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DO ENVIRONMENTAL TAXES PAY OFF? THE IMPACT OF ENERGY AND TRANSPORT TAXES ON CO2 EMISSIONS IN TRANSITION ECONOMIES

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Abstract

In this paper we investigate the impact of environmental taxes on CO2 emissions in the context of emerging market economies. An attempt has been made to identify what role environmental policy and specific tax policy measures play in understanding the relationship between economic development and environmental degradation. The empirical analysis covers ten Central and Eastern European countries in the period from 1995 to 2015. The latest data on environmental taxes are available only from 1995. We contribute to recent literature in two respects. First, we study this relationship within a dynamic framework in which we take into account the issues of serial correlation and endogeneity in the regressors due to the cointegration relationship. Specifically, we rely on the fully-modified least squares (FM-OLS) estimation technique to model the long-term relationship between income and carbon-dioxide emissions. Second, this paper advances our understanding on the effectiveness of tax policy measures in curbing CO2 emissions, on which we have scarce empirical evidence. The results of this analysis provide rather strong evidence in support of an inverted U-shaped relationship between economic growth and the environment. However, environmental taxes do not seem to be effective in modifying the behaviour of economic agents and in protecting the environment. The results are robust to different models.

Key words: *Environmental Kuznets Curve (EKC) Hypothesis, environmental policy, pollution, CO2 emissions, transition countries*

1. INTRODUCTION

The relationship between economic growth and the environment presents one of the critical questions prominent in today's policy debate. The conventional Environmental Kuznets Curve Hypothesis (EKC) is often used to explain the relationship. The EKC hypothesis implies the existence of the so called inverted-U relationship between economic development and environmental degradation. According to this phenomena, observed in number of early EKC studies (Grossman and Kreuger 1995, De Bruyn et al. 1998), the environment deteriorated in the phases of progressive growth following the structural transformation of the economy and industrialisation, up until

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a certain point (usually referred to as the threshold income level) that is then followed by a subsequent phase of improvement in environmental quality. The reverse influence is often associated with the so-called *technological effect* and the *composition effect* (see, for instance, Panayotou, 1993), which are considered the major driving forces explaining the downward slope of the inverted-U shape relationship. The technological effect reveals improvements in environmental quality following the introduction of more environmentally friendly technologies. Improvements in production efficiency and productivity reveal innovations that often result in lower pollution intensities, as well as the more efficient use of energy or input mix. The composition effect implies simply that the changes in the structure of the economy are associated with the growing importance of the service sector as an engine of growth. The structural changes of the economy are also linked with favourable changes in the structure and composition of demand in the wake of increasing consumer awareness of environmental issues (Ekins 2000).

Thus far, more recent empirical evidence fails to comply with the existence of an inverted-U relationship, thus casting serious doubts on the robustness of earlier findings (see for instance Stern 2004, Ekins 2000, Harbaugh et al. 2002, Borghesi 2000) and the suggested merits of technological and composition effects. In the wake of this scepticism, the importance of reconsidering the so-called *scale effect*, according to which economic activity is always environmentally damaging as increases in production and consumption imply intensified use of environmental resources, comes to the fore. Likewise, the role played by environmental regulation has gained increased attention among academic scholars and policy makers. In view of intensified efforts to protect the environment, and in particular to curb CO2 emissions globally, the question of how effective environmental policy has been in safeguarding the environment has become prominent in policy discourse.

In short, the *policy effect* (see for instance Yandle et al. 2004) has been considered an important factor that may influence the relationship between economic growth and the environment.

In view of inconsistent empirical evidence on the income-environment relationship, countries have put increasing efforts to regulate the environment and restrict pollution emissions. How effective these policy efforts have been is the principal question investigated by this empirical study. In particular, we explore whether environmental taxes have been associated with decreases in CO2 emissions in the context of transition economies. The literature often points to the adverse effect of environmental taxes on industry's competitiveness, suggesting that taxes bear significant economic costs (Hendersone 1996: 2000, Greenstone 2002, Walker 2012, Silajdzic & Mehic 2015).[1] The commonly accepted principle that prices should incorporate the full cost of environmental damage is often used to justify the imposition of higher and diverse environmental tax rates. Following increases in the overall tax burden imposed on companies operating within the EU market, it is worthwhile considering the effectiveness of these rigorous policy measures.

This said, comprehending the role played by environmental policy in safeguarding the environment requires a deeper understanding of the relationship between economic growth and the environment. In this paper, we look at how income is related to environmental quality, while also taking into account the policy effect. An attempt is made to investigate the impact of specific tax policy measures on CO2 emissions in transition economies. We analyse the existence of the Environmental Kuznetz Curve (EKC) hypothesis in the context of ten Central and Eastern European countries (CEECs) i.e. Czech Republic, Slovenia, Slovakia, Poland, Hungary, Estonia, Latvia, Lithuania, Romania, and Bulgaria.

We find rather strong evidence supporting the EKC hypothesis. The obtained results, indicate that continued economic growth provides for better environmental quality (EKC), while environmental taxes do not seem to be effective in curbing CO2 emissions in transition economies. The results of this study have profound policy implications that should be considered in the context of an international environmental policy agenda.

Overall, the critical question investigated in this paper is that of the policy effect on CO2 emission among new EU member states. Why and how these economies are different, and what purpose the analysis of policy effectiveness in this specific set of countries serves, seem important questions. Here, we emphasise that these countries embarked on the course of institutional and policy reform along the transition path and their integration into the EU. That is to say, these countries followed similar policies in an attempt to develop institutional structures compatible with EU membership. Notwithstanding this, the institutional and market related differences between the CEECs and the old EU member states still prevail (Pochencuk 2016, Rapacki and Prochniak 2009). It is important to

1 Indeed, a number of studies have suggested the benefits of cleaner air regulation in line with the so-called Porteer hypothesis (see for instance Deschenes et al. (2012); Lleras-Muney (2010).

acknowledge those differences for at least two reasons. First, differences in institutional capabilities across EU member states may result in low-carbon policy initiatives at the EU level that are incompatible with the existing institutional setting of the new EU member states. It seems reasonable to assume that differences in government capabilities across the two groups of EU member countries may curb policy effectiveness. Second, some specific policy measures proposed, including tax initiatives, may be ill-suited for countries that are at a lower level of economic development, and supposedly lower level of technological sophistication. Put differently, while tax-related policy initiatives may be effective in modifying the behaviour of economic agents in well-developed EU market economies, they could fail to properly address the environmental issues of CEE economies given their specific (underdeveloped) market and industrial structures (on the prevailing differences related to industrial and market structures (see for instance Labaj et al. 2018). In view of these differences, the responsiveness of economic agents to similar policy initiatives across EU countries may vary.

The reminder of the paper is structured as follows. First, we explore past empirical literature examining the relationship between income and the environment, and highlight the scarce empirical evidence investigating the effectiveness of environmental policy. In section three, we explain the model and econometric approach to investigating the EKC hypothesis. We embark from earlier studies in that we employ a dynamic econometric framework to account for the potential problems of endogeneity, serial correlation and cross sectional dependence in the data. Discussions of the results and policy implications follow. Section 5 concludes.

