UNIVERSITY OF MACEDONIA
ECONOMIC AND SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS

INTERDEPARTMENTAL PROGRAMME OF POSTGRADUATE STUDIES IN ECONOMICS

Thesis title: Corruption and Environmental Policy

Student: Ioanna Karypidou

M18/11

Supervisor: Eftichios Sartzetakis

Associate Professor

JANUARY 2013

THESSALONIKI, GREECE

Acknowledgements

Firstly I would like to thank my supervisor, Professor Eftichios Sartzetakis, for his useful guidance, comments and advice.

Special thanks to my parents and my sister for their support and patience all these years of my studies.

Finally, I would like to thank my six fellow partners not only for their help and cooperation but also our pleasant moments.

Contents

Abstract

The aim of the study is to identify the economic, socio-economic and political parameters that affect environmental indices. Using the fixed and the random effects panel data techniques; we examine which parameters affect environmental policy performance, energy generated from renewable resources and greenhouse gas emissions. The panel encompasses annual data from 24 out of 27 European Union countries, for the period 2000-2007. We find that corruption and shadow economy have negative effect on the environmental indices, while they reinforce each other. However, income has positive effect on indices except from emissions.

1. Introduction

Environmental problems in the developed world rose in the last third of twentieth century, not only as a consequence of economic development, but also due to mismanagement, incompleteness and structural defects in the market system. Nations throughout the world are struggling to limit and manage environmental damages stemming from economic production and consumption. In all countries, public policies have been implemented in an attempt to reduce these impacts. These policies are also reinforced by agreements between nations, which are trying to cooperate and implement a common environmental policy.

Despite the talk that environmental problems have been identified decades ago it is only recently that they have attracted the interest of both the academics and the politicians. Economics approached the issue initially by examining pure economic factors and suggesting market-based policies, while more recently there is an attempt to include socio-economic factors as well. The latter studies entered political parameters, which affect sustainable development of a country, such as corruption and shadow economy.

The present research examines the effect that economic and socio-economic parameters have on environmental indicators, mainly on the emissions of greenhouse gasses. The main goal of the research is to emphasize the effect of socio- economic parameters, such as corruption and shadow economy, on environmental performance. After a thorough review of the literature the present research investigates empirically these effects.

The structure of the research is as follows. Chapter 2 reviews the literature and theoretical analysis of the political and economic parameters. Chapter 3 describes the data, their sources and the meaning of indices. Chapter 4 presents the empirical results, which are briefly analyzed, while chapter 5 concludes the study.

2. Theoretical Backround and Literature Review

2.1 Introduction to Environmental Policies

The focus of the study is to examine the determinants of environmental policy performance. We investigate economic, socio-economic and political parameters, emphasizing in income, corruption and shadow economy. First of all, according to economic theory environmental quality is associated to income and economic growth. Secondly, corruption and shadow economy, which are very significant for the formulation and implementation of policy performance, constitute the most important part of the research. Recent researches stated that corruption and shadow economy affect both growth and environmental policy, having even ordinarily a negative or sometimes positive impact on them. Finally, resource curse is a parameter that affects and is additionally affected by income and corruption.

Environmental problems in the developed world, which became very pressing in the last third of the twentieth century, are embedded in economic structure and they are not only attributed in mismanagement and incompleteness, but they are also caused by structural defects in the market system. The existence of environmental problems requests the development of effective and efficient environmental policies. In order to design efficient policies address the problems, it is necessary to first understand their sources. A wider use of policies that provide economic incentives can significantly increase their effectiveness.

Following the development of a strong environmental movement in the 60s, there was a policy response especially in the developed countries and mainly in the U.S.A. and the EU. Some examples of the most important international treaties and their missions, which include air and water protection and elimination of nuclear weapons, are the following. First of all, the Non- Proliferation Treaty (1968) was adopted to control the spread of nuclear weapons, later in 1996 the Comprehensive Test Ban Treaty proposed to prohibit their testing in all environments. Besides this, the mission of the Ramsar Convention on Wetlands, which was adopted in the Iranian city of Ramsar in 1971, was the conservation and wise use of wetlands and their resources. The Montreal Protocol (1987) tried to limit the production of substances harmful to the stratospheric ozone layer. In the same field the Kyoto protocol, which was signed in December 1997 within the United Nations Framework on Climate Change, set binding limits on emissions of greenhouse gases from industrialized countries.

For decades the European Union (EU) has tried to develop a corpus of environmental policies within the EU but it also played a critical role in creating an international framework for the protection of the environment and the transition to sustainable development. The first effort was introduced in the 1972 United Nations Environmental Conference in Stockholm, between the period of late 1960s and early 1970s, when environmental awareness was firstly developed. Later, in 1973, the Program of Action on the Environment was drawn up and it covered the period between 1973 and 1976. In 1992, the Maastricht Treaty revealed attention for environmental protection, an effort for integrated inter-sectoral environmental policy and new standards based on higher level of protection. The Amsterdam Treaty in 1997 did not introduce any change in the EU environmental policy-making, but it strengthened the commitment for achieving sustainable development and environmental policy integration. Finally, the Treaty of Lisbon (2007) dealt with climate change and greenhouse effect with particular emphasis on energy policy.

The agreements mentioned above represent an effort of all EU members to cooperate and implement a common environmental policy. However, the EU country members vary in income, welfare, culture and regulations. This heterogeneity of EU members causes diversity in the formation and implementation of environmental policy. Despite the existing differences some scientists argue in favor of homogenous policies on the grounds that differences in environmental policy could produce pollution leakage.

After a brief introduction to actual environmental policy, the following chapter reviews the literature on the relationship between environmental indicators and income. The literature on corruption, shadow economy and resource curse will also be reviewed.

2.2 Income and Environmental Policy

According to Aidt's (1998) analysis, economic policy includes environmental policy, and both of them are determined by political and economic self-interest. Two different groups can influence environmental policy: economic agents, and lobby groups. Economic agents include firms, consumers and government. Each firm uses inputs and produces outputs, some of which have an external effect and harm the environment and consumers. Consumers form their preferences taking into account

the utility from consumption, and the disutility from the total level of emissions. Finally, government chooses environmental policy using the instruments of taxes and subsidies on input and output. Lobby groups care about the distribution of income and about efficiency. He also separated them on two different categories. The first one is the lobby groups that are fractionally specialized and they act like advocates for any aspect of environmental policy. The second category is the lobby groups that have multiple goals, and they contain trade unions and employees' associations. They act according to their members' interests, so environmental protection is one of their concerns. Given the assumptions above, the author concluded that internalization of the environmental policy depends on the competitive political process and on the fact that some lobby groups adjust their economic objectives to environmental concerns.

Performance of environmental policy is accepted to encompass the growing concern for the environment across countries, the emphasis on pollution control and natural resources management. Esty D.C. and Porter M.E. (2002) employed three measures of environmental performance: the level of urban particulates, urban SO_2 concentration and energy usage per unit of GDP. These characteristics constitute the index of measuring the performance of environmental policy. It is hypothesized to result from environmental regulatory regime, and the economic and legal context. The regulatory regime is influenced by context's structure and enforcement, standards of air, water, toxic and chemical regulations, the action of environmental institutions and finally the level of information that consumers have. Besides this the context of a country includes the administrative infrastructure of public and private sector, the support in science and research, and the importance of innovations and applying new technologies. According to this report, the three parameters mentioned above also influence economic competitiveness of a country.

Environmental quality is accepted to be a normal good, which means that its demand increases with income. It plays a major role in quality of life, through its direct impact on the health and safety of citizens. According to what has been termed as Environmental Kuznets curve, which shows an inverted-U income-pollution relationship, environmental degradation increases with income and after a turning point further rises in income imply a fall in pollution levels. This critical level of income per capita is estimated to be about $5,000 and $7,000. In poor and developing countries, people care about material well-being, but when they reach a

high level of income they give more attention to environmental quality. Besides these studies - Arrow et al. (1995) - support the view that policies could also affect people's preferences. They mention that institutional reforms could compel private users of environmental resources and polluters to take into account environmental and social costs of their actions. These policies contribute to the inverted- U shape of the relationship, but they cannot guarantee that this relationship holds in all cases.

