ENVIRONMENTAL TAX AND ECONOMIC GROWTH: A PANEL VAR ANALYSIS

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ABSTRACT

In recent years there has been tremendous debate among academics and policy makers about the interactions between economic growth and environmental taxation. In this study, the relationship between environmental taxes and economic growth is analyzed using 29 European countries' yearly data for the period 1996 to 2010. The main objectives of this study are to determine the reaction of economic growth in the face of a shock in different kinds of environmental taxes and to examine whether environmental taxation has a positive or negative effect on national economies. Using Panel Vector Autoregressive models, we find positive and statistically significant responses to an environmental tax shock.

Keywords: Environmental Taxation, Economic Growth, Panel Vector Autoregressive Models.

ÇEVRE VERGİLERİ VE EKONOMİK BÜYÜME: PANEL VAR ANALİZİ

ÖZ

Son yıllarda çevre vergileri ile ekonomik büyüme arasındaki etkileşim, hem politikacılar hem de akademisyenler arasında yoğun bir biçimde tartışılmaktadır. Bu çalışmada, çevre vergileri ile ekonomik büyüme arasındaki ilişki, 29 Avrupa ülkesinin 1996-2010 yılları arasındaki verileri temel alınarak analiz edilmiştir. Çalışmanın temel amacı, farklı çevre vergilerindeki bir şok karşısında ekonomik büyümenin verdiği tepkiyi belirlemek ve çevre vergilerinin ulusal ekonomi üzerindeki etkisinin negatif olup olmadığını incelemektedir. Panel Vektör Otoregresif model kullanılarak yapılan çalışmada, çevre vergilerindeki bir şok karşısında istatistiksel olarak anlamlı ve pozitif tepkilere ulaşılmıştır.

Anahtar Kavramlar: Çevre Vergileri, Ekonomik Büyüme, Panel Vektör Otoregresif Modeller.

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INTRODUCTION

The effects of environmental taxation on economic growth are a controversial issue. This topic is discussed from different aspects. According to economists, environmental taxes have a negative effect on economic performance (Roegen, 1971; Meadows et al., 1972; Daly, 1991). This perspective emphasizes that environmental taxes reduces the amount of fossil fuel use and decrease the volume of industrial production. On the other hand, environmentalists do not take the economic performance as a numerical value and focus on the nature of economic growth. This point of view takes environmental taxes not only to protect the environment but also as an important tool to improve sustainable development. The situation is explained by the double dividend hypothesis. According to the hypothesis, increased taxes on polluting activities can provide two kinds of benefits. The first is an improvement in the environment, and the second is an improvement in economic efficiency from the use of environmental tax revenues to reduce other taxes such as income taxes that distort labor supply and saving decisions. In this case, it would be expected a positive rather than a negative impact of environmental taxes on economic performance (Fullerton, Metcalf, 1997:1).

This paper investigates the long-run impact of an environmental taxation on economic growth and examines whether such taxation can influence economic growth negatively or positively. The empirical literature on this subject has mainly focused on the use of simulation models. However in this study, econometric methods are used to analyze the relationship between environmental taxation and economic growth due to availability of the environmental tax data (energy and transport) published by Statistical Office of the European Union[*].

The paper is organized as follows. In Section 2, we briefly review the related theoretical literature that indicates how environmental taxation should affect economic growth. Section 3 summarizes the data and presents the empirical findings. Conclusions are in section 4.

I. THEORETICAL BACKGROUND

Over the last four decades, numerous arguments have been raised about the relationship between economy and environment. In the early phases of the debate, the prevailing view was that economic growth was a threat to the environment. The world will not be able to sustain economic growth indefinitely without running into resource constraints or despoiling the environment beyond repair. This was primarily the view of a number of scientists such as Roegen (1971), Meadows et al., (1972), Daly (1991). These scientists noted that higher

[*] http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/.

levels of economic activity (production and consumption) require larger inputs of energy and materials and generate larger quantities of waste byproducts. Increased extraction of natural resources, accumulation of waste, concentration of pollutants would exceed the carrying capacity of the biosphere and result in the degradation of environmental quality and decline in human welfare despite rising incomes (Galeotti, 2007:428-429). Furthermore, it is argued that degradation of the resource base will eventually put economic activity itself at risk. To save the environment and even economic activity from itself, economic growth must cease and the world must make a transition to a steady-state economy (Panayotou, 2003:1).