2. *THEORETICAL BACKGROUND AND LITERATURE REVIEW*

The relationship between economic growth and the environment is commonly explained using the so-called Environmental Kuznets Curve (EKC) Hypothesis. The EKC hypothesis posits that the environment initially worsens as the economy grows up to a certain threshold, after which the increases in income are associated with significant improvements in environmental quality (Grossman and Kreuger 1995). However, there is no grounded theory on the income-environment relationship, and a number of diverse though complementary theoretical propositions have emerged in explaining the relationship. In the sections to follow we briefly explain the main theoretical propositions and review the empirical evidence on the matter.

The assumed inverse-U shape of the EKC curve is commonly explained while referring to the key drivers of the income-environment relationship, namely the *scale effect*, the *technological effect* and the *composition effect. The scale effect* implies that increases in production and consumption are always environmentally damaging as they are associated with the intensified use of natural resources. *The technological effect* implies that advances in technology underpin improvements in environmental quality. Innovation often leads to increases in production efficiency and subsequent productivity gains by affecting input mix (e.g. less dependence on natural capital), lessening the energy intensities of certain industries, and generally results in the more efficient use of environmental resources and less pollution. Panayotou (1993) stresses the importance of the changes in the technology structure of an economy as industrialisation takes place. Finally, *the composition effect* implies that changes in the structure of the economy along the development path are associated with less environmental degradation following the expansion of the service sector, which becomes the key driving force of growth.

The *composition effect* is closely associated with the structuralist approach to understanding the income environment relationship, or the so-called structuralist economic growth model (Lewis 1963, Chenery 1974). This 'closed-economy' model is, however, less applicable in today's increasingly globalised world, where, for example, de-industrialisation in the context of industrialised countries may occur as a result of a shift rather than a reduction in the levels of pollution. Put differently, if this growth model is taken as it is, with limited or no reference to the interrelatedness and inter-dependency of countries today, it may have implicit and profound implications on environmental policy (see for instance Everet et al. 2010).[2] In terms of developing countries, imposing stricter environmental regulation may be considered costly and unnecessary burden, while subsequently in the context of more advanced industrialised countries environmental policy can come at odds with broader societal

2 Ekins (2000) analyses the GDP growth and growth in emissions of CO2, SO2, and NOX in seven developed countries between 1970 and 1993. his study finds evidence on relative and absolute decoupeling. Increases in GDP have been associated with lower increases in emissions for majority of countries, while decreases in emmissions along GDP increeases have been found in few countries. For instance, the updated analysis using OECD data up to 2005 indicates absolute decoupling in UK, Germany, and France for all indicators.

goals linked to the impact of subsequent shifts in labour, scale and pollution intensive industries on employment and competitiveness in these countries. At last, the structuralist view may justify the hands-off approach to protecting the environment.

The persistent increases in aggregate consumption, and total energy consumption by industrialised countries in particular, alongside increases in income has become increasingly worrying (Everet et al. 2010). This commonly observed behavioural pattern is assumed to have profoundly adverse effects on the earth's environment, thus calling for proactive and integrated policy measures to safeguard the environment. On this ground the merits of environmental policy efforts have come to the fore of policy discussion. This is why integrating policy efforts in understanding the income environment relationship has become increasingly important nowadays. The *policy effect* reflects on incentive structures and policy measures specifically designed to protect the environment. Yet while the existence of EKC may reduce the relevance of environmental policy, preventing the adverse impact of economic activity on the environment seems essential. To be sure, the cost of repairing the environmental damage may be too high, or the environmental damage may prove irreversible. In light of this discussion, Yandle et al. (2004) highlight the role of environmental regulation, namely institutional and policy development as society progresses, to be the major driving force explaining the downward slope of the inverted-U shape relationship. Along these lines of reasoning, a study by De Bruyn (1997) suggests that the inverse relationship between income and environmental degradation is better explained by environmental policy than by economic factors, i.e., structural change, giving rise to the importance of environmental policy.

Notwithstanding this, the vital question, however, remains that of which policy options seem to pay-off. Environmental policy is a quite complex set of direct and indirect measures, i.e., incentive-structures aimed at protecting the environment. Where possible, policy options should induce convergence between the two pillars of sustainable development, namely the environment and economic growth, a principle that has trigged much of the most controversial policy debate. While environmental taxes are considered the most effective tool in protecting the environment, (OECD) countries often remain reluctant to impose those taxes, given the risks of inducing additional economic costs and jeopardising the competitiveness of local industries amid heterogeneous environmental regulations between countries.

A number of studies have found that environmental taxes adversely affect industries' competitiveness, and lower investments and employment opportunities. (Hendersone 1996: 2000, Greenstone 2002, Walker 2012, Silajdzic & Mehic 2015).[3] A more recent study by Greenstone et al. (2012) provides robust evidence on the negative impact of US air quality regulation on the total factor productivity of US manufacturing plants. Thus, more stringent environmental regulation is often associated with shifting production overseas, i.e., the Haven Pollution Hypothesis. This said, the critical question remains that of how effective environmental policy measures have been in modifying the behaviour of economic agents, regardless of economic costs.

Previous literature has mostly failed to study this relationship in an integrated framework (e.g. early studies using reduced-form regressions), and have failed to investigate the impact of environmental policy while referring to more disaggregated policy measures as argued by Stern (2004).[4] Similarly, most studies failed to address the relevance of the scale effect relative to composition and technological effects, since as pointed out by Arrow (1996) economic activity may always be environmentally disruptive in some way, and the scaling of either consumption or production is highly relevant for understanding the shape of the curve. After all, given the mixed evidence on the matter,[5] the relevant question becomes not that of the shape of the curve (since we may never be able to obtain robust evidence on income elasticities) but rather on the underlying processes that explain the factors that impact environmental degradation.

This said, it is worth mentioning that fixed effect models estimated in most of the past studies bear little information on the existence of EKC in an transition economy context. As shown by Hsiao (1986),

3 Indeed, a number of studies have suggested the benefits of cleaner air regulation are in line with the so-called Porteer hypothesis (see for instance Deschenes et al. 2012, Lleras-Muney 2010).

4 Previous studies indicating the importance of social and human capital, as well as political governance and corruption in lowering environmental degradation (Deacon 2005, Barros et al. 2002, Dacon and Norman 2004, Constantini and Martini 2006) may bear little information for policy makers. The causal links of some of these institutional and policy factors with pollutants or some indicator of environmental degradation may be questionable from a theoretical point of view.

5 The existence of an inverted U-shaped EKC hypothesis has been indicated in studies by (Wang 2013, Wagner 2008, Vollebergh et al. 2009, De Bruyn et al. 1998, Constantini and Martini 2006, Dutt 2008); an N-shaped EKC suggested by (Akbostanci et al. 2009, Inmaculada and Aurelia 2004, Galeotti et al. 2006, Grossman and Kreuger 1991). A number of studies found weak or no evidence to support the EKC hypothesis (Perman and Stern 2003, Harbaugh et al. 2002, Borghesi 2000).

fixed effect model results cannot be generalised to other samples of data. Transition countries have embarked on similar policy patterns in the process of far-reaching structural and institutional transformation. On these grounds, it is reasonable to analyse what role environmental policy has played in Central and Eastern European transition economies. Specifically, we analyse the impact of environmental taxes, i.e. energy and transport taxes, on CO_2 emissions, while referring to the sample of CEECs transition economies. The obtained results allow us to go into greater detail about these countries, minimising the risks of obtaining biased estimates.

