assert a definitive impact. The study comes to the conclusion that while the economic development initially raises carbon dioxide emissions, eventually lowers emissions beyond a certain point.

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Executive Summary

There has been a noticeable shift in the climate in recent decades, and this change has been both directly and indirectly attributed to human economic development. The purpose of this study is to investigate how human economic development affects air pollution emissions. The investigation specifically addresses how much carbon dioxide (CO2) is released into the atmosphere. The effects of human economic development on the environment have been examined in a sample of 50 countries, including all income levels, for 33 years from 1990 to 2022.

The first research that examined the relationship between human development and climate change has been conducted by Grossman and Kruger in 1995. The Environmental Kuznets Curve (EKC) hypothesis was used by the scientists to analyze this relationship, and the results pointed to an inverse U-shaped association between environmental deterioration and economic development. According to this theory, economic expansion raises carbon dioxide emissions up to a certain point in a nation's economy, at which point economic development lowers emissions. However, recent research has revealed a more complex link between economic development and environmental deterioration, with the economic development increasing emissions and the increased emissions restricting economic development (Francesco Bosello et al., 2012).

The research utilized the Environmental Kuznets Curve hypothesis in regression analysis, and going a step forward, this research studied the impact of fiscal policies as a measure to mitigate environmental pollution whilst economies grow. The results indicate that there is an inverted U-shaped curve that explains the relationship between environmental degradation and economic development.

1.Introduction

This research studies the impact of economic development on climate change and how fiscal policies can be used as a measure of improving environmental quality. The economic development and development are a concept that have been examined for many decades. However, the awareness about climate change hasn't been raised until 1938 when Guy Callendar connected carbon dioxide emission increases in Earth's atmosphere, higher temperature to global warming (G. S. Callendar, 1938), explaining how the air pollutions leads to environmental degradation, which is increasing the temperature in the atmosphere creating the phenomenon of climate change.

The first research that combined the two concepts, economic development and climate change, has been studied by Grossman and Kruger in 1995. The scientists examined this relationship by utilizing the Environmental Kuznets Curve (EKC) hypothesis, suggesting an inverted U-shaped relationship between economic development and environmental degradation. This hypothesis suggests that up to an economic threshold, economic development increases the carbon dioxide emissions, but when a country's economy achieve that threshold, economic development reduce emissions. However, further studies have been conducted suggesting that this relationship is more complex, stating that when economic development increases lead to environmental degradation, and the environmental degradation limits economic development and growth (Francesco Bosello et al, 2012).

The importance of economic development and environmental degradation and how fiscal policies can be used to mitigate the pollution whilst economies grow, has driven this research. To conduct this study, we used a panel data analysis for 50 countries for 33 years annually observed from 1990 to 2022. The results follow the Environmental Kuznets Curve (EKC) hypothesis since it explains the relationship between economic development and environmental degradation, and explaining the effect of fiscal policies on the environmental pollution. Furthermore, we used the Least Squared Dummy (LSVD) model in order to control both the effects of country and time variables. Our results indicate that there is an inverted U-shaped curve describing the relationship of climate change and economic development. It is also important to note that the results suggested that there are not enough evidence to describe the effect of taxes on the carbon dioxide emissions.

2.Literature Review

2.1 Economic development and Climate Change

Recognizing the global concern over the rising of CO_2 emissions level, acknowledging the environmental degradation, Kolade Sunday Adesina and John W. Muteba Mwamba (2019), studied the relationship of economic freedom and the levels of CO_2 emissions being released in the atmosphere across different income groups in Africa. In this study the economic freedom is measured by the fiscal freedom, trade freedom, business freedom and freedom from corruption. The result of the above study showed that fiscal freedom, which involves tax reduction policies, has a negative impact on CO_2 emissions across all the levels of income, meaning it constantly reduces the greenhouse gases and improves the quality of the environment. However, the rest forms of economic freedom vary depending on the income level of each country. More specific, in countries with upper -middle income, freedom of corruption and business freedom have a negative effect on CO_2 emissions, whilst trade freedom has negative impact only in lower-middle- income countries. Moreover, the study examines the relationship between the unemployment and the environmental quality. The results show that the unemployment rate has a negative effect on CO_2 emissions, reducing the levels of the emissions, in low-income countries but has no significant effect in lower-middle and upper-middle-income countries. Overall, the study suggests that freedom- promoting policies can benefit the environment, but their effects varied greatly across different income levels.

The significance of economic development and foreign direct investment (FDI) impact on environmental degradation, has been examined in order to emphasize the urgency of action (Ahmed Imran Hunjra et al. 2024). The research adopts the Environmental Kuznets Curve hypothesis, suggesting that development of a country's economy, initially leads to an increase of the environmental degradation. However, as the income levels rise, reaching a certain point to be considered as developed, the country utilizes greener technologies which eventually reduce the carbon dioxide emission. The study highlights the importance of utilizing technological advancement such as renewable energy sources, in reducing the negative environmental impacts that are caused by the consumption of natural resources.

The relationship between the environmental degradation and economic development is complex, as the economic development increases the carbon dioxide emission levels increases too. On the other hand, when emissions rise the economic development slows down, as the environmental degradation affect the health leading to a reduced productivity. Even though there have been many attempts and efforts to mitigate climate change, the world will unavoidably experience some degree of climate change and its effects. Therefore, in order to manage with these effects, adaptive methods are required (Francesco Bosello et al, 2012).

Additional, researches have done to examine the relationship between the industrial production and the carbon dioxide emissions. On of these researches is the study of Zhang X. and Ren. J (2010) pointing out the positive relationship between the industrial development and the climate change. Whilst development requires industrial development and economic expansion, yet both need to be regulated in order to have the least negative effects on the environment. The regulation of these two factors can be achieved be implementing greener technologies and by adopting sustainable industrial practices that can reduce the carbon footprint (Wiranya Puntoon et al, 2022).

To understand better the climate change and environmental degradation, scientist have studied the relationship between the population and the carbon dioxide emissions. Findings suggest that the continuously growth of the population affects positively the carbon dioxide emissions, as it leads to higher demand for energy consumption and economic activities (Rawshan Ara Begum et al, 2015). Specifically, studies suggest that the relationship between the population and the carbon dioxide emissions is statistically significant, indicating that an increase of 1% of the population results to 1% increase in the CO_2 emissions (Immaculada Martinez – Zarzoso et al, 2007). However, this linear relationship does not apply of all countries. In reality, countries like China and India, which have huge populations, growing faster and they are industrializing rapidly, it was observed a higher release of carbon dioxide emissions in the atmosphere (Thomas Dietz et al, 1997). On the other hand, F. Landis MacKellar and his colleagues (1995) argue that when examining the impact of population growth on environmental degradation, the household dynamics, such as the number of households and their size, should be considered. The findings of the study suggest that smaller households usually consume more electric energy than the larger households, due to the fact that smaller households have less efficient energy use leading to higher CO_2 emissions. Additionally, it was noted that even in case where the population size remains the same, a rice in the number of homes may results in a higher CO_2 emissions level. This study suggests that policymakers when the create policies to lower the carbon dioxide emissions should also consider the household dynamics, promoting shared living spaces, energy efficient housing with greener technologies.

Further investigations have been done in order to examine the cause of climate change, pointing out to the effects of electric consumption. Eric Abokyi and his colleagues (2021) examined the relationship of electric consumption and climate change by adopting the Environmental Kuznets Curve hypothesis. Their study showed that the electricity consumption affects in the environment in two ways, short – term and long – term. The results illustrate that the short – term effect increases the carbon dioxide emissions as higher electric usage needs more fossil fuel consumption leading to higher levels of environmental degradation. On the other hand, the long - term effect suggest an advancement in energy efficiency including the adoption of green energy technologies which can reduce the carbon dioxide emissions.

Since the awareness of the impact of electric consumption on climate change, many researchers have examined the relationship between the renewable energy consumption and the carbon dioxide emissions. The study of Chaoyi C., Mehmet P. and Thanasis S. (2022) finds that there are notable thresholds effects between the carbon dioxide emissions and the consumption of energy from renewable sources. They highlight the fact that consumption of renewable energy begins to have a greater impact on reducing the carbon dioxide emissions after a certain economic threshold is reached. Their findings suggest that policies regarding renewable energies tend to be more effective in wealthier countries and countries that with greater economic development. Furthermore, their study emphasizes how crucial it is to develop customized renewable energy policies that consider each countries economy. The research refers to policymakers and the necessity of creating economic conditions in which renewable energy policies can be employed effectively.

