

**EKC Hypothesis Revisited: An Empirical Study of Thirty
European Countries**

By

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1. INTRODUCTION

Nowadays, the issue of the environment is becoming controversial. All kinds of media are talking about pollution and debating what is best for our environment. Since the scope of the environment is very huge, it is not only environmentalists who are concerned about it but, also other people, such as economists and policy-makers. As always, environmentalists are in favor of conserving the environment even if it is at the expense of the majority of people. In contrast, policy-makers could prefer the other side of the issue, which does not take into consideration becoming harsh on the environment, if it helps in being reelected again. Differently from both groups, economists, in my opinion, try to investigate the issue in a balanced way and try to determine what would be the best for the environment and people at the same time.

There is no doubt about the fact that some environmental issues have been ignored in the last few decades. Global warming and climate change are clear signs that we have paid no attention to our environment. As an economist, I believe that it is time to clean up our environment and find clean technologies. In this paper, I am trying to determine the factors that could affect our environment either positively or negatively. Once these factors are known, it will be easier to make beneficial decisions regarding environmental quality.

In this paper, I will test the Environmental Kuznets Curve (EKC) hypothesis, which simply says that the relationship between the level of income and the pollution level is an inverted U-shaped relation. Some people believe that such a relationship is misleading and it could diminish once some other explanatory variables are added to the model. In this paper, I will focus two important variables that are believed to have an impact on

environmental quality. The variables are the type of political regime and openness to trade. The type of political regime has an influence on the decision-makers, which in turn have the power to clean or soil the environment. The claim that I want to test is that the more democratic a country becomes, the cleaner the environment it has. Through democratic channels, people can achieve their goal of living in a clean environment.

The other important factor is openness to trade. When it comes to environmental quality, I notice that many researchers have ignored this factor. Its effect on environmental quality could be positive if it encourages competition, which leads to greater efficiency in production. This is likely to have positive impact on environmental quality. A negative impact is possible as well; openness to trade could attract dirty industries.

Some studies, such as Farzin and Bond (2003), include the type of political regime as an explanatory variable in their empirical investigation of the EKC hypothesis. In this paper, I will duplicate what they do using different data. The main difference is the index that measures the degree of democracy. They do not take into account the time dimension in their regime when measuring the degree of democracy, which I believe is very important. My argument is that a country that has been practicing democracy for one hundred years should not be given the same score as a country that has just started the democratic process. In terms of measure of openness, I include it because I have not seen any study that investigates whether it plays a role in shaping the relationship between the level of income and the level of pollution. In conducting my empirical analysis, I will use data for thirty European countries. These countries provide data about the pollution level for a long period of time, which not all countries do.

My results show that including a political regime variable and openness to trade in the model does not lead to support for the EKC hypothesis. However, these variables have a significant impact on environmental quality. In terms of the type of political regime, I found that the more democratic a country is, the higher environmental quality the country has. Regarding the openness to trade variable, my results show that openness to trade leads to a decline in emissions levels.

This study consists of five sections. Section 2 is a literature review. Section 3 provides information about the data and its sources. Section 4 reports the empirical results. Section 5 is a conclusion for this paper.

2. LITRATURUE REVIEW:

In this part of my study, I am going to summarize seven papers written about environmental quality. Each study has a different approach to investigating the determinants that could lead to better or worse environmental quality. Some of the reviewed papers are pure theoretical papers, while the others combine theory with empirical work¹. It should be noted that not all the papers considered in this study are using the EKC model. However, all of them are trying to find out the determinants of environment quality. At the end, I identify potential determinants will help me to build my model.

2.1 Control of Pollution When the Offended Defend Themselves (Shibata and Winrich, 1983)

There are many methods that can help in cleaning our environment from pollution. The majority of these methods can be classified as prevention. Examples of these methods are using new clean technology, changing the composition of factors of production, moving to another place... etc. Most researchers have focused in their studies on these methods and either ignore actions that can be taken by victims to reduce pollution or consider them implicitly. Example of victims' actions includes: moving from a more polluted area to a less polluted one, installing air filters inside houses, etc. This paper distinguishes explicitly between private defensive methods and prevention methods and analyzes the cases in which of these methods are used.

As a first step for determining which methods, defensive or protective, should be implemented, the authors look closely at the marginal cost function of both methods. The

¹ For an exhaustive survey of literature one can look at Nahman and Antrobus(1999)

cost of prevention depends on the quantity of pollution in the environment. The cost function of the defensive method is a bit complex. It could depend on the quantity of pollution in the environment or the “quality of the pollution medium (measured by quantity of pollutants present in a given quantity of, say, water or air)” (p.428) or both.

In an economy with two goods Y and X (Y causes pollution Z, X is a numeraire good) and two groups of people, A (polluters) and B (victims), the authors set and solve three problems in order to determine the optimality conditions for consuming goods X and Y in the presence of different cost functions. The authors made some assumption about the externality in this model. They assume that the number of victims and generators of pollution are constant and each a group has a utility function, there is a method to measure the degree of pollution, there is no fixed cost for both methods, no group is willing to compromise in order to get something from the other group and the second order conditions are satisfied. If the victims of pollutions do nothing against the present situation, the optimal condition is to set a tax equal to victims’ marginal disutility. This paper shows that this is not necessarily the best solution.

The optimality conditions when the defense cost function depends on the quantity of pollution released shows that the marginal cost of prevention equals the marginal cost of defense. Accordingly, no method is preferred over the other. In contrast, when the defense cost function depends on the environmental quality in the medium, one of these methods can be preferred. The authors show from the optimality condition that the marginal defense cost can be larger or smaller than the marginal protective cost. For instance, when the marginal defense cost is lower than the marginal protective cost, the defensive method would be the superior choice. To elaborate on this point, the authors give the following example:

Recall the power plant that discharges warm water into a river. Suppose that it costs the power plant $\$X^p$ to reduce the temperature of the river's water by 1°C by reducing the temperature of discharge water by, say 5°C , while the cost of reducing the river's water by the same 1°C by the aforementioned cooling device is $\$X^d$, and both marginal (average) cost functions do not vary with the temperature. It is obvious that the cooling device (defensive method) should be used exclusively if $X^p > X^d$, and only the water to be discharged should be cooled (the preventive method) if $X^p < X^d$. (p.431).

Also, when the cost function depends on both the quantity of pollution and the quality of environment, the defensive method can be better than the protective method; thus, it can be used alone. In all types of cost function, except the one that depends on the quantity of pollution, there is a possibility of having two or more local optima. This problem is discussed by the authors in this paper.

2.2 The Distribution of Pollution: Community Characteristics and Exposure to Air Toxics (Brooks and Sethi; 1997)

It is known that air toxins released by manufacturers are responsible for an enormous amount of disease and environmental damage around the world. For the sake of raising American people's awareness about air toxins, the Environmental Protection Agency in the US releases an annual report the called Toxic Releases Inventory (TRI). It ranks states in terms of the level of air toxins released by firms in the state. It has been realized that this report has done a good job of putting more pressure on firms to reduce their releases to avoid bad publicity and a loss in their earnings consequently. Many researchers use TRI data to conduct their studies, which is criticized by the authors of this article. TRI data shows the level of emissions in aggregate form. It does not distinguish between the different types of toxins. This could have, the authors believe, some implications for people, firms and the reliability of studies on the environment. To avoid these implications, the authors develop an index to measure the level of exposure to toxins that

takes toxicity differences into consideration plus the distance from the polluter to its victims.

The main objective of the paper is to discover the community characteristics in the US that could play a role in determining the level of exposure to air toxins in the period 1988 - 1992. Using the constructed index “distance-weighted sum of sulfuric acid equivalent pound of emission” (E), the authors use OLS to estimate the following equation:

$$\ln(1+E_j) = \beta_1 + \beta_2 x_{2j} + \dots + \beta_n x_{nj} + \varepsilon_j ;$$

where j represents the zip code and ε_j is an error term. The explanatory variables included in this model are the following: the percentage of people living in the urban area, the percentage of black people, poverty levels measured as the percentage of poor people, the percentage of high school graduates over 24 year old, the percentage of college graduates over 24 year old, the percentage of people working in the manufacturing sector, the percentage of rented houses and apartments, median house values, median household earning, average population per zip code and the percentage of people with the right to vote in 1992.

The authors estimate the equation using data from each year separately. The effect of all characteristics, with exception of the median value of housing, is highly significant in all years and there are no major differences in the magnitude of the coefficients. The result shows that the proportion of black people in the community is positively associated with higher levels of exposure. A 1% increase in the percentage of black people in the community could lead the value of exposure to an increase of 2.8%. In contrast, an increase of 1% in the number of voters in the community would lower the value of exposure by 3%. The level of education (high school and college) is negatively associated

with the value of exposure in the US. Even though the “poverty” variable fits in the linear model, the quadratic model gives more information about this variable. The result shows that as long as the percentage of poor people in the community is less than 36%, there will be a negative relationship between this variable and the level of exposure. The sign of the relationship becomes positive when the proportion of poor people goes beyond 36%. This level of exposure as the authors say is “too high to be plausible as the mean poverty proportion is 15% with a standard deviation of 11% and may be capturing the effect of omitted or unobservable variables” (p.246). In terms of income effect, this study shows that community with a median income of more (less) than 67000 dollars or is exposed to less (more) pollution as the median income increase.