Finally, past empirical studies examining the existence of the EKC hypothesis mostly fail to account for the problems of endogeneity due to correlation in the regressors, the problems of serial correlation and cross-sectional dependence in the data, and often ignore the possible cointegration between income and CO_2 emissions. For a detailed discussion on methodological issues related to testing of the EKC hypothesis see Wagner (2008). Studies that rely on fixed effect models bear little relevance to understanding the dynamics of the income environment relationship. In this study, we employ a dynamic econometric framework. An attempt is made to remedy the methodological deficiencies that may bias the results, as we discuss later on.

3. CONTEXT OF INVESTIGATION

The interest of this paper is to examine the relevance of the EKC hypothesis and environmental policy measures in the context of the CEEC countries. The specificities that relate to economic restructuring and institutional transformation and development along the processes of transition and integration into the EU institutional and policy structures seem important to be acknowledged for at least three reasons. Although the income disparities between the CEECs and the EU-15 countries still prevail, it is principally the differences in their institutional capabilities, economic structures and levels of technological development that are of particular importance, in the sense that these pose a specific and distinctive context of investigation. More specifically, it seems reasonable to assume that these differences may not only affect government capabilities, policy orientation and choices, but also the responsiveness of economic agents (both consumers and producers) given the differences in the patterns of behavior and overall technological capabilities of firms and industries, which are important to consider in the context of environmental policy effectiveness and promotion. This is to say that although policy commitments to low-carbon age are imposed at the supranational, that is at the EU-28 level, specific policy measures may still vary across countries. Finally, given the aforementioned differences related to institutional and market structures among EU member states, the consequences and the effects of these policy measures may be different in view of the specific context of CEEC countries relative to more advanced EU member states.

For instance, it is worthwhile mentioning that average private and public R&D investments among CEECs remain generally below the EU-15 average. Similarly, environmental policy taxes seem modest relative to those applied in more advanced EU countries if one considers the revenues collected from environmental taxes, with the notable exception of Slovenia. The average environmental tax revenues relative to GDP are below the EU average of 2.3% (see Appendix, figure 3), while energy efficiency measured as energy consumption relative to output (i.e., energy consumption per unit of physical output) remains at much a lower level in these countries compared to those of the EU-15 (see Appendix, figure 2). The latter indicator is particularly important and indicative of the persistent reliance on energy intensive industries such as chemicals, steel and paper in the value added manufacturing industries. Over the period 2005-2009, improvements took place in all industrial branches across CEECs, such as -5.1%/year in Poland, -5.9%/year in Romania, -4.9%/year in Slovenia, -3.2% in Hungary, -2.2%/year in Czech Republic). Energy efficiency improvement in industry results from technical improvement in industrial process and electric motors, encouraged by policies combining tax incentives and voluntary agreements, investment and R&D subsidies. Given the persistent underperformance in terms of energy efficiency of CEEC countries, the improvements in energy efficiency, as well as shift in production structures of CEECs, remains a challenge.

In view of these differences, it seems important to address the issue of how environmental policy measures have been effective in modifying the behavior of producers and in curbing CO_2 emissions. In particular, we emphasise that investigating the influence of energy and transport taxes on aggregate carbon dioxide emmissions seems valuable from a EU-28 policy perspective. The energy and transport sectors did not show a gradual dicline in emissions as with other sectors. Emissions only started to decrease from about 2007 onwards, but still remain higher than in 1990 (European Commission, European Climate Change

Programme(s)). Transport accounts for about one-quarter of EU green-gas house emissions. In line with a new European Strategy for low- emission mobility (adopted in 2016) transport taxes are seen as an important market-based instrument initiated not only to integrate the 'full' costs of environmental degradation but to effectively modify the behavior of consumers and producers. Furthermore, in line with energy efficiency objectives, energy taxes (including oil and gasoline) are expected to contribute to the improvements in energy efficiency and provide incentive structures to acquire additional shifts in the production structure towards more cleaner and sophisticated production. These taxes also generate revenues that can potentially be used to finance environmental policy programmes.

However, in view of the abovementioned structural and technological differences between CEECs and EU-15 countries, we do postulate that the effectiveness of, for instance, an energy tax is dependent on a firm or industry's ability to either pursue subsequent shifts in structure of value added that would lead to improvements in energy efficiency, while shifts in the production structure would require building systemic technological capabilities across vital industrial branches to move up the technology ladder.

Environmental tax revenues as a share of total revenue from taxes and social contributions remain at about 6.4% at the EU level. Environmental taxes remain at a very low level despite increasing policy efforts and commitments to preserve the environment. Energy taxes account for about 76% of all environmental tax revenues, while transport tax revenues account for about 20%, and pollution and resources for only about 2.5%. A breakdown of tax revenues by country and type of tax is presented in Figure 3 below. In the specific context of CEEC countries, the tax revenues from pollution and resource are barely existent, with the notable exceptions of Slovenia and Estonia.

The EU has made a very strict commitment to cut its energy consumption by 20% (compared with projected levels) by 2020. The policy focus is on providing policy support measures and investing in a shift from fossil fuels to energy production from renewable resources. The CEECs do not seem to lag behind other EU member countries. Thus, when it comes to CEEC countries, most countries have already reached the 2020 targets for their share of renewable energy as a % share in total energy consumption or are very close to reaching those targets. Given the general tendency to lower energy consumption, its significant and economically important impact on aggregate carbon dioxide emissions would reflect on the relevance of existing policy efforts to reduce energy consumption. It is worth mentioning that energy consumption has decreased significantly compared to the 1990 level in the EU-28. Though energy consumption has been decreasing in relative terms (see Appendix, figure 1), it has been increasing in absolute terms, and since 1993 onwards at an average annual rate of 0.6 present.

4. *EMPIRICAL ANALYSIS*

The model

In this empirical analysis, data on CO2 emissions for CEEC-10 are examined in an attempt to provide information on not only whether EKC exists, but also on the role played by environmental policy. We examine the impact of environmental taxes by incorporating more disaggregated data on environmental policy, precisely taking into account the impact of individual energy and transport taxes. We also analyse the impact of technological and scale effects proxied by energy intensity of industry. We include a number of control variables, i.e., country-specific effects to control for time-invariant country effects, as well as time effects to control for the time-variant specific effects. Finally, as noted earlier, we analyse the relationship while referring to the case of more advanced transition economies of Central and Eastern Europe (CEE-10) in the period 1995-2013. Within the period 1992-2013, however, the data on environmental taxes are available from 1995. We use unbalanced panel data. In line with the above propositions, we estimate the following equation:

$$\log CO2pc_{it} = \beta_0 + \beta_1 \log GDPpc_{it} + \beta_2 \log GDP^2pc_{it} + \beta_3 \log EnergyIndustrypc_{it} + \beta_4 \log Energytaxpc_{it} + \beta_5 \log Transporttaxpc + \sum_{i=1}^{10} \beta CountryD_i + \sum_{i=1}^{10} \beta TimeD_i + \varepsilon_{it}$$

where:

the dependant variable, $CO2pc_{it}$ denotes CO_2 emissions per capita of the country *i* in the period *t; GDPpc and GDPpc²* denote real GDP per capita of the country *i* in the period *t*; *EnergyIndustrypc* denotes energy intensity of industry expressed as per capita energy consumption of industries of country *i* in the period *t*[6]; Energy environmental taxes ($EnergyTax_{it}$) denotes energy taxes per capita of the country i in the period t; Transport environmental taxes (TransportTaxit) denotes transport taxes per capita of the country i in the period t; CountryD denotes country dummy variables used to control for time-invariant country specific effects and TimeD denotes year dummy variables used to control for time specific effect, ε_{it} – random error (structure eit determined by the Fixed Effect (FE) model).[7] All variables are expressed in logs. Importantly, following Jaforullah and King (2017) we do not incorporate total energy consumption into the CO2 model, considering the demonstrated econometric consequences and the sensitivity of the obtained results with respect to both the magnitude and sign of the obtained coefficients when energy consumption is included in the model to be estimated.

