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The determinants of environmental protection in the European Union

Bachelor Thesis
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Abstract

In the last years in European economic policy, it has come to a paradigm shift from a necessary trade-off between economic growth and environmental quality, to the idea that economic growth can be achieved while or actually through increasing environmental quality: green growth.

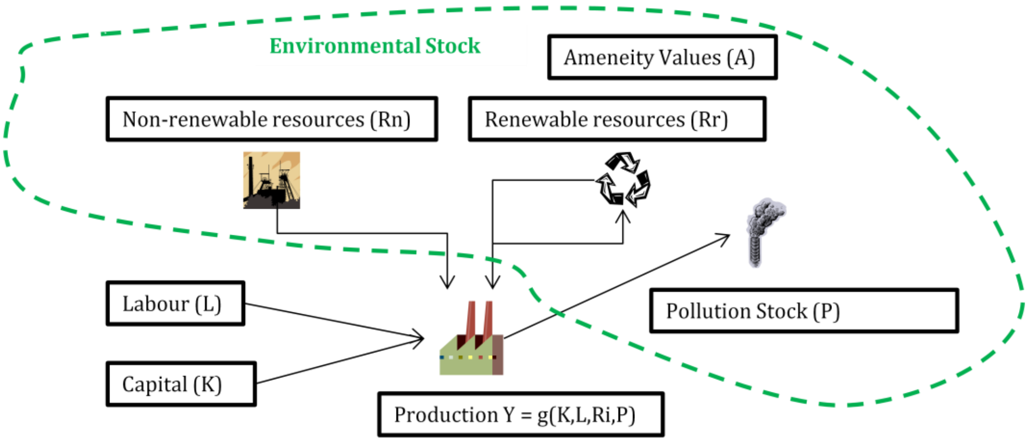
The extent to which European countries have achieved this in the past can be tested by looking at the growth of the size of their eco-industries, a synopsis of all their environmental protection expenditure aimed at improving environmental quality. Yet, there are large differences in magnitude of expenditures between countries.

This thesis uses a multiple regression model with fixed effects to examine the determinants of the environmental protection expenditure in the EU-27. Nine determinants for both exogenous socio-economic conditions as well as endogenous environmental policy measures impact the variation. Good socio-economic conditions are therefore a necessity to implement stringent environmental policy that will lead to green growth.

1. Introduction

Economic growth and the state of the environment are linked to each other and constantly interact. Economic activity requires resources from the environment, just as much as manufacturing industry also deteriorates its quality. According to Smulders (2000) there exists a circular flow between the environment and economic activity: first, the environment is a *source* of resources and secondly, acts as a *sink* for waste and pollution. Third, parts of the economic activity may be directed to *recycling* environmental resources or pollution *abatement*. Lastly, fourth, the society has an *amenity value* for good environmental quality. This relation is depicted in the figure below. [1]

Figure 1 - Stylized production process with non-renewable resources and pollution



There exist an upper boundary to the capacity at which the environment can absorb pollution P and provide resources R_N. In the 1970's, when environmental economics was still a young academic field, the 1972 report on *The limits to growth* (Meadows et. al.1972) by the Club of Rome, is based on a pioneering analysis of the interactions between humans and the Earth and its finite resources. A **trade-off** between economic activity and environmental quality was found. Without recurring investments in the environmental stock, economic stagnation would be risked and the environment would be out of equilibrium of its self-regenerating capacity.

In the late 1980's, the notion of ***sustainable development*** appeared: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987). It can be seen as the intersection between environment, the society and economy, rejecting that there are limits to growth if all three dimensions are in

[1] The consumption and pollution of households is also part of the flow as well as technological innovations., but were left out to focus on the relation of production and environmental stock

equilibrium. Related to the environment, we can speak of *strong sustainability* if consumption growth increases while environmental quality does not decline. Alternatively, *weak sustainability* even allows a decline in environmental stock if this is compensated with other capital increases and non-declining utility. Environmental quality becomes a relevant factor in the production function, but can be exchanged for higher utility in terms of increased consumption.

A further concept for economic development that evolved from the sustainable growth notion has been introduced in the early 2000's through so called '**green growth'**, economic growth that can be achieved while simultaneously improving the environmental quality. Conversely, adding a new perspective to sustainable growth, economic growth can be achieved exactly *because* more investments are made to improve the environment. During the 2008 recession, so called 'green elements' were added into EU stimulus packages including car scrapping schemes and subsidies for energy efficiency programs, intended to boost economic activity and employment (EC, 2009). A win-win situation therefore in terms of economic growth and environmental quality.

This shift in defining and measuring economic growth requires a parting from the "business-as-usual" scenario, new ways to produce and consume products need to be found. This is precisely the long-term strategy for the European Union, the 'Europe 2020 strategy': a 'smart, sustainable and inclusive growth' strategy. Two out of the seven 'Flagship initiatives' of this strategy have a specific focus on the environment (European Commission, 2010):

> (1) *Resource efficient Europe* – decouple economic growth from the use of non-renewable resources and corresponding pollution; boosting employment in the 'green technology' sector.
>
> (2) *An industrial policy for the globalization era* - Move to a more resource efficient economy.

Already earlier, in 2007, an Energy & Climate Package was endorsed by the European Commission with a range of climate targets, known as the '20-20-20' targets (European Commission, 2007).[2]

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[2] (1) reduce Greenhouse Gases (GHG) by 20% below 1990 emission levels;
(2)increase the share of renewable energy to 20% of final energy consumption by 2020
(3)increase energy efficiency by 20% compared to 1990 levels in 2020

To achieve these goals, there is a need for environmental services and goods that both reduce environmental damage and/or manage the use of environmental resources. These activities are also known as *Environmental Protection Expenditure (EPE)* or more simple and fashionable '*eco-industries'*. They act as a cornerstone of the 'Europe 2020 strategy'.

In the 2010 State of the Union address José Manuel Barroso, President of the European Commission, highlighted the importance of eco-industries as "[the] eco-industries have been increasing by 7% per year since 2000. I want to see 3 million "green jobs" by 2020." (Barosso, 2010)

As Mr. Barroso already pointed out, the eco-industries are gaining in importance and political attention, he also makes a reference to 'green jobs'. While the quality of the environment may have some importance for the median voter, job security is probably his main concern. Hence, boosting the economy that comes hand in hand with new job creation is immensely popular for politicians on both sides of the Atlantic.[3] The size of this employment potential is calculated using macro-economic models, although the concept is simple: The total output of a sector (in this context EPE) is multiplied by a Labour Compensation Factor and divided by the average wage per sub-sector.[4] Choosing the correct Labour Compensation Factor and average wage are critical in the equation. However EPE is the main factor of interest, as in the short-and middle run policy decisions can greatly influence its size and therefore boost job creation.[5]

Eco-industries are by definition are economic activities that produce environmental goods and services. Therefore the state and growth of the eco-industries can be utilized as an indicator to empirically test whether 'green growth' is actually possible, higher economic activity that positively benefits the environmental quality.

Recent reports indicate that the eco-industries are growing by 7% annually, however there are large differences between the countries of the EU in absolute and relative sizes of the eco-industries as well as their growth rates. To this end, it would be interesting to know why there are such significant differences between environmental protection expenditure and the reasons

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[3] Obama campaigned in 2008, with the promise to create more green collar jobs

$$\boldsymbol{Employment} = \frac{Environmental\ Protection\ Expenditure * Labour\ Compensation\ factor}{averagewage}$$

[4]

[5] There is globally a highly interesting debate going on regarding the net employment effects of creating green jobs. On the one hand, we only measure a substitution effect e.g. wind energy instead of coal energy and the net effect is not clear. Furthermore, in the long run, wages will increase and prices will rise as well for e.g. final energy, resulting in a shift of energy intensive sectors abroad, resulting in a net job loss. This is a topic for itself and too complicated to briefly mention here

behind the varying growth rates of the Member States. It is important to test whether green growth can actually actively be pursued through environmental policies or if it depends on socio-economic factors, the current state of a country? As Inglehart (2000) puts it: 'Only rich economies can afford to worry about the environment'.

The aim of this thesis is to examine the determinants behind the growth of Environmental Protection Expenditure in the European Union, which is the indicator for the size of the eco-industry. This examination will be achieved using balanced panel data of 27 European Union countries between 2000 and 2008 with EPE as dependent variable and 11 independent socio-economic and environmental policy factors as explaining variable. It can further be formulated into a crisp research question:

Research Question: What are the determinants of the Environmental Protection Expenditure in the European Union?

To this end, the thesis will study whether the determinants are exogenously defined or simply socio-economic conditions within a country or whether the environmental policy of a country can explain the magnitude of the EPE variation. The analysis will include on the one hand variables such as GDP per capita, income inequality, education levels, the degree of transformation towards a tertiary and services orientated industry, population density, urbanization levels and on the other hand tax levels on pollutants, the percentage of energy consumed from renewable sources, waste management performance, protected area for biodiversity purposes and the decrease in particulate matter emissions.

The thesis adds value to a current larger debate on the topic of economic growth and environmental quality as a new and broader dataset is constructed for the European Union analysis is in greater detail for the European Union and it adds environmental protection expenditure as a complementary factor to measure environmental quality.

Outline: The thesis is organized as follows: Chapter 2 will first review existing literature on the link between economic growth and environmental quality to develop the relevant hypotheses that will be tested later on. Chapter 3 includes the methodology, the data and the model, followed by the results of the model in Chapter 4. In Chapter 6 the main conclusions are drawn and the limits of the model and further research possibilities in are illustrated in Chapter 7.

2. Literature Review

The following section will provide an overview of existing literature that is relevant to explain a linkage between economic growth and environmental protection expenditure. However, as EPE in particular is still topic with little existing literature, the examination will utilize literature that analyses the connection between economic growth and environmental quality. Therefore it will be first illustrated why literature on environmental quality can be used to study environmental protection expenditure as well.