Some researchers have investigated the relationship between individual preferences and environmental quality, taking into account the Kuznets Environmental Curve. They use models with two key factors: individual preferences, income and technology. On the other hand, Roca (2003) emphasized that these models did not contain distributive conflicts between different social groups in the process of defining environmental policy. He also entered another restriction, differentiating the environmental costs caused by decisions of particular consumers and those which affect the consumers. These parameters affect the displacement of environmental costs. Besides this, the distance of transferred costs and the time horizon are also two important factors. Concluding, all these may affect consumption and formulate strategies of individuals.

Grossman and Krueger (1995) examine the relationship between many environmental indicators, which represent measures of environmental quality, and the level of a country's income per capita. They estimate this relationship with GLS using panel data on ambient pollution levels in many countries. They found that the inverted-U income-pollution relationship represents the most of the environmental indicators. On the other hand one indicator was found to have a monotonically decreasing relationship with income, while the rest of them have a positive one. They also represented an income level where each problem appears to reach its worst proportion. In general richer countries are found to have stringer standards and stricter enforcement of laws, so lower pollution levels than poor and developing countries. Finally they cannot reject the hypothesis that new cleaner technologies can reduce pollution.

2.3 Corruption, Shadow Economy and Environmental Policy

In recent decades economics of corruption has generated a wide range of productive research, both theoretical and empirical. Corruption is often defined as

the misuse of public office for private gain in a manner that contravenes the rules of the game. The focus is not on the vulnerable population, but they concentrate on occasions when ordinary people, business firms and public officials may behave corruptly if the economic reward is high enough. Corruption includes favoritism, tribute, competence and authority, and it can be categorized as political and business, or well- organized and chaotic corruption. The first categorization depends on the source of corruption. In each case, even government officials, or business executives respectively use power or bribes for illegitimate private gain. Under well-organized corruption, there is an absolutely organized system, where business executives know who they have to bribe and how much. In contrast, under chaotic corruption there is no certainty to the dimension of bribe and who will take it (Myint, 2000).

Corruption can convert resources from the public good to private consumption and result in loosing impacts that were proposed to be of wider benefit. It could also be mentioned as the provision of a service by a public servant or politician in exchange for a bribe. This creates negative externalities on others and may affect social welfare. In this occasion inefficient firms can win public tender, if they offer bribes, against the efficient firms.

Aidt (2003) divided corruption in four different categories:

1. Efficient corruption. In this case corruption can be beneficial, by promoting the allocative efficiency. Agents in the private sector are able to overtake government failures.
2. Corruption with a benevolent principal. This category covers cases in which a benevolent principal assigns a non benevolent agent (bureaucracy) with decision making power. The actual level of corruption is determined by how well the institutions governing the bureaucracy are designed.
3. Corruption with a non benevolent principal. This type of corruption means that non benevolent government officials introduce inefficient policies with the purpose of extracting rents from private sector. In this occasion both bureaucrats and politicians are corruptible, so there is no benevolent principal that can introduce optimal institutions and policies.
4. Self-reinforcing corruption. In contrast to the previous three cases, here the reward depends on the incident of corruption, namely how many individuals in the same organization or society are expected to be corrupt.

A feature of corruption is that it differs among different countries, as Bardhan (1997) mentioned. Firstly, this happens because of different regulatory states of each country, which involve the system of permits and licenses. Secondly, different degrees of insertion of the regulatory state in the economy plays an important role in differentiation of the incidents of corruption. Thirdly, norms in different nations are sometimes more favorable to corruption and in other cases they are more combative. Finally, different norms are responsible for the fact that something corrupt in one country could be routine of transaction in another.

The theory of causes of corruption is based on two different approaches: the standard economic and the social economic approach. According to the first approach, which emphasizes on incentives and punishment of corrupt acts, there are the following three necessary conditions for the corruption: bureaucrats have discretionary power, this power is associated with economic rents, and the deterrence of corruption is low. The first two fundamentals determine the benefit of corruption and the third one the cost. The social economic approach considers historical, cultural and demographic parameters, which will be mentioned below.

Adding more parameters, first of all we should mention the size of the public sector. Theoretically economists argue that corruption can be controlled by minimizing the public sector, but empirical analysis finds little correlation between the two variables. Privatization reduces public corruption and increases efficiency, but its impact on corruption is not always clear, because corruption might be shifted from the public to the private sector. Given this, we should also focus on the regulatory quality of each country. Bad regulations and ill-designed policies create corruption incentives for policy makers, bureaucrats, the public sector in general and the private sector too. On the other hand, when strong private interests capture public funds, which could be used to promote social welfare, then corruption causes bad regulations. Besides these, competition increases openness to international trade and investment and decreases corruption, because public servants and politicians have less to sell in exchange of bribes so their motivations to seek payoffs are reduced. Democracy also limits corruption through increased competition for offices but not immediately. In this occasion forms of democracy and voting systems plays important role. For example, competition between politicians usually reduces corruption. In addition to these, decentralization is a means of reducing corruption through the fact that strong local government brings government closer to people.

Finally, stating the parameter of culture, it is shown that countries with high levels of generalized trust, a large share of Protestants and little acceptance of hierarchy are less affected by corruption. Other cultural variables are related to traditionalism. In this case in countries where traditional values dominate, societies tend to be more corrupt. (Rose- Ackerman 2006)

According to Treisman (2000), causes of corruption are associated with historical and cultural traditions, economic development, political institutions and government policies. He analyzed several corruption indices and the relationship of their determinants. First of all, exploring the cultural traditions, Treisman (2000) found that countries with Protestant traditions tend towards higher quality of government and lower levels of corruption. Economic development has also the same effect, as it spreads education and rationalizes the private and public roles. Besides these, countries with British rule are observed to be less corrupt, as British colonies have common law legal system. He also includes another parameter: the practices and expectations about how the law is administered. According to this research, federal states were found to be more corrupt than unitary countries. As well as these, the level of democracy is not observed to affect corruption, but the period of exposure to democracy and to openness to trade is. Finally, many of the causes of corruption are shown to be also consequences, which make it hard for the researchers to separate the underlying determinants.

In the literature reviewed above some of the factors of persistence of corruption are also represented. Punishment of corruption declines as more officials become corrupt, because it is less likely to be discovered by a corrupt rather than non corrupt superior. Bribers' demand for corrupt services is negatively related with bribe size and positive related with the number of corrupt officials. Besides this, profitability of corruption depends on its frequency and its actual incidents. Finally reputation of previous generations –when a younger generation acts like their elders- plays an important role in increase and lasting effects of corruption.

It is commonly accepted that regulations and bureaucratic allocation of scarce public resources promote higher level of corruption. Recommended anticorruption policies suggest that legalizing the activity which was prohibited or controlled, eliminates the level of corruption. Besides this, authorities can reduce bureaucratic corruption by reducing monopoly power of the bureaucrats and giving them

competing jurisdictions. On the other hand, this anticorruption policy might cause laziness in some officials or prevent theft. (Bardhan 1997)

Other demographic and social parameters that affect corruption are: education attainment, media access, and historical influence. There is also negative correlation between corruption and female representation in politics. Finally, wage in public sector also affects it negatively.

The following table summariezes the previous analysis. It presents briefly the different categories, causes and impacts of corruption.

Categories of corruption	
According to source:	Business corruption
	Political corruption
According to level of organization:	Organized corruption
	Chaotic corruption
According to Aidt (2003):	Efficient corruption
	Corruption with a benevolent principal
	Corruption with a non benevolent principal
	Self- reinforcing corruption
Causes of corruption	
Standard economic approach	
Fundamentals	Discretionary power of bureaucrats
	Economic rents
	Low deterrence of corruption
Economic parameters	Economic development
	Degree of competition through openness to trade and investment
	Size of public sector and privatization
Policy parameters	Quality of regulations and policies
	Democracy level
	Period of exposure to democracy and to openness to trade
	Amount of decentralization
Institutional parameters	Law legal system
	Punishment of corruption
	Profitability of corruption
Social economic approach	
Cultural parameters	Level of generalized trust
	Share of Protestants
	Acceptance of hierarchy
	Reputation of previous generations
Demographic and social parameters	Education attainment
	Media access
	Historical influence
	Female representation in politics
	Wage in public sector

Table 1: Categories and causes of corruption

The most important impact of corruption is that it affects economic development and social welfare. There are two different opinions. The first one supports that it could improve efficiency, implying enhancement of economic growth by promoting private business especially in developing countries. According to this point of view government intervention may sometimes cause market distortions.