Principle variable of interest: the impact of environmental tax policy measures

In this study we assume that taxes may be efficient and linearly related to lowering CO2 emissions. However, we also allow for the neutral or even positive effect of taxes, given that in some or a number of instances taxes may not be associated with improved environmental quality, depending on the availability of the input alternatives. It seems reasonable to argue that in instances in which firms and industries reach the technological frontiers taxing energy consumption, resource use or pollution may not be effective, since more energy-efficient technologies may not be readily available, or it simply may take a significant time before new or alternative input and output structures of environmentally friendly technologies become available. Therefore, we have no a priori expectations with respect to the sign and the significance of the three principal variables of interest, i.e. the tax variables. However, we do assume that environmental taxes may pose good incentive structures in countries/industries that are at a lower level of technological sophistication and could relatively easily switch to/adopt more energy efficient as well as cleaner technologies, subsequently reducing CO2 emissions.

Most CEEC countries have introduced energy and pollution taxes, in an attempt to limit emissions of air pollutants, in particular of green gas emissions from power generations (see OECD 2004: 2010). They have done so mostly by introducing energy taxes. Energy use accounts for the largest proportion of environmental degradation estimated at about over 80% in OECD countries (OECD 2004). Energy taxes reflect on important measures to reduce energy demand via economic, that is, market-based instruments. How effective energy taxes are in lowering energy demand and in curbing CO2 emissions in transition economies presents the principal question of interest in this analysis.

Similarly, a number of countries (Slovakia, the Czech Republic, Slovenia and Hungary) have introduced sufficient transport taxes, since taxing transport seems an important and effective means of lowering air pollution. Although transport does contribute to economic growth and is important for overall social well-being, further growth in transport may lead to significant degradation to the environment given that it contributes to the depletion of non-renewable resources. Introducing transport taxes and restructuring transport taxes to better target negative externalities on the environment, e.g., by replacing fuel excises with per-kilometre charges, has been the practice in a number of transition economies. We investigate how effective transport taxes have been in curbing CO2 emissions via lowering demand for road transport.

An environmental tax is a tax whose base is a physical unit (or a proxy of a physical unit) of something that has a proven, specific negative impact on the environment. Environmental tax statistics present data on taxes in the following areas: energy, transport, pollution and resources. Considering the definition and the methodology of tax application, both energy and transport taxes attempt to reduce CO2 emissions emanating from transport, since energy tax base calculation encompasses taxing fuel from transport, while transport taxes principally includes motor vehicles import/sale, registration and use taxes, as well as

6 Energy intensity by industry is calculated as the sum of inland consumption of the five sources of energy solid fuels, oil, gas, nuclear and renewable sources by industry, including the manufacturing industry, construction and mining, expressed as the ratio to GDP. Since the gross inland consumption of industry is measured in kilograms of oil equivalent and GDP in EUR 1000, this ratio is measure in kgoe per EUR 1000. This data is then divided by poplation to obtain industry energy intensity in per capita terms. This data reflect on the economic efficieny of an industry. The energy consumption in the manufacturing sector represents around 98% of the consumption of industry. (source Eurostat) The share of energy consumption by industry may depict subsequent changes in the production structure of an economy, i.e. shifts from energy-intensive to more environmentally friendly or sophisticated production.

7 The source of CO2 data, Energy intensity of industry, and environmental taxes data is EUROSTAT. The source of GDP data is World development indicators; it refers to real GDP per capita income. Source of the FDI data is Vienna Institute for International Economic Studies (WIIW) database on FDI.

road taxes and other means of transport.[8] Hence, road transport accounts for about 75% of all GGH emissions from transport.[9] The definition and source of the variables used in our analysis are presented in Table 1, which also summarizes the predicted effects of each independent variable.

Table 1: Definition and Measurement of Variables

Variable Name	Variable definition (Indicator)	Source	Expected Sign
CO2pc	CO_2 emissions per capita	EUROSTAT	
GDPpc and GDPpc²	Real GDP per capita	World development indicators	+/-
EnergyIndustrypc	Energy intensity of industry expressed as per capita energy consumption of industries	EUROSTAT	+
EnergyTax	Energy taxes per capita	EUROSTAT	-
TransportTax	Transport taxes per capita	EUROSTAT	-

Table 2: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2	190	7.04	2.92	2.68	15.11
GDPpc	187	9001	5986	584	26260
Energy industry	190	529.38	226.38	222.48	1211.38
Energy tax	190	152.87	109.49	8.95	547.44
Transport tax	186	21.87	22.18	.20	106.32

Table 3: Correlation matrix (1995-2013)

	CO_2	GDPpc	$GDPpc^2$	EnergyIndustry	Energy_Tax	Transport_ Tax
CO_2	1.00					
GDPpc	0.27	1.00				
$GDPpc^2$	0.27	0.99	1.00			
EnergyInd	0.68	0.19	0.20	1.00		
EnergyTax	0.26	0.91	0.91	0.17	1.00	
TransportTax	0.05	0.66	0.66	0.04	0.70	1.00

Descriptive statistics

Tables 2 and 3 present the descriptive statistics of variables and the correlation matrix among variables, respectively.

8 Specifically, the list of environmental tax bases for: a) Energy (including fuel for transport) tax includes the following: 1. Energy products for transport purposes; *Unleaded petrol ; Leaded petrol; Diesel ; Other energy products for transport purposes (e.g. LPG, natural gas, kerosene or fuel oil)* 2. Energy products for stationary purposes; *Light fuel oil , Heavy fuel oil, Natural gas, Coal, Coke , Biofuels , Electricity consumption and production, District heat consumption and production, Other energy products for stationary use*, 3. Greenhouse gases; carbon content of fuels, emissions of greenhouse gases (including proceeds from emission permits recorded as taxes in the national accounts). The list of Transport (excluding fuel for transport) tax base includes: 1. Motor vehicles import or sale (one off taxes); 2. Registration or use of motor vehicles, recurrent (e.g. yearly taxes), 3. Road use (e.g. motorway taxes); 4. Congestion charges and city tolls (if taxes in national accounts), 5. Other means of transport (ships, airplanes, railways, etc.), 6. Flights and flight tickets, 7. Vehicle insurance (excludes general insurance taxes).

9 It is worthwhile to note that we also attempted to investigate the impact of the so-called implicit tax rate measured as the ratio between energy tax revenues and final energy consumption calculated for a calendar year. This variable may potentially allow for obtaining more precise estimates of the effect of environmental tax on CO2 emissions, given that it implicitly (proportionally) accounts for the energy intensity of an individual country. However, this variable could not be included in the model to be estimated given its high correlation with income, and a number of other energy intensity indicators included in the model (the pair-wise correlation coefficient is over 0.84 for these variables, and thus over 0.88 with the income variable).