2.1. Connection between economic growth and environmental quality

The term 'environmental quality' is a very broad term and different, often very narrow definitions can be found in the literature. Overall, it is defined as a 'state of environmental conditions in environmental media, expressed in terms of indicators or indices related to environmental quality standards' (United Nations, 1997). For example, it is measured in levels of particulate emissions in the air such as sulphur or carbon dioxide emissions (Stern & Common, 1996), the rate of deforestation (Cropper & Griffiths, 1994), toxic indicators (Goetz, Debertin, & Pagoulatos, 1998) or clean drinking water (Torras & Boyce, 1998).

Whereas environmental quality is the *state* of the environment, environmental protection expenditure consist of a *flow* of activities to reduce environmental damage, improve the environment and manage the use of resources. Hence, it becomes clear that to change the state of environmental quality in a positive manner, this can only be accomplished by investing in the reduction of pollutants and/or remediation of environmental damage. These activities are in other words environmental protection expenditure. Therefore, literature that refers to a factor or a condition that has a positive impact on environmental quality, implicitly implies that more investments have been made to protect the environment. As a result literature on the linkage between economic growth and environmental quality can be utilized to extract expectations on the connection between economic growth and environmental protection expenditure.

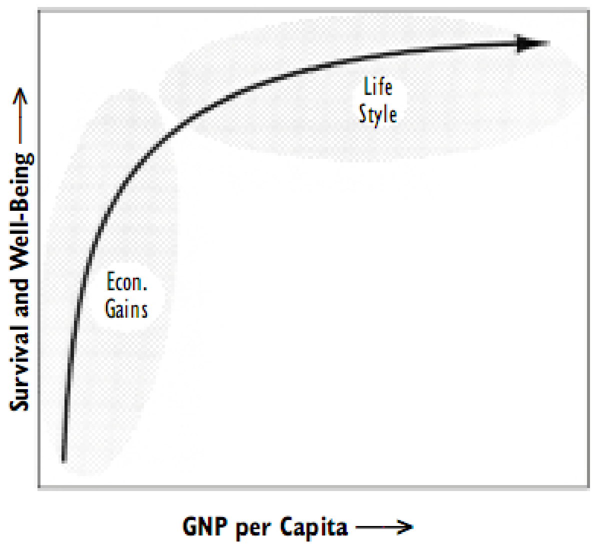
Shafik (1994) was the first person to developed determinants of environmental quality in any given country. He indentified four general determinants: (1) First, endowment factors that can include location-specific attributes such as climate or land. (2) Secondly, socio-economic conditions such as per income levels as well as urbanization and consumption patterns that include both the provision of private goods and environmental services. (3) Thirdly, exogenous factors such as technology available to all countries, but subject to change over time. (4) Fourth, political decisions and policies that reflect the social decision to provide environmental public good. However Shafik noted that the relevant policies are difficult to measure and 'do not lend themselves to such analyses'. In this specific analysis, Shafik only used income levels to test a relationship and concluded that patterns exist between rising incomes and environmental indicators. Water and sanitation improved with a rise in income, particulates and sulphur oxides first increase and then decrease and municipal waste and carbon emissions worsen steadily.

It is possible to built upon the categorization of Shafik and simplify the four determinants into two broad categories: socio-economic or exogenous and environmental policy or endogenous. The first can include the first three categories stated by Shafik (1994), and the fourth (political decision) determinant is part of the environmental policy.

Socio-economic determinants for environmental quality (exogenous)

According to Inglehart (2000), the early stages of economic development appear to make the largest impact on subjective well-being. However, at a certain point, the gains from every dollar per capita are marginal and at this threshold, the people of the country begin to value to a greater extent the quality of life, including environmental concern, free speech and liberty. This is part of what he explains as the shift from materialist values to 'post-materialist values' and can be visualized in Figure 2.

Figure 2 - Economic development and the shift in survival strategies



Source (Ingelhart, 2000)

Gelissen et al. (2007) also examines the relation between public support and willingness to pay for environmental protection and strengthens the hypothesis made by Ingelhart. In the study of

50 countries they find that publics that are on average higher in post-materialist orientation are willing to invest more in environmental protection and also have higher supportive levels.

This may also explain the current difficulties to find an agreement in the post-Kyoto Protocol negotiations of the COP-15 Copenhagen and COP-16 Cancún as the priorities of industrialized nations tend to lie with environmental quality compared to developing nations that do not want to risk economic growth due to environmental protections costs.

In Baldwin (1995) it is postulated that as the level of economic activity grows, it further spurs as a side effect the emission of pollutants, overwhelming the effects resulting from a gradual shift from an industrial to post-industrial and service orientated economy. However, the further the shift towards a service-orientated economy, and therefore also a rise in GDP per Capita, the less will be emitted either by decreased production or higher environmental protection standards. A phrase he states that is easy to comprehend is the following: 'Only rich economies can afford to worry about the environment; poor societies must direct most of their expenditure on basic necessities of life'. Furthermore, rich countries also have the advanced legal and social infrastructure.

In the early 90's, the Grossman and Krueger (1991) claimed a relationship between economic growth – in terms of GDP per capita - and an inverted U-shaped function of environmental quality, in this case sulphur emissions. This is what is referred to as the 'Environmental Kuznets Curve' (EKC). In the course of time with increasing data availability for OECD and worldwide comparisons similar studies were repeated and tested also with carbon emissions (Dijkgraaf and Vollebergh, 1998). However, recent studies by Stern (2004) show that the relationship between the two variables is spurious and they have a very 'flimsy statistical foundation'. Vollebergh *et al* (2009) conclude that the lack in robustness of the inverted U-shaped estimations is due to underidentification. As different studies chose different identifying assumptions on the independent variables, this reflects itself in varying model specifications and non-robustness is the result of these assumptions. Nonetheless, they find that there is sufficient empirical evidence to support the notion that "humanity can grow out of environmental problems" and the extent of the inverted relation are likely brought on by regulatory intervention or technological change.

Magnani (2000) contributed to the EKC literature by showing that income equality affects public policy decision and investment on environmental R&D in the EU between 1980 and 1991. It is hypothesized, that income inequality is inversely related to the 'relative income' of the median voter. Therefore, he or she is willing to first spend more on the consumption of private goods instead of investing in public goods such as protection of the environment.

Torras & Boyce (1998) further show that the inclusion of income inequality in the regression of GDP per capita and pollution levels, reduces the statistical significance of per capita income. This effect can especially be seen in lower income countries, overall supporting their conclusion that greater inequality in the distribution of income leads to higher levels of pollution and therefore lower environmental quality.

Goetz, Debertin & Pagoulatos (1998) indentified that a country has a better environmental quality if they have a highly educated population, even after controlling for income, population density and industrial composition. They argue that the investment in human capital can be seen as a complementary activity, if not alternative, to 'direct government intervention'. The level of measurement used consisted of the percentage of adults that completed a high-school degree.
Education in terms of literacy rates has also a statistically significant effect in the findings of Torras & Boyce (1998). The effect is overall strong, especially for low-income countries where higher literacy rates are associated with better environmental quality such as sulfur dioxide, heavy particles, dissolved oxygen in water and sanitation. Similar effects can also be observed for high-income countries, although the relation with 'smoke' has a positive sign, and therefore contradicts the theory. Overall, both papers show that a higher educated population has a positive effect on environmental quality.

In their broad study, Copper and Griffiths (1994) argue that a population growth is the main cause of air, water and solid-waste pollution, as a larger population exerts a greater pressure on the environment and therefore speeds up its degradation. It may be thus assumed, that countries facing a higher population density face deterioration in their environmental quality and thus have to even further increase per capita protection expenditure compared to low-density countries.
This line of argumentation is also in accordance with the view of Selden and Song (1994), stating that sparsely populated countries are likely to be less concerned about reducing pollution on a per capita level at the same levels of income than countries with a high population density. Also transport distances may be smaller, thereby naturally reducing emission levels.

The *Biophilia Hypothesis* first illustrated by Kellert and Wilson (1993), states that people have a 'innately emotional affiliation [to] other living animals'. It is hypothesized that people that are further removed from the environment - such as those living in densely populated urban areas - share greater value to preserve it.
In Brennan (1999), the report concludes that the larger the city, the greater the per capita environmental costs or damages. However, the larger the cities or the more people that are living in cities, the greater the economies of scale for environmental protection measures that

can be achieved through the spatial density. The report provides an overview of the world's megacities, including those in developing countries, it states that especially the condition within the cities has decreased, and rivers are 'literally large open sewers'. As the growth in large cities has slowed, the urban environmental problems have increased, mainly due to economic development with higher levels of waste and the use of cars. This results that on a per capita level the investments needed to abate the pollution are increasing.

Duroy (2005) studied the link of six economic, demographic, political, psychological and education factors to explain the environmental awareness of the population across countries according to three dimensions: Positive Environmental Attitudes, Willingness to Pay to Protect the Environment, and Human-Environment Relationship, retrieved from the World Values study (1995-1997). It appears that economic affluence has only a marginal direct influence, however the degree of urbanization, the level of subjective wellbeing and the level of income equality do have effects on environmental awareness. Furthermore, Education and population pressure have positive correlation with environmental behaviour.

Environmental policy determinants for environmental quality (endogenous)

As environmental quality is a public good, producers do not face the cost of their pollution, but only the benefits, resulting in a situation referred to as the *Tragedy of the Commons* (Harding, 1968). As Bovenberg and Smulders (1995) put it, without government intervention, two market failures would exist with respect to the public good in the form of the provision of nature and knowledge (specifically, knowledge to develop pollution-augmenting technologies). They further outline the optimal intervention of governments to achieve optimal economic growth and non-declining environmental quality in the light of sustained innovation that raises the marginal productivity of pollution. As a 'golden rule' a part of the environmental taxes should be reinvested in the development of pollution abating technologies, thus EPE.