At the opposite extreme the ecologists' pessimistic view was counteracted by a systematic relationship between income changes and environmental quality. Initial papers by Shafik and Bandyopadhyay (1992), Grossman and Krueger (1993) and Selden and Song (1994) presented evidence that economic growth may reduce environmental problems. This phenomenon has been referred to as the Environmental Kuznets Curve (EKC), named after Simon Kuznets who proposed a similar relationship for income inequality and per capita income (Kuznets, 1955:1-28). According to EKC, during the early stages of economic growth, degradation and pollution increase, but beyond some level of income per capita (which will vary for different indicators) the trend reverses, so that at high income levels economic growth leads to environmental improvement. This implies that the environmental impact indicator is an inverted U-shaped function of income per capita (Stern, 2004:518).

Environmental policy becomes quite controversial, especially when the relationship between economic growth and environment is taken into account. This is especially true when it comes to environmental taxation aimed at preventing pollution. The economic rationale for environmental taxation was developed by English economist Arthur Pigou during the first half of the 20th century. The basic rationale for the use of taxes in environmental policy is provided by the existence of environmental externalities: impacts on the environment, which are side-effects of processes of production and consumption and which do not enter into the calculations of those responsible for the processes. Where the effects are negative, externalities are costs. By levying a tax on the activity giving rise to the effect, the external cost can be partially or wholly internalized (Ekins, 1999:41).

There is no consensus in the literature about the effect of environmental taxes on the economic activity*. According to the majority of economists, environmental taxes negatively affect economic growth. In empirical analyses such as Gollop and Roberts (1983), McDougall (1993), Gradus and Smulders (1993), Van Der Ploeg and Ligthart (1994), Labandeira, Labeaga and Rodríguez (2004)

* See Table 3 in Appendix for the some of the studies in the literature.

and Siriwardana, Meng and Mcneill (2011) environmental regulations have frequently been regarded as the main source of productivity slowdown. This situation is described as follows. Environmental taxes, especially carbon taxes, curtailing the use of fossil fuels as a source of energy for production proposes and, with a decline in the use of one of the factors of production, there is a reduction in national output compared to the case where there are no restrictions. Economist costs of a carbon tax are, therefore, usually measured as the percentage change of future GDP (Cuervo, Gandhi, 1998:20).

The effects of environmental taxes on economic growth have been addressed in two contexts. In a static context, it is quite obvious that a restrictive environmental policy lowers aggregate output because it imposes an additional constraint on the production possibilities set. In fact, in order to decrease pollution firms undertake abatement activities which result in increased production costs. In a dynamic context, a similar argument claims that higher production costs reduce return on capital and incentives to investment and lower investments leads to slower economic growth (Ricci, 2007:689).

Contrary to economists who argue that carbon tax could hamper economic activity, environmentalists argue that carbon taxes seem to be a particularly attractive instrument to enhance environmental quality without seriously damaging economic growth. This was primarily the view of a number of scientists such as Pearce, (1991), Ewijk and Wijnbergen (1995), Bovenberg and Smulders (1995), Goulder (1995), Bovenberg and Mooij (1997). These scientists noted that environmental taxation, which positively affect the quality of the environment, may have a positive impact on growth. In particular, by increasing taxes on carbon emissions and using the proceeds to cut distortionary taxes on income, governments may be able to reap a 'double dividend', namely, not only a cleaner environment but also a less distortionary tax system, thereby stimulating economic activity (Bovenberg, Mooij, 1997:208).

The idea behind this suggestion is that environmental taxes not only produce improvements in the environment (the first dividend) but they also generate substantial amounts of government revenue (the second dividend). This new government revenue would allow governments to reduce the rates of other taxes in the economy while maintaining a constant level of total revenue and expenditure: the revenue-recycling effect. As these other taxes are generally regarded as distortionary, the reduction in their rates can be seen as improving efficiency and thus producing a second benefit from the adoption of environmental taxes (Markandya, 2005: 1379).

According to Goulder (1995), there are three forms of the double dividend hypothesis, based on the size of the cost reduction of the implemented carbon tax. The weak form claims that using the revenue from an environmental tax to finance reductions in existing distortionary taxes reduces the costs of the policy compared to lump-sum redistribution to tax payers. The intermediate form claims that it is possible to find a distortionary tax rate such that a revenue neutral substitution of an environmental tax for this particular tax involves a zero or negative gross cost. The strong form claims that a revenue neutral substitution of an environmental tax for *typical* or *representative* distortionary taxes involves a zero or negative gross cost. These welfare gains are specified in concrete economic terms, such as reduced unemployment or increased profits (IILS, 2011:5).

Alongside controlling or reducing unemployment and increasing economic benefits, the additional constraint imposed on firms by environmental taxation could trigger technological adjustments capable of expanding production possibilities. According to Porter (1991), environmental policy can have a win-win outcome: i.e., it can improve the quality of the environment while fostering the rate of growth of value added. Likewise, Itaya (2008:1157) shows that because an environmental tax reduces the profits of intermediate firms, the induced reduction in their outputs (i.e., intermediate inputs) releases more resources to R&D activities, which are the engine of growth.