Although sometimes it is regarded as ameliorating these problems by helping to open up new contractual possibilities and to reestablish market efficiency, most evidence shows that corruption decreases economic development. This is because corruption may reduce the incentive of private investment, distort public investment decisions and induce talented people into rent-seeking activities. It can also be added that it has a negative impact on the quality of goods and services.

Studying corruption in relation to environmental policy is very important, particularly in developing countries where the level of corruption is very high, and they suffer from much environmental damage. It is well known that government institutions are usually weaker, less effective and more corrupt in developing than in developed countries. Especially government's rent-seeking behavior is more often observed in developing than in industrialized countries, and including lobbying they are important sources of environmental degradation. Besides this, environmental issues are a part of problems, which includes self-interested bureaucrats. Finally, analyzing the relationship between environmental policies and corruption, and understanding the factors of corruption associated with environmental regulations, are of practical importance, as Damania (2002) mentioned. He analyzes the relationship between corruption and environmental regulations. He focuses on corruption in bureaucratic mechanism, which is mentioned to influence more the developing countries. Besides this, he tried to understand the determinants of corruption, to find the suitable types of environmental policy and the optimal limits of them. The efficiency of judiciary affects the design and implementation of optimal policy. An increase in prosecution rate is a means to reinforce efficient judiciary, which is difficult to achieve since many of corrupt bodies are involved in institutional reforms. The author suggests that there is a need for multifaceted policies which tackle both problems of corruption and pollution simultaneously.

Corruption is also related to economic growth. Some researches recommend that corruption might be desirable, because it could be used as an incentive to smooth operations, by avoiding inefficient regulations. This could imply that efficiency of the economy will rise. On the other hand, others support the view that corruption tends to hurt innovative activities, and as a result it will reduce private investment. Besides this, corruption creates inequality in opportunities, which is similar to wealth and income inequality. In this field, Mo (2001) studied the role of corruption in economic growth. He used panel data of the following parameters,

applying OLS estimation: growth rate, level of corruption, GDP per capita, index of political rights, political instability, rate of private investment, schooling years and rate of population growth. Corruption is proved to have negative effects both in investment and in growth rate. Specifically, a 1% increase in the level of corruption implies a decrease in growth rate of about 0.72%. Political instability is also negatively related to the rate of growth. The rest of parameters could be described as institutional characteristics of corruption.

Another efficiency argument, which is mentioned by Bardhan (1997), in favor of corruption, is that it can reduce delay in removing files in administrative offices and in slow moving queues for public services. Other opinions state that this incident, called speedy money, can actually cause administrative delays in order to attract more bribes. Besides this, bribes between officials or politicians and firms can cause discrepancy between the bribers and the bribees, the size of the bribe, or there might be a slip between the bribing transaction and the actual delivery of the good or the services involved.

Some papers attempt to study the interconnections among environmental policy, pollution, corruption and growth, and they also introduce other parameters. López and Mitra (2000) examined the implications of corrupt and rent-seeking behavior, between pollution and growth. They used both the cooperative and non cooperative assumption between government and the private sector in order to analyze the consequences of government corruption. They found that in developing countries, where the levels of corruption and pollution are higher than the industrialized countries, the growth process implies a reduction in corruption but an increase in pollution levels. Besides this, it is observed that in these countries pollution arises until a higher level of income turning point than in developed ones. Finally, corruption is not found to preclude the existence of Kuznets environmental curve, under in both of the examined assumptions.

Pellegrini and Gerlagh (2006) investigated stringency of environmental policies using cross-section of new and old members of EU and candidate countries. They represented an OLS estimation using Environmental Regulatory Regime Index (ERRI) as an independed variable, in order to identify its determinants among income, level of corruption, schooling, urbanization and a dummy for being or not an old member of EU. The main purpose of the research is to examine the importance of corruption's influence on income and to estimate the impact of corruption in

different EU countries. They observed that although new members were affected by corruption to a higher degree, some of them did better than the old ones, like Greece and Italy. Diversity caused by heterogeneous preferences of residents and institutional failure are shown to be the most important factors for the diversity of environmental policies. Finally, they concluded that improving a country's institutional quality would be beneficial for both environmental quality and economic growth.

The same authors -Pellegrini and Gerlagh (2006) – in another research explored the relative importance of incomes democracy and corruption on the stringency of environmental policy. They used OLS estimation on cross-section of 54 countries, in order to investigate if income per capita, corruption and democracy indexes determine Environmental Protection Stringency Index. They showed statistically significant and considerable coefficients of corruption and democracy, when they are regarded individually; a negative and a positive coefficient respectively. However, high correlation between them was observed, which means that democracy could be a determinant of corruption, so part of its effect on environmental stringency is due to democracy. Finally, they rejected the assumption that a positive effect of democracy index, rely on the correction between high level of democracy and low level of corruption.

There is general acceptance in the literature that the political competition can reduce corruption, but there is little formal modeling to support this view. Wilson and Damania (2005) examined the interactions among corruption, political competition, environmental policy and environmental outcomes. They presented a model in which polluting firms, politicians and/or bureaucrats interact with the aim of examining if political competition could be responsible for environmental damage, petty and grand corruption. They define grand corruption as the attempt to bribe politicians in order to influence the setting of policy, while petty corruption reflects the payments in order to avoid consequences of the existing policy. They found that, in general, higher political competition implies more stringent environmental policy, so lower environmental damage and elimination of corruption. On the other hand, they conclude that when political competition is at a maximum, grand corruption may not be reduced. Besides this, petty corruption seems to increase in cases of weak judicial institutions. Finally, they express the view that even in the examined example, which is simplified, the relationships between the variables are complex.

Political instability and corruption lead to sub-optimal governmental policies, which imply large undesirable effects on social welfare. Fredriksson and Svensson (2003) investigated the relationship among environmental policy formation, corruption and political stability. They used OLS and 2SLS estimations, in order to identify the relationship between indices of pollution taxes, stringency of environmental policy, level of corruption and degree of political instability. They inserted an additional parameter, an interaction term between corruption and political stability. Thereby, in contrast to previous researches which investigated separate effects of the two main variables, they included the joint impact of them. They mentioned that interaction between them is important. Specifically, they found a negative relationship between democracy, corruption and environmental policy, but the interaction term had a positive coefficient.

A subsequent analysis made by Fredriksson and Vollebergh (2009) analyzed the effects of government corruption and federalism on the energy policy stringency. They accepted the hypothesis that in federal systems local governments choose final policy, so the national lobby groups want to influence political units. They used panel data of 11 sectors in 12 OECD countries for the years 1982-1996, applying GLS estimation, with the aim of discussing the impact of corruption, federalism and other determinants on energy stringency. Empirical analysis shown that, higher levels of corruption raised the use of energy, while the effect is reduced or sometimes neutralized in federal systems. This means that government corruption leads to weaker energy policy. Besides these, capital owners and workers lobbies, relative prices of factors and relative prices of oil and electricity were demonstrated to be significant.

In the same field, Stephen Morse (2006) explored the relationship among performance of environmental policy, corruption and income. He divided the Environmental Sustainability index (ESI) into indicators, which represent pressure, state, impact and response and each indicator includes some variables. So, he tried to identify the correlation among those variables, the Corruption Perception Index (CPI) and Income per Capita in 64 countries. Many of the variables appeared to be correlated, but this does not mean that they have the same effect on environmental sustainability. Besides this, the results showed that indicators about pressure, state and impact are not correlated with residual CPI. Generally, ESI was derived to have a positive relationship with income, while CPI was found to worsen with increasing

income. Finally, corruption was proven to decrease any positive contribution from the indicators of ESI towards environmental sustainability.