Environmental policies by governments can be seen in a broad context. A good overview of the economics of environmental protection is provided by Hahn and Stavins (1992). They outline the two basic policy instruments that policy makers have at hand to achieve environmental protection: Instruments that set clear standards and guidelines, giving companies less flexibility to adjust – *command-and-control mechanisms* – and those that look for the most effective ways to attain the objective – *market based on incentive-based mechanisms*.
Command and control mechanisms can include regulations on waste management, water purity standards or fine particle emissions from cars in city areas; The European Emission Transfer System (ETS) is a good example for a market-based mechanism to reduce carbon emissions and improve air-quality or a car scrap scheme to pull old and polluting vehicles from the roads.

2.2. Classification of Eco-industries in the European Union

The previous section has highlighted relevant literature on the connection between economic growth and environmental quality. This section will present available literature on eco-industries, classification of the eco-industries and research conducted to measure environmental protection expenditure in the EU. These descriptions are important to develop a coherent dataset for the dependent variable.

Regarding the overall link between the environment and the economy in the EU, one of the first research papers to estimate the size and structure of EU Eco-industries consisted of the working paper by ECOTEC and Eurostat (1994). The authors were the first to analyse then recently available data on eco-industries and developed the first methods to categorize the sub-sectors of eco-industries.

In the following years, additional attempts have been made, primarily to update figures, as in the '*Analysis of the EU Eco-Industries, their Employment and Export Potential'* (ECOTEC, 2002). The study delivered an overview of the export potential for environmental goods and services provided by the European Union. The authors estimated that the EU had a market share of around one-third of the global market of environmental goods and services and could further exploit the global growth potential. Figures where updated and revised for the newly acceded member states by Ernst&Young (2006) and the scope of the eco-industries was enlarged by GHK (2007). Eco-industries also included sectors difficult to measure such as eco-construction and eco-tourism, as well as sectors that are directly dependent on the environment that includes organic farming and sustainable forestry.[6] Furthermore, indirect and induced effects of the eco-industries were measured through the application of a general Input-Output model. The study concluded that the turnover of the total industry was EUR 1.1 trillion and including multiplier effects almost tripled in size to EUR 3 trillion for the year 2000. Accordingly, over 20 million people were directly employed in 2000 and another 15 million positions were generated through indirect and induced effects.

In the most recent study on this topic for the EU by Ecorys (2009), the eco-industries were analyzed in a wider context regarding trade patterns and its position on the international market. The study found that both Green Jobs as well as EPE grew by almost 7% per annum over the period between 2000 and 2008 – the basis for Mr. Barroso's speech - and the European eco-industries were global leaders in 5 out of 7 environmental technology categories in terms of Relative Comparative Advantage.

[6] The assumptions made to include these sectors are valid for policy recommendations but do not render themselves suitable for scientific research

The basis for research by Ernst&Young (2006), and Ecorys (2009) is the data collection handbook by Eurostat (2009). The authors of extensive methodological report, in cooperation with OECD define the expenditure for environmental protection goods and services as follows: "*[activities] which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco systems. This includes cleaner technologies, products and services that reduce environmental risk and minimise pollution and resource use*". Ecorys (2009) use a slightly adapted definition of this version, stressing the need of a 'environmental purpose', as a proxy to define 'eco-industries': the industries producing the supply of the environmental protection goods and services.

These activities can be divided into two sub-categories: (1) activities which directly protect the environment from physical outputs and (2) others that manage the input of natural resources. The first refers to Environmental Protection (EP) 'includes technologies and products of both a preventive or remedial nature for the prevention, reduction, elimination and treatment of [environmental domains]'. The second is also labeled Resource Management (RM) and 'comprises technologies and products to manage and/or conserve the stock of natural resources against depletion phenomena including both preventive and restoration activities as well as the monitoring and control of the levels and uses of natural resource stocks. '(EuroStat, 2009)

Activities can either be carried out by the Business Sector (including Agriculture, Mining and Quarrying, Manufacturing and Electricity and Water provision), General Government, Private Enterprises or a combination of privately run and specialized organizations financed by the government. Optimally, EPE should also include activities by households, however, the effort to survey these would be tremendous and do not lie within the capacity of statistical offices.

Furthermore, to be considered an environmental activity, the activity must have been done with an *'environmental purpose'* and must also be the main purpose. This includes for example waste management services, although cleaning up waste and not protecting the environment is the main purpose, the main activity is to get waste away from the environment.[7] Natural risk management is mainly aimed at the protection of humans and not for the protection of the environment per se.

As the focus of protection expenditure does not purely lie and end-of-the-pipe goods or services, the full supply-chain, also referred to c*onnected services and goods* are considered. These are a necessary requirement to the process of either EP or RM. For example, this includes the

[7] There is still much debate as to where to draw a line. For example nuclear energy has lower carbon emissions than coal, but cannot really be considered 'green'. Similarly, the facility cleaning services are part of eco-industries as well according to some definitions.

production and maintenance of septic tanks or machines that can separate different minerals and metals that can be used in recycling processes. It is possible to further distinguish between these *connected goods* and *adapted goods* – goods less polluting and consume fewer natural resources than benchmark products e.g. recycled paper and ecological soap – and *environmental technologies* - technical processes, installations and methods or services, the technical nature or purpose of which is environmental such as environmental consulting.

The next step is to further classify *environmental domains*, where all the technologies, goods and services are actively preventing or reducing damage or minimizing the use of resources. The following list of domains can be produced. These environmental domains form the core of the 'eco-industries'. As stated previously, the classification of the environmental domains and previous literature on eco-industries will form the basis to develop coherent dataset for the dependent variable, EPE per capita.

Protection activities[8]

1. Protection of ambient air and climate
2. Wastewater management
3. Waste management
4. Protection and remediation of soil, groundwater and surface water
5. Noise and vibration abatement
6. Protection of biodiversity and landscape
7. Protection against radiation
8. Research and development
9. Other environmental protection activities

Resource Management

10. *Management of waters*
11. Management of forest resources
    a. Management of forest areas
    b. Minimisation of the intake of forest resources
12. Management of wild flora and fauna
13. *Management of energy resources*
    a. Production of energy from renewable sources
    b. Heat/energy saving and management
    c. Minimisation of the intake of fossil resources as raw material for uses other than energy production
14. *Management of minerals (such as recycling)*
15. Research and development

[8] Domains underlined represent domains, where data is available, those in *italic* were retrieved from other sources. Relevant for section 3.2

16. Other natural resource management activities

2.3. Hypotheses for the research question

Based on the findings from the global literature presented in the previous sections, several expectations relating to the research question on the determinants for EPE in the EU specifically can be generated. These will be formulated into hypotheses that will be tested in the following sections for significance to explain the variation in environmental protections expenditure.

First, one of the most widely applied and tested links refers to income and environmental quality. Although the results were mixed depending on the environmental indicator, overall it is expected, but not necessarily so, that environmental quality increases with increasing income levels.

Hypothesis 1: Economic development in terms of GDP per capita leads to higher environmental protection expenditure and therefore better environmental quality.

Similarly, one can speak of the development path of an economy from a manufacturing orientated industry towards a service orientated economy with rising per capita income levels. During this transition path, less goods are produced within the country and more end-of-pipe assembly jobs, resulting automatically in less heavy industry and fewer emissions.

Hypothesis 2: The further an economy develops towards a tertiary and service orientated economy, the less production takes place and more value is given to environmental quality through investments in environmental protection expenditure .

Income inequality is also a condition that is expected to have an influence on environmental quality. If wealth is unequally distributed within a country, the 'poorer' majority may have the priority to first recover lost ground in terms of materialistic value and think of the environment in a latter place. A more evenly distributed country may share a greater value for public goods, rather than private goods.

Hypothesis 3: A higher income inequality reflects negatively on the expenditure for the protection of the environment.

Investing in education can be viewed as a complementary or even alternative way to direct government intervention. This should also hold true in terms of understanding for the environment.

Hypothesis 4: A higher educated population shares greater value for the quality of the environment and policy will therefore invest more to protect the environment.

A higher population density within a country exerts more pressure on the environment, especially because population becomes concentrated and the space for the nature to recover is smaller.

Hypothesis 5: A higher population density requires in a higher level of protection of the environment to maintain the same standard of environmental quality.

In line with the previous hypothesis, if people are living in more densely populated areas and thus further away from the environment, they share greater value to protect what they do not have in their current dwelling.

Hypothesis 6: Higher levels of urbanization are leading to higher environmental protection expenditure.

When a product becomes more expensive due to higher taxes, consumers will either shift their preferences or consume less of the goods. The same holds true for taxes on pollutants.

Hypothesis 7: Higher levels of taxes on pollutants result in increased levels for environmental protection expenditure.

After extracting these seven hypotheses from the literature, it is possible to develop additional connections between environmental policy and environmental quality. Policies include those measures that can actively be pursued by a government where results can be measured after a short time-period. These would be considered ‘endogenous’ factors, measures policy makers can take to steer the economy towards a ‘green growth’. Environmental taxes are such an example of a endogenous environmental policy. The other factors mentioned above are rather ‘exogenous’.

From a government perspective, it is possible to regulate environmental protection and resource management levels, as presented in the list above. To limit the selection, the most relevant environmental policies for a policy maker relate to waste management, water management, air quality through regulation on emission levels, directives on biodiversity, setting of recycling guidelines or promote renewable energy. From this point of view, it is possible to formulate additional hypotheses:

Hypothesis 8: Higher levels of waste water treatment are positively related to environmental protection expenditure.

Hypothesis 9: Higher levels of waste treatment are positively related to environmental protection expenditure.

Hypothesis 10: The more territory that is officially protected area, the more is invested to protect the environment.