2.2 Fiscal & Monetary Policies:

The importance of mitigated the carbon dioxide emissions have led the scientists examine the impact of various monetary and fiscal policies on the climate change. Specifically, many researchers have studied the relationship of real interest rate and carbon dioxide emissions. Studies, suggesting a negative relationship indicating that higher real interest rates reduce investments in energy – intensive industries leading to lower carbon dioxide emissions (Aliya Zhakanova Isiksal et al, 2019). Monetary policy, which includes changing lending rates, can be a useful tool for mitigating the carbon dioxide emissions. In order to encourage sustainable development, policymakers should take the environmental effects of monetary regulations in to account (Mohammed Yaw Broni et al, 2020).

There are differences in the efficiency of environmental taxes in accomplishing environmental goals. On one hand, the environmental taxes in some cases can successfully decrease pollution by preventing environmentally harmful behavior. On the other hand, in other occasions the effect is constrained due to tax rates, exceptions and the design of each country's tax system (Thomas Sterner and Gunnar Kohlin, 2004). The environmental taxes play a role when determining trend of carbon dioxide emissions, although the efficiency of such taxes differs among nations due to varying degree of acceptance and integration with other policies (Francisco et al. 2022).

Having knowledge on impact of taxes on climate change can lead policymakers to create fiscal polies that reduce carbon dioxide emissions. To expand this knowledge, researchers have studied the impact of taxes on petrol and diesel, suggesting that higher taxes lead to lower emissions but highlighting that the effect is limited (Michal Ptak et al. 2024). However, based on Pichayakone Rakpho and her colleagues (2023), suggest that environmental taxes are affective up to a certain threshold and beyond that point if taxes increase, they could lead to increase carbon dioxide emissions. The reason behind this, is that businesses may find it more difficult to invest in greener technology and increased energy efficiency as a result of excessive high taxes. Alternatively, companies may choose to relocate operations to countries with less strict environmental regulations or reduce expenses in ways that result in higher emissions.

Additionally, the relationship between the environmental taxes and carbon dioxide emissions was described by Buhari Dogan and his colleagues (2022), mentioning that traditional energy use, such as the combustion of fossil fuels, dramatically raises emissions. They continue by explaining that environmental taxes, reduce the impact by raising the cost of fossil fuels and promoting the adaption of greener energies. The researchers also examine economic complexity, suggesting that economies with higher complexity typically embrace greener technology and implement efficient environmental regulations more quickly than other countries.

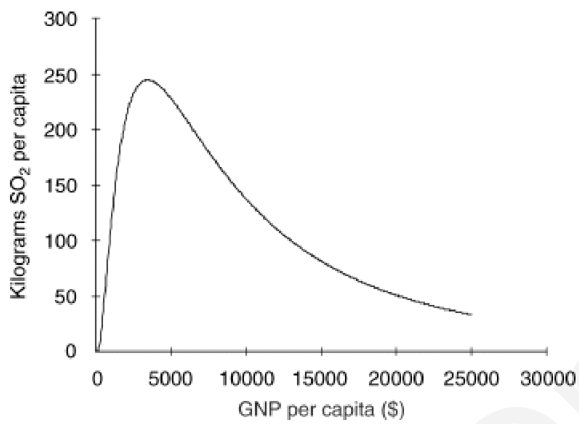
On the other hand, the relationship between strict environmental policies and CO_2 emissions have been examined by Wolde Rufael and his colleagues (2023) suggesting that should be implemented strict environmental taxes in order to for countries to achieve higher reduction of carbon dioxide emissions. They also suggested that the revenues of those taxes should be invested to fund cleaner technologies.

3.Theoretical Background

There are many theories that examine economic development and development, this is because of its important role in people's quality of life, such as the neoclassical growth theory given by Solow-Swan (1956) which studies how the three economic forces of labor, capital and technology interact to produce a steady economic development.

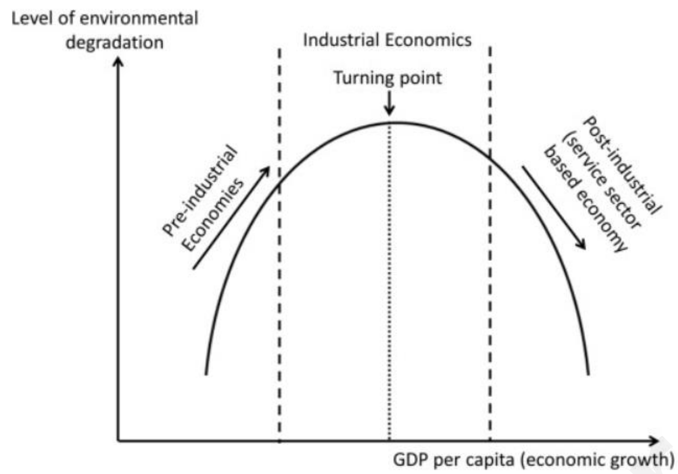
As it was previously said, there have been several studies conducted on economic development, from which numerous hypotheses have been developed. However, since the introduction of the Environmental Kuznets Curve theory (EKC), the consequences of environmental pollution and climate change have not been taken in to account. The hypothesis is named after the economist Simon Kuznets who initially suggested a similar relationship between economic development and income inequality (David I. Stern, 2004). The relationship between economic development and environmental quality was investigated by Grossman and Kruger (1995), analyzing environmental indicators, such as heavy metals in river basins and the urban air pollution. Specifically, the urban pollution was initially measured by sulfur dioxide (SO_2) and the study used a polynomial form model in order to examine and identify of the non-linear relationships. In the graph figure (1) below we can see the inverted U-shaped curve indicating the relationship between the sulfur dioxide (SO_2) per capita and the Gross National Product (GNP) per capita, as shown in the figure (1) below. This patter implies that the increase of economic development up to a certain level increases the environmental pollution. However, after an economy reaches that level, as the economic development continues to rises the environmental degradation declines.

Figure 1: SO_2 - GNP



The Environmental Kuznets Curve hypothesis examines the relationship between the economic development and the environmental degradation, suggesting that the relationship is explained by an inverted U-shaped curve, where at an early stage of a country's economic development it reaches its peak on air pollutions levels, and then as economic development increases the air pollution declines. (Uchiyama Katsuhisa, 2016). The figure 2 explains the Environmental Kuznets Curve, showing the relationship between the level of environmental degradation and the economic development (GDP per capita). As it can be seen from the figure (2) below (Majeri Narasimha Vara Prasad, 2024), there are three levels of economies, the first one is the pre-industrial economies, where an increase in the economic development implies an increase of the environmental degradation. The second, is industrial economies showing the turning point, where a developing country becomes developed. Beyond the turning point is the third level, whereas the economic development continues to rise the air pollution reduces. To study the effect of economic development on the environment in our research, we will apply the Environmental Kuznets Curve hypothesis.

Figure 2: CO_2 - GDP



4.Empirical and analytical methodology:

As it was previously said, the Environmental Kuznets curve model will be employed in our study under the econometric approach to get our research results and help us in forming our conclusion.

This study uses two different econometric models to investigate how the various economic and environmental factors affect CO_2 emissions. The main focus is a comprehensive global model analysis, referred as *Model 1*, that incorporates data from 50 different nations and covers the period between 1990 to 2022. Across four income levels – high income, upper-middle income, lower middle income, and low income – this model evaluated the impact of GDP per capita, electricity consumption, renewable energy consumption, renewable energy consumption, real interest rates, population and industrial development on CO_2 emissions. The aim is to find trends and insights that can guide international strategies for reducing carbon dioxide emissions whilst economic development keeps growing.

Furthermore, we have created a second model, referred as *Model 2*, for additional study that covers the years between 2011 to 2022, and focuses exclusively on European Union (EU) countries. The variable for real interest rates was excluded of the model because there was insufficient data. Making this decision is essential to maintaining the integrity and reliability of the model's output. Including variables in econometric research that have insufficient data can result in biased estimates, increased standard errors, or misleading interpretations (Olawale et all, 2019). Therefore, we decide to eliminate the variable of real interest rates from our analysis, in order to ensure the robustness of our conclusions.

Moreover, *Model 2* of this research emphasizes the need of analyzing the effect of the environmental tax revenues on CO_2 emissions in the EU, represented as a percentage of the GDP. The EU's legislation, which introduced environmental tariffs to financial incentives for pollution reductions and the promotion of sustainable practices, provide the justification for this variable's focus. Examining the revenue generated by the environmental taxes sheds light on how well these fiscal measures affect the environmental results, particularly when it comes to decreasing the levels of carbon dioxide emissions (Thomas Sterner and Gunnar Kohlin, 2004).