Fredriksson, List and Millimet (2003) examined the influence of corruption on capital flows through two different channels: its impact on environmental policy stringency and theft public funds earmarked of public spending. They used panel data of four different industrial sectors in the US -aggregate manufacturing, chemicals, metals and food and kindred products- over the period 1977-1987. Authors entered two innovations: environmental policy stringency is assumed endogenous and governmental corruption is taken into account. According to the empirical examination, there is no direct impact of corruption on capital inflows. However, corruption affects supply of public goods and stringency regulations, which influence capital flows and stocks.

In the following table the most important impacts of corruption are briefly represented.

Impacts of corruption	
Impact on:	**Sign of the impact:**
Economic development	Promotes development through improvement of efficiency
	Reduces development through investment, openness to trade and political instability
Social welfare	It depends on the impact on development
Quality of goods	Negative impact
Environmental policy	Higher levels of corruption imply weaker environmental policy
Democracy	Negative relationship
Energy policy	Higher levels of corruption raise use of energy, implying weaker energy policy
Capital flows	Negative effect through supply of public and stringency regulations

Table 2: Impacts of corruption

Over the last years a growing concern over the phenomenon of the shadow economy has captured the attention of economists. It is especially observed in developing countries or economies in transition, where legal and political institutions are weak or insufficient. Shadow or unofficial economy includes all currently unrestricted economic activities, whether legal or illegal, that are not calculated in Gross National Product. It depends on the frequency of unofficial activities, whose magnitude is fundamental for making effective and efficient decisions. It is very difficult to get accurate information and count shadow economy activities both in

goods and services market and in labor market. Schneider, Buehn and Claudio (2010) estimated the extent of shadow economy in 162 countries from 1999 to 2007. They extended the definition of shadow economy by including that legal activities are deliberately concealed in order to avoid payment of income, value or other taxes; payment of social security contributions; compliance with certain legal labor market standards; and compliance with certain administrative procedures.

Given the previous definition, we conclude to some important determinants of shadow economy. Taxes and social contribution burdens have a positive effect in shadow economy. The bigger is the difference between total cost of producing in official and unofficial economy, the higher is the rate of shadow economy. Besides this, intensity of regulations in labor market, trade barriers and labor restrictions for foreigners is a substantial parameter. Stronger regulations lead to increased labor costs in the official economy, so they reinforce unofficial activities. Furthermore, in a booming official economy people have a lot of opportunities to earn income, in contrast to a decreasing economy, where they try to balance their losses of income from official economy by participating in unofficial activities. Finally, high rate of shadow economy lead to reduced revenues, which in turn reduces quantity and quality of public goods and services. The consequences of this reduction could be higher taxes and then stronger incentives to participate in the shadow economy.

Consequences of the existence of shadow economy include the misallocation of resources and loss of revenues, but the most important is the impact on the official institutions, norms and rules. If shadow economy is reduced, it may lead to an increase in tax revenues, which implies greater quality and quantity of public goods and services, so it reinforces economic growth through public-infrastructure. On the other hand unofficial economy may sometimes lead to more competition and higher efficiency, implying stronger institutions and increased financial resources. This is due to the fact that most of the earnings of the unofficial sector are spent in the official sector. Finally, recent studies investigate the relationship between shadow economy and corruption. Most of the studies conclude to the fact that there is a highly significant relationship between the two variables. It is remarkable that countries with high rates of corruption tend to have larger unofficial sector.

Biswas, Farzanegan and Thum (2012) studied the effects of a shadow economy and corruption on environmental damage. They used panel data for the period 1999-2005 for more than 100 countries and OLS method in order to test the

statistical significance of these variables on the depended variable of emissions. They also employed other variables such as energy efficiency, trade openness urbanization, population density, polity, school enrollment, GDP per capita and outputs of all sectors. They found that the coefficient of shadow economy on emissions is positive and statistical significant. Besides this, corruption seems to amplify the effect of shadow economy. They finally concluded that shadow economy can be reduced by decreasing the level of corruption, so policy makers should firstly control both of these factors and then increase environmental standards and regulations.

Choi and Thum (2005) developed a framework analyzing the links between corruption and unofficial economy and their implications on official economy. They take into account heterogeneity in entrepreneurs' ability to generate income, which depends on the differences in the firm's capital stock. Besides this, they assumed that briberies are observed both in entering the official sector, and in exchange for keeping silent. They concluded that enlarged unofficial sector may reduce the ability of corrupt entrepreneurs, so it may enhance economic activities in official sector. According to this conclusion, official and unofficial sectors are complementary. Therefore, better controls in entrepreneurs lead corrupt officials to charge higher bribery payments, so more firms are driven to operate in the shadow economy. On the other hand, if the two sectors compete for resources and shadow economy is harmful for economic growth. Finally, they supported that attempting to eradicate the shadow economy without dealing with corruption is inefficient.

The following table summarizes the determinants and impacts of shadow economy as they were mentioned above.

Determinants of shadow economy	
Positive relation:	Taxes and social contribution burdens
	Intensity of regulation
Negative relation:	Total revenues
Impacts of shadow economy	
Negative impacts:	Allocation of resources
	Loss of governmental revenues
	Negative impact on official institutions, norms and rules
	Negative impact on economic growth
	Positive effect on level of emissions
	Positive effect on level of corruption
Positive impacts:	Reduces the ability of corrupt entrepreneurs, so enhances official activities
	Implies more competition
	Leads to higher efficiency

Table 3: Determinants and impacts of shadow economy

2.4 Resource curse in relation to income and corruption

Resource curse is the paradox that countries with an abundance of natural resources tend to experince less economic growth and worse development outcomes than countries with fewer natural resources. Specifically, valuable natural resources create economic stagnation rather than economic growth in developing countries. They could be an important source of revenue for developing countries, in order to promote and sustain economic growth and development. However, developing countries tend to fail in exploiting their resources and sometimes they are also harmed. As Lewis (2007) mentioned, these countries often score low on development, they have large rate of population in poverty and higher levels of corruption. Shaxson (2007) added that they also have worse rates of infant and under-five mortality. The consequences of this phenomenon include not only declining economic growth but also social disorders like violence, greater inequality, less democracy and more corruption. The poorer and weaker countries are harmed more by the exploitation of the natural resources. According to the literature the explanations of this paradox could be divided into economic and political-economic, which highlight the role of policy and institutional failure.

Economic factors include the fluctuations of resource prices -especially of oil, gas and minerals- sometimes compared to the cost of imported manufactured goods, the poor employment generation and technological diffusion in the natural resource

sector, and finally economic disorder and resource revenues that causes exchange rate to rise, which is called 'Dutch disease'. These issues lead to reduced competitiveness of other economic sectors and harm economic growth.

Natural resources could be a potential source of income, which would be used for construction of roads, educational and health programs and generally in infrastructure in order to achieve sustainable development. But resource-rich countries with weak institutions could not reach this objective. These countries suffer from lack of judicial institutions, which imply tolerance of illegal behavior and non punishment of defaulters. Besides this the low bureaucratic quality leads to high levels of corruption, while economies which are characterized as tax havens lead to high levels of shadow economy. One way to measure policy performance is whether or not it promotes or counters corruption. Another way is to look into the allocation of money, which also influences the level of democracy.

Resource curse is believed to have direct and indirect effects on economic growth. Papyrakis and Gerlagh (2004) examined these effects, using transmission channels. They investigated the direct effects of natural resources on explanatory variables such as corruption, investment, terms of trade, openness, schooling and then, indirect effects on economic growth. First of all, they investigated the short-run and then long-run, direct impact of all the parameters on growth. Finally, they estimated the impact of natural resources on corruption, investment, openness, terms of trade and schooling, in order to find their indirect effect on growth. They concluded that when the transmission channels are included, the effect of natural resources on economic growth is negative and strong. This implies that a resource-rich country which suffers from corruption, low investment, protectionist measures in openness, deteriorating terms of trade and low educational level will probably not benefit from resource abundance.