Hypothesis 11: The higher the share of renewable energy in consumption , the higher the levels of environmental protection, as the production of renewable energy requires additional funds.

Hypothesis 12: The reduction of Particulate Matter (PM) emissions per capita are positively related to the amount of environmental protection expenditure

To conclude the section on drawing up hypotheses, 12 hypotheses were developed, 7 from literature and 5 through possible environmental regulations that policy makers can choose to further enhance the protection of the environment.

3. Methodology, data and model

3.1. Model

For a model with 27 countries over 9 years with multiple independent variables, a dated panel set has the best fit and is accordingly configured so. As *Vollebergh et al.*(2009) pointed out, panel sets are especially useful as they allow for the possibility to control at the individual and cross-sectional level and in addition for time controls to take into account unobserved effects. However, caution must be paid to the level of heterogeneity allowed to estimate the equation.

The Ordinary Least Squares (OLS) regression is as follows:

Equation (1) $$y_{EPE,i,t} = \beta_{\mathrm{i}} + \tau_{\mathrm{t}} + VX_{it} + \varepsilon_{it}$$

$$X_i = X_1 \dots X_n$$

y_{EPE} represents dependent variable, Environmental Protection Expenditure per capita, i indexes the countries and t indexed the time effects. V is defined as a vector and X are the different independent variables, β represents the cross-sectional coefficient. The error term is composed of the usual term ε. The fixed effects estimator assumes that the cross-section and time components are fixed intercepts. Thus it is assumed that there is a common time effect and income coefficients in all countries and fixed differences between countries.

Stern (2010) noted that panel data contain two dimensions of variation – the differences between countries – the “between variation” and the differences over time within countries – the “within variation”. The estimation with fixed effects estimation – also known as the “within estimator" – eliminates the average differences between countries prior to estimation. The estimates for the coefficients primarily exploit the variation between the countries and not within. The between estimator first averages the data for each country over time.

The between estimator is also referred to as fixed effects. Thus it is possible to control for unobserved heterogeneity between the countries, when it is assumed that the heterogeneity is constant over time. In this case with 27 EU countries over a rather short period of time, the fixed effects model applies and will be used to give additional explanatory power. The control for time includes special event occurring at a certain point in time or technology changes.

As a means to improve the robustness of the model, three test runs will be completed: The first without any fixed effects, the second with only fixed time effects and the last with both fixed cross-section and fixed time effects. In the end it will show the degree of explanation that a model under different circumstances has, allowing it to account for heterogeneity between cross-sections (countries) and for the mere passage of time.
A fourth test run is included that where the independent variables of the two categories are regressed only as single groups using fixed time effects only. The interpretation of the results should add value to the robustness of the data.

3.2. Dependent variable - Environmental Protection Expenditure

As the aim of the thesis is to examine the determinants for Environmental Protection Expenditure in the EU, a data collection exercise has been completed of this variable for the European Union. The dataset as used in Ernst&Young (2006) and Ecorys (2009) is used as a basis, however larger improvements were made in terms of data completeness and scope of the data to form a novel dataset. To put the absolute figures of EPE for the countries into perspective compared to their population size, EPE was divided by the population size to retrieve per-capita environmental protection expenditure, as also outlined in Table 1.

Collecting data and increasing scope

Data of EPE was primarily collected from the Eurostat database. EPE data for all 14 environmental domains would be considered optimal, however explicit EPE is only available for the environmental domains 1 to 6 and 9. To increase the scope of available data, output values were obtained from the national accounts of all countries regarding Water supply (NACE Code 41 and environmental domain 10) and Recycling (NACE Code 37 and environmental domain 14). Although there might be an overlap in accounting for waste management that partly also includes recycling and purely output measured in monetary terms of recycling processes, both will be included as previously done in Ecorys (2009). Data for other environmental domains is difficult to retrieved and not possible to calculate without making strong assumptions e.g. the forest managing sector.

As renewable energy is a sector that attracts large sums of investments and is booming in the last years, greater efforts were undertaken to estimate the size of this sector as no free, scientific data is available. Previous data was based on absolute values dating back to 1998 (Ecorys, 2009). The calculation of EPE for 'Renewable energy production' was a difficult task, as Eurostat data is only available for supplied renewable energy source (RES) in terms of MW. Therefore, to come to a good estimation, total installed renewable energy capacity per year is being used per country and multiplied this by the average investment costs per megawatt (MW) installed. (Ecofys 2011). The underlying assumption is average investments in renewable energy can be taken as a proxy for EPE in renewable energy. The total installed capacity for the renewable energy sources in MW per year have been retrieved from EuroStat.[9] Using the average investment cost per MW – multiplied by the annual installed capacity - the annual average investment per technology group and EU-27 Member State per year was calculated. Given this methodology, the average investment in renewable energy source technologies stands at €54 billion in 2009, close to the figures provided by The European Renewable Energy Council who put the figure at €70 billion. By further scanning existing literature on this topic, the investment figures for wind energy - €11 billion in 2009 – are the same as those published by the European Wind Energy Association (EWEA, 2011). For photovoltaic the estimation - €25 billion in 2009 – is very close to other estimates, such as Greenpeace: €21 for 2009, (Greenpeace, 2011).

In total the database contains 10 environmental domains over the period 2000-2008 for each of the 27 EU countries analyzed. Overall the data availability is good and presented in more detail in Appendix 1 - Data availability. Information regarding the sources of data for Eurostat is presented in Appendix 4 - Sources of EPE for Eurostat

Data results

Total environmental protection expenditure grew – in nominal terms - from almost EUR 250 billion to EUR 390 billion between 2000 and 2008. Table 5 in Appendix 5 – EPE data depicts the result.. Total figures are higher than in Ecorys (2009) due to better data availability, data completeness and updated data for the early 2000's. Nonetheless, inflation adjusted annual growth decreased from 7% to 3,1% therefore undermining the statement made by Mr. Barroso.

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[9] Data for: Hydro (small, medium and large scale), Solar Photovoltaic, Solar Thermal Electric, Wind, Municipal Waste, Biomass Waste, Tidal, Landfill Gas, Sewage Sludge Gas and Other Biogas (note: Biofuels and Fuels cells have been excluded).

This is due to updated data for the year 2000,[10] which therefore decreased the growth rate during the same period.

As previously stated in the introduction, there are large differences in absolute and relative sizes of the eco-industries between the countries of the European Union: the highest EPE per capita for 2008 is registered in Austria with EUR 1.524 and the smallest with EUR 158 in Greece (Table 8, Figure 5 and Figure 6). Likewise, the annualized growth rates of EPE between 2000 and 2008 differ between 31% for Estonia and a negative growth of -3% for Finland, with an average of 9% over all EU-27. This gives additional motivation to analyze the determinants of this variation. Furthermore, the newly accessed Members States (EU-12) have per capita EPE rates below European average, except Slovenia. Although Ireland and Greece have the lowest per capita rates (mainly due to gaps in the data), is seems that there exists a disparity between 'old' and 'new' EU members.

The largest growth originates in the recycling and renewable energy sector. Although the waste management domain is the largest in terms of expenditure, the growth has been moderate after correcting for inflation. (Table 5 in Appendix 2 – Environmental Domains),

Comparing the annual nominal GDP growth and EPE growth, aggregated for the 27 EU countries in Figure 7, annual growth in EPE fluctuates quite strongly, although also GDP growth experiences a higher degree of fluctuation. Altogether, the nominal annualized growth rate for EPE is 6% and thus two percentage points higher than the nominal annualized GDP growth of 4%. Based on the limited number of highly aggregated observations, it would be premature to draw conclusion between a relation of economic growth (in terms of GDP) and EPE.

3.3. Independent Variables

The aim of the thesis is to examine the determinants of EPE. Furthermore, the goal is to test whether the determinants are *exogenously* defined, such as overall structure of the economy and population, or *endogenously* influenced, relating to environmental policy measures by governments. Can 'green growth', in terms of the size of the eco-industries, mainly be influenced by stronger environmental policy such as emission reduction and increased recycling rates, or are other external factors the main driver? Thus, the independent variables were grouped accordingly.

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[10] Changes are due to updated data provided by Eurostat. It is not certain what the causes for this update compared to data by Ecorys (2009).

Based on the hypotheses developed in section 2, independent variables are created with specific relation to the EU to test these hypotheses. The description and classification of the independent variables can be found Table 1 with the corresponding descriptive statistics in Table 2.

Due to high multicollinearity, the independent variables solid waste management and waste-water treatment were grouped together into one explanatory variable: ‘waste management’. Further checking for multicollinearity between independent variables with a threshold for rejecting or tolerating a correlation of +/- 0,5, the results in

Table 6 in Appendix 3 – Correlation matrix show that industrialization has a high correlation with GDP per capita and population density with urbanization. Therefore these variables were dropped in the following analysis. Although waste management also shows a high correlation with GDP per capita, it remained included.