In order to improve our understanding of how economic tools might be used to advance environmental goals within the framework of the EU (Nils Meyer - Ohlendorf, 2020), the study intends to draw attention to the connection between fiscal environmental policies and their observable effects on CO_2 emissions. To ensure that the conclusion drawn from this analysis are both statistically valid and relevant to environmental economics stakeholders and policy makers, strict econometric approaches and tests will be utilized.

Model 1:

$$CO_2\,em_{i,t} = \alpha_0 + \beta_1 GDP_{i,t} + \beta_2 GDP^2_{i,t} + \beta_3 ElcPwr_{i,t} + \beta_4 ReEng_{i,t} + \beta_5 IndPrd_{i,t} + \beta_6 Ri_{i,t} + \beta_7 Popl_{i,t} + \varepsilon_{i,t}$$

Model 2:

$$CO_2\,em_{i,t} = \alpha_0 + \beta_1 GDP_{i,t} + \beta_2 GDP^2_{i,t} + \beta_3 ElcPwr_{i,t} + \beta_4 ReEng_{i,t} + \beta_5 IndPrd_{i,t} + \beta_6 Ri_{i,t} + B_7 TAX_{i,} + \beta_8 Popl_{i,t\,t} + \varepsilon_{i,t}$$

Where:

$CO_2\ em_{i,t}$ = Carbon Dioxide emissions per capita

$GDP_{\ i,t}$ = Economic Development per capita (Gross Domestic Product)

$ElcPwr_{\ i,t}$ = Electric Power Consumption per capita

$ReEng_{\ i,t}$ = Renewable Energy Consumption per Capita

$IndPrd_{\ i,t}$ = Industrial Production including costruction (% of GDP)

$Ri_{\ i,t}$ = Real interest rate (%)

$Popl_{\ i,t}$ = Population

$TAX_{\ i,t}$ = Total revenues on environmental taxes (% GDP)

4.1 Data Samples:

The first data set that was used for our methodology to produce the outcomes of our study, is a panel data since it includes observations from several time periods (cross sectional and time series) (Gary Chamberlain, 1984). In particular, data from 50 countries from around (see appendix, table (22)) the world are provided on an annual basis for the years 1990 to 2022 (see section 4., table (1)). The second data set, also a panel data, focuses in the 27 European Union countries from 2011 to 2022, was used to determine the impact of fiscal policies on carbon dioxide emissions.

4.2 Dependent Variable ($CO_{2\ i,t}$)

The dependent variable which we are studying, is the degradation of the environment and the data that are used to describe this variable, are data from CO_2 emissions per capita, as it has a linear relationship with the climate change and it is the closer factor that describes it (James Hansen et all, 2013). The data set was assembled from statistical sources, such The World Bank, Our World in Data and the International Energy Agency (IEA). Initially the data set was included observations of all countries, to specific it was 197 countries, from 1950 to 2022. However, due to the inconsistency of available data that the data set suffered, it had to be restricted to 50 countries, including low income, lower-middle income, upper-middle-income and high- income, from 1990 to 2022.

4.3 Independent Variables

1. Economic Development per capita (GDP per capita)

   The data set for the GDP per capita, which describes the economic development, was assembled by the statistical sources of The World Bank and the International Monetary Fund (IMF). The initial data set has observations for all countries for more than 70 years. As it was mentioned before due to the lack of observations the data set was restricted to 50 countries, including all income levels, from 1990 to 2022.

2. Exponential Economic Development per capita (GDP per capita squared)

   This data is the same as the economic development, which was assembled by The World Bank and the International Monetary Fund (IMF) restricted to 50 countries from 1990 to 2022.

3. Electric Power consumption per capita (ElcPwr per capita)

   The data set for this variable, was first created to contain data for all countries electric consumption per capita, but it had to be restricted to 50 countries from more than 30 years due to the lack of data. The statistical sources that were used to conduct this data set is The World Bank and the International Energy Agency (IEA).

4. Renewable Energy consumption per capita (ReEng per capita)

   This data set, as well as the others had to be restricted to 50 countries from 1990 to 2022. The statistical sources that were used to create this data set is The World Bank and the International Energy Agency (IEA).

5. Industrial Production (including construction) per capita (IndPrd per Capita)

   The data set for the industrial production, which included the construction sector, was restricted the same way with the other variables. In order to assemble this data set, we used the statistical sources of the World Bank.

6. Real Interest rate (RI)

   The data set for the real interest rate, (lending rate) was obtained from the statistical source of World Bank, but again it had to be restricted to 50 countries, including all income levels, from 1990 to 2022.

7. Revenues of environmental Taxes (TAX)
8.
   In this case the data set differs from the others, because it was only obtained for the EU countries, 28 to be more specific and for only 11 years, from 2011 to 2022. The data set was used in a separate model and the statistical source for the data is Euro Stata.

9. Population (POP)

   Finally, the data set for the variable of population had to be restricted the same way as the other variables, obtaining only 50 countries from 1990 to 2022, collecting the data from The World Bank.

5.Empirical Analysis:

5.1 Diagnostic Tests for the regression model

1.Multicollinearity:

To determine the form of the *Model 1*, a correlation test between the independent variable was used, in order to prevent multicollinearity problem. Multicollinearity is the overlapping of the independent variables, meaning they are high correlated with each other, such phenomenon creates less reliable coefficients (D. Stephen Voss). To prevent this problem, we used a statistical test, called Variance Inflation Factor (VIF), and the results are shown in the table (2) and table (3). Based on the results, it is shown that there is no correlation between the independent variables. The same technique was also used for *Model 2*.

2.Heteroskedasticity:

To determine whether or not the models suffer from heteroskedasticity, a statistical phenomenon where the variance of the residuals (errors), is not constant across all levels of the independent variables, breaking one of the key assumptions of Gauss-Markov suggesting that the regression model must have homoskedasticity (the error term must have constant variance) in order the least square estimator to be B.L.U.E. (Best Linear Unbiased Estimator). To examine if our models suffer from heteroskedasticity, we used three tests. The first test is Breusch–Pagan/Cook–Weisberg which is designed for cross-sectional data assuming a linear form of heteroskedasticity. The White's test includes both the independent variables and their squared values. Lastly, the Modified Wald test, is used to test group-wise heteroskedasticity in the residuals of a fixed effects regression model.

3.Autocorrelation:

Furthermore, to determine whether or not the models suffer from autocorrelation, which is the correlation of a variable with its own lagged values. This issue provides us with incorrect inferences of the results of the regression. In order to examine if the models suffer from autocorrelation or serial correlation, we utilized the Wooldridge test (David M. Drukker, 2003). The Woolridge test is designed to address the issue of autocorrelation in panel data analysis. Specifically, it examines for correlations between the lagged residuals of one period and the residuals of the next. This is crucial to prevent wrong conclusions from underestimated standard errors.

4.Stationarity:

Testing for stationarity, the statistical properties such as variance, mean and autocorrelation structure do not change over time. If a data set does not have stationarity, then the analysis can lead to misleading results because the characteristics of the series change over-time (Yuichiro Kakihara, 2003). Thus, in order to determine if our data set are stationary, we used two tests, the first one is Levin, Lin & Chu (LLC) test and the second one is Phillips-Perron (PP) test. The LLC test assumes homogenous autoregressive coefficients, while the PP test handles a broader range of serial correlation and heteroskedasticity in the error terms.

5.2 Descriptive Statistics:

Table 1: Descriptive Statistics

Variable	Observations	Mean	Std.dev	Min	Max
CO2em	1650	6.75898	5.14662	0.047858	30.88212
GDP	1650	20251.06	19948.06	96.7193	108729.2
ElcPwr	1650	5679.706	5160.079	33.89998	29087.43
RenEng	1550	1057.143	2318.004	0.4871182	17577.55
IndPrd	1591	29.22819	8.48138	11.79204	66.50211
RI	951	5.038805	8.979908	-43.0507	77.61684
POP	1650	107000000	240000000	1900151	1420000000

The dataset that is being analyzed includes a wide range of variables that are relevant to evaluating the effects of industrial factors, energy consumption, and economic activities on the degradation of the environment, particularly CO_2 emissions.