As a complementary step, the authors run a logarithmic regression with the same independent variables used in the previous model with inclusion of the initial level of exposure, “Chem90”. The dependent variable in this regression represents the change in the level of exposure in the period 1990- 1992. The authors find that an increase of 1% in the black population in the community is likely to lead to an increase in the probability of greater exposure by 0.002 %. In contrast, the likelihood of being exposed to more toxics would decrease by 0.0025 if the number of voters in the community increased by 1 %. The coefficient of poverty and college variables is significant but the coefficient signs are contrary to what is hypothesized.

2.3 Democracy and Environmental Quality (Farzin and Bond, 2003)

Many authors, including the authors of this article, have tackled the relationship between environmental quality and the level of income. In this paper, the relationship is reexamined while taking into account the presence of many independent variables. However, the paper mainly focuses on the structure of political institutions as an

explanatory variable, both on its own and in combination with other explanatory variables.

This paper also provides a justification for including this variable. The authors claim that environmental quality can be considered a public good and that it is too costly to be supplied by the private sector. Thus, the government has to intervene and provide it. The state may not make the decision about the level of environmental quality to be supplied in isolation from citizens' preferences. Taking citizens' preferences into account depends on the level of democracy that a country has. The more democratic a country is, the more its citizens' preferences play an important role in shaping environmental decisions.

The authors estimate two reduced equations (basic and extended) for five different pollution indicators: emissions of carbon dioxide (CO₂), emissions of sulfur dioxide (SO₂), emissions of nitrogen oxides (NO_x), emissions of non-methane volatile organic compounds (VCO) and concentration of SO₂ (GEMSSO₂).

The basic equation is:

$$X_{it} = k_i + \sum_{j=1}^3 \beta_j Y_{it}^j + \sum_{k=1}^3 \beta_{k+3} P_{it}^k + \beta_7 D_{it} + \beta_8 D_{it} Y_{it} + \delta t + \varepsilon_{it}$$

where X_{it} represents the pollution measure for country i in year t , Y_{it} is GDP per capita, P_{it} is population density, D_{it} is a democracy measure, t is a time trend to capture technological progress and k_i is a constant. The democracy measure is an index ranked from 0 to 10. The country that is given 0 is strongly autocratic. Higher values mean greater degree of democracy. The country that is given 10 is very strongly democratic. The World Bank provides good data for GDP per capita, population density and all pollution indicators. D_{it} is provided by Polity IV (2003) database, Center for International

Development and Conflict Management, University of Maryland. This center specializes in collecting yearly information about independent regimes around the world.

As many other studies show, the result of estimating the basic equation is not consistent with the EKC hypothesis in all regressions, with the exception of the VOC regression. D_{it} 's effect on pollution indicators is significantly negative for all indicators except NO_x . This suggests that democracy plays a role in preserving and restoring the environment. In addition, its effect on the pollutants that depend on income could be magnified when it is combined with higher income. This result shows that the effect of democracy on the environmental quality could vary between countries depending on their level of income.

In the extended model, the authors add some preference shifters, which they think that these variables affect people's preferences about the environment. They assume that people in the society can get the environmental quality that they prefer through political channels, which is represented in their paper by D_{it} . In order to take this assumption into account empirically, the authors interact each shifter with the political variable D_{it} in their extended equation, as follows:

$$X_{it} = k_i + \sum_{j=1}^3 \beta_j Y_{it}^j + \sum_{k=1}^3 \beta_{k+3} P_{it}^k + \beta_7 D_{it} + \beta_8 D_{it} Y_{it} + \beta_9 U_{it} + D_{it} (\beta_{10} G_{it} + \beta_{11} A_{it} + \beta_{12} U_{it} + \beta_{13} I_{it}) + D_{it} Y_{it} (\beta_{14} G_{it} + \beta_{15} A_{it} + \beta_{16} U_{it} + \beta_{17} I_{it}) \quad \delta t + \varepsilon_{it}$$

where U_{it} measures the degree of urbanization, I_{it} measures the illiteracy rate, G_{it} ² is a measure inequality and A_{it} is the percentage of population under 15 years old. The data of all added variables are The World Bank.

² GINI coefficient is used here as a proxy for income inequality

Again, the resulting regression for this equation does not support the EKC hypothesis for the majority of the models. The results of the CO₂, SO₂ and GEMSSO₂ regressions do not support the EKC hypothesis, and as for the basic model, the results of the VOC regression do support the EKC hypothesis. In the extended model, the polity variable's effect is significant only in two of the five models, and this is an indication of the importance of the variables added to this model. The coefficients of all preference shifters combined with the polity variable are significant, which leads to the conclusion that the higher the degree of democracy is, the more attention is paid to the level of environmental quality demanded by the society.

The authors explain the theoretical and the empirical effect for each preference shifter conditional on the type of the political regime. The first shifter is urbanization. Theoretically, this factor could have either a negative or a positive impact on environmental quality. On the one hand, there is the argument that an increase in urbanization may lead to more environmental damage since it is "likely to be associated with a greater per capita and per unit area consumption of fossil fuels and industrial chemical inputs." (p.13) On the other hand, there is another argument that says that urbanization may have a beneficial effect on the environment. It does so because it brings victims of pollution close to policy makers. Thus, victims can influence the environmental decisions that are made. Empirically, this study finds that at a high degree of democracy and income level, urbanization is positively associated with the level of pollution in all regressions, except for the CO₂ regression. As an explanation for this result, the authors state that "this suggests that the effects of increased fossil fuel use in urban societies mostly dominate any economies of scale or preference effect. However,

some preference effects are evident through the negative interaction terms for CO₂, NO_x, SO₂ emissions.” (p.20)

The second shifter that is discussed in this paper is income inequality. In theory, there are two opposite arguments. One of these arguments is that wealthy people are in favour of enjoying a healthy environment. Therefore, they are against activities that could pollute the environment around them. They can also influence policy makers more easily than poor people. On the other hand, poor people may not consider environmental quality to be a priority. They may accept lower environmental quality in order to get hired. Based on these two arguments, one cannot precisely determine the relationship between environmental quality and income inequality. This study shows that at the sample mean, the emissions of CO₂, VOC and SO_x concentrations are negatively associated with income inequality.

The third preference shifter is the age composition of the population. There are also various arguments regarding whether or not young people care about environmental quality more than older people. This study shows that there is a negative relationship between two pollution indicators (the emission of NO_x and VOC) and A_{it}. In contrast, the emission of carbon dioxide increases as A_{it} increases. The relationship between A_{it} and the emission of SO_x depends on income level. It is negative at low-income levels and positive at higher income levels.

The last shifter discussed in this paper is the education level of the population. Theoretically, a positive relationship is expected between education level and environmental quality. This study shows that literacy increases pollution levels at low levels of income, and the relationship becomes negative at high levels of income.

2.4 Openness and the Environment in Central and Eastern Europe: Can Trade and Foreign Investment Stimulate Better Environmental Management in Enterprises? (Andonova, 2003)

The North American Free Trade agreement was the trigger for starting an investigation of the relationship between free trade and capital movements between countries and environment protection. Environmentalists criticize free trade. They argue that free trade and capital movements could lead to the transfer of dirty industries to countries that have weak environmental regulations. Moreover, firms in poor countries might take advantage of such weak regulations and try to lobby the government in order to make environmental regulations more lenient. On the other hand, the proponents of a free international market disagree with environmentalists' argument. They believe that, through competition, free trade and capital movements could lead to increased efficiency which in turn leads to decreased environmental damages. In addition, free trade helps to diffuse more environmental friendly technologies among counties.

The author tests the impact of free trade and an increase in the flows of direct foreign investment (FDI) on environmental management at the firm level in five central and eastern European countries (Bulgaria, Hungary, Lithuania, Poland and Slovakia). The economies of these countries underwent a transition to open-market economies during the period 1990-1997. Thus, the effects of openness on environmental management, as the author argues, would be apparent in these economies. The author believes that eliminating trade barriers between central and east European countries and west European countries and stimulating FDI could improve environmental performance in the central and east European countries through three mechanisms: technology diffusion and efficiency gains, reputation, and regulatory pressures.

Allowing international firms to compete with domestic firms in the Central and East European countries would force domestic firms to adopt more efficient technologies, which are most likely to be clean technologies. Also, eliminating trade barriers would facilitate the movement of new capital to Central and East European countries, which helps in modernizing the old capital.

Reputation could play an important role in increasing the level of environmental management. It is an advantage for Central and East European firms to have a good reputation for their products and methods of production, since having this reputation would make selling their products in EU and OECD markets much easier. In short, firms will be use clean technologies in order to maintain a good reputation, which in turn could keep EU and OECD markets open to them.

The last mechanism is regulatory pressures. To be a member of the EU or OECD c, any country has to meet specific requirements in terms of adopting clean technologies. Therefore, openness to EU and OECD markets implies that higher standards have to be met by central and east European firms.

Even though there are many mechanisms that could support the hypothesis that says openness is useful for the environment of central and east European countries, there is still the possibility that openness could have a negative impact on the environment. Take, for example, international firms that transfer old capital to Central and East European countries during the transition in order to take advantage of weak regulation at that time.

The purpose of this study is to examine empirically whether the openness in the economy could lead to an improvement in the environmental management at firm level or not. The

data used in this study is firm-level data for 1712 firms distributed over the countries under study.