Table 1 - Overview of variables

		Variable	Code	Measurement	Source	Expected relationship
	C	Environmental protection expenditure	C	EPE per capita (in Euros, nominal)	Eurostat, Ecofys (2011)	
Exogenous – socio-economic properties	1	Income	GDP_cap_ppp	GDP per capita at purchasing power parity (PPP)	Eurostat	positive
	2	Income inequality	Gini	Gini coefficient (0 = total equality, 100 = one man has all the wealth)	Eurostat	negative
	3	(Level of service-economy)	Industrialization	% of GVA produced in service-related sectors (NACE codes rev. 1.1 G – P)	Eurostat	positive
	4	Level of Education	Education	% of people aged 15-64 with a tertiary education degree	Eurostat	positive
	5	(Population density)	Pop_density	Inhabitants per square kilometer	Eurostat	positive
	6	Level of Urbanization	Urbanization	% of population living in areas with more than 100 people per km^2	Eurostat	positive
Endogenous - environmental policy	7	Environmental Taxes	Env_tax	% of total tax revenue from the levying of pollution/resources	Eurostat	positive
	8	Waste management	Wastemgmt	(% of urban wastewater treated + % of waste generated that is either incinerated or recycled) ÷2	Eurostat	positive
	9	Protected area	Protarea	% of total terrestrial area protected under Natura 2000	Eurostat	Positive
	10	Renewable energy	Renewable	% of inland consumption of energy from renewable resources	Eurostat	positive
	11	Particulate Matter	PMcap	Kg of PM10 (particles measuring 10µm or less) emissions per capita	Eurostat	negative

Table 2 - Descriptive statistics

	Mean	*Standard Deviation*	*Minimum*	*Maximum*
EPEcap	509	376	49	1.792
GDP_cap_PPP	21.140	10.143	5.000	70.000
Gini	29,01	4,16	22,00	39,20
Industrialization	0,69	0,07	0,50	0,85
Education	0,12	0,04	0,03	0,23
PopDensity	119	91.647	395	1.203
Urbanization	0,64	0,19	0,31	1,00
Env_taxes	0,45	0,55	0,01	3,65
WasteMGMT	0,80	0,11	0,51	0,98
ProtArea	0,13	0,06	0,04	0,31
Renewable	0,15	0,16	0	0,72
PMcap	48,24	17,34	24,32	97,00

4. Results

The aim of the research is to examine what factors determine the magnitude in variation of EPE between countries. Therefore, by observing what explanatory variables have a significant effect and also the sign of these effects, we can establish a conclusion to answer the research question.

The results of the standard linear regression without any effects as well as the OLS of equation (1) including fixed time and fixed cross-section effects are presented in Table 3. Furthermore, the outcome of the Wald test to test the hypothesis that all variables are jointly significant is available at the bottom of the table.

Table 3 - Results from OLS

		Model 1: No effects		Model 2: Fixed time Effects		Model 3: Fixed cross-section and time effects		Model 4: Divided categories	
	C	-390,49		-342,68		547,06		6,03	
		(174,61)		(177,4)		(324,5)		(177,4)	
exogenous - socio-economic properties	GDP_CAP_PPP	0,01	**	0,00	**	-0,00		0,01	***
		(0)		(0)		(0)		(0)	
	GINI	-21,96	***	-23,76	***	-8,85	**	-2,78	***
		(3,52)		(3,6)		(4,2)		(3,6)	
	EDUCATION	918,59	**	729,52	*	-894,72		3,58	
		(375,3)		(389,7)		(679,7)		(389,7)	
	URBANIZATION	966,47	***	977,59	***	-44,37		6,30	***
		(92,4)		(93,1)		(306,2)		(93,1)	
endogenous - environmental policy	ENV_TAXES	86,05	***	83,38	***	-27,90		1,72	***
		(26,4)		(26,6)		(36,2)		(26,6)	
	WASTEMGMT	712,12	***	736,08	***	511,13	***	1,46	***
		(162,9)		(164,4)		(188,1)		(164,4)	
	PROTAREA	717,10	***	607,43	**	464,51		4,99	
		(254,9)		(261,4)		(959,8)		(261,4)	
	RENEWABLE	724,49	***	739,22	***	-485,62	**	1,36	
		(110,6)		(111,7)		(223,1)		(111,7)	
	PMCAP	-2,56	**	-1,92	*	0,12		-,89	***
		(1)		(1)		(1,7)		(1)	
	R^2	0,69		0,7		0,95		0,51 / 0,38	
	Wald test (proability)	<0,00		<0,00		>0,65			

**** = Significant at the 1% level; ** = 5% level; * = 10% level; standard error In parentheses*

The first column shows the results of the standard least square regression without any effects. The coefficients for Gini, urbanization, environmental taxes, waste management, protected area and renewable energy are significant at the 1% level, the remaining variables GDP per capita, education and PM per capita are still significant at the 5% level. Furthermore, the results are quite strong and a R^2 of 0,69 for the model implies that around 69% in the variation can be explained through these nine variables. The standard errors are very high for education, urbanization levels, protected area, environmental taxes and renewable energy, this may be due to the high differences in those levels that the countries experience.

Hypothesis fit with the results with no effects

Socio-Economic factors

The coefficient for GDP per capita is significant at the 1% level, however the coefficient is very small (=0.005). Nonetheless, this confirms the expectations made by hypothesis 1, wealthier countries tend to invest more in the protection of the environment compared to less wealthier countries. However, the results of this analysis show that it is not the most determining factor in the magnitude of the variation.

The results further show that it could depend on how the money is spent, rather than how much output per capita is generated. The Gini coefficient, or the extent of income inequality is significant at the 1% level (P<0,0000) and the coefficient has a negative correlation, as also is expected from the hypothesis. This leads to the conclusion that the 3rd hypotheses cannot be rejected and a lower income inequality in a country has a positive effect on environmental protection expenditure. The 'poorer' majority of the population may have the priority to first recover lost ground in terms of materialistic values and think of post-materialistic values, such as the environment in second or even later place.

The percentage of population with a completed tertiary education is positively correlated with EPE at a 5% level. Investing in education can be viewed as a complementary or even alternative way to direct government intervention and leads. Therefore the assumptions from hypothesis 4 also apply to this model.

A further significant correlation at the 1% level can be found with the levels of urbanization within a country. As the variable for population density is correlated with urbanization, we can expect the same results running the test with this variable. As more people are located on the same piece of land, the Earth, has less space to regenerate itself. Thus pollution identified by a greater number of people and more is invested to remedy this situation. Hence, hypothesis 6 can be confirmed from these results

The previous four results are also in line with the results achieved by Duroy (2005); economic affluence has only a marginal direct influence, however the degree of urbanization and the level of income equality do have effects on environmental awareness and education and population pressure have positive correlation with environmental behaviour. Although Duroy's study is based on empirical and subjective data, these findings match the results found on macroeconomic level.

Environmental Policy

According to the result, the higher the levies on pollution and resources the more investments are made for environmental protection. The variable for environmental taxes is significant at the 1% level and confirms hypothesis 7. Through higher taxes, entities are nudged to invest in cleaner technology and similar activities. This shift leads to an increase in turnover for environmental goods and services and thus the positive link is confirmed from a logical standpoint.

The combined variable for waste management is significant at the 1% level (P<0,0000) and leaves no room to dismiss hypotheses 8 and 9. The more a country does to improve the levels of solid waste and waste water properly disposed, cleaned and/or recycled, the higher magnitude in investments on environmental protection expenditure.

Officially protected area for biodiversity and natural habitat preservations under the Natura 2000 network is expressed with the variable protected area and also shows a positive correlation with environmental protection expenditure. This confirms hypothesis 10 and the results can be logically reasoned, as more land officially under protection needs more resources activities to preserve that current situation

Moreover, while the energy consumed by almost all EU countries increased in the last decade, the percentage of energy consumed from renewable resources increased as well. The investments made in renewable energy sources leads to a rise in environmental protection expenditure. Therefore the positive and significant correlation at the 1% levels results in the confirmation of hypothesis 11.

Lastly, in the last decade many efforts have been undertaken by European countries to decrease the level of Particulate Matter (PM) emissions within a country. Consumers can face these measures through maximum-speed reductions on highways through neighborhood areas and banning of highly polluting vehicles from the city centre. Logically, producers react and develop products that emit less PM and this reduction is significantly and positively (conversely, higher PM levels negatively) related to EPE. Therefore, also hypothesis 12 cannot be rejected.

Fixed time effects

Following the interpretation of the results of the least square estimation without any effects, the results of OLS with fixed time effects are also presented in Table 3. Overall, the results did not alternate with respect to the sign of the correlation, although the size of the coefficients changed but within reasonable boundaries. The level of significance for education has dropped to a 5% level and PM10 per capita and education are now only significant at a 10% level. Correcting for the unobserved heterogeneity between time periods, the proportion of variability of the depended variable that is accounted for by this increases by 0,01 to an R^2 of 0,7. This low additional explanatory power may be due to the relatively small time scale for this data, nine years. The analysis regarding the expectations of the hypotheses are the same as the analysis done in the paragraphs above with no effects. The conclusion lie at hand that the inclusion of fixed time effects does not add great explanatory power to the model, however the results should be considered as more reliable due to improved R^2.

Answers to the main research question

Returning back to the main research question and the sub-question whether green growth can actually actively be pursued through environmental policies of a country or does it depend on socio-economic factors. To resolve what factors are determinant for environmental protection expenditure, the results indicate that actually all variables chosen are significant to explain jointly 69% -70% of the variation of EPE. Although interpreting a mixed result would be more interesting, the variables were carefully chosen and a connection was already expected from the literature review. Therefore a full range of significant variables may be surprising, but not unexpected.

As a means to improve the robustness, the results of the OLS with fixed time effects for each of the two grouped categories are presented by model 4. This allows to control for interaction between the variables of the two categories. This first observation shows that the coefficients of the independent variables have decreases in absolute size, likely due to the smaller data set and less interaction between independent variables. As was expected, the signs of the coefficient did not change, however the significance of the variables for education, protected area and renewable energy decreased to a level below 90%. Education and protected area previously already had lower levels of significance; however the non-significance of renewable energy is a bit surprising.

Lastly, to test whether green growth can actively be pursued by endogenous policy decisions, the models (2) and (4) yield is interesting results. As all explanatory variables from the exogenous category are significant, as well as those variables relating to endogenous environmental policy, a reasonable answer therefore should be: 'Yes, but'. Yes, more stringent environmental policy leads to higher expenditures for environmental protection, but good socio-economic are the basis for a country to fully exploit the outcomes of environmental policy. An unequal society will probably shoulder stricter taxes on resources or pollutants at a lower level than an equal society and a higher educated population will support to a greater extent renewable energy policies.