II. EMPIRICAL ANALYSIS

A. EMPIRICAL METHODOLOGY

The effects of environmental taxes on economic growth are examined a using Panel Vector Autoregressive (PVAR) models. VAR models provide useful methodology to investigate the issue. First, dynamic effects can be inferred from VAR models. For instance, the model captures the long-term changes of economic growth over time as influenced by environmental protection policy, especially taxes. Second, some interactions between the environmental protection and macro variables can be allowed in the model (Kim, Lee, 2008:246).

PVAR methodology fits the purpose of this paper, given the absence of a priori theory regarding the relationship between the environmental protection policy and economic growth. This methodology is based on a framework that allows all variables to enter as endogenous within a system of equations, where the short run dynamic relationships can be subsequently identified (Filippaki, Mamatzakis 2009:2053).

This technique combines the traditional VAR approach, which treats all the variables in the system as endogenous, with the panel-data approach, which allows for unobserved individual heterogeneity (Love, Zicchino, 2006:193). The econometric model takes the following reduced form:

$$Z_{it} = \Gamma(L)Z_{it} + \mu_i + \varepsilon_{it}$$

Where i denotes the country, $t = 1,.......T$, Z_{it} is a vector of stationary variables, $\Gamma(L)$ is a matrix polynomial in the lag operator with $\Gamma(L) = \Gamma_1 L^1 + \Gamma_2 L^2 + ...\Gamma_p L^p$, μ_i is the vector of country specific effects and ε_{it} represents the vector of idiosyncratic errors.

The PVAR approach works by integrating the traditional VAR framework with the panel data setup, where unobserved individual heterogeneity is permitted. When estimation is considered, it is known that the standard fixed-effect estimator is biased in dynamic panel specifications because of the presence of correlation between the regressors and the fixed effects. Biased coefficients would be created by the mean differencing procedure that is used for eliminating fixed effects. The generalized method of moments (GMM) estimator is considered to handle this matter. In a more precise manner, forward mean-differencing, which is also known as "Helmert procedure" is used. In Helmert procedure, all variables in the model are converted into deviations from forward means for removing the fixed effects, and after that the variance is standardized by weighing each observation (Bouvatier et al., 2012:1040).

This transformation is an orthogonal deviation, where each observation is expressed as a deviation from average future observations. In order to standardize the variance, each observation is weighted. If the original errors are characterized by a constant variance and they are not autocorrelated, similar properties should be displayed by the transformed errors. Therefore, this transformation conserves homoscedascity and serial correlation is not induced. In addition, through this technique the lagged values of regressors can be used as instruments, and the coefficients can be figured by the GMM (Boubtane, Coulibaly, 2011:8).

After the estimation of the coefficients, in order to identify the shocks the impulse response functions (IRFs) are calculated by counting on the Cholesky decomposition. The impulse response functions describe one variable's reaction in reply to changes in another variable in the system, as all other shocks are held equal to zero. However, so as to isolate shocks to one of the variables in the system, it is essential to decompose the residuals using a method by which they turn into orthogonal, because the actual variance-covariance matrix of the errors is unlikely to be diagonal. The usual convention is adopting a particular ordering, and then any correlation between the residuals of any two elements is allocated to the variable coming first in the ordering. The identifying assumption is that the following variables are affected simultaneously by the variables that come earlier in the ordering, as well as with a lag, whereas the variables coming later affect the preceding variables only with a lag. That is to say, in the system, the variables coming earlier are more exogenous, while the variables coming later are more endogenous. Finally, in order to analyze the impulse response functions an estimation of their confidence intervals is needed. The standard errors of the impulse response functions need to be taken into account, because the matrix of impulse response functions is constructed from the estimated VAR coefficients. Consequently, the standard errors of the impulse response functions and the confidence intervals are generated by use of Monte Carlo simulations (Garita 2011:16).

B. DATA AND VARIABLES

In this study, the effect of environmental taxes on economic growth is handled in terms of both quantity and quality. For this purpose, the data set consists of a panel observation of 29 European countries* over the years 1996-2010. The sample does not include earlier years because environmental taxes are newly introduced in most European countries. The variables that used in the study** are total environmental tax revenue (TETAX), energy tax revenue (ETAX), transport tax revenue (TTAX), gross national income growth (GNI), household final consumption expenditure (HCE), gross capital formation (GCF) and general government final consumption expenditure (GCE). The data are obtained from World Bank databank and Eurostat and are expressed in annual % growth.

The variables used in this study and their descriptive statistics and correlation matrix are shown in Table 1.