Recent literature focuses on the political- economic explanation of resource curse, relying on the causes and consequences of corruption and on political conditions. Lewis (2007), examining global corruption in the context of natural resource curse, concludes that lack of institutions and transparent transactions between governments and enterprises, which are usually observed in developing countries, amplify the level of corruption. According to this study, on the one hand transnational extractive industries undermine principles of good governance, by promoting bribery and not reporting revenue payments made in host countries. On

the other hand, weak judicial institutions, that allow illegal behavior and do not punish defaulters, favor the unrestrained actions of transnational industries.

Shaxson (2007) emphasized the importance of governance for the existence of high levels of corruption, and thus of resource curse especially in oil and mineral-rich countries. Poor governance helps companies shift blame away from themselves towards politicians. So it depends on whether or not one policy is likely to promote or counter systemic corruption. Two different views of corruption are added. The first is a view that corruption does not only depend on the particular actors and their behavior but there is also a systemic perspective. The second is a view of corruption as a global and not only a domestic problem. The researcher also added trust as a parameter that affects corruption. He supported that in a society where too many cheat, and take or pay bribes, thus they are corrupted, there is a little incentive not to join in. Besides these, polarization and social fragmentation are affected by conflicts over mineral money. But more divided societies perform less than more homogeneous ones. Furthermore, common culture and a strong middle class create a consensus for growth. Finally they conclude that corruption makes it difficult for large tides of money from natural resources to be absorbed, so all these factors have a negative impact on poverty and growth.

In the same research field, Bhatacharyya and Hodler (2010) investigated the relationship between natural resources and corruption. The theoretical part of the research contains a game between politicians –bad and good- and the people. They conclude that resource abundance increases corruption, which affects negatively economic growth. This happens only when the quality of democratic institutions is below a certain threshold level. On the other hand, countries with strong democratic institutions are neutrally or sometimes positively affected by resource rents. Investigating the existence of these results they used an empirical research, using a reduced form model and panel data which covers 124 countries for the period 1980-2004. The estimated models confirmed that the relationship between the resource rents and corruption depends on the quality of democratic institution, and indicated that the lowest level of democracy score should be 8.6 out of the maximum 10.

Extending the research, Dietz and Neumayer (2007) introduced another perspective by combining resource curse with corruption, through genuine saving, in order to examine whether political institutions can lead resource-rich countries to development, when investing in more sustainable forms of capital. Genuine saving,

which is a measure of net investment in produced, natural and human investment, should not be persistently negative. It is a measure of weal sustainable development. However, resource-rich countries sometimes fail to achieve positive net investment rates. This amounts to an unsustainable consumption of recourse rents. The authors estimated the impact of three institutional indicators –corruption, bureaucratic quality and institutional quality – on gross and genuine saving. They also tested whether some aspects of these indicators are more significant. They used a panel of data of 115 countries and 18 years. They found only a little correlation between lack of corruption and the other two institutional indicators. They conclude that resource-rich countries with good quality institutions have achieved higher levels of savings. They found a statistically significant interaction term between lack of corruption and resource exports, which reveals that corruption is a major factor of this phenomenon. Analytically, corruption may discourage or misdirect investment, which implies a decrease in genuine savings. Finally, they found only a little evidence of the rule of law on the depended variable.

The following table represents a summary of the impacts and explanations of the resource curse paradox, which were investigated above.

Impacts of resource curse paradox	
Economic impacts:	Strong negative indirect effect on economic development
Socio- Economic impacts:	Large rate of population in poverty
	High rates of infant and under-five mortality
	High rates of corruption
Social disorders:	Violence
	Great inequality
	Low democracy level
Explanations of the paradox	
Economic explanation:	Fluctuations of resource prices in comparison to prevalent state institutions
	Dutch disease
Political- Economic explanation:	Policy performance
	Poor governance
	Institutional failure

Table 4: Impacts and explanations of resource curse paradox

3. Empirical research

In what follows we attempt to empirically examine the relationship of the effect of corruption and shadow economy on environmental performance. In this chapter we first describe the set of data used in the analysis and then the methodology used.

3.1 Data

3.1.1 Data description

The panel encompasses 24 out of 27 European Union countries, which are Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Nederland, Poland, Portugal, Romania, Slovenia, Slovakia, Spain and United Kingdom. The panel refers to annual data for the period 2000-2007. The data was converted in logarithmic form. It contains the following variables:

- Environmental Performance Index (EPI), was obtained from the database of Yale University
- Energy generated from Renewable Sources (RENWEABLE), was obtained from the database of Eurostat

- Greenhouse Gas Emissions (EMISSIONS), was obtained from the database of Eurostat
- Corruption Perception Index (CPI), was obtained from Transparency International
- Shadow Economy (SHADOW), was obtained from Schneider, Buehn and Montenegro (2010)
- GDP per capita (GDP_PC), was obtained from the World Bank

The following section describes analytically the variables mentioned above.

3.1.2 Indices

I. Environmental Performance Index (EPI)

The Environmental Performance Index provides a quantitative basis for comparing, analyzing and understanding environmental performance. The Yale Center for Environmental Law and Policy suggested the EPI, which focuses on a narrow set of environmental issues for which governments could be held accountable. The EPI ranks countries on 22 performance indicators connecting policies which include both environmental public health and ecosystem vitality. The first core objective measures environmental stresses to human health and the second, ecosystem health and natural resource management. These policy categories contain:

- Environmental health
- Water and its effects in human health
- Air pollution and its effects in human health
- Air pollution and ecosystem effect
- Water resources
- Biodiversity and habitat
- Forests
- Fisheries
- Agriculture
- Climate change

Each of the previous categories is composed of at least one indicator, some of which represent direct measures of issue areas, while others are proxy measures that offer a gauge of policy progress. The index aims at providing political leaders

with a tool that will help them to recognize the strengths and weaknesses of their nation's performance in comparison to other countries.

II. Energy Generated from Renewable Sources (RENEWABLE)

Energy Generated from Renewable Sources is expressed as a percentage rate of the total electricity consumption. It is the ratio between the electricity produced from natural sources and the gross national electricity consumption calculated for a calendar year, and it measures the contribution of electricity. It comprises the electricity generation from hydro plants, wind, solar, geothermal and electricity from biomass/wastes.

III. Greenhouse Gas Emissions (EMISSIONS)

This index is expressed in thousands of tones and it comprises the release of greenhouse gases into the atmosphere over a specific area and period of time. These gases could be either natural or anthropogenic and they absorb and re-emit infrared radiation. The Kyoto Protocol quoted as greenhouse gases the following: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perflruorocarbons (PFCs).

IV. Corruption Perception Index (CPI)

CPI is a composite index, which uses surveys of business people and assessments by country analysts. It ranks countries in terms of the degree to which corruption is perceived to exist among public officials and politicians. It is based on expert surveys carried out by a variety of reputable institutions. They all define corruption as the misuse of public power for private benefit, for example bribery of public officials, kickbacks in public procurement, or embezzlement of public funds.

The index is published by Transparency International and it scores from 0 to 10, with 10 being the least corrupt country score. Finally, it does not reflect actual levels of corruption, but it highlights the quality of prosecutors, courts and the media in exposing corruption.

V. Shadow Economy (SHADOW)

The index of Shadow Economy has been estimated by Schneider, Buehn and Modenegro (2010). They define shadow economy as all currently unregistered economic activities that contribute to the officially calculated Gross National Product. It includes all market-based legal production of goods and services that are

deliberately concealed from public authorities to avoid payment of income, value added or other taxes, payment of social security contributions, compliance with certain legal labor market standards and certain administrative procedures.

The size of shadow economy is expressed as a percent of the GDP and is calculated with a Multiple Indicators Multiple Causes (MIMIC) model.

VI. Gross Domestic Product per capita (GDP_PC)

The Gross Domestic Product represents the sum of gross value added by all resident producers in the economy plus product taxes, minus any subsides not included in the value of products. GDP per capita is the GDP index divided by the mid-year population.

3.2 Methodology

The relationship among the variables mentioned above, were estimated using panel data analysis. A panel data set provides multiple observations on the same individuals in the sample which are repeated at different points in time. It combines time series and cross sections. We applied fixed effect models, using OLS estimator, and random effect models, using GLS estimator. We chose the more appropriate model using the Hausman test.