Overall, the descriptive statistics suggest huge differences across all indicators, including economic, structural and technological as well as environmental policy indicators. More precisely, the levels of real per capita GDP range from about €584 to €26260 in the period under observation. Particularly pronounced are the differences in the levels of pollution. The levels of CO2 emissions show huge discrepancies related to differences in energy intensity of industries and overall production activity. Similarly, the levels of taxes vary greatly across countries. Total energy taxes per capita collected range between €8.95 to €547.44, while transport taxes per capita range between €0.20 to €106.32.

In view of this, the model developed in this analysis attempts to control for these profound differences in the scope and character of environmental policy, patterns of technological and income convergence when examining the relationship between income and pollution. Hence we note that within country variations of all independent variables allow for models to be estimated with great precision since all variables exhibit significant variation across time.

Finally, Figure 1 and 2 below reveal the timely relationship between real GDP per capita and per capita CO2 emissions across countries and within individual country settings, respectively. No clear pattern can be observed from observation relating to CO2 emissions across countries and time (Figure 1). A cursory inspection of individual country indices reveals slow and or stagnating growth in per capita CO2 emissions, along with relatively stable per capita income growth. This may be indicative of evidence supporting the EKC hypothesis, and a 'decoupling' phenomena among CEECs. Further, it may be observed that countries at the higher level of economic development exhibit higher per capita pollution intensities, as is a priori expected considering the scale effect associated with more developed and diversified industrial structures of countries like the Czech Republic, Slovenia, Estonia and Poland. A notable exception seems to be Hungary, which exhibits relatively high GDPpc along with a relatively diversified and technologically advanced industrial composition (see Labaj 2018), while having comparatively lower levels of per capita emissions. This, however, may be associated with the relatively low energy intensity of industries in Hungary compared to other CEE economies.

Figure 1: CO2 emissions and GDPpc, 1995-2013

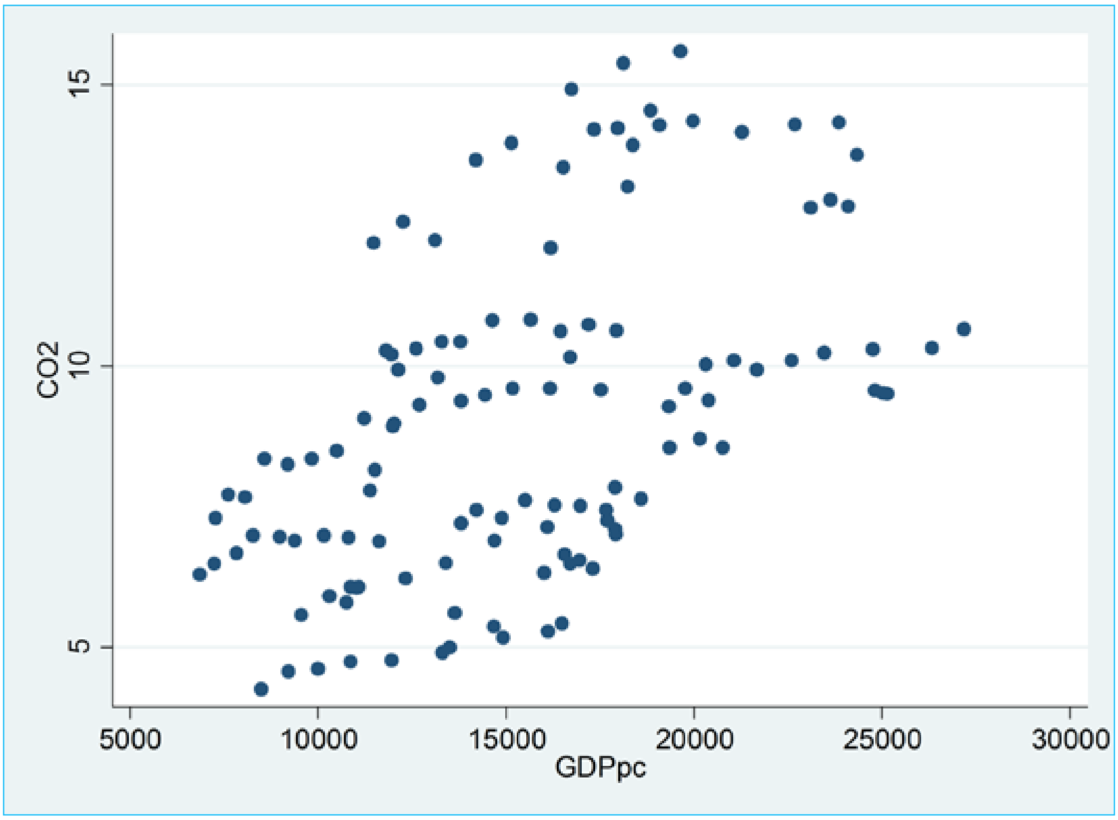
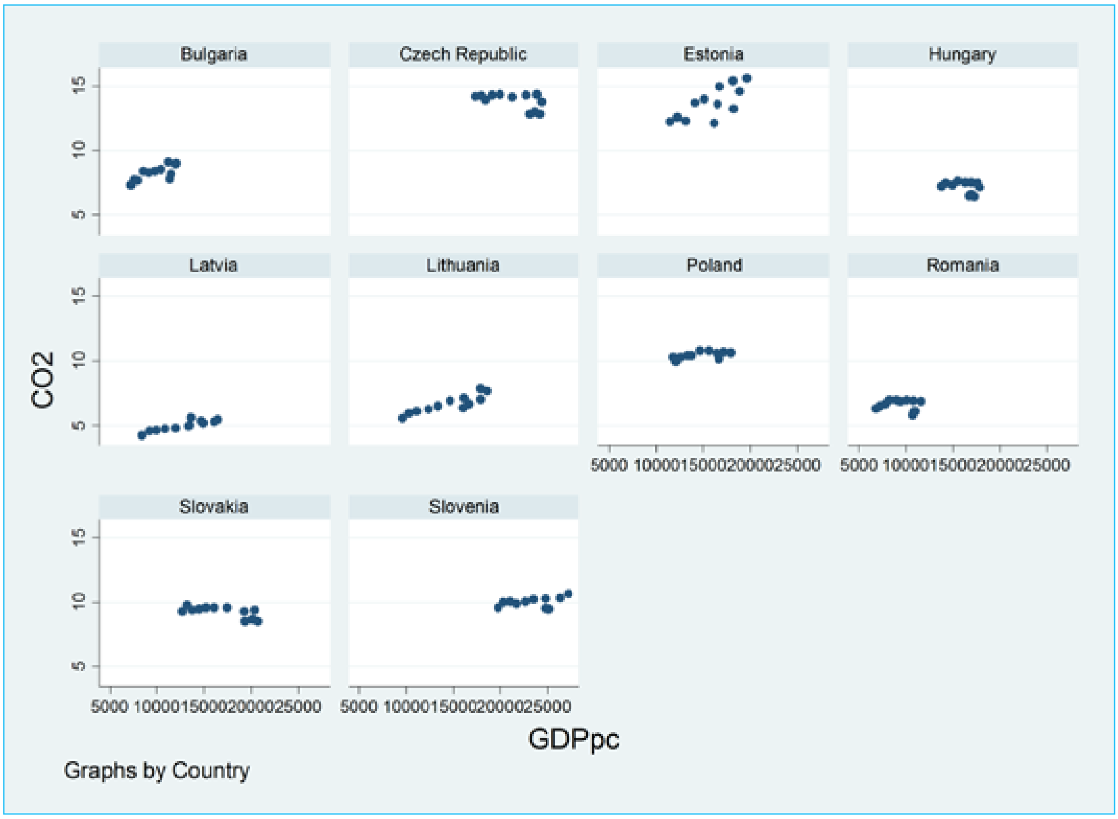