Table 1: Description Statistics and Correlation Matrix for Variables

Variable	Mean	Std. Dev.	Min	Max	GNI	GCF	HCE	GCE	TETAX	ETAX	TTAX
GNI	3.009	4.417	-25.065	16.914	1						
GCF	3.868	13.906	-57.713	94.515	0.658	1					
HCE	2.948	4.186	-24.085	21.249	0.662	0.551	1				
GCE	2.401	4.402	-26.469	44.094	0.303	0.257	0.203	1			
TETAX	4.942	12.512	-118.29	52.475	0.228	0.464	0.323	0.193	1		
ETAX	5.49	13.022	-123.15	58.305	0.161	0.354	0.233	0.167	0.918	1	
TTAX	0.795	38.281	-413.53	85.996	0.165	0.245	0.236	0.096	0.332	0.139	1

* The country sample include: Austria, Belgium, Bulgaria, South Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden and United Kingdom.

** The variables are employed in the analysis, their sources and descriptions are given in Table 4 (see in Appendix).

Table 1 reports the range of data (minimum-maximum), the mean and standard deviation for each variable. Some interesting facts are revealed in Table 3. Environmental taxes have fluctuated within a relatively broad band between 1996 and 2010. The highest and lowest growth rates of total environmental tax revenue are 52.475 and -118.292. Growth rate of energy taxes and transport taxes are faced a similar situation. Correlation analysis is also given in the Table 3. It's clearly observed that gross national income growth has a strong positive correlation with other economic variables.

C. EMPIRICAL RESULTS

In this study, panel VAR techniques are used to estimate impulse response functions. Before employing panel VAR analysis, it is essential to verify that all variables are integrated of order one in levels. Therefore, we test our series for the existence of unit roots. In recent years some tests for unit root within panels are developed in the literature. Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003), Maddala and Wu (1999) and Choi (2001) have developed panel unit root tests. Levin, Lin and Chu (2002) suppose a common unit root under the null hypothesis against the alternative of stationarity of all individuals, whereas the other tests allow for individual unit roots under the alternative hypothesis. The results of panel unit root test are reported in Table 2.

Table 2: Results of Panel Unit Root Tests

Variables	Levin, Lin & Chu		Im, Pesaran and Shin		ADF-Fisher		PP-Fisher	
	Individual Intercept	Individual Intercept and trend	Individual Intercept	Individual Intercept and trend	Individual Intercept	Individual Intercept and trend	Individual Intercept	Individual Intercept and trend
GNI	-6.32 (0,00)*	-6.76 (0,00)*	-5.42 (0,00)*	-3.10 (0,00)*	132.00 (0,00)*	101.50 (0,00)*	136.07 (0,00)*	151.32 (0,00)*
GCF	-6.81 (0,00)*	-7.70 (0,00)*	-6.23 (0,00)*	-4.58 (0,00)*	142.41 (0,00)*	117.33 (0,00)*	194.80 (0,00)*	186.18 (0,00)*
HCE	-6.15 (0,00)*	-7.16 (0,00)*	-4.62 (0,00)*	-3.34 (0,00)*	115.35 (0,00)*	101.20 (0,00)*	120.34 (0,00)*	130.27 (0,00)*
GCE	-3.49 (0,00)*	-7.67 (0,00)*	-4.78 (0,00)*	-3.51 (0,00)*	120.12 (0,00)*	104.80 (0,00)*	221.47 (0,00)*	214.09 (0,00)*
TETAX	-5.94 (0,00)*	-5.30 (0,00)*	-6.10 (0,00)*	-4.48 (0,00)*	136.77 (0,00)*	114.30 (0,00)*	257.12 (0,00)*	253.81 (0,00)*
ETAX	-5.42 (0,00)*	-4.76 (0,00)*	-6.01 (0,00)*	-4.41 (0,00)*	136.72 (0,00)*	112.66 (0,00)*	266.42 (0,00)*	275.55 (0,00)*
TTAX	-30.45 (0,00)*	-24.49 (0,00)*	-10.38 (0,00)*	-9.18 (0,00)*	151.03 (0,00)*	142.45 (0,00)*	238.60 (0,00)*	210.86 (0,00)*

Note: Automatic lag length selection (Schwarz Information Criteria) is used. P values shown below test statistics. The null hypothesis for the first test is a unit root (assumes common unit root process). For the other three tests, the null hypothesis is a unit root (assumes individual unit root process). * indicate significance at the 1%.