Results with full fixed effects

Next, the results of the regression model including both fixed time and period effects are presented in the last column of Table 3. Allowing for heterogeneity between the countries changes the outcome of the model greatly. Now the regression estimates the pure effects of the relationship between the predictor and dependent variable within a country as it fixes the country specific effects to estimated cross-section coefficient.

Because of these properties of the fixed effects, a range of variables previously significant, now lose their explanatory power. This is not very surprising as a constant for the cross-section coefficient is added in each regression which removes a great deal of the characteristic of the independent variable, leaving the net effect of the variable.

However, it is rather unexpected that the signs of the variables change for all but three variables (Gini, waste management and protected area). There could be a number of reasons why this change in sign may have occurred. An omitted variable that has a positive effect on EPE per capita, but is negatively related to e.g. renewable energy could have been the reason for the sign change. As the full effects adds both time variable and cross-sectional dummies, a model with a higher number of these variables may experience multicollinerarity, with sign changes as a result. However, testing the independent variables individually yields the same signs. High variance of the variables may be the cause, however, observing the standard errors of the variables show that both variables with high and low standard error terms change their sign. Another possibility could be outliers that skew the mean relationship between the variables, but also here, after analyzing the raw data there is little evidence that outliers are the cause of the sign change. Moreover, the variables have been tested individually with EPE per capita and the sign relation did not change. Therefore, two possible conclusions lie at hand: first, the results of the fixed effects regression are actually correct and the signs are false for the without-effects regressions or second, there is a flaw in the data or model specification and further analysis needs to investigate possible improvements.

As the Wald test for the full-fixed effects model is non-significant, meaning that the hypothesis that all variables are jointly significant needs to be rejected, it is assumed that second of the two options valid. The results retrieved from the full-fixed effects regression are flawed and further analysis needs to be made in the model specification. Further interpretation of the results is will thus not be continued, although not entirely disregarded for future research. Conclusions that can be drawn from the results are thus narrowed down to model specifications without effects or only fixed time effects, as described above.

5. Conclusion

This thesis has examined the determinants of environmental protection expenditure within the European Union. Based on the results of a balanced panel of the 27 EU countries between 2000 and 2008, both exogenous and endogenous factors consisting of nine determinant variables were found to impact the variation of per capita environmental protection expenditure within the EU.

A distinction between the different explanatory variables has been made in exogenous socio-economic conditions within a country and endogenous environmental policy measures. The socio-economic/exogenous category includes the explanatory variables GDP per capita, income inequality, education levels and urbanization levels. Environmental policy / endogenous measures consist of tax levels on pollutants and resources, the percentage of energy consumed from renewable sources, waste management performance, protected area for biodiversity purposes and the decrease in particulate matter emissions.

Utilizing the determinants for growth of the eco-industries, it was empirically tested whether 'green growth' can actively be pursued by endogenous government regulations. The result is a 'Yes, but'. Yes, more stringent environmental policy leads to higher expenditures for environmental protection, but good socio-economic conditions are the basis for a country to fully exploit the outcomes of environmental policy. Both categories are equally important to explain the variation of levels for environmental protection expenditure on a per capita basis in the European Union.

The findings are in accordance with relevant economic literature consulted between the links of economic growth and environmental quality. Although GDP per capita at purchasing power parity is a significant variable, the coefficient is marginally relevant and the conclusion lies at hand that it rather depends on how money is invested within a country, such as income inequality reduction and investments in education, compared to absolute amounts in wealth. Furthermore, through choosing more stringent environment policies for waste-, air-, biodiversity- and natural resources management, governments can influence the magnitude of their environmental protection expenditure, thereby contributing to the growth of eco-industries and thus overall green growth.

In summary, this thesis has shown that to maximize green growth in the European Union, a combination of exogenous and endogenous factors are both essential parameters to ensure success.

6. Limitations and possibilities for further research

In specific, gaps in data for EPE for certain countries need to be further investigated to reduce variation. Alternative methods to estimate the size of the eco-industry should be compared to the methodology presented in this thesis to further improve upon data gathering exercises. Furthermore, independent variables should be alternated and different measurement bases testes to introduce a set of explanatory variables with a greater robustness.

In principle the panel dataset used, as well as the independent variables chosen and statistical methods applied are correct, however, the results are limited due to the change of sign effect that appeared for the least square regression applying full fixed effects. Individual components of the data, methodology and statistical foundation need to be scrutinized to improve the robustness of the outcome. Accounting for heterogeneity between countries will greatly add to the robustness of the results.

Furthermore, it would be interesting to compare data between the EU and countries with a lower development index. On a global comparison, the EU countries are probably performing comparatively well in terms of eco-industries and conclusions drawn from the limited data sample may not yielded for global conclusions. However, access to good global environmental quality data, let alone environmental protections expenditure data is difficult and often filled with missing figures.

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8. Appendix

8.1. Appendix 1 - Data availability

For some countries data for entire environmental domains were missing as can be seen from Table 4. It is not clear whether the activities were not measured or incorporated into other environmental domains by the national agencies. Blank environmental domains were therefore left empty. Although Estonia, Ireland and Greece have 5-6 empty environmental domains, the 4 remaining domains account for the majority in EPE. To increase the robustness, extrapolation took place for missing values within environmental domains for certain years applying an annualized growth rate of the previous years and interpolated gaps between two years by taking the average of the preceding and succeeding year.

Table 4 - Data availability for EPE

Data availability	Air	Waste water	Waste	Soil	Noise	Biodiv ersity	Others	Recycli ng	Water supply	Rene wable
Belgium	V	V	V	V	x	V	V	V	V	V
Bulgaria	V	V	V	V	V	V	V	V	V	V
Czech Republic	V	V	V	V	V	V	V	V	V	V
Denmark	V	V	V	V	V	V	V	V	V	V
Germany	V	V	V	x	V	x	x	V	V	V
Estonia	V	x	V	x	x	x	x	V	V	V
Ireland	x	x	V	x	x	x	x	V	V	V
Greece	x	x	V	x	x	x	x	V	V	V
Spain	V	V	V	V	V	V	V	V	V	V
France	V	V	V	V	V	V	V	V	V	V
Italy	V	V	V	x	x	x	V	V	V	V
Cyprus	V	V	V	V	V	x	V	V	V	V
Latvia	V	V	V	V	x	V	V	V	V	V
Lithuania	V	V	V	V	V	V	V	V	V	V
Luxembourg	V	V	V	x	V	V	V	V	V	V
Hungary	V	V	V	V	x	V	V	V	V	V
Malta	V	V	V	x	V	V	V	V	V	V
Netherlands	V	V	V	V	V	V	V	V	V	V
Austria	V	V	V	V	V	V	V	V	V	V
Poland	V	V	V	V	V	V	V	V	V	V
Portugal	V	V	V	V	V	V	V	V	V	V
Romania	V	V	V	V	V	V	V	V	V	V
Slovenia	V	V	V	V	V	V	V	V	V	V
Slovakia	V	V	V	V	V	V	V	V	V	V
Finland	V	V	V	V	V	V	V	V	V	V
Sweden	V	V	V	X	x	V	V	V	V	V
United Kingdom	V	V	V	V	V	V	V	V	V	V

not available

own calculations and estimations

Trend/data	Reliable data	Unreliable data
Upward trend	A linear annual growth rate was calculated using the first and last available data point of the last 5 years. With this growth rate the data was extrapolated. For intrapolation, if one year was missing, the average of the previous and following datapoint were used. For larger gaps, a linear annual growth rate was calculated using the previous and the following datapoint.	A linear annual growth rate was calculated using 2 reliable (often highest or last) data points. With this growth rate the data was extra- and/or intrapolated
No or downward trend	Average of all years/sectors were taken to fill the gaps	Average from only reliable (often highest or last) data points were taken to fill the gaps

8.2. Appendix 2 – Environmental Domains

Table 5 - Environmental Protection Expenditure in EU-27 between 2000 - 2008 in billion EUR

Env Domain / Year	*2000 (in billion EUR)*	*2008 (in billion EUR*	*annualized growth (nominal)*	*Inflation adjusted*
Air	15	19	3,1%	*0,5%*
Wastewater	48	62	3,1%	*0,5%*
Waste	85	117	4,1%	*1,5%*
Soil & groundwater	4	6	6,7%	*4,0%*
Noise	1,3	1,5	1,3%	*-1,3%*
Biodivesity and Landscape	4	8	7,2%	*4,5%*
Other	20	34	6,8%	*4,1%*
Water supply	39	55	4,4%	*1,7%*
Recycle	20	49	12,2%	*9,4%*
Renewable	12	38	15,6%	*12,7%*
Total	248	389	5,8%	*3,1%*

8.3. Appendix 3 – Correlation matrix

Table 6- Correlation Matrix of independent variables

	GDP_cap-PPP	*Gini*	*Industriali-zation*	*Edu-cation*	*PopDensity*	*Urbani-zation*	*Env-taxes*	*Waste-MGMT*	*Prot-Area*	*Renew-able*	*PMcap*
GDP_cap_PPP	1,00										
Gini	0,26-	1,00									
Industrialization	0,57	0,08	1,00								
Education	0,39	-0,05	0,32	1,00							
PopDensity	0,36	0,08-	0,29	0,11	1,00						
Urbanization	0,43	0,03-	0,54	0,05	0,66	1,00					
env_taxes	0,07	0,14-	0,18	0,22	0,27	0,14	1,00				
WasteMGMT	0,59	0,07-	0,36	0,32	0,18	0,16	0,04-	1,00			
protArea	0,14-	0,04-	0,26-	0,12-	0,25-	0,29-	0,16-	0,15-	1,00		
renewable	0,01	0,13-	0,12-	0,09-	0,28-	0,38-	0,05-	0,25	0,14	1,00	
PMcap	0,22-	0,09	0,09-	0,08	0,38-	0,15-	0,00-	0,32-	0,38	0,36-	1,00

8.4. Appendix 4 - Sources of EPE for Eurostat

National statistical agencies are responsible for the data collection of environmental protection expenditure. These agencies have developed varying methodologies to account all EPE. While interpreting the data for single countries, this fact should not be disregarded. Eurostat provides guidelines as to the methodology of data collection, of which the above descriptions in section 2 are a (very) short extract, to streamline the 27 national statistical bodies. Data are collected every year in some countries and every other year in other countries. An analysis to outline the different methods is a topic for itself and the data collection handbook by Eurostat (2009) gives more detail. For example, the Netherlands first identifies companies if they belong to an environmental business association or are mentioned in the group environment in the 'Yellow Pages'. Sweden on the other hand, has built a database containing more than roughly 10.000 EGS companies.