Based on the data in the table above, the “CO_2em” represents carbon dioxide emissions across 1650 observations. Its average value is roughly 6.76t (metric tons) per capita and its standard deviation is approximately 5.15t suggesting significant variation in the amount of emissions released. This variation indicates different levels of energy use, industrial productivity and environmental policies among the countries under observation. Additionally, Nepal had the lowest CO_2 emissions in the sample in 1990 – a figure of just 0.0478t – which at that time likely reflected the country’s low levels of industrial development and economic development. On the other hand, the United Arab Emirates recorded the highest emissions in 1995, with a total of 30.88t per capita. This suggests that the country’s economic expansion was the driving force behind the high industrial development and energy consumption.

There are notable differences in the economic activities of the countries under study, as evidence by the 1,650 observations of GDP, which have a mean about 20,251.06$ per capita and a relatively high standard deviation around 19948.06$ per capita. This is further supported by the wide range of GDP values, indicating different economic levels that are expected to be correlated with variations CO_2 emissions. Additionally, Vietnam had the lowest income – economic development in 1990 with a $96.72 per capita. On the other hand, Norway recorded the highest GDP in 2022, with a total of $108,729.19 per capita. This wide rage represents various economic developments stages and the associated threats to the environment.

Furthermore, from the data analysis of the electric power consumption, it was observed that it has a mean of 5679.71kWh (kilowatt hours) and a standard deviation of 5160.08kWh. The amount of electricity consumed per capita varied dramatically as well. In 1990, Nepal consumed the least amount of electricity, approximately 33.90kWh, while in 2021, Norway consumed the most electric power with 29087.43kWh per capita. These numbers illustrate the varying degrees of energy use and infrastructure, which are essential to understanding energy – related CO_2 emissions.

Additionally, the data set includes the variable of Renewable Energy Consumption ("REC"), with 1,550 observations, illustrating how the environmentally friendly energy sources are implemented. It was observed that this variable has a mean of 1057.14kWh per capita and standard deviation of 2318.004kWh. However, adoption rates of this renewable energy sources vary greatly. Norway was the country which utilized the greatest amount of electricity in 2020 with 17577.55kWh per capita, demonstrating its leadership in the use of renewable energy consumption. The lowest, on the other hand, was almost insignificant in Saudi Arabia in 1996 with 0.49kWh per capita.

In addition, the "IndPr" variable that measures industrial production (including constructions) across 1,591 observations, is directly correlated with CO_2 emissions, indicating the extent to which industrial activities have an impact on the environment. As a measure of GDP, industrial production peaked its highest in 2008 with 66,50% of GDP in Saudi Arabia and lowest in 2021 with 11,79% of GDP in Saudi Arabia, showing the disparities in industrial sectors and their possible effects on the environment. It was also observed that this variable has a mean of 29.23% of GDP and a standard deviation of 8.48% of GDP.

Based on the above data table, the variable “RI” which measures the real interest on lending across 951 observations, has a mean of 5.04% and a standard deviation of 8.99%. The interest rate of lending varied dramatically as well. In 1993 Romania had the lowest interest rate, with -43.05% while in 1998 Brazil had the highest rate with 77.62%.
Lastly, the variable “POP” indicates population, and as it was shown on the table as evidence of 1650 observations, the mean is 107million people and a standard deviation around 240 million people. The lowest observation was estimated in the United Arab Emirates in 1990 with only 1.9 million people while the highest was in 2022 in India with 1.42 billion people. These numbers show the extent to which industrial and consumer demand could have an impact on environmental pollution.

5.3 Figures

The below graphs are scatter plots which illustrate the relationship of the dependent variable, CO_2 emissions, with the independent variables. The data points, shown as blue dots on the plot, indicate variations in the relationships, with the first scatter plot (figure 3) illustrating the variability in how different levels of economic development (GDP per capita) correlate with CO_2 emissions across the sample. This indicates that when economic development (GDP per capita) increases then the carbon dioxide emission levels also rise. A higher GDP is typically correlated with higher level of emissions.

Based on Kuznets Curve theory (Grossman and Kruger, 1995), the scatter plot below (figure 4) illustrates the link between the different levels of GDP per capita, showing the difference between developed and developing countries, and the amount of greenhouse gas emissions released into the atmosphere. Specifically, from the point where a country is considered to be developed, as its economic development rate increase the CO_2 emission level decreases. Furthermore, it was observed that when a developing country’s GDP per capita increases, then the carbon dioxide emissions level increases. From the figure we can see the turning point, where the blue dots are spread lower when the GDP per capita pass increases.

Figure 3: CO_2 Emissions per capita – GDP per capita

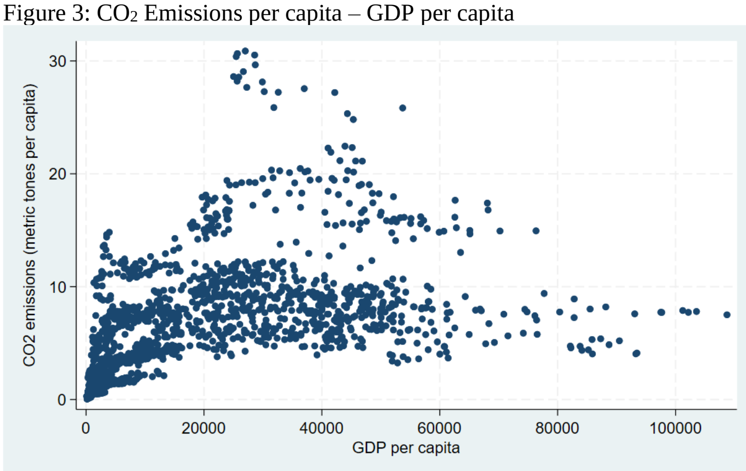


Figure 4: CO_2 Emissions per capita – GDP^2 per capita

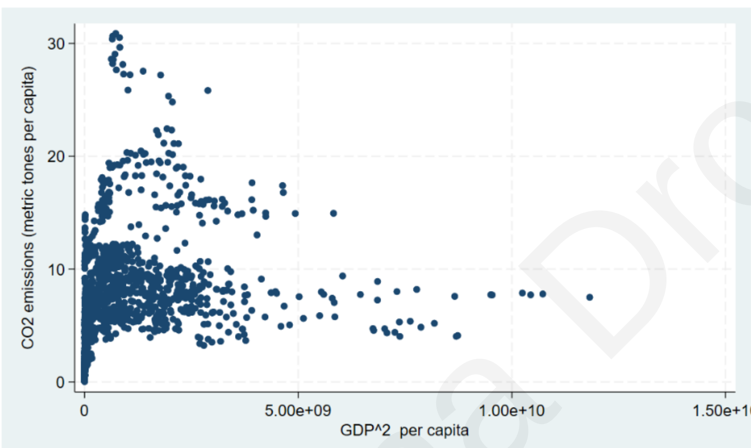
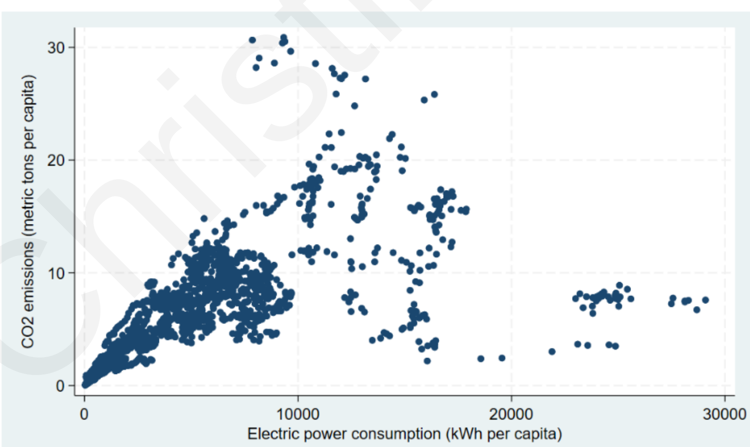
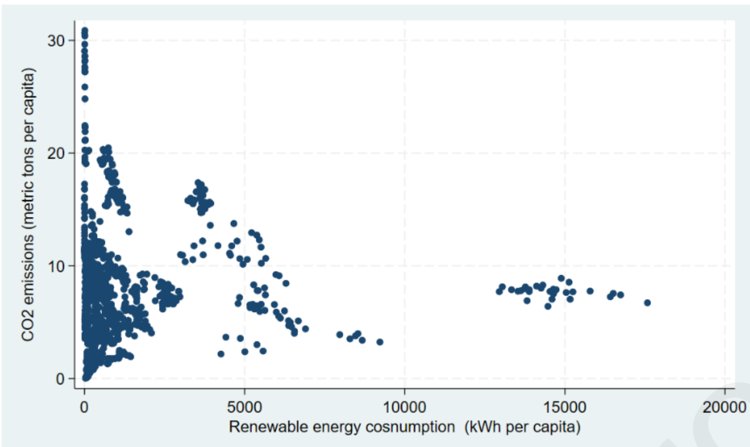