The tests results show that all the variables are stationary in levels for all countries. When the variables are stationary in levels, a VAR model is employed. As is common in VAR analysis, the discussion of the results focuses on impulse response functions that are derived from the coefficients which are reported in Table 5[*] (see Appendix). Before estimating the PVAR[**] based impulse response functions, coefficients in the model will be interpreted. Our results show that gross national income responds positively to total environmental taxes. This result that is statistically significant at the 1 percent level introduces the relationship between environmental taxes and economic growth. This result also indicates the effect of environmentally friendly tax policy, applied in predominantly industrialized European countries, on economic performance. In Table-3, besides total environmental taxes, results regarding the taxes on energy and transportation are also given place. While these results indicate a positive and statistically significant relation between energy taxes and the gross national income, they also indicate a negative but statistically meaningless evidence between transportation taxes and gross national income. This present outcome can be handled as an indicator that energy taxes change the productive capacity of the economy by affecting production technology and amount of resource usage.

Our point of view is that the results in Table 5, being estimates from a reduced form model do not convey much information. Instead, one should pay attention to the underlying moving average representation of the VAR model, namely the impulse response functions and the associated variance decompositions. Impulse response functions describe the response of an endogenous variable over time to a shock in another variable in the system. Variance decompositions measure the contributions of each source of shock to the (forecast error) variance of each endogenous variable, at a given forecast horizon. These two combined, convey information on how each variable responds to a surprise change (a shock) to another variable in the system.

To analyze the impulse response functions we need an estimate of their confidence intervals. We calculate standard errors of the impulse response functions with Monte Carlo simulations and generate confidence intervals[*]. Monte Carlo simulations method essentially randomly generates a draw of coefficients of the VAR using the estimated coefficients and their variance covariance matrix to re-calculate the impulse responses (Love, Zicchino, 2006:195).

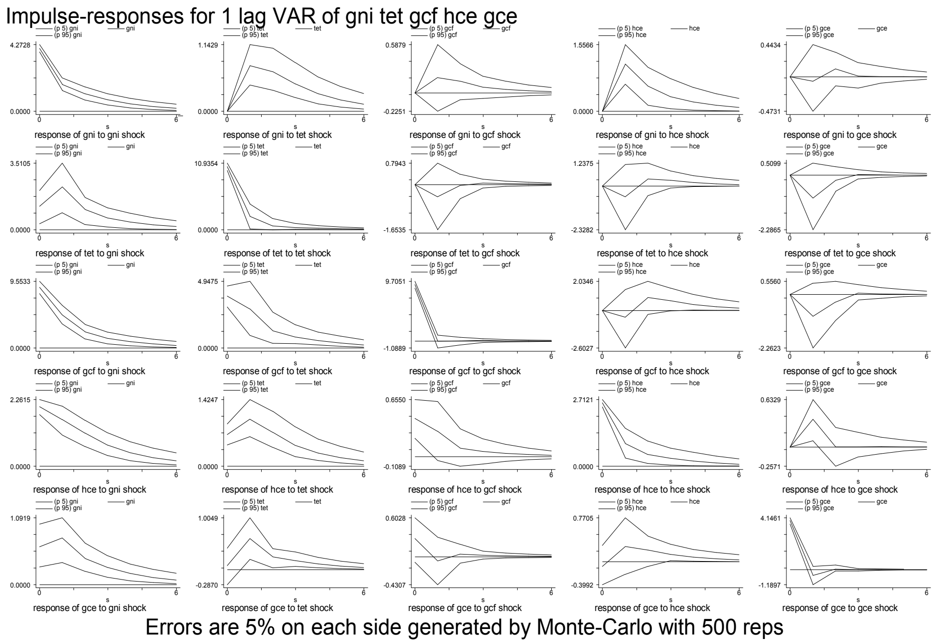
[*] The panel VAR is estimated by using the Stata package provided by Inessa Love. This package is used in Love and Zicchino (2006).

[**] Prior to the estimation of the panel VAR we have to decide the optimal lag order j of the right-hand variables in the system of equations (Lütkepohl, 2005). Optimum lag order is determined by Schwartz Criterion (SC) in our model. The SC suggests that the optimum lag order is one.

[*] This procedure is repeated 500 times to generate 5th and 95th percentiles of this distribution, which are then used as a confidence interval for the impulse-response.

In the impulse response function graphs obtained; on vertical axis, the direction and the percentile magnitude of other variables' reaction in response to one standard deviated impulse increase given to a related variable; and on horizontal axis, time elapsed in annual basis after the impulse is given are indicated. Dashed lines represent a ±*2* standard error confidence bound for reactions of variables and this confidence bound plays a significant part in determining the statistical meaningfulness of the results. The dynamic effects of the various shocks are illustrated by the impulse responses presented together with their % 5 error bands in Figure 1.