8.5. Appendix 5 – EPE data

Table 7 Environmental Protection Expenditure in the EU – 2000 – 2008 – in thousand Euros (nominal)

Total	2000	2001	2002	2003	2004	2005	2006	2007	2008	annualized growth (nominal)
Belgium	8.069.438	8.991.372	9.785.640	10.122.956	10.447.023	11.339.721	12.283.946	12.863.185	14.765.661	*7,8%*
Bulgaria	559.584	645.725	1.148.032	1.997.519	1.582.663	856.221	1.145.030	1.428.614	1.762.155	*15,4%*
Czech Rep	1.511.322	1.748.199	2.159.694	2.915.848	3.149.456	3.163.979	4.505.354	5.105.150	5.917.091	*18,6%*
Denmark	5.015.181	4.503.224	5.175.453	4.830.545	4.982.232	4.939.609	4.693.990	5.202.417	6.533.992	*3,4%*
Germany	52.326.008	53.437.413	53.133.400	54.532.085	56.259.730	55.654.615	62.197.010	60.444.055	64.964.031	*2,7%*
Estonia	89.236	110.019	174.786	164.599	266.720	353.379	470.792	490.829	782.177	*31,2%*
Ireland	463.824	418.785	437.925	596.050	620.945	674.725	852.450	662.392	780.338	*6,7%*
Greece	879.325	937.850	975.025	1.246.838	1.445.863	1.413.475	1.784.650	1.777.025	1.767.125	*9,1%*
Spain	17.635.383	21.611.027	31.102.223	25.712.735	29.773.238	31.801.006	36.073.550	43.431.055	52.980.213	*14,7%*
France	47.534.383	50.257.367	54.761.269	60.416.095	59.705.281	63.287.180	68.987.060	71.304.588	75.779.847	*6,0%*
Italy	47.136.068	56.437.698	55.928.487	52.821.256	57.540.835	59.136.525	61.548.781	64.895.431	70.283.244	*5,1%*
Cyprus	85.095	103.625	133.241	224.318	253.529	263.608	333.657	336.214	364.376	*19,9%*
Latvia	138.242	196.476	239.976	210.867	206.809	207.426	305.695	388.173	440.674	*15,6%*
Lithuania	293.092	327.370	352.187	374.635	475.713	552.454	896.845	736.642	772.666	*12,9%*
Luxembourg	296.167	335.380	327.825	387.832	414.160	383.064	412.130	436.412	493.068	*6,6%*
Hungary	1.767.115	2.003.394	2.270.895	2.245.553	3.126.557	3.384.853	3.114.177	3.209.401	3.232.460	*7,8%*
Malta	79.123	85.026	86.331	113.127	124.814	129.603	128.593	135.526	152.954	*8,6%*
Netherlands	16.302.188	18.600.651	16.188.801	16.626.032	16.898.298	17.381.226	18.261.890	19.675.941	20.548.130	*2,9%*
Austria	7.937.867	8.382.898	8.836.512	11.834.232	9.564.729	9.781.402	11.798.771	14.843.741	12.674.779	*6,0%*
Poland	5.482.466	6.188.437	7.057.156	6.819.977	8.389.864	8.639.289	9.579.697	11.139.985	12.121.852	*10,4%*
Portugal	2.178.786	2.315.382	2.490.566	2.423.079	3.686.668	3.556.245	3.969.234	4.280.915	4.370.947	*9,1%*
Romania	1.677.621	1.089.502	2.102.082	1.128.755	1.971.750	2.169.160	3.280.160	4.053.694	4.804.886	*14,1%*
Slovenia	990.372	903.210	989.736	1.098.117	1.058.995	1.153.936	1.319.197	1.499.200	1.700.597	*7,0%*
Slovakia	722.455	4.300.710	850.863	781.281	962.986	1.044.719	1.841.642	1.560.469	1.567.958	*10,2%*
Finland	2.841.453	2.465.280	2.259.278	2.479.448	2.518.448	2.504.500	2.790.213	2.311.153	2.259.794	*-2,8%*
Sweden	3.311.872	5.128.978	3.644.835	3.898.419	5.485.228	6.840.515	8.346.337	5.616.384	4.844.900	*4,9%*
UK	22.551.119	23.558.094	20.555.815	21.964.583	22.461.462	17.440.248	18.399.388	21.177.624	22.154.239	*-0,2%*
Total	247.874.785	275.083.092	283.168.030	287.966.780	303.373.995	308.052.682	339.320.240	359.006.214	388.820.151	*5,8%*

Table 8 Environmental Protection Expenditure per capita in the EU-- 2000 – 2008 – in Euros (nominal)

Total	2000	2001	2002	2003	2004	2005	2006	2007	2008	annualized growth
Belgium	788	876	949	978	1.005	1.086	1.169	1.215	1.384	*7,3%*
Bulgaria	68	79	145	255	203	110	148	186	231	*16,4%*
Czech Rep	147	170	212	286	308	310	440	496	570	*18,5%*
Denmark	941	842	964	897	923	913	865	955	1.193	*3,0%*
Germany	637	650	645	661	682	675	754	734	790	*2,7%*
Estonia	65	80	128	121	197	262	350	366	583	*31,6%*
Ireland	123	109	112	150	154	164	203	154	177	*4,7%*
Greece	81	86	89	113	131	128	160	159	158	*8,7%*
Spain	440	534	759	617	703	739	824	977	1.170	*13,0%*
France	785	824	892	977	958	1.008	1.091	1.120	1.184	*5,3%*
Italy	828	991	981	921	994	1.012	1.048	1.097	1.179	*4,5%*
Cyprus	123	149	189	314	347	352	435	432	462	*18,0%*
Latvia	58	83	102	90	89	90	133	170	194	*16,3%*
Lithuania	83	94	101	108	138	161	264	218	230	*13,5%*
Luxembourg	683	764	738	865	910	831	879	916	1.019	*5,1%*
Hungary	173	196	223	221	309	335	309	319	322	*8,1%*
Malta	208	217	219	285	312	322	318	332	373	*7,6%*
Netherlands	1.028	1.163	1.005	1.027	1.039	1.066	1.118	1.203	1.253	*2,5%*
Austria	992	1.045	1.096	1.461	1.175	1.193	1.429	1.792	1.524	*5,5%*
Poland	142	162	185	178	220	226	251	292	318	*10,6%*
Portugal	214	226	241	233	352	338	376	404	412	*8,5%*
Romania	75	49	96	52	91	100	152	188	223	*14,7%*
Slovenia	498	454	496	550	530	578	658	746	846	*6,8%*
Slovakia	134	800	158	145	179	194	342	289	290	*10,2%*
Finland	549	476	435	476	482	478	531	438	426	*-3,1%*
Sweden	374	577	409	436	611	759	922	616	528	*4,4%*
UK	384	399	347	370	376	290	305	348	362	*-0,7%*
Average	393	448	441	474	497	508	573	599	644	*6,4%*

Figure 3 – Environmental Protection Expenditure EU-15 – 2000 – 2008 – in thousand Euros (nominal)

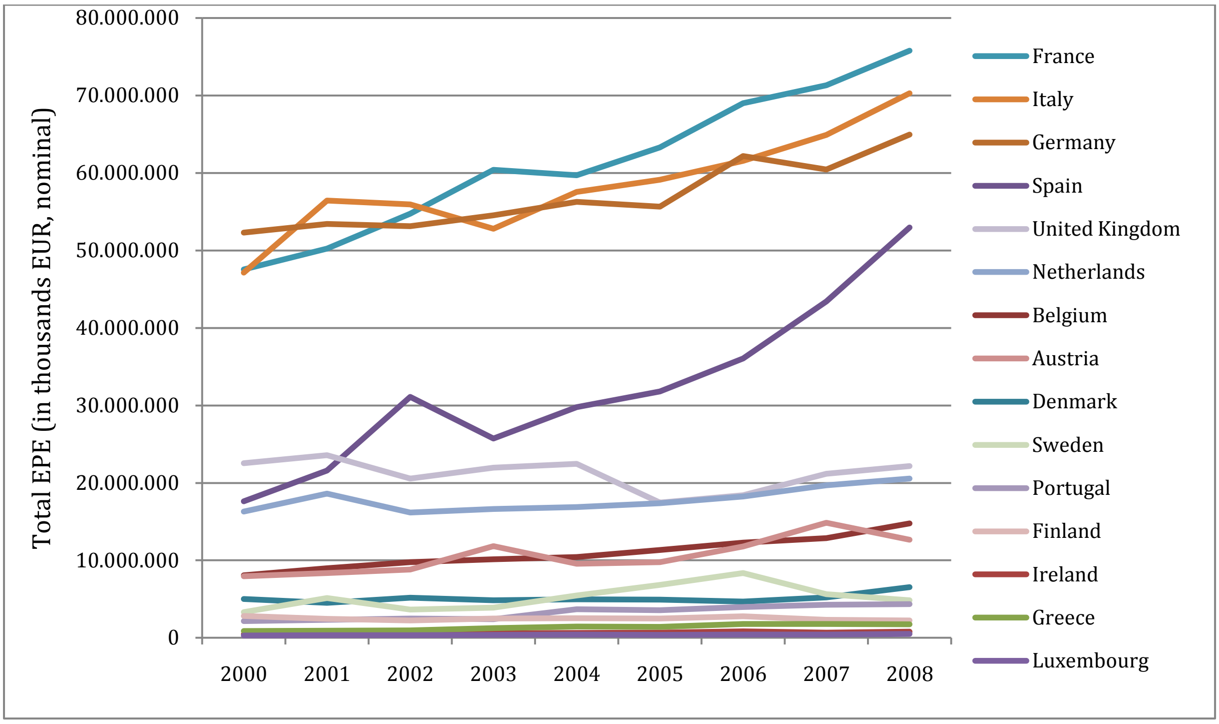

Figure 4 - Environmental Protection Expenditure EU-12 – 2000 – 2008 – in thousand Euros (nominal)