The dependent variable in the model is firm-level environmental management. The author uses three different measurements for this variable, which are CLEANTECH “the percentage of plant and equipment replaced by cleaner technology in the period 1993-1997” p.187, AUDIT a “binary variable that indicate the existence of the internal systems for environmental protection and monitoring” p.187 and ISO1400 which is a variable that “indicates whether a firm has taken specific steps compatible with ISO (International Organization for Standardization)” p.187. The main independent variables in this model are the percentage of exported product (EXPORT) and the share of the company owned by foreigners (MULTINATIOAL). In addition to these two variables, the author includes some control variables: SIZE, which represents the size of the firm in 1997; PERMIT, which shows whether the law forces the firm to have a permit for using some or all of its units in the period 1990-1997; ENFORCEMENT, which represents the number of penalties, warnings and orders that a company received from the official authority during the period 1990-1997; and COMMUNITY, which indicates the number of occasions that the company has faced some pressure from anyone but the official authority.

Using cross section data, the author runs a linear regression with and without country dummies for each dependent variable. Se finds that the impact of MULTINATIOAL on CLEANTECH, ISO1400 and AUDIT is positive and significant for except its effect on CLEANTECH. Therefore, it can be concluded that multinationals play an important role in increasing the level of environmental management at firm-level. In terms of the other main variable, EXPORT, the result was unexpected. The coefficients of this variable are not significant, except in the model that uses CLEANTECH as an environmental

indicator and introduce country dummies. This implies that opening a firm to foreign markets is not sufficient to increase its level of environmental management. The only control variable that grasps reader attention is ENFORCEMENT. Its effect on all environmental indicators is positive and significant. That leads us to conclude that implementing strict regulations helps in inducing firms to increase their level of environmental management.

2.5 Environmentalism, democracy, and pollution control (Fredriksson, Neumayer, Damania, Gates, 2005)

In this paper, the authors examine the role of lobby groups, democratic participation and political competition (which is measured as the total percentage won by all parties except the winner) in determining the level of pollution allowed by a government. To do this, the authors introduce a theoretical model that predicts three results. The first result is that the stringency of environmental policy increases as the number of environmental lobby groups increases. The second result is that democratic participation positively affects environmental policy, and the effect is magnified when it is combined with higher political competition. The third result is that higher political competition leads to higher environmental quality, and it becomes even greater if it coincides with a higher participation rate.

These theoretical results are tested empirically. In order to do so, the authors collect data on the lead content of gasoline from 82 developing countries and 22 OECD countries. They run a regression for the following linear equation:

$$t_i = x_i' \beta^x + \beta^k k_i + \beta^s s_i + \beta^c c_i + \beta^{sc} s_i c_i + \varepsilon_i$$

where t_i represents the environmental policy stringency in a country i as reflected by the level lead content of gasoline in a country i , x_i is a vector of control (LOG income per capita for year 1993 and 1996), k_i is the number of lobby groups, s_i is the participation rate, c_i is the degree of political competition and ε_i is an error term. $\beta^x, \beta^k, \beta^s, \beta^{sc}$ are the estimated coefficients.

The equation is estimated with on cross-section data using different methods. The authors run a regression by using the OLS method (model 1), Tobit with full sample (model 2), OLS using the developing countries data (model 3) and 2SLS (model 4). The authors carry out an outlier analysis in models 5 to 7.

The results of this empirical study show that the effect of environmental lobby groups (ENVIRGROUP 1996, defined as the number of public environmental organizations in a country) on the level of lead content is insignificant in all models except model 1. In the authors' point of view, this is due to an underestimation of the number of lobby groups. They support this hypothesis by using a recent survey of lobby groups that is believed to be more accurate. Using this data, the effect of lobby groups is significant in all except two models, and it is highly significant in the models that focus on developing countries. Based on this result, the authors think that international organizations can participate in improving environmental quality in developing countries by supporting non-governmental organizations in developing countries. The effect of the number of lobby groups that fight against decreasing the level of lead is positive and significant and positive in models (1-4). This result coincides with what was expected theoretically.

In terms of the participation rate, the result is not what the theoretical model predicts. In all models, the effect of the participation rate is insignificant. Developing countries could be the reason for this outcome. Poor citizens in these countries, if they are allowed to participate in elections, may not support the policy of decreasing the level of lead content of gasoline due to the fact that such a policy would increase gas prices. In contrast, the other political indicator (political competition) is significant at the 5% level in all models. As the theoretical model predicts, combining political participation and political competition affects environmental policy negatively in models 1, 2 and 4. Therefore the participation rate would have an impact only in a country that has high political competition.

2.6 Air pollution during growth: accounting for governance and vulnerability (Wheeler, Dasgupta, Hamilton and Pandey, 2005)

The author of this study reexamines the EKC hypothesis empirically with and without including two important explanatory variables. The authors believe that governance is an important factor in determining the EKC relationship. Nevertheless, most studies ignore it. They argue that eliminating this variable from the EKC model leads to a magnified income effect on pollution level due to the correlation between income and governance. They also argue that environmental governance could be relatively high in low-income countries; therefore, the pollution level could be low even if the income level is low.

The authors criticize studies that assume that all activities in the economy yield the same rate of pollution when they test the EKC hypothesis. They support their position with a recently conducted study that proves that only seven sectors among 82 industrial sectors in the economy are responsible for at least 90% of air and water pollutants. This study

also considers an exogenous factor, which is geography. Most studies assume implicitly that once a pollutant is emitted in the air, it will cause the same damage anywhere. However, in reality, the geographical factor plays an important role in determining the level of damage. For example, rainy areas would suffer less from air pollution compared to less rainy ones.

To support their argument, the authors conducted an empirical study. The pollution indicator used in this study is suspended particulate matter (TSP)³. It was measured using 340 monitors in 70 cities around the world from 1986 to 1999⁴. The authors examine the EKC relationship by including the following variables: governance, vulnerability, population, pollution-intensive sector share and population density. They compare this model with the usual EKC model.

The authors estimate the coefficients of the EKC using different methods. They divide the time series into three periods and compute the average of each variable. They run a regression using quadratic and linear specifications. In all periods the effect of income on air pollution is negative. Using a quadratic form gives a significant result in all three periods and the elasticity with respect to income is 0.04%. They also run a regression using pooled data to estimate the coefficients for the OLS model, the random effect model and the fixed effects model. In the first two models, the value of the income coefficient is the same as before, 0.04 %, and it is highly significant.

The authors also run period and pooled regressions for the extended model. In all the regressions, the results are supportive of the hypothesis that governance and vulnerability are important factors in determining the EKC relationship. These factors influence the

³ TSP is an air pollutant. It causes health problems for humans.

⁴ Some cities have more than one monitor.

pollution rate (TSP) significantly. In contrast, the income effect is insignificant in the majority of the regressions, except when governance, vulnerability, population density and urban population are excluded.

In order to analyze the relative impacts of governance, vulnerability and population on urban air pollution on the TSP level, the authors carried out a simulation. The authors classify each variable into three categories, low value, medium value and high value, and construct an index for each variable. They use the random effects model to determine how the effect of each explanatory variable would change as its value change. They find that geography alone can decrease the level of TSP to a level comparable with the upper bound of the OECD cities level even if a city has low income, bad environmental governance and high population. The authors conclude that combining high governance with high local advantage would reduce the level of TSP in poor cities to levels around the medium level of OECD cities.

2.7 Pollution Effects of Free Trade Areas: Simulations from General Equilibrium models (Peridy, 2006)

The relationship between free trade and the environment has been a controversial issue in recent years. The objective of this paper is to investigate this relationship. The author develops a complex model, which will hopefully provide plausible results. It is assumed that there are three countries and each country, assumed to have an open economy, produces two goods A and B. Good A is produced by using capital factors more than labour, and thus its production could generate higher levels of pollution. Good B needs more labour than capital. In this model, the pollution level Z_A resulting from producing good A is given by the following equation:

$$Z_A = e_A(\theta_A) \varphi_A S,$$

$$\varphi_A = P_{WA}^0 Q_A / (P_{WA}^0 Q_A + P_{WB}^0 Q_B)$$

$$S_A = P_{WA}^0 Q_A + P_{WB}^0 Q_B$$

where “ e_A is the pollution intensity (emissions per unit of A) in this industry” p.40, θ_A is the abatement technology, “the share in total factors allocated to produce a cleaner technology” (p.40), φ_A is “composition effect” (p.40), S is “scale effect” (p.40) and P^0 is “initial world prices.” (p.40). Differences between countries in terms of capital and labor, level of pollution, abatement technology, and marginal disutility of pollution and the effect of terms of trade are all incorporated in this model in addition to world prices.

Instead of solving the model analytically, the author uses simulation techniques. As mentioned before, the author assumes that there are three countries, 1, 2 and 3. Country 1 is capital intensive while country 3 is labor intensive. Country 2 has more capital than country 3 and has more labor than country 1. A consumer in a country with high capital intensity is expected to be more pollution-averse than one that has less capital. Pollution tax levels are assumed to be initially higher in a country that has more capital. Based on these assumptions and the developed model, the author concludes that country 1 is likely to adopt clean technology even though it has a comparative advantage in producing dirty good A. In contrast, country 3 will not adopt the clean technology even though it is specialized in producing clean good B. It should be mentioned here that producing good A or B will yield pollution. However, the production of good A causes more pollution than producing good B.

The author distinguishes between countries based on empirical evidence, and he says: “indeed it is generally recognized that Northern countries [such as country 1] have a

cleaner technology for a given industry, but are specialized in polluting capital-intensive goods, although consumers are more sensitive to pollution. In the northern countries charge higher pollution taxes than southern countries [country 3 is one of them].”(p.45)

The author carries out three simulations. The first one is done under the assumption that each country imposes a tariff on all its imports from all countries. He finds that countries 1 and 3 have high pollution levels compared to country 2. Even though country 1 uses clean technology, it has a high level of pollution. This is due to the fact that it has a comparative advantage in producing the dirty good A. Such an advantage leads the country to produce a greater quantity of good A and a lesser quantity of good B. Therefore, its pollution level is high. Country 3 has a high pollution level due to the fact it does not use clean technology.