Figure 1: Impulse Response Functions for Total Environmental Taxes

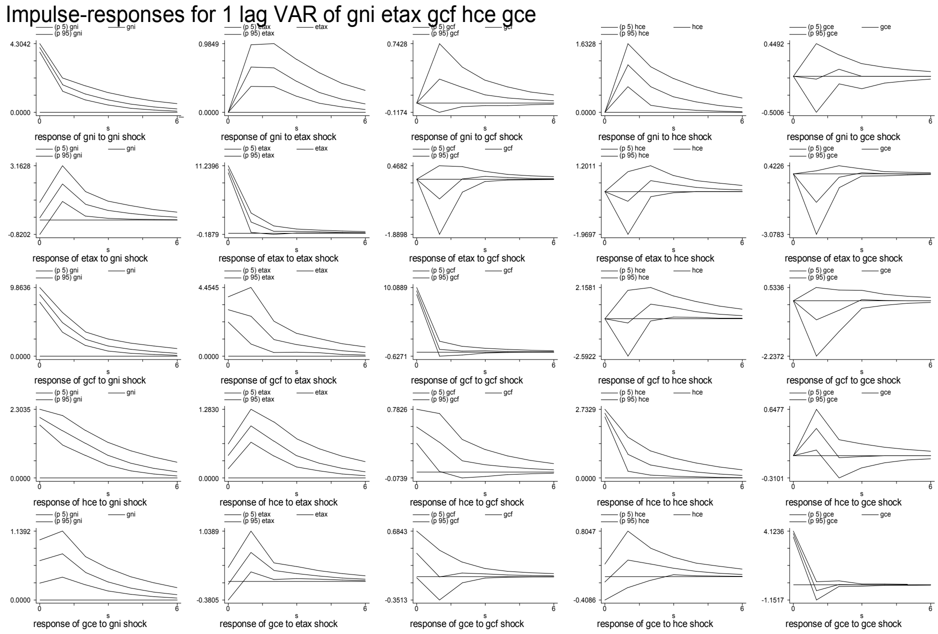


As it is seen in Figure 1, during entire period, the reaction of gross national income in response to one standard deviated impulse given to total environmental taxes is as increasing. Reaching its maximum level in the first period, the increase in income level has appears nearly about 0.75 %. This positive response of income conserves its statistical meaningfulness during the entire period. The response of the gross capital formation, which represents the productive capacity of economy, is positive and statistically meaningful during the entire period. However the response of this variable shows a gradually decreasing tendency. Similarly, the reactions of household consumption expenditure and public expenditure are positive and statistically meaningful in response to an impulse given to total environmental taxes. These results indicates that an increase in total environmental taxes at European Union countries has no negative influence on real sector; on the contrary, it affects gross capital formation and gross national income positively.

Some simulation studies, based on general equilibrium model, give us quite a similar result with impulse response function. The empirical conclusions from this studies find that environmental taxation is positively associated with economic activities (Cao, 2007:229-235; Leiter et. al., 2009:20-21; Zhixia, Ya, 2011:1760-1961). A common emphasis in these studies is that environmental taxation leads to more efficient use of energy while at the same time wage cost are lowered. It also leads to improve competitiveness for energy-businesses and for the development of new products which also can be exported (Anderson, 2007).

In this study energy taxes are also discussed as well as total environmental taxes. Impulse response results are shown in Figure 2.

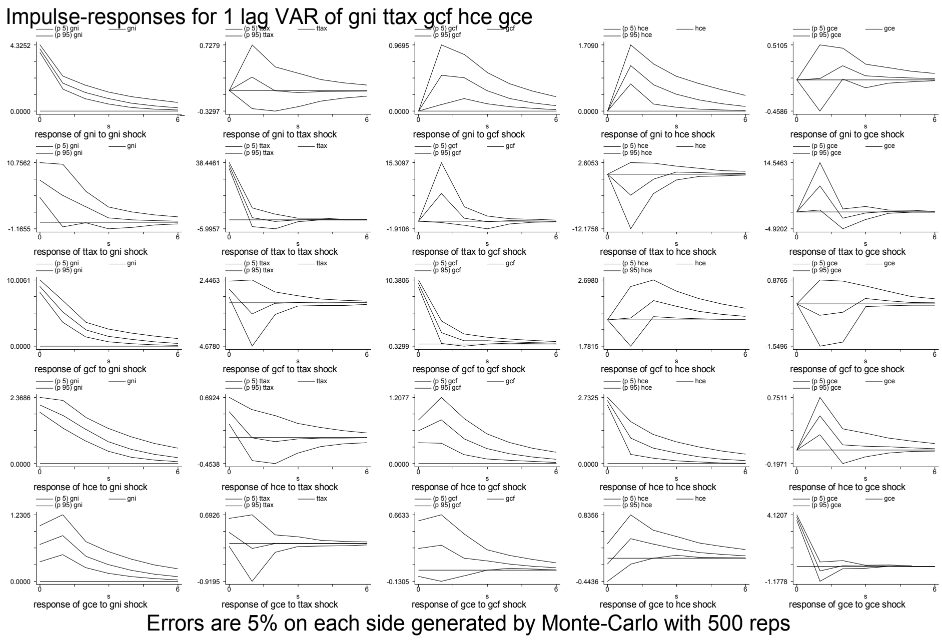
Figure 2: Impulse Response Functions for Energy Taxes



According to impulse response functions obtained from subtypes of environmental taxes, the reaction of income in response to an impulse given to energy taxes is statistically meaningful and positive during the entire period. As in the case of total environmental taxes, in response to an impulse in energy taxes, the reactions of other real variables are also meaningful and positive. These results indicate that taxes taken for energy do not affect real economic growth and real variables negatively; on the contrary, it has an incentive role.