Figure 5: CO_2 Emissions per capita – Electric Power Consumption per capita



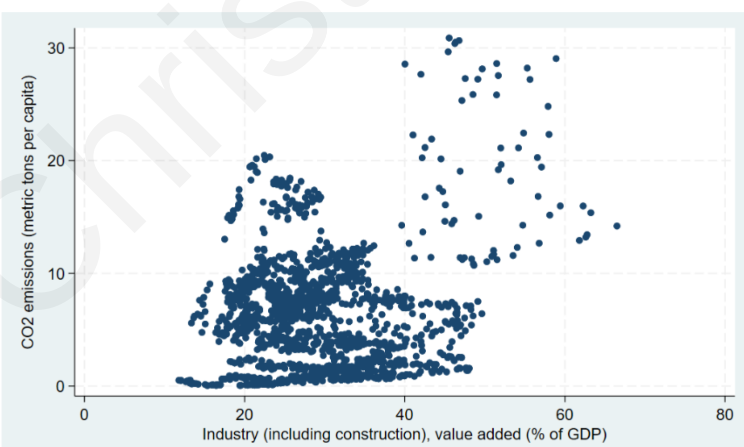
The graph above illustrates the relationship between the dependent variable, CO_2 emissions per capita and the independent variable, electric consumption (EC) per capita. Based on the graph, we can see that there is a positive relationship between the two variables, meaning that when the electric energy consumption increase so does the carbon dioxide emission levels. This positive relationship also means that when the electric consumption decreases, the CO_2 emission levels decrease as well.

Figure 6: CO_2 Emissions per capita – Renewable Energy Consumption per capita



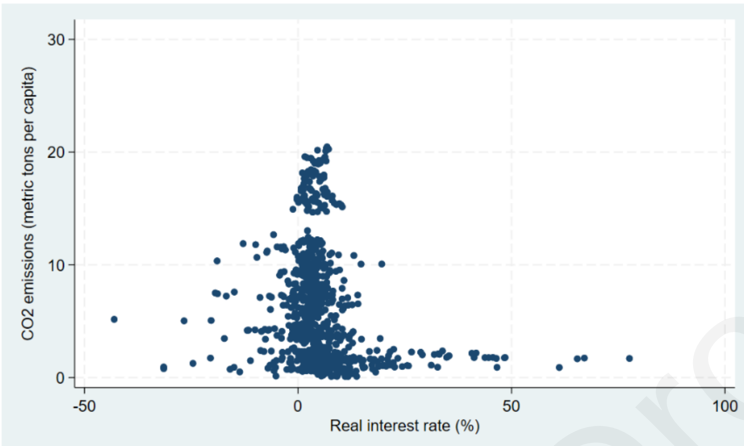
Moving on, the figure 6, explains the relationship between the climate change (CO_2em) and the energy consumption of renewable energy sources (RE). From the scatter plot we can understand that there is a negative relationship between the dependent and independent variable, meaning that when the energy consumption of renewable energy source increases then the levels of carbon dioxide in the atmosphere decreases.

Figure 7: CO_2 Emissions per capita – Industrial Production



Furthermore, the figure 7 demonstrates the relationship between the dependent variable and the industrial production which also includes the construction sector. Based on this graph, it is shown a positive relationship between the two variables. As the industrial production increase, the levels of carbon dioxide in the atmosphere increase as well. Additionally, when the industrial production levels are lower, then the CO_2 emissions follow.

Figure 8: CO_2 Emissions per capita – Real Interest Rate



This scatter plot, demonstrates the relationship between the environmental degradation and the real interest rate. From the figure 8, shows us an interesting relationship between the two variables. What stands out in this scatter plot is that when the real interest rate is close to zero then the CO_2 emissions levels are high. However, as it can be seen from the graph, when the real interest rate increases then the levels of carbon dioxide emissions fall dramatically.

Figure 9: CO_2 emissions per capita by Country

The above figure (9) demonstrates a series of line graphs, each representing the dependent variable, CO_2 emissions, for 50 countries from 1990 to 2022. Each graph is labeled, corresponding to a different country illustrating how the carbon dioxide emissions have developed in each country across the years we are studying.

Based on the above line graphs we can see that the developed countries over time have a decreased trend in CO_2 emissions. For example, countries like Sweeden and Switzerland after 2000 reveal that there has been a steady decline in the number of carbon dioxide emissions in the atmosphere per capita. Additionally, developed countries with high CO_2 emissions, such as, Denmark, United States and Finland, after a certain point they show a gradual drop in the levels of air pollutants in the atmosphere.

On the other hand, the graph demonstrates the trend that the developing countries are following. What can be clearly seen in this figure, is the steady increase of carbon dioxide emissions in counties like China, Malaysia and Vietnam.

Additionally, based on the graph, we can see that in countries with high supply of oil, even though they have high income and complete some of the criteria of the developed countries, such the United Arab Emirates, there is a high level of carbon dioxide emission. The figure also reveals that from 2010 there is an upward trend in the CO_2 emissions.

By examining this patterns and trends, we can identify whether existing environmental policies are effective in reducing the air pollutants emissions and if or where new policies are needed.

6.Results

6.1 Multicollinearity Tests:

1.Correlation Test:

The table (2) below shows the results from the correlation test, illustrating a high correlation between the independent variable "EC", electric consumption per capita, and the independent variable "GDP", suggesting that the electric consumption is interlinked with the economic development. The correlation between the two variables is moderate to strong, reinforcing the presence of multicollinearity. However, before deciding if we are going to remove EC from our model, a statistical test (VIF) will be employed.

Table 2: Correlation between the variables of the model

	CO_2 em	GDP	GDP^2	EC	REC	IndPr	RI	POP
CO_2 em	1							
GDP	0.6063	1						
GDP^2	0.3935	0.9283	1					
EC	0.7386	0.7429	0.6107	1				
REC	0.1752	0.4540	0.5005	0.7199	1			
IndPr	-0.2330	-0.4387	-0.3334	-0.2871	-0.1172	1		
RI	-0.2171	-0.1495	-0.1207	-0.1461	-0.0062	-0.1890	1	
POP	-0.1704	-0.2206	-0.1508	-0.2089	-0.1083	0.2197	-0.0239	1

2.Variance Inflation Factor (VIF)

The Variance Inflation Factor (VIF) test, measures the amount of multicollinearity in the regression analysis. The table (3) below, shows the results of the test If the VIF value is greater than 10 ($VIF \geq 10$), this indicates a high multicollinearity, while a VIF value less than 5 ($VIF < 5$) is considered acceptable (SQ Lafi and J.B. Kaneene, 1992). Moreover, the results of the test illustrate that all the values from the test are relatively low.

Table 3: VIF test results

Variable	VIF	1/VIF
EC	3.89	0.257020
GDP	2.65	0.377107
REC	2.22	0.450724
IndPr	1.40	0.715962
RI	1.15	0.870876
POP	1.08	0.924932
Mean VIF	2.06	

6.2 Heteroskedasticity Test

Moving on, three tests have been employed to determine whether or not the regression analysis suffers from heteroskedasticity. The tests follow the null hypothesis (H_0) where homoskedasticity is presented in the regression analysis (the residuals are distributed with equal variance) and the alternative hypothesis (H_1) where heteroskedasticity is presented in the regression analysis (the residuals are not distributed with equal variance). If the p-value = < 0.05 then the null hypothesis is rejected, thus we can say that heteroskedasticity is presented. The table (4) illustrates the results, suggesting that regression suffers from heteroskedasticity since the null hypothesis has been rejected in both OLS models and the Fixed Effect model. Heteroskedasticity creates incorrect and biased standard errors, however this problem can be solved by regressing with robust standard errors (Kennedy, 2014). This way the results are more trustworthy and the coefficients are not affected.

Table 4: Heteroskedasticity tests results

Heteroskedasticity Tests	P-value results
Breusch–Pagan/Cook–Weisberg test for heteroskedasticity	p = 0.0000
White's test	p = 0.0000
Modified Wald test	p = 0.0000

6.3 Autocorrelation Test

Furthermore, the regression was also tested for autocorrelation. The table (5) below illustrates the results of the test, showing that the regression suffers from autocorrelation as well as heteroskedasticity, which leads to misleading standard errors. Thus, a good way of correcting the problem, same as heteroskedasticity, is to run a robust regression model, in order to get more trustworthy standard error and also for coefficients to not be affected.