In the second simulation, the author assumes that there is a free trade agreement only between country 1 and country 2. The result shows that the pollution level increases in country 1 and decreases in country 2. Since country 1 specializes in producing the dirty good A, it will take advantage of this and produce more of this good and export it to country 2. At the same time, it will import good B from country 2, which means country 2 will produce more of good B. These changes in scales and composition can explain the changes in the level of pollution in countries 1 and 2. Country 3 has a lower level of pollution compared to the previous simulation. This country decreases its production of both goods due to the restrictions on these goods. The level of pollution in the world decreases in this simulation.

The last simulation is carried out under the assumption that no country imposes a tariff at all in the world. Country 3 will produce more of the clean good B since it specializes in it. As a result of that, the pollution level in this country decreases. Country 2 will lose the

comparative advantage of producing good B that it had when a tariff was imposed on country 3's export. Therefore, it will produce more of good A and less of good B. This will increase the pollution level in country 2. For the same reason the level of pollution will increase in country 1. The world pollution level decreases compared to the previous scenario.

In short, the conclusion of this research is that free trade may not only be non-harmful to the environment, but it also helps in decreasing the overall level of pollution.

2.8 Recapitulation

Due to the obvious negative effects of pollution, environmental quality has become a controversial issue in the last decade. There are enormous numbers of studies that tackle this topic. From an economic point of view, environment quality concerns economic agents, both individuals and firms. At the individual level, people could get sick or their health could get worse if they live in a polluted environment. At the firm level, profits may go down due to negative externality that is created by another firm that produces a polluted product. As a matter of fact, the problem of negative externality could arise between two economies or more in some cases, which makes the problem a global issue.

Some researchers such as Farzin and Bond (2003) and Andonova (2003) have investigated what the detriments of environmental quality are. They have used different data sets and different models. One of the famous models that has been used extensively is the environmental Kuznets curve, or EKC model. In this model, it is hypothesized that a poor economy pollutes more as it grows, until a society reaches middle-income status; then, pollution goes down as the economy grows. The intuition behind the EKC hypothesis is that people living in a poor society want to gain more income, and they

ignore the damage to the environment due to the production process. Obviously, such behavior leads to poor environmental quality. As people get rich, they are likely to prefer a clean environment over getting even more income. Thus, they will choose any option that leads to better environmental quality. At that point, the pollution level is going to decline.

One of the important questions that papers covered in my literature review have been trying to answer is what are the detriments of environmental quality? Knowing the answer helps policy makers to choose the best policy to be implemented in order to either improve the environmental quality or to restore the environment. If policy makers know that poverty, for example, in the country is the reason behind worsening environmental quality, they can devote their efforts to solving the environmental problem through solving the poverty problem.

Some of the papers reviewed here argue that the type of political regime in the country has an influence on environmental quality. Given that it is democratic, the political regime can be a tool in the hand of people if they are interested in improving the quality of the environment. Its impact on the environment is likely to vary depending on country income level.

Some researchers are skeptical about the EKC hypothesis. They believe that the studies that supported the hypothesis exclude some explanatory variables from the model. These researchers think that governance and geographic vulnerability are important factors in determining environmental quality, and that once they are included in the EKC model,

the relationship between income level and pollution level will not be as the EKC theory predicts.

When it comes to environmental quality, openness to trade is considered an important issue, as some researchers believe. Openness to trade may lead to a positive effect on the quality of the environment if it encourages competition, which in turn leads to efficiency in production. On the contrary, openness to trade could attract dirty industry to the country, which in turn leads to damaging the environment.

Some studies tackle the issue of the environment from a different angle. These studies, such as Sihooobata Winrich (1983), are trying to take into account that fact that some types of pollution can be dealt with by the victim himself. In some pollution cases, it might be cheaper to let the victim decrease the pollution in his own environment rather than decrease the pollution on huge scale.

In this paper, I use an empirical method to test the EKC model while taking into consideration two important factors. The first factor is "polity," which measures the democracy level in the country. My aim is to test the hypothesis that a democratic country is likely to have higher environmental quality than an autocratic one. Also, I would like to see whether including this factor would lead to support for the EKC hypothesis or not. The second element is openness in trade. I want to investigate whether openness would attract dirty industries to a country with implemented free trade policies. In addition to these variables, polity and openness, I include some other variables that will be explained later on in this paper.

3. EMPIRICAL ANALYSIS

In this section I am going to introduce the model that I am going to use. I will also explain to the justification for including each explanatory variable in the model, and what is the predicted theoretical impact of each variable. In addition, in this section I am going to describe the data that I use and the limitations that these data have.

3.1 The Model

The model that I use is specified in a way that allows us not only to see if there is a relationship between the dependent variable and explanatory variables, but also to see how the relationship evolves over time. I use several types of emissions as indicators of the pollution level, which is the dependent variable. As explanatory variables, I include income, polity, openness and income inequality.

The issue of the causality between income and environmental quality, which is measured as the level of emissions, arises once we talk about EKC model. To avoid the complication of the causality issue, I assume that income has an impact on the environment but the environment does not have any effect on income Farzin and Bond (2003). Farzin and Bond (2003) ,to allow for some flexibility, add higher –order terms in GNP per capita and population density . following their method, I add high-order terms in GDP and population density to my model .

I use the OLS method to run the regression using a pooled time-series cross-section data set for the period 1990-2003. I focus my study on thirty European countries that provide good environmental data for a long period of time for many pollution indicators. The countries included in this study listed in the Appendix 1.

The model is specified as follows,

$$PN_{it} = \beta_1 GDP_{it} + \beta_2 GDP^2_{it} + \beta_3 GDP^3_{it} + \beta_4 PD_{it} + \beta_5 PD^2_{it} + \beta_6 PD^3_{it} + \beta_7 P_{it} + \beta_8 II_{it} + \beta_9 EXP_{it} + \beta_{10} E_{it} + C_{it} + \varepsilon_{it} \quad (1)$$

where PN_{it} represents the pollution indicator for country i in year t , P_{it} is a polity variable that measures that degree of democracy, PD_{it} is population density, II_{it} is income inequality measure, EXP_{it} is exports, C_{it} is a constant term, E_{it} is participation in secondary school education and ε_{it} is an error term

3.1.1 Dependent variable

Environmental quality is measured using the emission levels of pollutants. I consider several pollutants in this study to see how the level of these pollutants would change as a response to changes in the explanatory variables. The first pollution indicator is the emission of CO_2 (carbon dioxide). There are many sources of this element. Generally, when there is fuel burned, there is emission of CO_2 . Humans can develop health problems if they are exposed to high levels of CO_2 . The second pollutant is the emission of NO_x (nitrogen oxides). The main source of NO_x is the industrial sector. It is believed that NO_x exposure could lead to health problems, but this is not yet confirmed. The main problem with NO_x is its reaction with other elements to form acid rain, which causes devastating health and economic problems. The third pollution indicator is the emission of SO_x (sulphur oxides). SO_x is mainly released by consumption of fossil fuel and is considered to be one of the elements that causes acid rain. The last pollutant I consider is PM_{10} (particulate matter). Particulate matter is released as a result of burning fossil fuel

in cars and plants. Inhaling particulate matter can cause serious health problems for human⁵.

3.1.2 Independent variables

There are six independent variables included in the model and all of them are theoretically important. The variables are the following:

GDP: Theoretically, it has been suggested that the relationship between national income and environmental quality has an inverted-U shape. In order to test this hypothesis, we add GDP, GDP² and GDP³ as explanatory variables. The signs of the coefficients of these variables determine whether the hypothesis is supported empirically or not.

Polity (P) : Polity is a measurement of the level of democracy. Improving environmental quality can be done effectively if the government implements the right policies to decrease the pollution level. But it is not always in the decision maker's best interest to implement the right environmental policy. In some countries that lack democracy, influential people may use their power to shape the policies in a way that coincides with their interests even if the policies would lead to a potential environmental disaster. Such a situation would not exist if the majority of people in the country had the power to prevent it.

When it comes to the environment that people live in, each person has his or her own preferences. However, it is more likely that people have what they prefer in a democratic country as opposed to a non-democratic one. One can say that democracy is like a tool that people use to get what they prefer (Farzin and Bond, 2003). Assuming that citizens

⁵ The source of this information is this web-site: <http://en.wikipedia.org/wiki/>

prefer high environmental quality, we can conclude that a higher democracy level may increase the environmental quality.

Income inequality (II): Most studies that have been conducted in order to test the EKC hypothesis included income inequality as an explanatory variable in their model, such as Frozin and Bond (2003) and Boyce (2002). In theory, it is suggested that this explanatory variable has an effect on environmental quality, but the direction of this effect is not obvious. In a highly democratic country, high income inequality might lead to adopting strict environmental policies, if wealthy people are in favour of these policies. Wealthy people are likely to prefer such policies due to the fact that they prefer to live in a healthy environment. Since rich people are more active in the political arena, they are likely to have the power to influence the decision makers.

The right to vote could produce the completely opposite scenario with respect to income inequality. Poor people tend to choose getting more income over less income, even if doing so would result in damaging their environment. Therefore, through their votes, poor people can influence decision makers and make them implement lenient environmental regulations. In short, when it comes to income inequality's effect on environmental quality, we have two possible opposite effects, and the theory cannot predict which effect is going to dominate.