Figure 2: CO2 emissions and GDPpc by individual country, 1995-2013



Panel unit-root tests

Consideration of data properties in the EKC models seems important. The EKC hypothesis assumes a long-run relationship between per capita income and environmental degradation that needs to be modelled properly taking into account the stationarity or non-stationarity in the data. The long-run relationship implies that the EKC regression could be spurious in the case of variables that are nonstationary. On that account we first proceed with unit root tests for the variables, and then proceed with a panel cointegration test to examine the presence of a long-run relationship between economic growth and environmental degradation.

Table 4 provides the results of Unit-root tests. Specifically, we present the results of Im, Pesaran and

Table 4: Panel Unit Root Test

Variable	Im Pesaran and Shin (IPS)		Harris-Trivallis (HT)	
	Constant	(No time Trend)	Constant	(No time Trend)
logCO2	-1.26053 (0.1037)		-2.4824** (0.0065)	
logGDPpc	-0.91781 (0.9133)		2.3695 (0.9911)	
$logGDPpc^2$	-1.41775 (0.5855)		2.3694 (0.9901)	
logIndustry			-0.6390 (0.2614)	
logTransTax	-2.04360 (0.8991)			
logEnergyTax	-2.00994 (0.1269)			

Note: We obtain similar results when we include time trend in test statistics. The results are not reported here due to space limitations. ** indicates the rejection of the null hypothesis at the 5% level of significance.

Shin (IPS) and Harris-Tzvalis (HT) panel unit-root tests. While the IPS test is suitable in small samples, the HT test is preferable where the number of time units (T) is larger than the number of cross-section units (N), which is the case with our sample, by assuming that the time dimension is fixed. This test can only be performed on balanced data. Therefore, we present the results of this test for environmental and economic indicators, while policy indicators are in the non-balanced series. Both tests investigate the null hypothesis of a unit root against the alternative that the variable is stationary. At the 5% level of significance, the null hypothesis of a unit root can only be rejected for the log CO2 variable, while GDPpc, and industry variables seem non-stationary processes according to HT test statistics. The results of the IPS tests indicate that we cannot reject the null hypothesis that all series contain a unit-root at the 5% level of significance. In other words, the IPS test statistics suggests that all series are nonstationary in level; that is, the variables are integrated of order one (i.e. I(1)). Given the nature of our panel series, we proceed with investigating the cointegration relationship between the income and CO2 pollution indicators, relying on the Pedroni cointegration test.

Panel cointegration test

Given the long-run relationship between economic growth and environmental degradation substantiated in the literature, we proceed with our empirical analysis by testing for cointegration between income per capita and per capita CO2 emissions. Following Song et. al. (2008), we use a panel cointegration test proposed by Pedroni (1999). This test is preferable since it allows for heterogeneity among countries (cross-sectional units) which is an important feature given the indicated cross-sectional dependence in this empirical analysis.

Table 5 presents the results of Pedroni test statistics. The table reports panel test statistics (*v, rho, t, adf* in the first column) relating to the within-group (dimension) investigation of stationarity of error processes by restricting the autoregressive parameter to be the same across all cross-sections. The group test statistics of the same parameters (second column) thus allow the autoregressive parameter to vary over the cross-section. The results of the test statistics give rise to the assumption that there is some cointegration in the system, abd with the panel *t* statistics significant at the 5% level, and *rho* statistics significant at the 10%, we can reject the null hypothesis of no cointegration.

Table 5: Panel Cointegration test

Statistics	Panel	Group
v-statistics	0.6295	----
rho-statistics	-1.527*	-0.137
t-statistics	-1.725**	-1.074
adf	0.237	-0.3148

Note: All statistics are from Pedroni's procedure (1999), where the adjusted values can be compared to the N(0,1) distribution. The Pedroni (2004) statistics are one-sided tests with a critical value of -1.64 ($k < -1.64$ implies rejection of the null), except the *v*-statistic, which has a critical value of 1.64 ($k > 1.64$ suggests rejection of the null). *, ** indicates rejection of the null hypothesis of no-co-integration at 10% and 5% levels of significance.

Method of investigation

In order to obtain asymptotically efficient, consistent estimators in panel series we proceed with estimating the EKC model in a cointegration dynamic framework. The results of unit-root and cointegration tests reveal the potential problems of spuriousness in the EKC regression due to serial correlation and endogeneity issues associated with a non-stationary panel series with heterogeneous unit-roots. There are several dynamic estimation techniques that deal with the problems of serial correlation and endogeneity in the presence of cointegration. Kao and Chiang (2000) discusses the properties of different conitegration dynamic models, namely FM-OLS and dynamic OLS (D-OLS) estimators. They conclude that both estimators have a negligible bias in small samples. On that account, we further proceed with choosing the optimal cointegration model. Namely, we estimate the EKC models relying on FM-OLS estimators that seem preferable to a cointegration model in our case for the following reasons. First, we are operating with a small sample, and second, the results of the unit root tests indicate that for our model with I (1) regressors a FM-VAR estimator seems suitable.

Fully modified least squares (FM-OLS) regression was designed for modelling cointegration relationships by Phillips and Hansen (1990). To be precise, FM-OLS is a panel cointegration estimation technique that modifies least squares to account for serial correlation effects and for the endogeneity in the regressors due to the cointegration relationship. Phylips (1993) study the asymptotic behaviour of FM-OLS in an econometric framework estimating various models that include different stationarity and unit-root properties of regressors in the estimated models, e.g. models with I(1) regressors, models with I(1) and I (0) regressors, models with unit roots, models with only stationary regressors and models with I(1) and I(0) regressors as well as deterministic trends. According to Phylips (1993) the findings of FM-OLS cointegration models have some interesting and desirable features indicating hyperconsistency in the obtained coefficients when there is some cointegration in the system, and also considering the different nature of the deterministic processes of the regressors. Phylips, P. (1993) points out that when the system has a full set of unit roots, as is the case in this analysis, '*the FM VAR estimator of the complete unit root matrix is hyperconsistent*'. On that account, the FM-OLS model seems preferable. Table 6 reports the empirical results of the FM-OLS cointegration model.

4. RESULTS

Table 5 reports the results of econometric analysis. To be precise, we report the results of the FM-OLS cointegration model. The table include the results with respect to the 3 models estimated; namely the reduced from equation, and the two models incorporating tax variables.