The simplest form of a panel data model is a pooled regression which can be described with the following equation:

$$y_{it} = a + \beta x_{it} + u_{it}, (i = 1, 2, ..., N, t = 1, 2, ..., T)$$

where y_{it} is the dependent variable, α is the intercept term, β is the k×1 vector of parameters of independent variables and x_{it} is a 1×k vector of observations on the independent variables. The subscript i is referred to the cross-sectional elements, the 24 EU countries, while the subscript t is referred to the time-series data, period 2000-2007.

The two techniques which were used in this essay are the fixed effects and the random effects model. The two models differ in how they treat the individual effect.

3.2.1 The Fixed Effects Model

The Fixed Effects model can be expressed by decomposing the disturbance term of the pooled regression model, u_{it}, into an individual specific term, μ_i and a disturbance term v_{it}.

$$u_{it} = \mu_i + v_{it}$$

So the general form of the Fixed Effects model is expressed by the equation:

$$y_{it} = \alpha + \beta x_{it} + \mu_i + v_{it}$$

This model is estimated by using dummy variables, encapsulated by the term μ_i. This term contains all of the variables that affect y_{it} cross-sectionally, but do not vary over time. It treats μ_i as a fixed but unknown constant which differs across individuals.

3.2.2 The Random Effects Model

The Random Effects model also proposes different intercepts, constant over time, for each individual. The difference between the two models is that under random effects, the intercepts consist of a common intercept α, which is the same for all individuals, and a random variable ε_i, which varies cross-sectionally but is constant over time, which measures the random deviation of each individual's intercept from the global intercept term. The general form of this model could be expressed as:

$$y_{it} = \alpha + \beta x_{it} + \omega_{it}, \omega_{it} = \varepsilon_{it} + v_{it}$$

In contrast to the fixed effects model, there are no dummy variables to capture heterogeneity in cross-sections. The random variable ε_i has zero mean and constant variance.

3.2.3 Hausman Test

The most appropriate between fixed and random effects model is chosen by applying the Hausman test. Hausman proposed the test in 1978, in order to test the significance of an estimator against another estimator. Specifically, given a model and data in which fixed effects estimation would be appropriate, it tests whether random effects estimation would be almost good. We consider a model:

$$Y = bX + u$$

There are two estimators for b: b_0 and b_1.Under the null hypothesis both estimators are consistent but b_1 is more efficient than the other, which means that it has a smaller standard error. Under the alternative hypothesis, at least one estimator is inconsistent. A large and significant Hausman statistic means a large and significant difference, and so we reject the null hypothesis in favor of the alternative that the fixed effects estimator is consistent. Table I in Appendix presents the Hausman test, results showing the Hausman statistic, degrees of freedom and probability.

In the analysis that follows the dependent variables are: EPI, RENEWABLES and EMISSIONS. We estimated whether they are affected by corruption, shadow economy, GDP per capita, or whether they affect each other. Specifically we estimated the following models:

- Greenhouse Gas Emissions

$$LEMISSIONS = a + \beta_1 LCPI + \beta_2 LSHADOW + \beta_3 LGDP\_PC + u$$
$$LEMISSIONS = a + \beta_1 LCPI + \beta_2 LSHADOW + \beta_3 LGDP\_PC + \beta_4 LCPI \cdot LSHADOW + u$$
$$LEMISSIONS = a + \beta_1 LCPI + \beta_2 LSHADOW + \beta_3 LGDP\_PC + \beta_4 LEPI + u$$
$$LEMISSIONS = a + \beta_1 LCPI + \beta_2 LSHADOW + \beta_3 LGDP\_PC + \beta_4 LCPI \cdot LSHADOW + \beta_5 LEPI + u$$

- Energy generated from natural resources

$$LRENEWABLE = a + \beta_1 LCPI + \beta_2 LSHADOW + \beta_3 LCPI \cdot LSHADOW + u$$
$$LRENEWABLE = a + \beta_1 LCPI + \beta_2 LSHADOW + \beta_3 LGDP\_PC + \beta_4 LCPI \cdot LSHADOW + u$$

- Environmental Performance Index

$$LRENEWABLE = a + \beta_1 LCPI + \beta_2 LSHADOW + u$$
$$LRENEWABLE = a + \beta_1 LCPI + \beta_2 LSHADOW + \beta_3 LGDP\_PC + u$$
$$LRENEWABLE = a + \beta_1 LCPI + \beta_2 LSHADOW + \beta_3 LGDP\_PC + \beta_4 LCPI \cdot LSHADOW + u$$

4. Empirical Results

This chapter introduces and describes analytically the descriptive statistics and characteristics of the variables, and the results of the estimated equations which were presented above. In Appendix graphs of the variables are presented.

Table 5 presents the descriptive statistics of the examined variables. According to them we observe that the production of energy from renewable resources varies among countries more than all the other indices. Corruption and shadow economy are also strongly changing variables. Finally, the environmental performance has the least fluctuations among the examined EU countries, which is due to the fact that EU countries make efforts to develop a common corpus of environmental policies.

	Observations	Mean	Median	Standard Deviation	Minimum	Maximum
LEPI	192	4.110714	4.131193	0.107234	3.723844	4.248671
LRENEWABLE	192	2.197422	2.484383	1.249978	-1.469676	4.283862
LEMISSIONS	192	11.54338	11.35339	1.264547	9.169102	13.86788
LCPI	192	1.783039	1.840550	0.351622	0.955511	2.302585
LSHADOW	192	3.023167	3.100092	0.363568	2.240710	3.608212
LGDP_PC	192	9.382407	9.586751	0.897646	7.364768	10.94003

Table 5: Descriptive Statistics

Table 6 reports the results with Greenhouse Gas Emissions as the dependent variable. According to the Hausman test's results, we chose the random effects model. We started the analysis with the simplest regression, which includes corruption, shadow economy and GDP per capita, where all the coefficients are statistically significant. Corruption has a small negative coefficient which is due to the fact that CPI ranks from 0 to 10, with 0 being the most corrupt country. This means that corruption weakly raises the emissions. In addition to this, shadow economy and GDP also raises the quantity of emissions, with shadow economy having the greatest impact.

In the second and forth regression model we added an interaction parameter between corruption and shadow economy, in order to investigate the joint effect of the two variables on emissions. In both of the cases, adding this parameter, its

coefficient and the coefficient of corruption are not significant. Shadow economy and GDP have almost the same effect as at the previous model.

Finally, models 3(a) and 4(a) include the effect of environmental policy performance. They differ only on the existence of the interaction term between corruption and shadow economy. We observe a decreasing and statistically significant effect of the environmental policy on emissions, which means that stringer policies reduce emissions.

Dependent Variable: Greenhouse Gas Emissions				
Independent Variables	Model 1(a)	Model 2(a)	Model 3(a)	Model 4(a)
CPI	-0.093633** (-2.977242)	-0.126174 (-0.694310)	-0.075384 ** (-2.465780)	-0.209435 (-1.193015)
Shadow Economy	1.103929 ** (3.566647)	1.081639 ** (3.158411)	0.995651 ** (3.319238)	0.887899 ** (2.663180)
GDP_PC	0.520574 ** (6.421536)	0.516531 ** (6.023137)	0.579193 ** (7.289516)	0.561378 ** (6.748460)
CPI*Shadow Economy		0.012703 (0.182113)		0.052470 (0.775706)
EPI			-0.495147 ** (-3.905693)	-0.509468 ** (-3.969800)
Adj. R^2	0.306056	0.303569	0.357911	0.357868
Observations	192	192	192	192
Number of countries	24	24	24	24

Table 6: Random effects model with Greenhouse Gas Emissions as dependent variable. The constants are included in the regressions, but they are omitted from the table. Superscripts * and ** corresponds to 10% and 5% significance respectively.

Table 7 shows the determinants of the quantity of energy generated from natural resources, using the fixed effects models. We investigated the impact of corruption, shadow economy and income on the dependent variable. In both models 1(b) and 2(b) we used the interaction term of shadow economy and corruption. The difference of two models is the existence of income in the estimation, which implies important variation in the statistical significance of the coefficients.