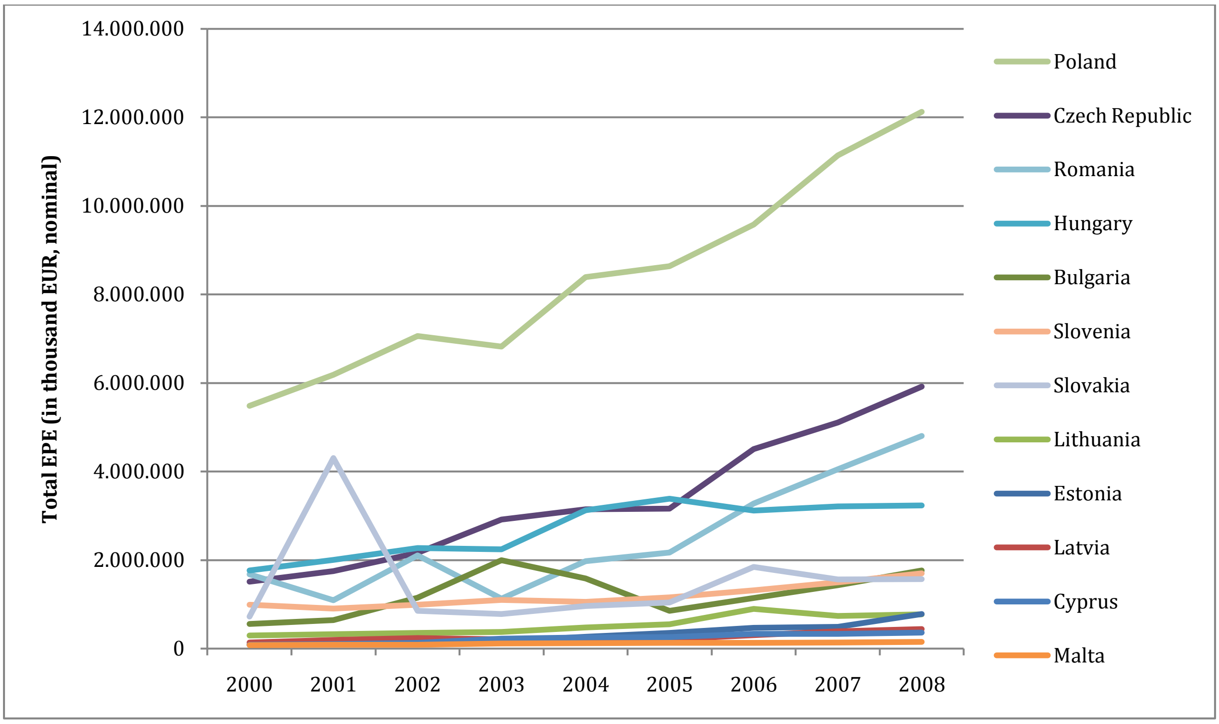

Figure 5 - EPE per capita - EU-15

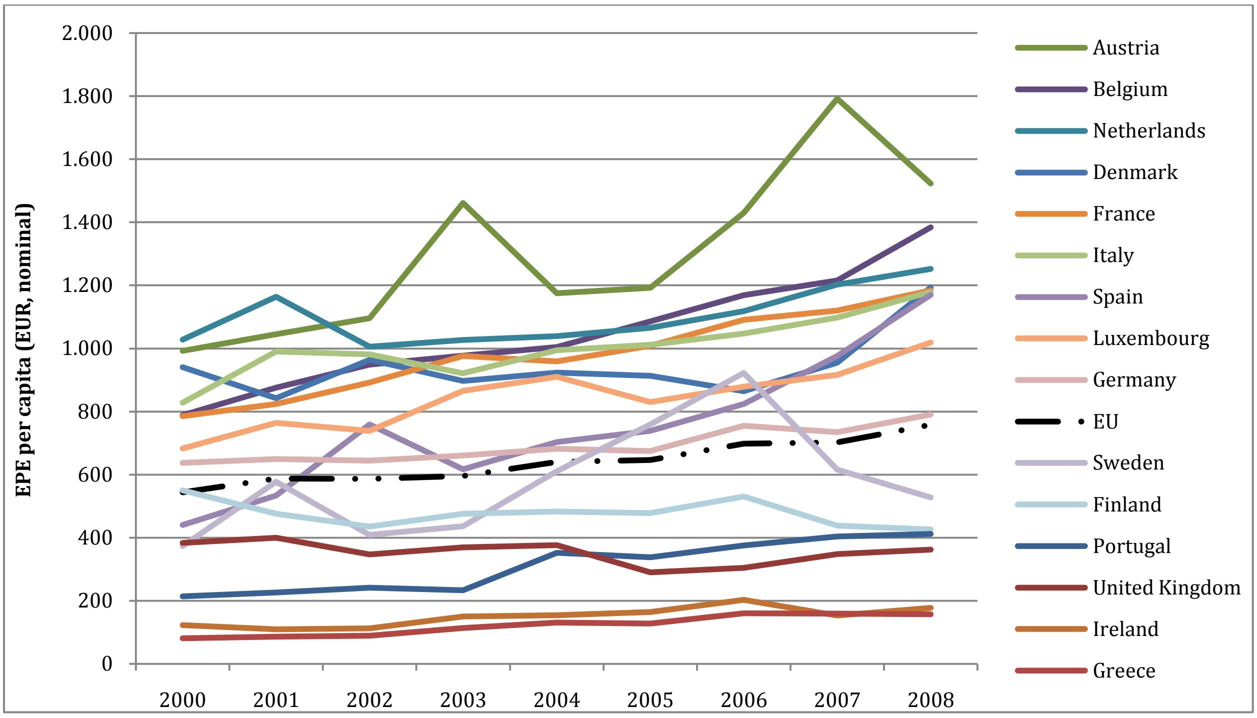

Figure 6 - EPE per capita - EU-12

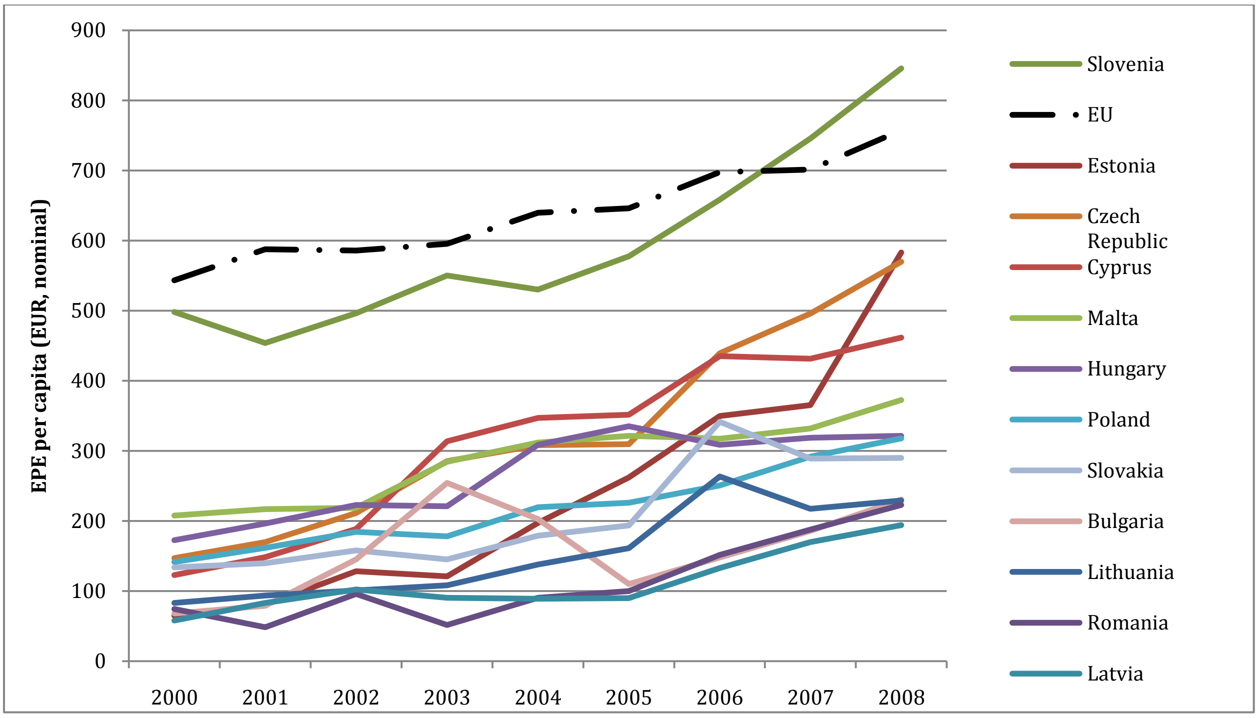

Figure 7 - Annual growth of GDP and EPE for the European Union