Population density (PD): I add this variable to control for size of the country since I am using GDP level instead of GDP per capita.

Openness to trade: There are several arguments regarding the relationship between environmental quality and trade (Andonova, 2003). Allowing free trade could attract dirty industries to the country, especially if the country does not have strict environmental regulations. Firms might find moving their factories from one country to another profitable if the latter has not yet implemented tough environmental regulations. On the other hand, there are some who argue that there is a considerable benefit for the environment associated with free trade. The argument is that free trade will increase competition between firms. Thus, firms will adopt more efficient technologies, which are likely to be clean technologies. Also, free trade would stimulate investment and make people richer. In turn, they are going to demand a clean environment. In this paper, I use the country's export level (EXP) as a proxy for openness to trade.

Awareness: It has been suggested that awareness is important factor in determining the level pollution. Once people become aware of the risk associated with polluting the environment, they will be against any action that would lead to damaging the environment. My argument is that reaching high school level makes students aware of their environment. I claim that raising awareness of pollution's damaging effects would lead to a decrease in the level of pollution, because people are going to ask their government to implement policies that help in decreasing pollution level. Measuring people's awareness about their environment is rather difficult. To make things easier, I use the percentage of students who are enrolled in secondary education (E) as proxy for awareness.

3.2 Data

I have used different sources to collect the data needed for this study. Eurostat provides cross-section data for all pollution indicators from 1990 to 2003⁶. All pollution indicators are measured in metric tons. I should notify the reader that I exclude Germany when I run a regression for MP10 model. Germany in the data set I am using has very low emission of PM10 and that is not likely to be true since Germany is a big industrial country.⁷

The data on GDP⁸, exports (EXP) and population density (PD) were obtained from The World Bank⁹. The GDP used in this study is the real GDP. The democracy measure is constructed in a way that accounts for the type of regime and the duration of that regime in democracy. The Polity IV database, created by Centre of International Development and Conflict Management at University of Maryland, contains all information needed to construct this indicator. Polity IV has an indicator for democracy level that ranges from 0 to 10. 0 implies that there is no democracy and 10 means the country is very democratic. Also, Polity IV provides information about the number of years that country has been practicing democracy up to each specific year¹⁰. Multiplying the number of years by the value given by the democracy indicator yields the variable P used in this study.

To explain how the index is constructed, here is an example. The democracy index in Polity IV does not distinguish between countries that have long been practising democracy, such as the United Kingdom, and countries whose democratic process has

⁶ Eurostat is a web site that specialized in collecting European statistics:
<http://epp.eurostat.ec.europa.eu>

⁷ I have contacted the source of the data about this problem. They too are sceptical about the low numbers. They are going to investigate this potential problem.

⁸ I use GDP level not GDP per capita. I have tried to use GDP per capita however; the statistical indicators show that the specification of the models was not very good.

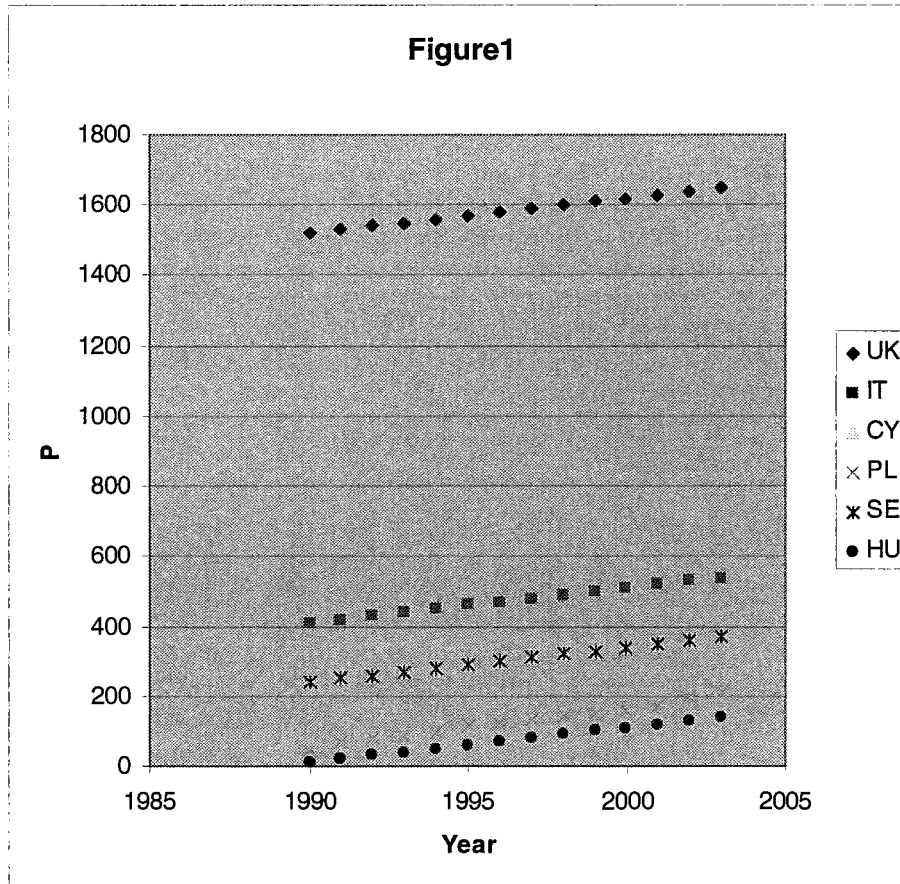
⁹ The World Bank provides exports data as a percentage of GDP. Using this percentage I calculate export level for each country

¹⁰ War periods are excluded.

just started, such as Hungary. For 1990, both countries, the United Kingdom and Hungary, are given the score of 10 out of 10 in the democracy index. I believe that using such an index could lead to a misleading outcome, because the time factor is missing in this index. In 1990, while the democratic process had been working for 153 years in the United Kingdom, democracy in Hungary had just begun. Since changing the country's regime to a democratic one cannot have an instantaneous effect on all aspects of life, we should differentiate between countries that adopted a democratic regime a long time ago and the ones that recently adopted it. To account for the time dimension in my new index, I will multiply the score that is given for the UK in 1990 by the number of years since democracy started, and I get 1530; we will do the same thing for Hungary and I get 10.

Figure 1 shows how my political variable (P) changes over time for several countries. In the figure, I included six countries, which are the United Kingdom (UK), Italy (IT), Cyprus (CY), Poland (PL), Sweden (SE) and Hungary (HU). It is obvious that there is variation in the index that I construct. Countries like the UK are given more weight compared to countries like Hungary. Also, the graph shows also that democracy index increases over time for all chosen countries.

There are several possible measures of income inequality. The one used in this study is called the Gini coefficient, reported by Eurostat. This explanatory variable has a problem in the sense that a complete time series for it is not available. However, since this variable does not change much over time, we can deal with this problem. In order to fix it, I assume that any missing observation between two available observations is equal to the average of those two. All unavailable observations from the beginning of the time series are equal to the first observation that is available.



The United Nations web site is the source from which I collected the information about the awareness variable, E. I use the percentage of students from the total population who are enrolled in the secondary school as a proxy for awareness.

3.3 Data Analysis

The main purpose of this subsection is to look closely at the relationship between GDP and our pollution indicators. Figures A1 to A4 appear to be inconsistent with the EKC hypothesis. It is obvious that the relationship between GDP and the pollution indicators is a positive relationship. The figures show that more income will lead to more pollution, which comes through the production process. Looking at the figures in appendix 2 reveals

notice some interesting results. Generally, the level of pollution is high in countries that have high income such as Germany (GR), United Kingdom (UK), France (FR) and Italy (IT). If one looks at pollution at the country level, one finds that the impact of growth on the pollution level depends on the type of pollutant. Countries such as Germany (GR) release less CO₂, SO_x and NO_x as they grow. In some countries the levels of some types of pollutants go down as the country grows while other types go up. An example of this case is Italy (IT). The level of CO₂ emissions rises as Italy grows. In contrast, the level of SO_x declines as GDP goes up.

At the country level, it is clear that the relationship between GDP and the pollutants differs across countries and from one pollutant to another. Some countries may suffer from one type of pollution more than the other. Consequently, they will make more effort to decrease that type of pollutant throughout implementing strict regulations. At the same time, the level of the same type of pollutant could increase in another country as it grows. This may happen either due to the fact that the country is not suffering from that pollutant or it ignores it.

Table A1 presents a descriptive statistics for the variables used in this study. One can see the standard deviation is greater than the mean for many variables such as SO₂, CO₂, NO_x, PM, and GDP due to the great variation across countries. The number of observations also differs from one variable to another due to the fact that there are some observations that are missing for certain countries. The number of observations for each country that were included in the sample is indicated in Appendix 1.

4. Results

Using the OLS method, I estimated equation (1) for all pollution indicators considered in this study, and the results are reported in table (1)¹¹. Since I am using pooled cross-section time-series data in my study, there is likely to be a heteroskedasticity problem. To correct for this problem, I used White's Heteroskedasticity consistent covariance matrix estimator to control for both contemporaneous correlation between countries and different variances for each country. The result of the regressions is very significant. R squared is high in all models, which means that the explanatory variables considered in this paper explain most of the variation in the pollution indicators. In each model (1-4), all the independent variables have highly significant coefficients except model (4). The coefficient of GDP³ is not significant in model (4).