Table 5: Autocorrelation Test result

Autocorrelation Test	P-value results
Wooldridge test	p = 0.0000

6.4 Stationarity Test

Furthermore, two unit root tests have been conducted to check for stationarity, where the statistical properties like variance, mean and autocorrelation structure do not change over time, in the regression analysis (Santiago et al. 2018). The results, shown in the table (6) below, indicate that the data are not stationary. Thus, a good way to solve this issue is to run the regression with first differences in order to get more reliable results that are not affected by the time.

Table 6: Stationarity Test result

Stationarity Tests	P-value results
Levin, Lin & Chu (LLC)	p = 1.0000
Phillips-Perron (PP)	p = 1.0000

7 Regression Analysis Results

7.1 Pooled OLS model regression - results

The table (7) below, illustrates the results of the Pooled Ordinary Squares (Pooled OLS) regression. Based on the results of the regression, and the Environmental Kuznets Hypothesis, it is shown that there is an inverted U-shape relationship between the economic development (GDP) with the climate change (CO2em), however this relationship is not statistically significant. Furthermore, in the table it is shown that there is a statistically significant negative relationship between the renewable energy consumption and the environmental degradation, which means an increase of one kWh per capita of renewable energy consumption leads to a decrease of 0.001896kt of carbon dioxide emissions. Additionally, there is another one statistically significant negative relationship, between the real interest rate and the CO2 emissions.

Table 7: Pooled OLS model regression result

		Robust				
CO2em	Coefficient	Std. err	t	P>|t|	[95% conf. interval]	
GDP	.00006	.000051	1.18	0.239	-.00004	.00016
GDP2	-7.10e-10	4.87e-10	-1.46	0.145	-1.67e-09	2.45e-10
EC	.0011851	.0001386	8.55	0.000	.0009131	.0014571
REC	-.001896	.0001793	-10.57	0.000	-.002248	-.0015441
IndPR	.0415457	.008163	5.09	0.000	.0255244	.057567
RI	-.0125528	.0047989	-2.62	0.009	-.0219715	-.0031341
POP	2.13e-10	1.10e-10	1.94	0.052	-2.28e-12	4.29e-10
_cons	-.0478231	.2933172	-0.16	0.871	-.6235079	.5278617

7.2 Least Squared Dummy Variable (LSDV (1) – Dummy Variable: Country)

In this part of the research, we conducted a dummy variable regression analysis with the dummy variable being the Country, in order to control unobserved heterogeneity. The table (8) below shows the result of the analysis. More over from the regression analysis there is evidence showing that there is an inverted U-shaped relationship between the carbon dioxide emissions (CO2em), which lead to environmental degradation, with the economic development (GDP). In this regression analysis we can also see that the relationship and the results are statistically significant. Thus, we can accept again the hypothesis of Environmental Kuznets curve, indicating a negative relationship between the economic development and carbon dioxide emissions in the developed countries, while in the developing countries there is a positive relationship between the two variables. It is also important to mention the statistically significant negative relationship between the real interest rate and the environmental degradation, and an increase of 1% of the real interest rates leads to decrease of 0.131966kt of carbon dioxide emissions.

Wald Test

Moving on, we conducted a Wald test to determine which model is preferable, the Least Squared Dummy Variable (1) or the Pooled OLS. The null hypothesis (H_0) of the test is that the country dummy variables are not significant, and the alternative hypothesis (H_1) is that the country dummy variables are significant. Based on the result, shown in the appendix table (14), the null hypothesis is rejected since the p-value is less than 0.05. The outcome is that, the LSDV (1) regression model is more suitable than the Pooled OLS regression model.

Table 8: Least Squared Dummy Variable model (Dummy variable: Country) regression result

		Robust				
CO2em	Coefficient	Std. err	t	P>|t|	[95% conf. interval]	
GDP	.0000472	.0000122	3.87	0.000	.0000232	.0000711
GDP2	-1.13e-09	1.64e-10	-6.87	0.000	-1.45e-09	-8.05e-10
EC	.0006732	.0000536	12.55	0.000	.0005679	.0007785
REC	-.0024518	.0001856	-13.21	0.000	-.0028161	-.0020876
IndPR	.0188656	.0065172	2.89	0.004	.0060737	.0316574
RI	-.0131966	.002491	-5.30	0.009	-.0180859	-.0083073
POP	4.49e-09	6.80e-10	6.60	0.000	3.15e-09	5.82e-09
Country_dummies1	-29.36224	2.102084	-13.97	0.000	-33.48817	-25.2363
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
Country_dummies50	-30.80583	2.009661	-15.33	0.000	-34.75036	-26.86131
_cons	31.01693	2.064822	15.02	0.000	26.96413	35.06973

7.3 Least Squared Dummy Variable (LSDV (2) – Dummy Variable: Year)

Moving on, in this part of the study we run a regression analysis using dummy variables for each time period, in order to control shocks or trends that are specific to particular time points but also are common across all entities. The table (9) below illustrates the results of the LSDV (2) regression, showing again the inverted U-shaped relationship between the economic development and the environmental degradation, however as we can see it is not statistically significant. Moreover, it is important to note that there is a negative relationship between the real interest rate and the environmental degradation. When the real interest rate increases by 1% then the CO_2 emissions decrease by 0.188991kt.

Table 9: Least Squared Dummy Variable model (Dummy variable: Year) regression result

		Robust				
CO_2em	Coefficient	Std. err	t	P>|t|	[95% conf. interval]	
GDP	.0000634	.0000507	1.25	0.212	-.0000362	.000163
GDP2	-6.96e-10	4.69e-10	-1.48	0.138	-1.62e-09	2.25e-10
EC	.0011731	.0001378	8.51	0.000	.0009026	.0014435
REC	-.0018538	.0001861	-9.96	0.000	-.002219	-.0014886
IndPR	.0315162	.0082162	3.84	0.000	.0153897	.0476427
RI	-.0188991	.0057713	-3.27	0.001	-.0302267	-.0075715
POP	3.59e-10	1.41e-10	2.55	0.011	8.30e-11	6.35e-10
Year_dummies1	-.001368	.4867265	-0.00	0.998	-.956698	.9539619
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
Year_dummies31	-1.78585	.7755712	-2.30	0.022	-3.308114	-.2635853
_cons	.660845	.4494709	1.47	0.142	-.2213609	1.543051

Wald Test

Continuing, we conducted a Wald test to determine which model is preferable, the Least Squared Dummy Variable (2) or the Pooled OLS. The null hypothesis (H_0) of the test is that the time variant effects are not significant, and the alternative hypothesis (H_1) is that the time variant effects are significant. Based on the result, shown in the appendix table (14), the null hypothesis is accepted since the p-value is more than 0.05 ($p = 0.1070 > 0.05$). Despite the fact that, the Pooled OLS model is preferable than the LSDV (2) regression model, we can not use it as the LSDV (1) model is more suitable as it is shown in the previous section and the appendix table (14).

7.4 Least Squared Dummy Variable (LSDV (3) – Dummy Variable: Country and Year)

Moreover, we conducted a third least square dummy variable model (LSDV 3), running a regression analysis with two dummy variables, Country and Year, in order to control both special (country-specific) and temporal (year-specific) heterogeneity. Thus, the model can have more accurate estimations of the influence that the independent variables have on the dependent variable, due to the reduction of the omitted variables bias. The results in the table (10) are evidence of the existence of an inverted U-shaped relationship between the environment degradation and the economic development. Since the p-value is statistically significant for 90%, 95%, and 99% significant levels, we accept the Environmental Kuznets Curve hypothesis. It also important to note that the negative relationship between the real interest rate and the environmental degradation, which is also statistically significant. When the real interest rate increases by 1% then the carbon dioxide emissions are decreased by -.0120873kt per capita.