When the impulse response functions of transportation taxes as part of environment taxes are examined, it is seen that different consequences than others are obtained. Results are shown in Figure 3.

Figure 3: Impulse Response Functions for Transportation Taxes



In response to an impulse given to transportation taxes, the reaction of gross national income is positive until the first period, but a statistically meaningful relation does not exist. Similarly, no statistically meaningful reactions of gross capital formation, household consumption expenditure and government consumption expenditure can be observed in return to an impulse given to transportation taxes.

Even though impulse responses give information about the size of environmental taxes pass-through to gross national product, they do not show how important environmental taxes are in explaining income fluctuations. To assess the importance of environmental taxes for income fluctuations, we perform a variance decomposition of gross domestic product. The variance decompositions display the proportion of movements in the dependent variables that are due to their own shocks versus shocks to the other variables. Table 6 (see Appendix) reports variance decompositions derived from the orthogonalized impulse–response coefficient matrices.

The variance decomposition for the coming period which takes place in Table 6, clarifies the relation among total environmental taxes, energy taxes and transportation taxes as part of environmental taxes, and gross national income, gross capital formation, household consumption expenditure and government consumption expenditure. The variance decomposition analysis confirms the results of impulse responses functions; it shows that environmental taxes shocks are more important in explaining economic growth fluctuations in European Union countries. Total environmental taxes shocks explain (after 30 quarters) 5.87 % of gross national income. The results in Table 6 also indicate that energy taxes shocks are important to explain the fluctuations of the gross national income. Energy taxes shocks explain (after 30 quarters) 4.67 % of gross national income.

Our empirical findings suggest that environmental taxes are positively related to economy. From the impulse response function and variance decomposition results, it is found that the environmental tax cause a great impact on European countries in the short term, but had not long term influence on gross national income. This didn't mean that a environmental tax wouldn't have any affect an economy in the long run. On the contrary environmental tax could change the structure of economy. Countries in implementing environmental taxes are engaged in deep processing and high tech industries with less carbon dioxide emission. This situation allows to increase the economic growth more environmentally friendly elements.

CONCLUSION

The relationship between environment and economy is a controversial issue. Some people argue that society faces a trade-off between environmental policy and economic growth. Others, however, maintain that environmental policy is a necessary condition for sustainable economic growth. As a result of recent concerns relating to the link between environmental policy and economic performance, policymakers have become increasingly interested in the use of environmental taxation. This research aims to address this issue, by determining whether environmental taxes have had any significant effect on the economic growth within the European countries.

This article seeks to examine the effect of environmental taxation on economic performance based on a data collected from 26 European countries from 1996 to 2009. To test the relationship between economic growth and environmental taxes, we used panel datasets that consist of time-series measurements on each of the cross-sectional observations. Results suggest that the average effect of an increase in environmental taxes is followed by a statistically significant increase in gross domestic product. Indeed, we find that an increase of environmental taxes by one standard deviation leads at its peak to an increase in gross domestic product. However the response of this variable shows a gradually decreasing tendency. To shed more light into our analysis, we report the total effect accumulated over 10, 20 and 30 quarters. The variance decomposition analysis give support to the results of impulse responses functions, it shows that environmental taxes are significant in explaining fluctuations in gross domestic product. Taking these results from the impulse response function and variance decomposition, environmental taxation obviously reveals a positive but diminishing impact an economic growth in our sample of European countries.

These result shows that it is theoretically as well as empirically possible that environmental taxation increases economic growth. In addition to this, environmental policy is seen as an important tool not only for the protection of the environment, but also for growing economies, so taxes on environment have become a central instrument of environmental policies in European countries.