In the first three models in Table 1, the effect of GDP on pollution level is not as expected. None of the regressions support the EKC hypothesis. The only regression that supports the EKC hypothesis is the PM₁₀ regression, if one considers the estimated coefficient on the cubic term to be zero. In fact, the estimated coefficient on the cubic term in the PM regression is not significantly different from zero. In Figure 2, I plot the relationship between each pollution indicator, measured in metric tons, and the level of GDP, measured in billions of dollars, to show how the level of pollution changes as GDP increases¹². The figure shows that the level of CO₂, SO_x and NO_x emissions increases as GDP increases.

¹¹ All estimation was carried out using Eviews 5.1.

¹² With the exception of GDP, GDP² and GDP³, I set all explanatory variables equal to their sample means. I set the estimated coefficient on the cubic term in the PM regression equal to zero.

Figure 2

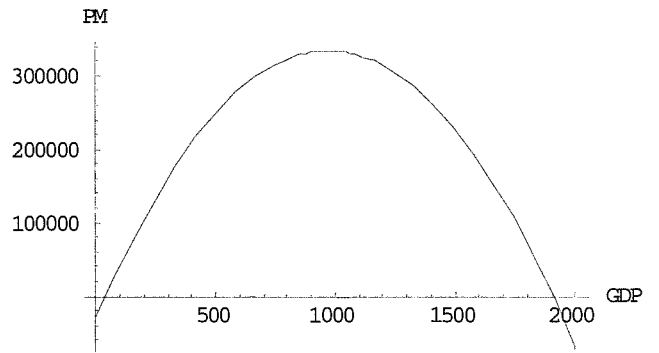
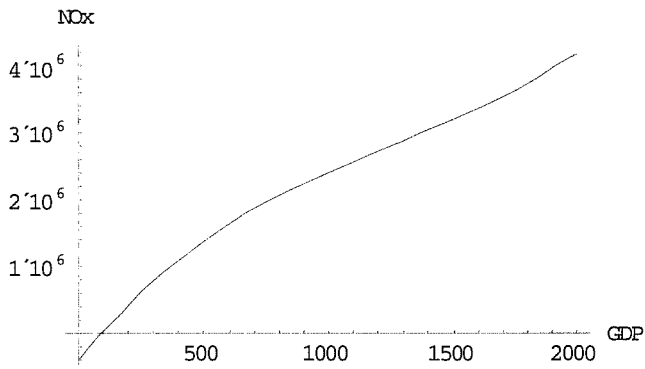
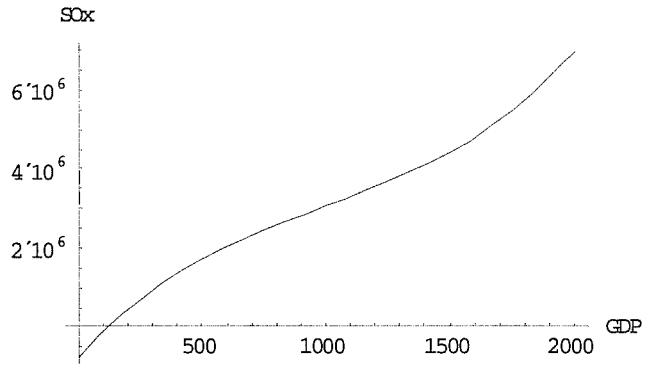
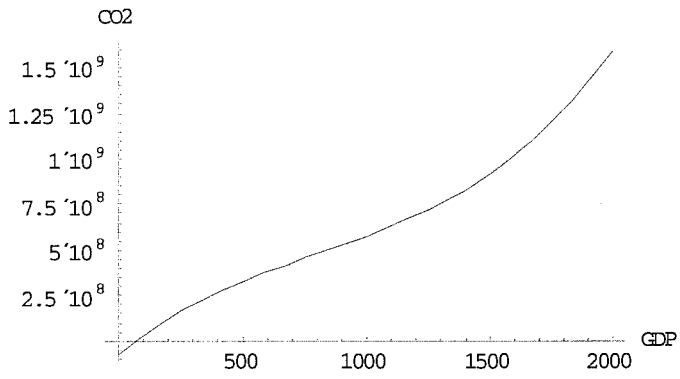


Figure 2 also shows that the level of PM₁₀ emissions increases as long as GDP is less than 972.22 billion dollars. When GDP exceeds this level, the level of PM₁₀ emissions starts decreasing. The turning point is actually quite high, as the average GDP for the sample is equal to 317.67 billions of dollars. This implies that more than half of the countries considered in this study are far away from the point where they start decreasing the level of PM₁₀ emissions, if one considers the level of GDP to be the only factor that affects the level of pollution.

In all models (1-3), the pattern of population density's impact on the pollution level is the same. When the population density increases, pollution increases until it reaches some point, and then the effect of population density is reversed. The last model shows that high population density will increase the level of PM₁₀.

The impact of the polity variable "P" on the pollution indicator is negative in three regressions, the NO_x, CO₂, and SO_x regressions. This means that as the country becomes more democratic, these pollutants will go down. Once people realize the harmful effects of these pollutants, they will use democratic channels, which are a visible option in democratic countries, to decrease the level of these pollutants. Model (4) shows that the level of particulate matter does not respond to the degree of democracy in the direction that theory suggests. The reason behind this result may be due to the source of this type of pollutant. There are natural sources that produce particulate matter such as forest fires. Therefore, the level of PM₁₀ may not respond to type of political regime and regulation as the theory predicts.

The effect of political variable (P) on the level of pollution is not likely to be spontaneous. It needs some time to make some impact. Suppose that the change in the

political index is 100 over a given period of time, let say five years. If this happens, holding all else constant, the level of pollution will go down, especially in the CO₂ case. The level of CO₂ emissions will fall by 7414 tons, which is 0.003% of the fitted value estimated at sample means. The impact of a change in P on SO_x and NO_x emissions will be increase of 30 and 14 tons, respectively. These values, 30 and 14 tons, are equivalent to 0.003% and 0.002% of the fitted value estimated at the sample means for SO_x and NO_x respectively. These calculations show that the magnitude of the effects of P on CO₂, SO_x and NO_x emissions is not very great. In terms of the impact of P variable of the level of PM, the results show relationship between these two variables is only weakly significant.

In terms of income inequality, measured by the GINI coefficient, my findings support the argument that higher income inequality leads to higher pollution levels, at least in the case of SO_x and CO₂. These regressions show that income inequality is associated positively with pollution indicators. The results show that the level of emissions of CO₂ responds to the change in income inequality by more than any other pollutant. An increase in the income inequality measure by 1 point increases the CO₂ emissions by 2556 tons, which is 0.001 % of the fitted value estimated at sample means. The impact of II on the other pollutants considered in this study is not very large.

Table (1)

	<u>Model (1)</u>	<u>Model (2)</u>	<u>Model (3)</u>	<u>Model (4)</u>
	SO_x	CO₂	NO_x	PM₁₀
GDP	6863.034** (166.20)	1118235** (67410)	4588.628** 163.7	743.1497** (65.23)
GDP²	-4.614694** (0.36)	-787.8611** (81.5)	-2.403403** (0.311)	-0.382192** (0.096)
GDP³	0.001560** (0 .00013)	0.322333** (0.02)	0.000628** (0 .00013)	9.48E-05 (5.27-E5)
P	-0.301630** (0.028)	-74.14344** (4.87)	-0.148511** (0.015)	0.012232* (0.0052)
II	30.57969** (1.96)	2556.295** (306.9)	13.50109 (1.11)	1.510895 (0.34)
PD	-359.2708 (527.2)	-208602.0* (59227.2)	-1054.721* (284.7)	1528.502** (77.22)
PD²	32.62714** (6.09)	6053.642** (456.2)	18.61668** (2.55)	-10.01083** (0.61)
PD³	-0.063884** (0.01)	-11.03138** (0.73)	-0.033720** (0.004)	0.014551** (0.00097)
EXP	-114.7517** (9.93)	-11285.22** (575.9)	-50.34896** (4.30)	-5.914637** (1.52)
E	-3229.994** (173.6)	-290302.6** (15311)	-1144.428** (69.6)	-177.9436** (16.86)
C	-595828.4** (61577)	-35709438** (10745706)	-268167.6** (40982)	-79015.81** (120.35)
R²	0.61	0.94	0.93	0.68
F-statistic	43.84	463.08	373.5	54.3
No of Obs	284	284	284	256

** denote significance at 1% level. * denote significance at rate 10% level .

() numbers between parentheses are the standard errors.

The possibility of attracting dirty industry, the pollution haven hypothesis, is not supported in all models. Using exports (EXP) as a proxy for openness to trade, it seems that the emission of CO₂, NO₂, PM₁₀, and SO_x will go down as the country becomes more open to trade. Free trade leads to more competition in the markets. As a result, more efficient equipment will be used in production. In general, efficient equipment produces

less pollution. Also, free trade may incite countries to specialize in producing specific goods. Once they do so it will become easier to control pollution that results from producing these goods (Andonova; 2003). Openness can lead to spreading clean technologies between countries, which can effectively participate in decreasing the level of pollution. Again, the magnitude of the EXP's coefficient is much larger in the CO₂ regression compared to the others. An increase in EXP by 1 billion will decrease the level of CO₂ emissions by 11285.22 tons, which is 0.005 % of the fitted value estimated at sample means.