First, we note that we estimate all equations with country-specific and time-specific effects. The results reported in Table 6 support the EKC hypothesis when the relationship between income per capita and per capita CO2 emissions is studied in a dynamic cointegration framework. In all three models estimated we find strong evidence to support the significant relation between income and pollution. To be precise, the relationship depicts an inverted U hypothesis in reduced form equation Model 2. Similarly, after controlling for environmental tax variables and the energy intensity of industry (Models 2 and 3; the variables are included singly into the regression equation due to the potential problem of multicolinearity between the environmental tax variables), the income variable and its quadratic transformation remain significant, suggesting strong evidence in support of the EKC hypothesis in a transition economy context. However, these results need be treated with caution given the indicated problem of multicolinearity in the data (see Table 2b and Appendix 1 - the correlation matrix and the VIF statistics i.e. 1/VIF is below 0.2 for the energy tax variable).

The environment does not seem to be a sole function of income, since other factors tend to explain the shape of this relationship. The scale effect, proxied by the energy intensity of industries, seem to be the most important contributor to environmental degradation as a priori expected. Lower economic efficiency of industries is associated with significant increases in CO2 emissions as anticipated. This result implies the importance of technological progress and the subsequent increases in energy efficiency of industries. Lower energy consumption of industries in relative terms is associated with structural transformation of industries and higher value added of more technologically sophisticated produce.

Finally, energy taxes seem not to be effective and seem associated with higher CO2 emissions. This is to say that energy taxes are ineffective for most industrial activities that face no or limited alternatives to switching to lower energy use while facing higher economic costs. In this particular context, companies may very likely be incapable of inducing new technologies to comply with stricter regulation, or to opt for alternatives, and will continue scaling up their production activities albeit with higher economic costs, jeopardising their productivity, investment and employment potential. Transport taxes, on the other hand, are negatively related to CO2 emissions, but the results do not seem to render much support to the proposition that they present a meaningful instrument in curbing CO2 emissions. Transport taxes are expected to lower aggregate demand for non-renewable resources such as oil and fossil-fuels, most probably because they can easily affect the behavioural patterns of individual consumption.

While government action is needed to prevent and limit environmental degradation, misguided policies and ineffective policy measures can generate the opposite results. This is not to say that governments should reconsider the imposition of energy taxes, since the costs of environmental degradation should be incorporated fully in prices. However, inducing environmentally friendly technological innovation, and energy efficient technologies in particular, goes well beyond individual firm capacity, and taxing energy use may not lead to significant improvements in environmental quality. These policy efforts should be accompanied by systematic and concurrent efforts to collectively induce technological progress, especially alternative energy use, and support for the use of renewable energy and its production.

Finally, based on panel cointegration estimation and the obtained inverted U relationship between income per capita and per capita CO2 emissions, we calculated the turning points, i.e., the threshold levels for all three models, respectively. Essentially, all threshold levels fall within the range of per capita income in the sample. However, it is interesting to note that the threshold level increases substantially once we control for energy tax, suggesting the importance of integrating environmental regulation in determining the turning points.

Table 6: Results

	Model 1	Model 2	Model 3
logGDP pc	.517*** (2.32)	1.925*** (9.06)	.653*** (2.85)
logGDP pc^2	-.038*** (-2.53)	-.143*** (-9.72)	-.034*** (-2.23)
Energy industry	.228*** (4.74)	.243*** (5.34)	.255*** (5.07)
Energy tax		.151*** (5.48)	
Transport tax			-.015 (-1.47)
Turning point (TP)	809	13,062	803
No. of observations	186	186	182

Notes: TP denotes the turning point of the quadratic curve; the turning point is computed by $\hat{\tau} = \exp(-0.5\hat{\beta}_1/\hat{\beta}_2)$*; Z statistics are given in brackets; all regressions include a constant, country and time dummies (not reported in the table); *denotes statistical significance at the level of 10%, **denotes statistical significance at the level of 5%, ***denotes statistical significance at the level of 1%.*

5. CONCLUSION

The purpose of this study was to analyse the presence of the EKC hypothesis in the context of transition, namely the CEEC-10 countries (i.e. Czech Republic, Slovenia, Slovakia, Poland, Hungary, Estonia, Latvia, Lithuania, Romania and Bulgaria). More importantly, an attempt has been made to identify the role environmental tax policy measures play in understanding the EKC hypothesis. The results of our analysis provide strong evidence in support of the EKC hypothesis. Notwithstanding this, the energy intensity of industry seems to be the most prominent factor associated with increases in CO2 emissions. Hence, we find no evidence to support the proposition that energy taxes are an effective means of lowering CO2 emissions. The tax related incentive structures do not seem to lessen energy and pollution intensity; quite the contrary. Moreover, transport taxes, although negatively related to CO2, seem to be an insignificant determinant of lower CO2 emissions.

This paper advances our understanding on the underlying mechanisms that explain the relationship between income and pollution by incorporating environmental policy factors that have not been empirically investigated in previous literature, and by reflecting econometric issues that we suggest be taken into consideration in the empirical investigation of the EKC hypothesis.

Following the results obtained on the ineffectiveness of environmental taxes, we question the popular perception that market-based instruments, including environmental taxes, are among the best policy options. Environmental taxes are commonly considered the most effective, most easily administered and least costly approach (OECD 2001: 2002). The basic premise is that the costs of environmental degradation should be fully incorporated into the costs of production - the view that the prices should fully reflect the costs of environmental degradation. However, we argue that market-based instruments may still not be effective, let alone sufficient, to achieve the outcome of better environmental quality. Obviously, the impact of environmental taxes and other incentive structures depend on a host of factors, but predominantly they depend on the structure of the industrial base and its diversification, which in turn determine the character of the further scaling and upgrading of production activities, the degree of the technological sophistication of firms and industries on which it is being imposed, the availability of technological solutions (presumably technologically friendly solutions) and the complexity of its adoption.

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Appendix 1

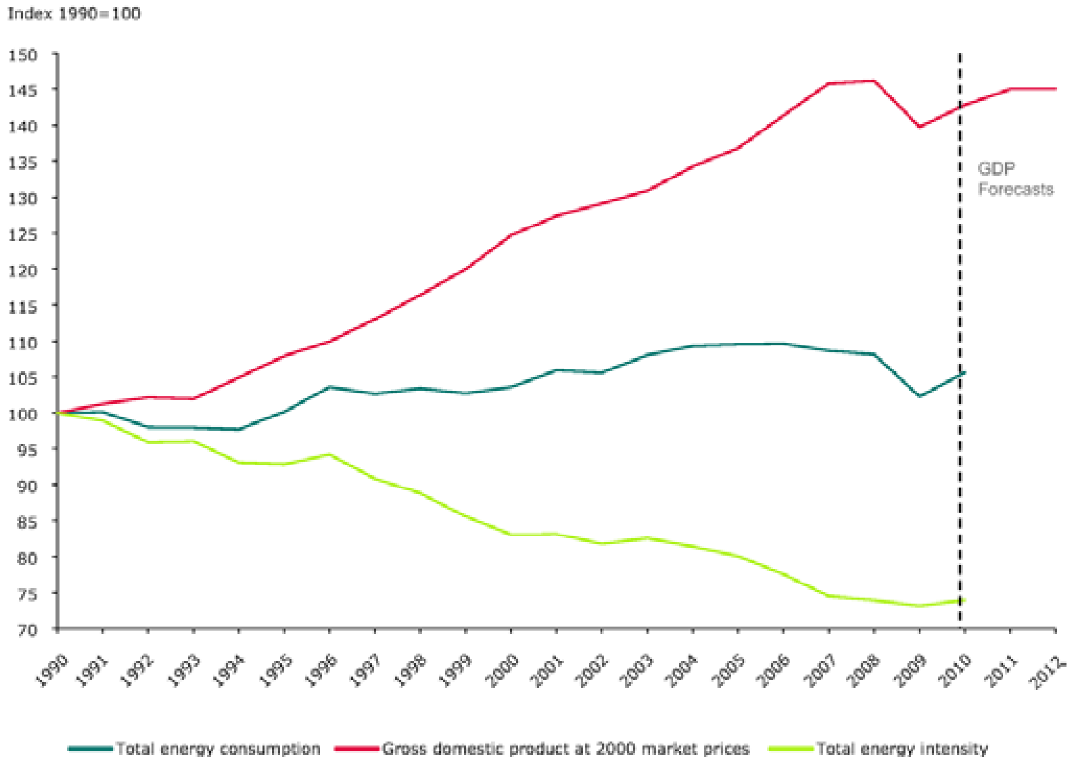
Table 1: Variance inflation factors (VIF) statistic