In model 1(b) corruption has no impact on the production of energy from renewable resources, but shadow economy is the only significant parameter which has a strong negative effect. In contrast in model 2(b) the coefficient of corruption is positive, and it also has an indirect affect on energy energy production. Taking the cross derivative of the equation with respect to corruption, we observe an indirect

negative impact of corruption which depends on the level of the shadow economy. Specifically we have:

$$\frac{\partial LRENEWABLE}{\partial LCPI} = 2.690915 - 1.214321 \cdot LSHADOW$$

The previous identity means that a decrease in the level of corruption will lead to an increase in production of energy from renewable resources proportionally reduced by the level of shadow economy. So the sign and size of the final impact of corruption depends on the level of shadow economy. The larger the shadow economy, the smaller is the impact of a reduction on renewable energy production.

Dependent Variable: Energy generated from renewables		
Independent Variables	Model 1(b)	Model 2(b)
CPI	1.438270 (1.078741)	2.690915** (1.976912)
Shadow Economy	-4.802201** (-5.162608)	2.889813 (1.093844)
GDP_PC		2.045602** (3.099899)
CPI*Shadow Economy	-0.717321 (-1.406252)	-1.214321** (-2.324095)
Adj. R^2	0.951970	0.954629
Observations	192	192
Number of countries	24	24

Table 7: Fixed effects model with Energy Generated from renewable sources as dependent variable. The constants are included in the regressions, but they are omitted from the table. Superscripts * and ** corresponds to 10% and 5% significance respectively.

Table 8 presents three models with environmental policy performance as the dependent variable. We chose the fixed effects model according to the Hausamn statistics.

According to the first model both corruption and shadow economy have negative effects on the performance of environmental policy, with shadow economy having a higher coefficient. Adding income and the interaction term in the models, the statistical significance of the coefficients of shadow economy and corruption change respectively.

Firstly, in model 2(c) corruption has a low positive effect on EPI, which implies that it worsens the performance of environmental policies. However, when entering the interaction term (model 3(c)), shadow economy has a negative impact

on environmental performance, which is reinforced by the joint effect of the variable with corruption. Taking the partial derivative we get:

$$\frac{\partial LEPI}{LSHADOW} = -0.415309 + 0.077100 \cdot LCPI$$

The derivative implies that an increase in shadow economy will lead to a decrease of the level of environmental performance index, reduced by a term proportional to the level of corruption. The positive sign of this coefficient is due to the fact that higher level of CPI means less corrupt country, so the higher the index is the more reduced the impact of shadow economy is.

Dependent Variable: Environmental Performance Index			
Independent Variables	Model 1(c)	Model 2(c)	Model 3(c)
CPI	0.037817** (2.018463)	0.036477* (1.969419)	-0.161333 (-1.523193)
Shadow Economy	-0.653993** (-9.755224)	-0.256612 (-1.35600)	-0.415309** (-2.020232)
GDP_PC		0.110412** (2.241673)	0.080533 (1.568349)
CPI*Shadow Economy			0.077100* (1.8963650)
Adj. R^2	0.960692	0.961854	0.962672
Observations	192	192	192
Number of countries	24	24	24

Table 8: Fixed effects model with Environmental Performance Index as dependent variable. The constants are included in the regressions, but they are omitted from the table. Superscripts * and ** corresponds to 10% and 5% significance respectively.

Generally, income has a positive impact on the three dependent variables. It affects more the production of energy from renewable resources, while it has a very low impact on performance of environmental policy. This result is consistent with the theory of Environmental Kuznets curve.

The last table shows the correlation between the investigated variables. First of all a strong positive correlation is observed between CPI and GDP_PC, which means that low levels of corruption are related to high levels of income. The same relationship between shadow economy and income is represented by the high negative correlation parameter of the two variables. Besides these, corruption and shadow economy has a negative correlation. This is consistent with the literature, which supported that countries with high rates of corruption tend to have stronger unofficial sector (Biswas, Farzanegan and Thum (2012)). As well as this, positive

correlation between EPI and GDP_PC confirms the fact that richer countries have stringer standards and stricter enforcement of laws (Grossman and Krueger (1995)). Finally EPI is also negatively correlated with high levels of corruption and shadow economy.

	LEPI	LRENEWABLE	LEMISSIONS	LCPI	LSHADOW	LGDP_PC
LEPI	1	0.057804	0.057257	0.471299	-0.578532	0.621859
LRENEWABLE		1	-0.010499	0.095878	-0.099688	0.138609
LEMISSIONS			1	0.138416	-0.189634	0.245715
LCPI				1	-0.668381	0.846229
LSHADOW					1	-0.776662
LGDP_PC						1

Table 9: Correlation matrix

5. Conclusions

The objective of this study was to investigate political and economic factors which affect the Greenhouse Gas Emissions, Energy production from renewable resources and Performance of Environmental Policy. For our estimation we used panel data analysis, applying Fixed and Random effects models.

The results of our empirical analysis are consistent with the literature. The most important of them are:

- High levels of corruption and shadow economy increase the quantity of greenhouse gas emissions, while they reduce the production of energy from renewable resources and affect negatively the performance of environmental policy.
- Countries with higher per capita income suffer from higher levels of emissions, but they invest more in renewable resources and they have stringer standards and stricter enforcement pf environmental legislation.
- The interaction term which was introduced, discloses a joint effect of corruption and shadow economy. An important conclusion is that corruption and shadow economy reinforce each other. In the case of renewable energy production, high levels of shadow economy amplify the impact of corruption on them. However, lower level of corruption reduces the negative impact of shadow economy on the performance of environmental policy.

- Finally, by observing the coefficients, we conclude that in all regressions the coefficients of shadow economy and corruption have the higher values. These findings imply that policy makers should make efforts to reduce the levels of these parameters before increasing environmental standards and regulations.

REFERENCES

Aidt T.S., (1998), "Political internalization of economic externalities and environmental policy", *Journal of Public Economics* 69: 1-16

Aidt T.S., (2003), "Economic Analysis of Corruption: A Survey", *The Economic Journal* 113(November):F632-F652

Arrow K., Bolin B., Costanza R., Dasgupta P., Folke C., Holing C.S., Jansson B.-O., Levin S., Mäler K.-G., Perrings C., Pimentel D., (1995), "Economic Growth, Carrying Capacity and the Environment", *Science* 268 (April): 520-521

Baldagi H. Badi, (2005), *Econometric analysis of Panel Data*, England: John Wiley and Sons, Ltd

Bardhan P., (1997), "Corruption and Development: A Review of Issues", *Journal of Economic Literature* XXXV: 1320-1346

Bhattacharyya S. and Hodler R., (2010), "Natural resources, democracy and corruption", *European Economic Review* 54: 608-621

Biswas A.K., Farzanegan M.R. and Thum M., (2012), "Pollution, shadow economy and corruption: Theory and evidence", *Ecological Economics* 75: 114-125

Brooks Chris, (2008), *Introductory Econometrics for Finance*, Cambridge: University Press

Choi J.P., Thum M., (2005), "Corruption and the Shadow Economy", *International Economic Review* 46(3): 817-836

Damania R., (2002), "Environmental controls with corrupt bureaucrats", *Environment and Development Economics* 7: 407-427

Dietz S., Neumayer E. and De Soysa I., (2007), "Corruption, the resource curse and the genuine saving", *Environment and Development Economics* 12: 33-53

Grossman G. M. and Krueger A. B., (1995), "Economic Growth and the Environment", *Quarterly Journal of Economics* 110(2): 353-377

Fredriksson P.G., List J.A., and Millimet D.L., (2003), "Bureaucratic corruption, environmental policy and inbound US FDI: theory and evidence", *Journal of Public Economics* 87: 1407-1430

Fredriksson P.G. and Svensson J., (2003), "Political instability, corruption and policy formation: the case of environmental policy", *Journal of Public Economics* 87: 1383-1405

Fredriksson P.G. and Vollebergh H.R.J., (2009), "Corruption, federalism and policy formation in the OECD: the case of energy policy", *Public Choice* 140: 205-221