I used education E as a proxy for awareness. I hypothesize that educated people are aware of the environmental quality and they tend to prefer to live in a clean environment. My findings are very statistically significant. I found that awareness is negatively associated with the level of pollution in all models (1-4), and this supports the hypothesis. In terms of the coefficients' magnitude, E has the largest coefficient after GDP in all models.. A 1% increase in the number of students enrolled in high school could lead to a decrease in CO₂, SO_x , NO_x and PM emissions by 290302.6, 3229.9 , 1144.4 and 177.94 tons, respectively. In percentage terms, the impact of E on the level of CO₂ emissions is the largest, 0.13 % of the fitted value estimated at sample means, whereas the impact of E on the level of SO_x , NO_x and PM emissions are 0.002%, 0.001% and 0.001% of the fitted value estimated at sample means , respectively.

5. Conclusion

Many studies have tried to find the determinants of the environmental quality, using different models. One of the most famous models is the EKC model. The problem with this model is that many studies show that the EKC hypothesis is not valid and the reason

behind this is as yet undetermined. It has been suggested that there could be some missing explanatory variables that cause the problem. In this paper, I try to investigate whether the EKC hypothesis is valid or not by introducing two potential variables that could play an important role in determining environmental quality.

In this empirical paper, I use four different pollution indicators as a proxy for environmental quality. As independent variables, I introduced three important variables that could affect the environmental quality, which are the type of political regime, openness to trade and awareness.

At the end of this paper, I have discovered two main results. The first result is that the conventional relationship between the level of income and the level of pollution, which called the EKC hypothesis, does not necessarily exist. I found that there is no such relationship between three pollutant indicators and GDP , which are CO₂ , SO_x and NO_x . the only pollutant that has inverted-U relationship with GDP is PM. The second result is that there are important factors other than income that have a significant impact on environmental quality.

My findings show that the type of political regime plays a role in determining the level of pollution. I find that a high degree of democracy is associated with high environmental quality. Also, both free trade and higher awareness have positive impact on the environment. These findings help us to understand the problem of pollution.

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Appendix 1

Names of Countries Included in This Study:

- 1- Czech Republic (11 obs)
- 2- Denmark(13 obs)
- 3-Estonia (11 obs)
- 4-Finland(13 obs)
- 5-France(13 obs)
- 6-Germany(13 obs)
- 7-Greece(13 obs)
- 8-Hungary(12 Obs)
- 9-Iceland(0 obs)
- 10-Ireland(13 obs)
- 11-Italy(13 obs)
- 12-Latvia(13 obs)
- 13-Lithuania(0 obs)
- 14-Luxembourg(12 obs)
- 15-Netherlands(12 obs)
- 16-Norway(12 obs)
- 17-Poland(13 obs)
- 18-Portugal(12)
- 19-Romania(0 obs)
- 20-Slovak Republic(11 obs)
- 22-Slovenia(11 obs)
- 22-Spain(13 obs)
- 23-Sweden(13 obs)
- 24-Switzerland(13 obs)
- 25-United Kingdom(13 obs)
- 26-Austria(13)
- 27-Belgium(11 obs)
- 28-Croatia(12 obs)
- 29-Cyprus(13 obs)
- 30-Bulgaria(0 obs)

() numbers between parentheses are the numbers of observations of the variable that has the lowest number of observations compared to the other variables