Variable	VIF	1/VIF
log2RealGD~c	361.33	0.002768
logRealGDPpc	342.24	0.002922
logENERGYT~C	6.90	0.144896
logTRANSPO~C	2.00	0.498843
logINDUSTR~C	1.08	0.922346
Mean VIF	142.71	

Variable	VIF	1/VIF
log2RealGD~c	511.87	0.001954
logRealGDPpc	475.69	0.002102
logENERGYT~C	10.84	0.092271
logFDImanpc	3.35	0.298066
logTRANSPO~C	1.91	0.522998
logINDUSTR~C	1.34	0.746375
Mean VIF	167.50	

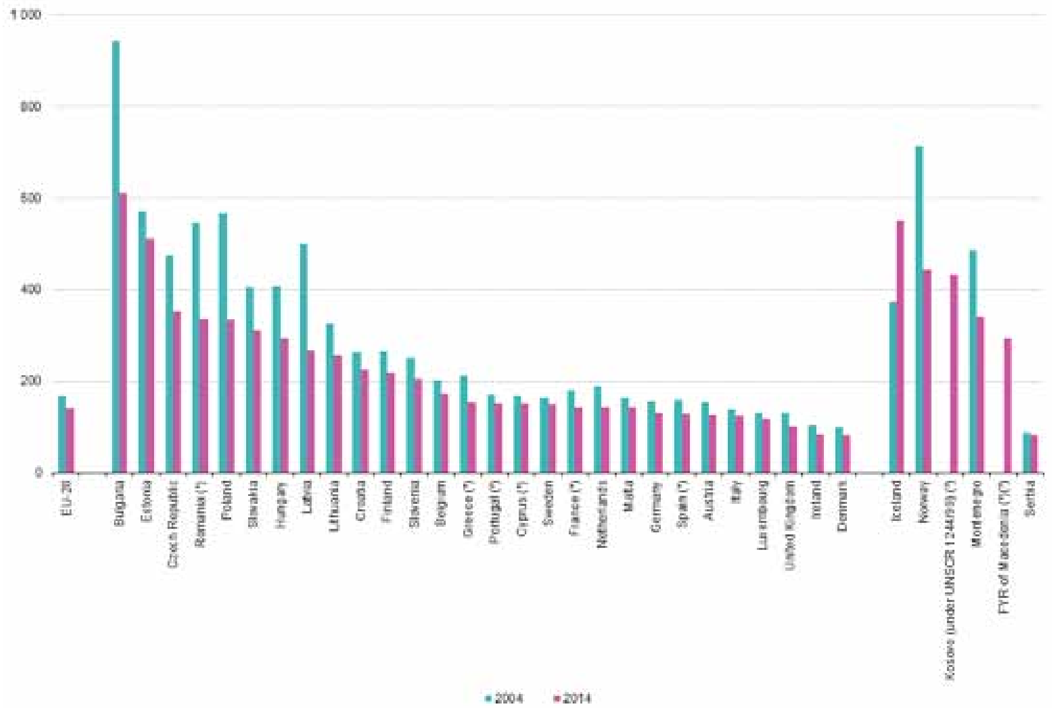
Appendix 2

Figure 1: Energy intensity and economic growth in the EU-28



(source Eurostat)

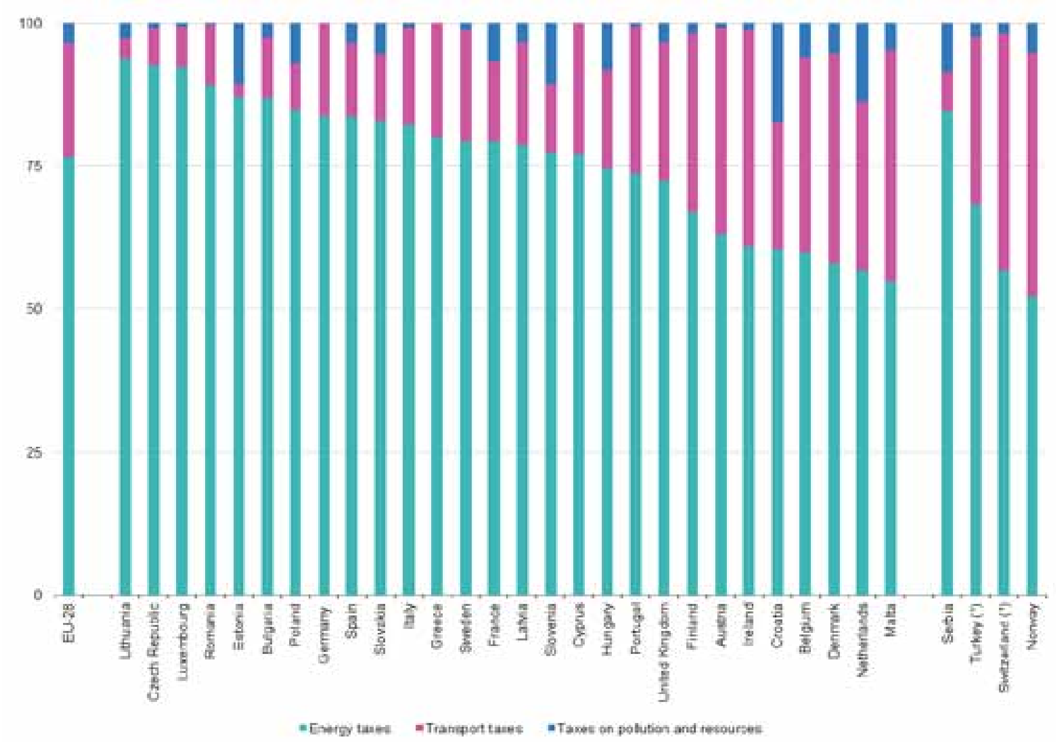
Figure 2: Energy_intensity of the economy, 2004 and 2014_(kg of oil equivalent per 1000 EUR of GDP)



(1) 2014: provisional.
(2) 2014: estimate.
(3) 2004: not available.
Source: Eurostat (online data code: tsdec360)

(source Eurostat)

Figure 3: Environmentaltaxes by tax category,2014 (% of total environmental taxes)



Note: Ranked on the share of energy taxes.
(¹) 2013.
Source: Eurostat (online data code: env_ac_tax)