Table 10: Least Squared Dummy Variable model (Dummy variable: Country and Year) regression result

CO2em	Coefficient	Robust Std. err	z	P>|z|	[95% conf. interval]	
GDP	.0000339	.0000157	2.16	0.031	3.08e-06	.0000647
GDP2	-1.03e-09	1.81e-10	-5.68	0.000	-1.38e-09	-6.71e-10
EC	.0006682	.000052	12.84	0.000	.0005661	.0007703
REC	-.002374	.0001811	-13.11	0.000	-.0027295	-.0020185
IndPR	.0086072	.0069825	-4.79	0.218	-.0050987	.022313
RI	-.0120873	.002526	-3.27	0.000	-.0170455	-.007129
POP	4.27e-09	8.12e-10	5.26	0.000	2.68e-09	5.86e-09
Country_dummies1	-28.64662	2.008502	-14.26	0.000	-32.58909	-24.70416
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
Year_dummies31	-.2287106	.2605621	-0.88	0.380	-.7401643	.282743
_cons	30.51699	2.002244	15.24	0.000	26.58681	34.44717

<u>Wald Test</u>

To extend the analysis, we conducted a Walt test, to determine which of the two models is more suitable, the LSDV (1) which includes the cross-sectional dummy variables or the LSDV (3) which includes both cross sectional and time variant effects. The null hypothesis (H_0) of the test is that the time variant effect are not significant, and the alternative hypothesis (H_1) is that they are significant.

Based on the result, shown in the appendix table (14), the null hypothesis is rejected since the p-value is less than 0.05 (p-value = 0.00 < 0.05) for all significant levels (90%, 95% and 99%) . The outcome is that, the Least Squared Dummy Variable (3) regression model, which includes both cross-sectional and time variant effect, is more suitable for our research analysis.

7.5 Random Effects

Time-invariant variable can function as explanatory variables since random effects assumes that the entity's error term is uncorrelated with the predictors (Oscar Torres- Reyna, 2007). The table (11) below, shows the results from the random effect model regression analysis, illustrating a negative relationship between the squared value of GDP per capita and CO2 emissions, suggesting an inverted U-shaped relationship between the two variables, while the GDP per capita has a positive relationship with the dependent variable. Thus, we can accept the Environmental Kuznets Curve hypothesis, suggesting that after the turning point an increase in the economic development decreases the carbon dioxide emissions. Furthermore, we can see the positive effect of energy consumption and industrial production with the environmental degradation as well as the positive effect of the population increase on the carbon dioxide emission level. On the other hand, it was observed a negative relationship between the real interest rate and the CO_2 emissions. All the above are statistically significant on 95% and 90% of significant levels.

Table 11: Random Effects model regression result

Random Effects						
CO2em	Coefficient	Std. err	z	P>|z|	[95% conf. interval]	
GDP	.0000489	9.60e-06	5.09	0.000	.0000301	.0000677
GDP2	-1.04e-09	1.16e-10	-9.03	0.000	-1.27e-09	-8.18e-10
EC	.0006036	.0000259	23.33	0.000	.0005529	.0006543
REC	-.0019465	.0000981	-19.84	0.000	-.0021388	-.0017542
IndPR	.0220551	.0089513	2.46	0.014	.004511	.0395993
RI	-.0124252	.0040422	-3.07	0.002	-.0203478	-.0045026
POP	2.98e-09	5.76e-10	-3.07	0.000	1.85e-09	4.10e-09
_cons	3.903463	. 4911717	7.95	0.000	2.940784	4.866142
sigma_u	1.9233955					
sigma_e	.5813115					
rho	.91630126					

7.6 Fixed Effects (FE)

The fixed effects (FE) model is a common econometric approach for controlling the variables that are constant over time but vary among entities, in a panel data analysis (George Farkas, 2005). The table (12) below, shows the results from the fixed effects model regression analysis, illustrating again an inverted U-shaped relationship between the dependent variable and the economic development per capita. Additionally, there is a negative relationship between the real interest rate and the dependent variable. When the real interest rate increases by 1% then the CO_2 emissions are decreased by 0.0131966kt per capita. From the table (9) below we can see that are all statistically significant in 90%, 95% and 99% of significant levels except the Industrial production's coefficient which is statistically significant on 90% and 95% of significant level.

Table 12: Fixed Effects model regression result

Fixed Effects						
CO2em	Coefficient	Std. err	z	P>|z|	[95% conf. interval]	
GDP	.0000472	8.63e-06	5.47	0.000	.0000302	.0000641
GDP2	-1.13e-09	1.04e-10	-10.79	0.000	-1.33e-09	-9.22e-10
EC	.0006732	.0000248	27.10	0.000	.0006244	.000722
REC	-.0024518	.0001012	-24.23	0.000	-.0026504	-.0022533
IndPR	.0188656	.0080146	2.35	0.019	.0031347	.0345965
RI	-.0131966	.0035924	-3.67	0.000	-.0202477	-.0061455
POP	4.49e-09	5.69e-10	7.88	0.000	3.37e-09	5.61e-09
_cons	3.235957	.3013439	10.74	0.000	2.644484	3.827429
sigma_u	5.987673					
sigma_e	.5813115					
rho	.99066257					

7.7 Hausman Test

The Hausman test is based on the difference between the Fixed Effects (FE) model and the Random Effects (RE) model estimators. The null hypothesis (H_0) of the Hausman Test is that the random model is more suitable for the analysis, on the other hand the alternative hypothesis (H_1) is that the random model is not suitable. The table (13) below shows the results from the Hausman test, suggesting that the null hypothesis (H_0) is rejected for all significance levels (90%, 95% and 99%), thus the regression analysis it is more suitable to use the Fixed Effects (FE) regression model.

Despite the fact that the Hausman test determines that the Fixed Effects (FE), which takes into consideration and control the cross-sectional effects, model is more suitable than the Random

Effects (RE) model, the Least Square Dummy Variable (3) model that controls both cross-sectional effects as well as time variant effects which are statistically significant.

Table 13: Hausman Test result

Hausman Tests	P-value results
Random Effects Vs Fixed Effects	p = 0.0000

7.8 Model 2:

This model was used to determine the relationship between the fiscal policies and environmental degradation. Specifically, we examined the impact of the revenues of environmental taxes on carbon dioxide emissions in European Union countries (EU) from 2011 to 2022. Furthermore, in this case we didn't include the Environmental Kuznets Curve hypothesis, since the all of the European Union countries are considered to be developed. The reason that the examination was limited to 12 years, is the lack of data on environmental taxes. As it was done to previous mode (1), the second model had also been tested for multicollinearity, heteroskedasticity, autocorrelation and stationarity.

The table (15) in appendix shows the results from the correlation test, illustrating a high correlation between the independent variable "EC", electric consumption per capita, and the independent variable "REC", suggesting that the electric consumption is interlinked with the electric energy consumption. The correlation between the two variables is moderate to strong, reinforcing the presence of multicollinearity. However, before deciding if we are going to remove EC from our model, a statistical test (VIF) was be employed. The results from the VIF test are shown in the table (16) in the appendix. As it was mentioned in the previous model, if the VIF value is greater than 10 ($VIF \geq 10$), this indicates a high multicollinearity, while a VIF value less than 5 ($VIF < 5$) is considered acceptable (SQ Lafi and J.B. Kaneene, 1992). Moreover, the results of the test illustrate that all the values from the test are relatively low.

Moving on, as we did with the previous model, we have employed three tests to determine whether or not the model (2) suffers from heteroskedasticity. If the p-value = < 0.05 then the null hypothesis is rejected, thus we can say that heteroskedasticity is presented. The results illustrated in the table (17) in the appendix suggest that model (2) suffers from heteroskedasticity in both OLS models and the Fixed Effect model. Furthermore, we also have employed a test to check for autocorrelation, the results can also be found in table (17), showing that the model 2 also suffers from autocorrelation. The way to resolve these issues is by regressing with robust standard errors (Kennedy, 2014), in order to have results that are more trustworthy and the coefficients are not affected. Additionally, we conducted a test for autocorrelation, the results are shown as well in the table (17) in the appendix, suggesting that the regression analysis does not have unit root. Therefore, the data can be treated as stationary.

Moving on we can see the results of the Pooled OLS regression analysis in the table (18) in the appendix. The results suggest that the coefficient is not statistically significant thus there are not enough evidence to support the relationship and drive a conclusion. Additionally, it is important to highlight the relationship between the independent variable, population, and CO_2 emissions. Based on the table we can see that when the population increases by 1 person in the developed countries, then the CO_2 emissions decrease by 0.0000000217, which statistically significant.

Additionally, in the table (19) below, shows the results from the random effect model regression analysis, illustrating a positive relationship between the revenues of environmental taxes and CO2 emissions, statistically significant for 95% and 90% significance level. Furthermore, we can see the negative effect of population and renewable energy consumption with the environmental degradation as well as the positive effect of the electric consumption and industrial production on the carbon dioxide emission level. Besides the random effects (RE) model we also run the fixed effects (FE), with the results showing in tables (19) and (20) accordingly in the appendix, suggesting a negative relationship between the exponential GDP per capita and the carbon dioxide emissions in the developed countries, which is statistically significant. Thus we can accept the Environmental Kuznets Curve (EKC) hypothesis.