Appendix 2

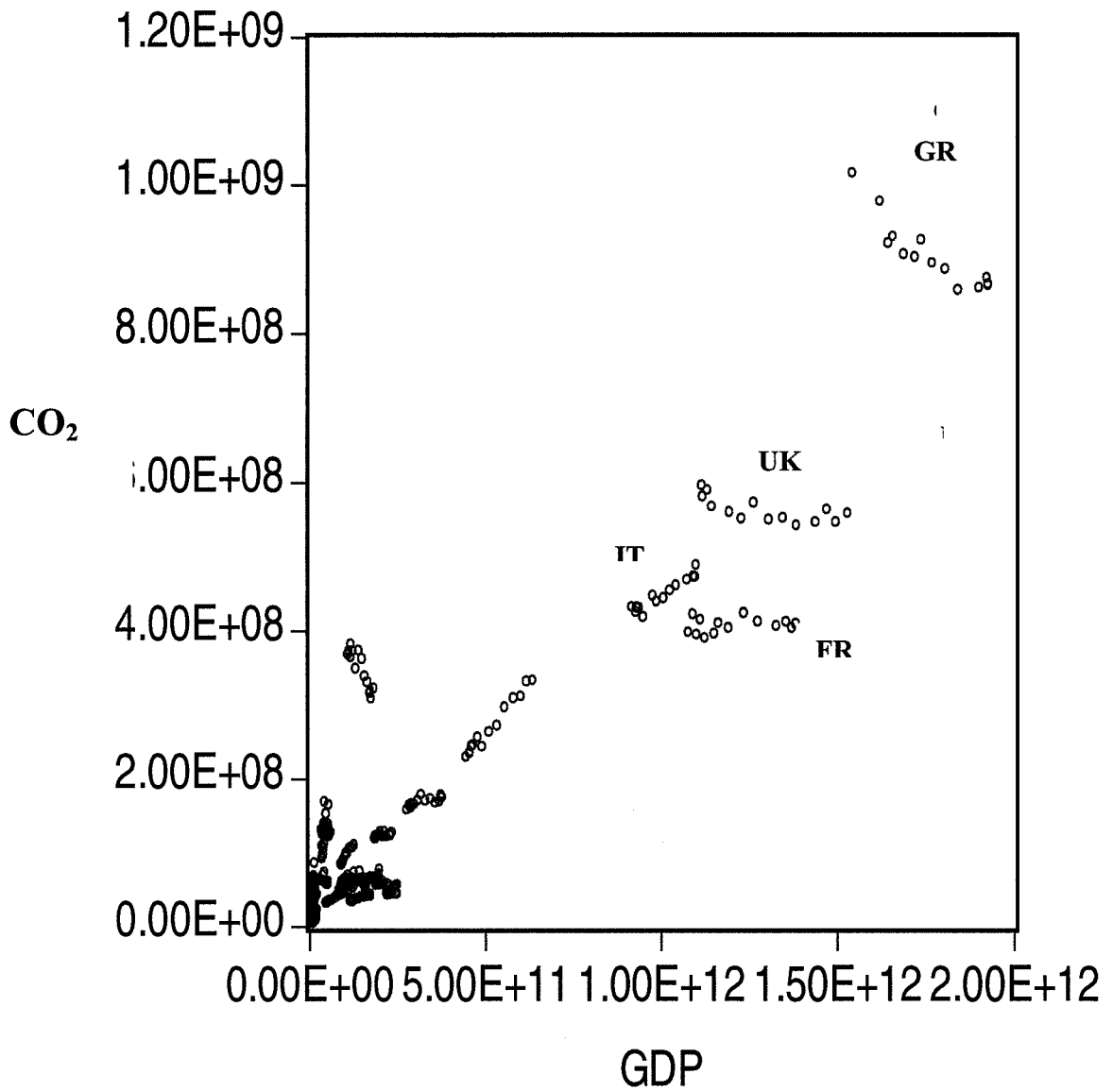


Figure A1

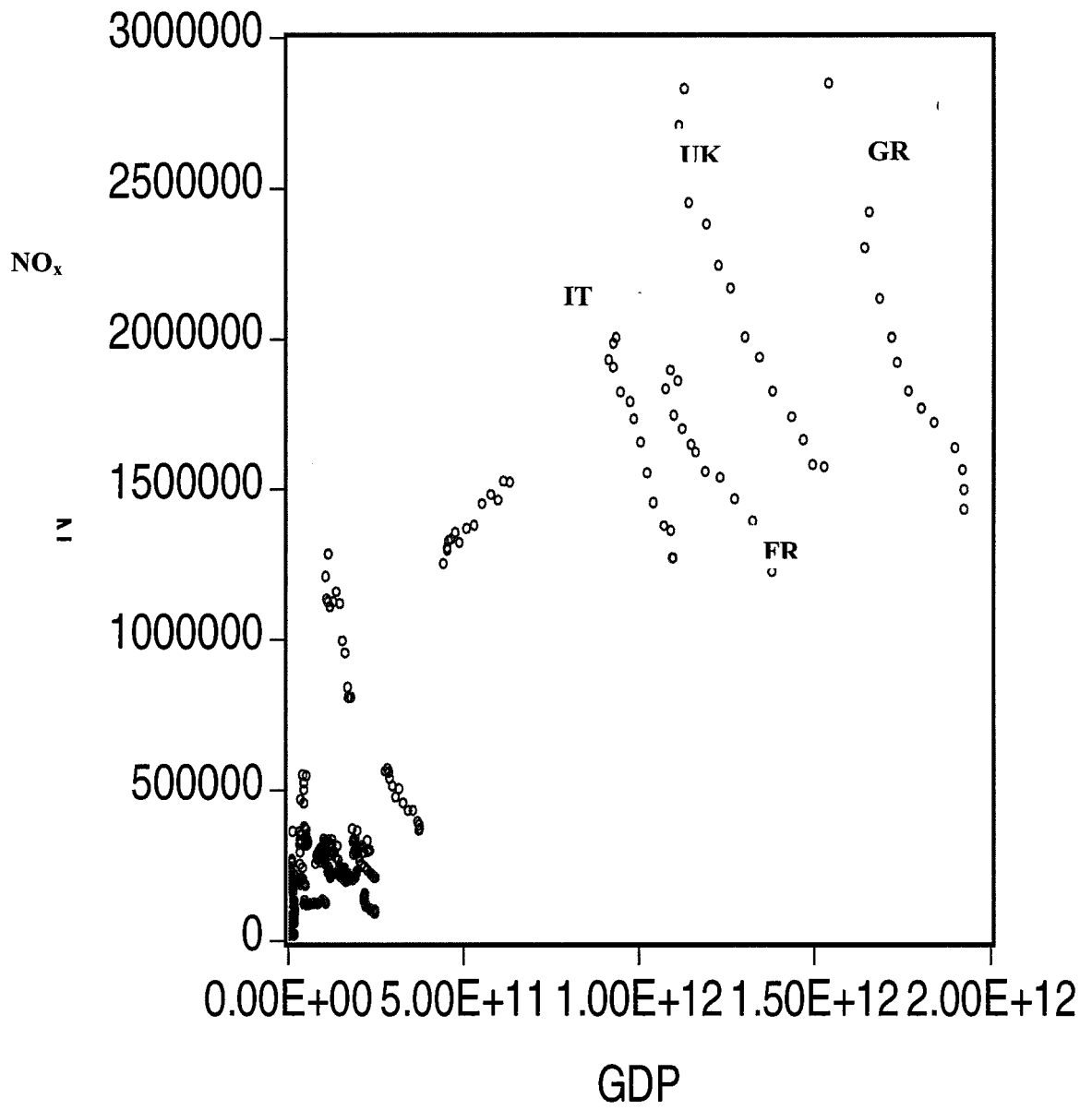


Figure A2

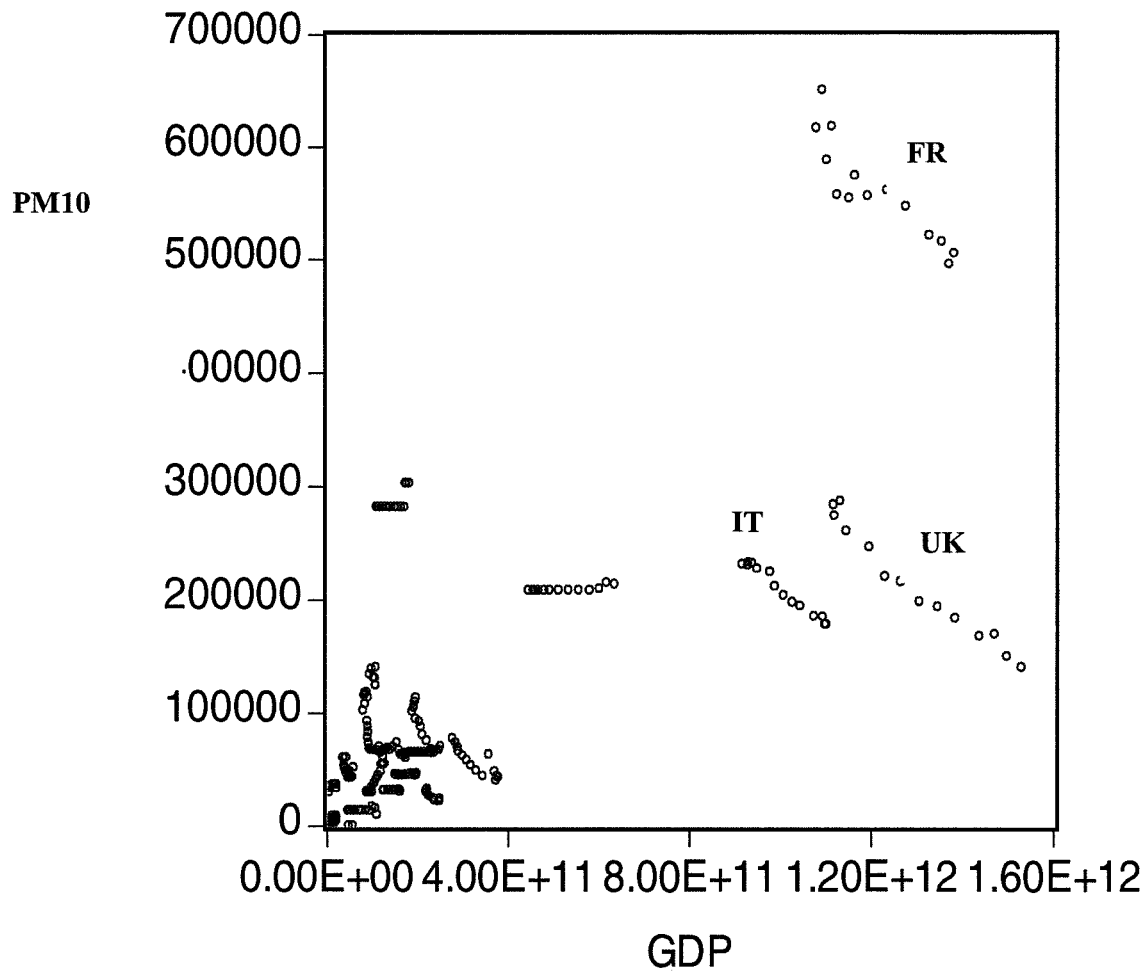


Figure A3

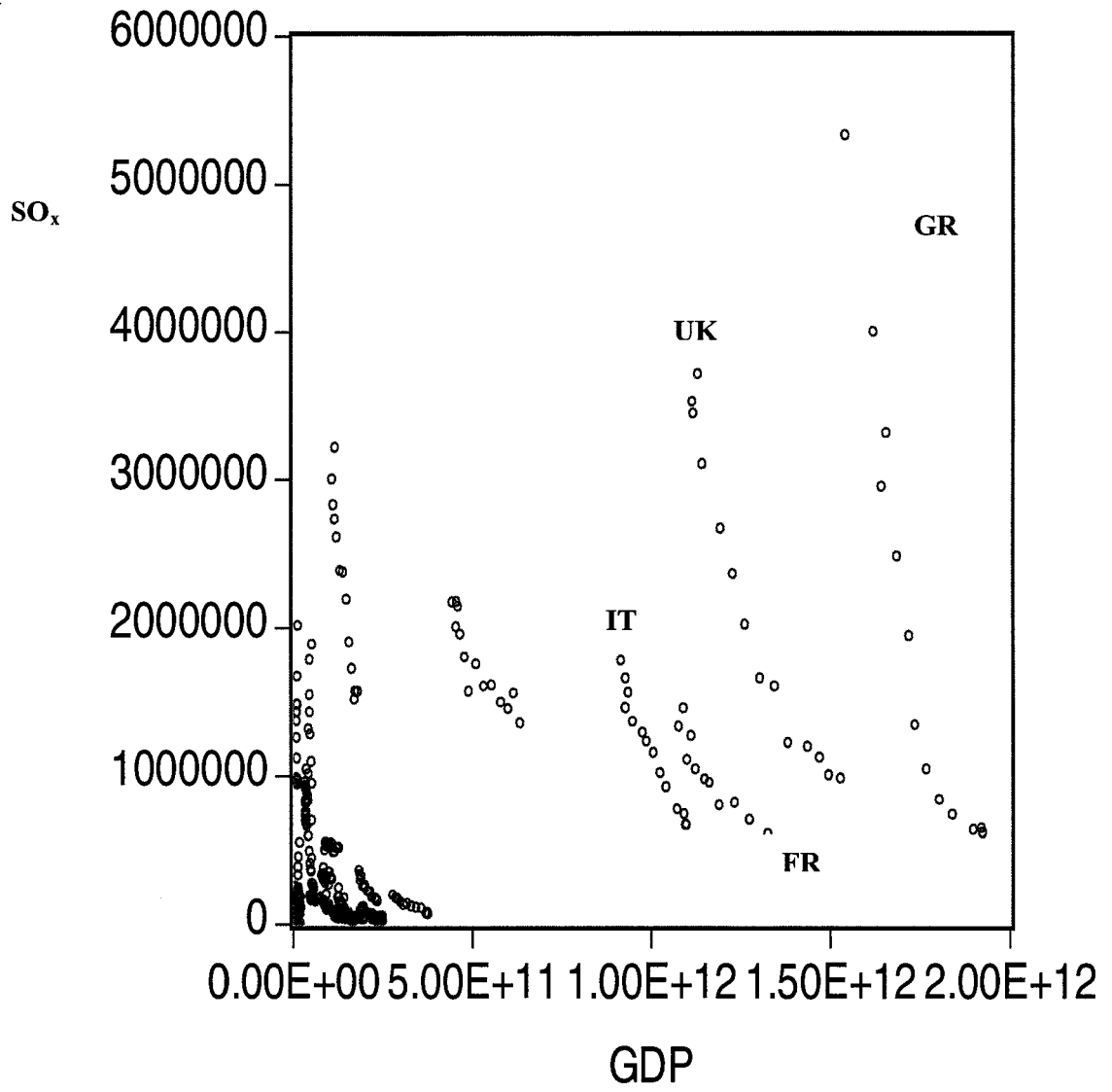


Table A 1
Descriptive Statistics

Variable	units of measurment	No. of Obs. ¹³	Mean	Sd.Dev.
SO _x	metric tons	420	590162.9	762852.4
CO ₂	metric tons	420	1.67E+08	2.15E+08
NO _x	metric tons	420	559203.5	653029
PM ₁₀	metric tons	378	99580.07	128771.2
GDP	billions (constant 2000 US\$)	287	317.67	477.68
P	P*1000	287	529750	427596.5
II	GINI*1000	287	28573.9	4275.391
EXP	billions (constant 2000 US\$)	287	9801.23	13036.60
PD	people per sq.km	287	121.21	96.94066
E	percentage of students	287	23.10	39.72168

¹³ Number of observation differs because some observations for some variables are missing and I am using I balanced data.