Jordan A., (2005), *Environmental Policy in the European Union,* London: Earthscan

Lewis J. M., (2007), "The resource curse: Examining corruption in the extractive industries", *Perspective on Global Issues* 2(1)

López R. and Mitra S., (2000), "Corruption, Pollution, and the Kuznets Environmental Curve", *Journal of Environmental Economics and Management* 40: 137-150

Mo P.H., (2001), "Corruption and Economic growth", *Journal of Comparative Economics* 29: 66-79

Morse S., (2006), "Is Corruption Bad for Environmental Sustainability? A Cross-National Analysis." , *Ecology and Society* 11(1): 22

Myint U., (2000), "Corruption: causes, consequences and cures", *Asia- Pacific Development Journal* 7(2): 33-58

Neumayer E., (2002), "Do Democracies Exhibit Stronger International Environmental Commitment? A Cross-Country Analysis", *Journal of Peace Research* 39(2): 139-164

Papyrakis E. and Gerlagh R., (2004), "The resource curse hypothesis and its transimission channels", *Journal of Comparative Economics* 32: 181-193

Pellegrini L. and Gerlagh R., (2006), "Corruption, Democracy and Environmental Policy: An Empirical Contribution to the Debate", *The Journal of Environment and Development* 15 (3): 332-354

Pellegrini L. and Gerlagh R., (2006), "Corruption and Environmental Policies: What Are the Implications for the Enlarged EU?", *European Environment* 16: 139-154

Roca J., (2003), "Do individual preferences explain the Environmental Kuznets curve?", *Ecological Economics* 45: 3-10

Rose- Ackerman S., (2006), *International Handbook on the Economics of Corruption*, Cheltenham: Edward Elgar

Schneider F., Buehn A. and Modenegro C.E., (2010), "New Estimates for the Shadow Economies All over the World", *International Economic Journal* 24(4): 443-461

Schneider F., and Enste D., (2000), "Shadow Economies: Size, Causes, and Consequences", *Journal of Economic Literature* 38: 77-114

Shaxson N., (2007), "Oil, corruption and the resource curse", *International Affairs* 83: 1123-1149

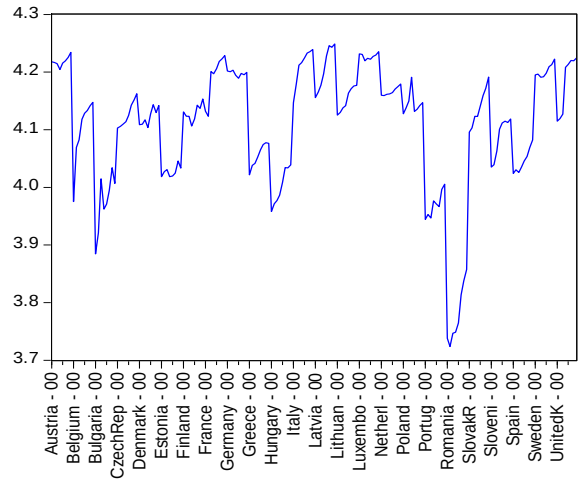
Treisman D., (2000), "The causes of corruption: a cross- national study", *Journal of Public Economics,* 76: 399-457

Wilson J.K. and Damania R., (2005), "Corruption, political competition and environmental policy", *Journal of Environmental Economics and Management* 49: 516-535

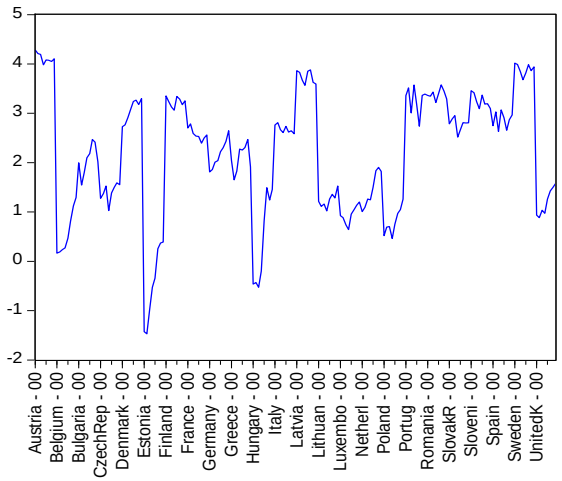
APPENDIX

TABLE I: Hausman Test Results			
	Hausman Statistic	Degrees of Freedom	Probability
Model 1(a)	1.792793	3	0.6165
Model 2(a)	1.752255	4	0.7812
Model 3(a)	1.768663	4	0.7782
Model 4(a)	1.706251	5	0.8881
Model 1(b)	20.816195	3	0.0001
Model 2(b)	12.565775	4	0.0136
Model 1(c)	39.849023	2	0.0000
Model 2(c)	24.029218	3	0.0000
Model 3(c)	20.699748	4	0.0004

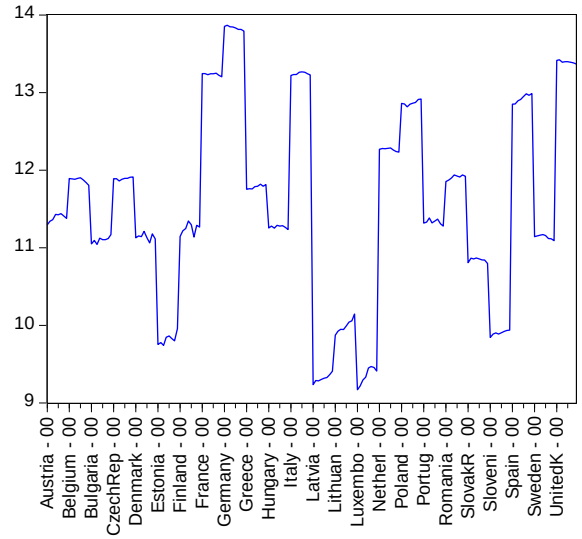
LEPI



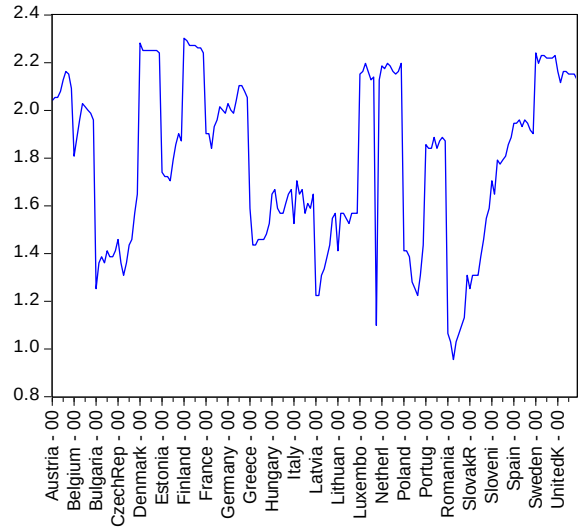
LRENEWABLE



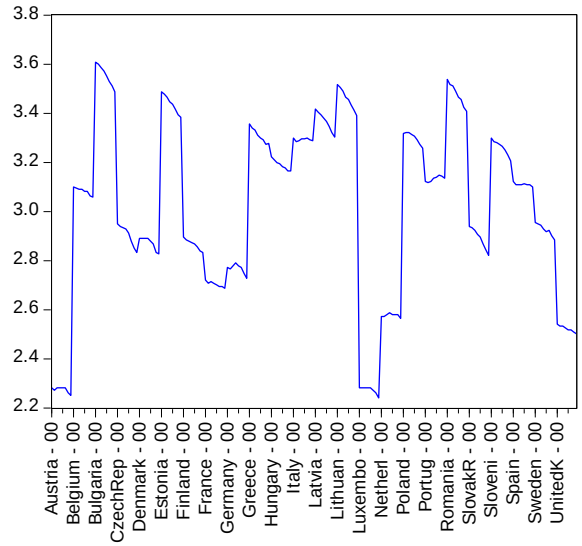
LEMISSIONS



LCPI



LSHADOW



LGDP_PC