Finally, we use the Hausman test to determine which model we will utilize, between the Fixed Effects (FE) model and the Random Effects (RE) model. As it is mentioned in the previous model (1), the null hypothesis (H_0) of the Hausman Test is that the random model is more suitable for the analysis, on the other hand the alternative hypothesis (H_1) is that the random model is not suitable. The results of the test are shown in the table (21) in appendix, suggesting that the null hypothesis (H_0) is rejected for all significance levels (90%, 95% and 99%), thus the regression analysis it is more suitable to use the Fixed Effects (FE) regression model.

8. Conclusion

As it was mentioned before, in this paper we used the Environmental Kuznets Curve (EKC) hypothesis in order to examine the impact of economic development and climate change. The hypothesis suggests that the relationship between the economic development and the environmental degradation, is explained by an inverted U-shaped curve, where at an early stage of a country's economic development it reaches its peak on air pollutions levels, and then as economic development increases the air pollution declines after reaching a certain economic threshold. (Uchiyama Katsuhisa, 2016). Our study, used this hypothesis for the regression analysis of model (1).

Before the regression analysis we conducted some test to determine whether our study suffers from multicollinearity, heteroskedasticity and autocorrelation. The results from the tests showed that our model suffers from heteroskedasticity and autocorrelation, thus we run the regression using robust standard errors (SE) to solve this issue in order to have more trustworthy results. Moving on with our regression analysis, we conducted some test to check if our model is stationary and the results showed that it is not. Thus, we used Least Squared Dummy (LSVD) method which controls the effect of country and time variable, which based on tests it was suggested as more suitable for our analysis, alongside with the Environmental Kuznets Curve (EKC) hypothesis. The results show that economic development has positive relationship with CO_2 emissions per capita, while the economic development in developed countries has a negative relationship with carbon dioxide emissions per capita. Thus, we can accept the Environmental Kuznets Curve (EKC) hypothesis, since the results suggest that up to a certain point, economic development leads to high emissions, but after that economic threshold is achieved the economic development reduces the environmental degradation, there is an inverted U-shaped relationship between economic development and emissions.

Furthermore, based on the results of our literature we can see that the fiscal policies, including the environmental taxes, have a negative impact on the emissions. Thus, the research findings of Aliya Zhakanova Isiksal et al (2019) and Mohammed Yaw Broni et al (2020) that have examined and accepted both hypotheses. However, as our results have shown that the coefficients are not statistically significant, we can not drive a conclusion of the effect of environmental taxes on carbon dioxide emissions. Additionally based on the results of our literature, found by Thomas Sterner and Gunnar Kohlin (2004) and Francisco et al (2022), suggesting that efficiency of such taxes differs among nations due to varying degree of acceptance and integration with other policies.

In conclusion, this study emphasizes how complex the connection is between the economic development and the environmental sustainability. The Environmental Kuznets Curve (EKC) hypothesis is valid, suggesting that higher economic development may lead to lower carbon dioxide emissions; nevertheless, the impact of environmental taxes is still inconclusive.

Appendix:

Table 14: Wald Test result

Wald Test	P-value results
Pooled OLS Vs LSDV (1)	p = 0.0000
Pooled OLS Vs LSDV (2)	p = 0.1070
LSDV (1) Vs LSDV (3)	p = 0.0000

Table 15: Correlation between the variables of the model 2

	CO_2 em	GDP	GDP2	EC	REC	IndPr	TAX	POP
CO_2 em	1							
GDP	0.6000	1						
GDP2	0.6647	0.9434	1					
EC	0.2763	0.4231	0.2779	1				
REC	-0.0871	0.1975	0.0685	0.7936	1			
IndPr	-0.0636	-0.2892	-0.2960	-0.0180	0.0689	1		
TAX	-0.1380	-0.2385	-0.2595	-0.0307	0.0157	-0.2738	1	
POP	-0.0545	0.0077	-0.0904	-0.0191	-0.1447	0.0879	-0.2273	1

Table 16: VIF test results model 2

Variable	VIF	1/VIF
EC	3.49	0.286404
REC	3.05	0.328141
GDP	1.63	0.613927
TAX	1.31	0.764455
IndPr	1.30	0.766698
POP	1.11	0.899289
Mean VIF	1.98	

Table 17: Statistical tests results model 2

Heteroskedasticity Tests	P-value results
Breusch–Pagan/Cook–Weisberg test for heteroskedasticity	p = 0.0000
White's test	p = 0.0000
Modified Wald test	p = 0.0000
Autocorrelation Test	P-value results
Wooldridge test	p = 0.0000
Stationarity	P-value results
Levin, Lin & Chu (LLC)	p = 0.0000
Phillips-Perron (PP)	p = 0.0095

Table 18: Pooled OLS model 2 regression result

		Robust				
CO2em	Coefficient	Std. err	t	P>|t|	[95% conf. interval]	
GDP	.0000694	.0000125	5.55	0.000	.0000448	.000094
GDP2	1.17e-09	1.54e-10	7.57	0.000	8.63e-10	1.47e-09
EC	.0006142	.000115	5.34	0.000	.0003878	.0008406
REC	-.0013375	.0001415	-9.45	0.000	-.0016161	-.0010588
IndPr	.0848368	.0277705	3.05	0.002	.0301561	.1395176
TAX	.1409799	.1356654	1.04	0.300	-.1261488	.4081085
POP	-2.17e-08	5.57e-09	-3.89	0.000	-3.26e-08	-1.07e-08
_cons	.5106429	.9750203	0.52	0.601	-1.409197	2.430482

Table 19: Random Effects model regression result

Random Effects						
CO2em	Coefficient	Std. err	z	P>|z|	[95% conf. interval]	
GDP	1.48e-06	.0000113	0.13	0.896	-.0000207	.0000237
GDP2	-5.57e-10	2.29e-10	-2.44	0.015	-1.01e-09	-1.09e-10
EC	.0004524	.0000341	13.28	0.000	.0003857	.0005192
REC	-.0022055	.0001829	-12.06	0.000	-.0025639	-.0018471
IndPr	.0698917	.0252294	1.98	0.006	.0204429	.1193405
TAX	.4195461	.2121171	-3.07	0.048	.0038042	.835288
POP	-3.32e-08	2.05e-08	-1.63	0.104	-7.33e-08	6.85e-09
_cons	4.836436	1.19077	4.06	0.000	2.502569	7.170302
sigma_u	2.0638497					
sigma_e	.56759746					
rho	.9296831					

Table 20: Fixed Effects model 2 regression result

Fixed Effects						
CO2em	Coefficient	Std. err	t	P>|t|	[95% conf. interval]	
GDP	-.0000322	.0000123	-2.61	0.009	-.0000565	-7.95e-06
GDP2	-5.56e-10	-5.56e-10	-2.40	0.017	-1.01e-09	-1.00e-10
EC	.0004742	.000031	15.28	0.000	.0004131	.0005354
REC	-.0028278	.0002097	-13.48	0.000	-.003241	-.0024147
IndPr	.0864249	.0248142	3.48	0.001	.0375403	.1353096
TAX	.2298068	.2002671	1.15	0.252	-.1647241	.6243378
POP	-1.91e-07	1.20e-07	-1.59	0.112	-4.27e-07	4.51e-08
_cons	9.460716	2.219188	4.26	0.000	5.088863	13.83257
sigma_u	5.6325566					
sigma_e	.56759746					
rho	.98994732					

Table 21: Hausman Test result for model 2

Hausman Tests	P-value results
Random Effects Vs Fixed Effects	p = 0.0000

Table 22: Countries used for the research: Model 1

1. Argentina	26. Mexico
2. Australia	27. Nepal
3. Austria	28. Netherlands
4. Bangladesh	29. New Zealand
5. Belgium	30. Nigeria

6. Brazil	31. Norway
7. Canada	32. Pakistan
8. Chile	33. Peru
9. China	34. Philippines
10. Colombia	35. Poland
11. Czechia	36. Portugal
12. Denmark	37. Romania
13. Egypt	38. Russia
14. Finland	39. Saudi Arabia
15. France	40. Singapore
16. Germany	41. South Africa
17. Greece	42. Spain
18. India	43. Sweeden
19. Indonesia	44. Switzerland
20. Iran	45. Thailand
21. Israel	46. Turkey
22. Italy	47. United Arab Emirates
23. Japan	48. United Kingdom
24. Korea	49. United States
25. Malaysia	50. Vietnam

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