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APPENDIX

Table 3: Studies Examining The Relationship Between Economic Growth and Environmental Regulation

Authors	**Countries**	**Method**	**Empirical Results**
McDougall, 1993	Australia	Computable General Equilibrium (CGE) Model	The energy and carbon taxes would lead to falls in real GDP estimated at around 0.5 percent.
Bovenberg and Goulder, 1997	US	General Equilibrium Model	It is found that double dividend doesn't exist.
Labandeira, Labeaga and Rodríguez, 2004	Spain	Static General Equilibrium Model	The Green Tax Reforms reduces GDP by 0.7% at basic prices, although the GDP at market prices experiences a 0.2% growth.
Ahammad, Curtotti, Gurney, 2004	Japan	Dynamic General Equilibrium Model	The US$31 carbon tax has a small negative impact on both carbon emissions and economic growth while the US$410 carbon tax is projected to reduce Japan's emissions closer to its Kyoto Protocol target but at a substantial cost to the Japanese economy.
Cao, 2007	China	CGE Model	The results suggest that the impacts of all three taxes (carbon tax, fuel tax, and output tax) on consumer utility for commodity consumption and GDP are positive in the long run.
Conefreya et al. 2008	Ireland	General Equilibrium Model	It is found that a double dividend exists if the carbon tax revenue is recycled through reduced income taxes.
Jaafar, Al-Amin and Siwar 2008	Malaysia.	CGE Model	Simulation results indicate that while imposition of carbon tax reduces carbon emission, it also results in lower GDP and trade.
Siriwardana, Meng and Mcneill, 2011	Australia	Computable General Equilibrium (CGE) Model	In the short run, Australia's real GDP may decline by 0.68 percent, consumer prices may rise by 0.75 percent, and the price of electricity may increase by about 26 percent as a result of the tax.
Lu, Cockfield and Zhang, 2011	China	CGE Model	The simulation results show that overall the introduction of a carbon tax will have a negative impact on the economy, namely, it will lead to a small decreases in household consumption, total consumption, exports, total demand and total supply and an increase in imports.
Zhou et al., 2011	China	CGE Model	The results show that carbon tax rate will lead to a reduction of CO2 emissions as well as a decline in the GDP if carbon tax revenues are collected by the government.
Zhixina and Ya, 2011	29 Chinese Provinces (1999-2008)	Generalized Least Squares estimation	The results are as follows: the impact of carbon tax on economic growth in China varies considerably between different regions; carbon tax could stimulate economic growth of most eastern regions, while can hinder some provinces' in middle and western areas.
Leiter, Parolini and Winner, 2009	23 countries (1995-2005)	Dynamic panel model	Environmental tax revenue, as an example of an environmental regulation, has a positive but diminishing effect on investment.
Morley and Abdullah, 2010	Twenty three European Union countries (1995-2006)	Dynamic panel model	The results suggest some evidence of long-run causality running from economic growth to increased revenue from the environmental taxes, with also some evidence of short-run causality in the reverse direction.

Table 4: Definitions of Variables

Variables	Definition/ Data Source	Description
TETAX	Total environmental tax revenue (annual %)	An environmental tax is a tax whose tax base is a physical unit (or a proxy of it) of something that has a proven, specific negative impact on the environment. Total revenues for environmental taxes include taxes on transport, energy, pollution and resources.
ETAX	Energy Tax Revenue (annual %)	Energy tax revenues is the sum of taxes on energy products used for both mobile and immobile purposes.
TTAX	Transport Tax Revenue (annual %)	Transport taxes mainly include taxes related to the ownership and use of motor vehicles.
GNI	Gross national income growth (annual %) (WB, 2012)	GNI is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad.
GCF	Gross capital formation (annual % growth) (WB, 2012)	Annual growth rate of gross capital formation based on constant local currency. Gross capital formation consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements; plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.
HCE	Household final consumption expenditure (annual % growth) (WB, 2012)	Annual percentage growth of household final consumption expenditure based on constant local currency. Household final consumption expenditure is the market value of all goods and services, including durable products, purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. It also includes payments and fees to governments to obtain permits and licenses.
GCE	General government final consumption expenditure (annual % growth) (WB, 2012)	Annual percentage growth of general government final consumption expenditure based on constant local currency. General government final consumption expenditure includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation.

Table 5: Results of the Estimation by System GMM for PVAR

Dependent Variable	GNI	TET	GCF	HCE	GCE
GNI $_{it-1}$	0.199	0.702	1.178	0.152	0.156
[t-stat]	[1.940]***	[1.854]***	[3.183]*	[1.275]	[1.462]***
GCF $_{it-1}$	-0.000	-0.029	0.015	0.011	-0.008
[t-stat]	[0.000]	[0.352]	[0.221]	[0.554]	[0.347]
HCE $_{it-1}$	0.429	-0.229	-0.180	0.361	0.101
[t-stat]	[3.979]*	[0.576]	[0.366]	[2.640]*	[0.836]
GCE $_{it-1}$	-0.015	-0.245	-0.234	0.094	-0.118
[t-stat]	[0.201]	[1.109]	[1.093]	[2.284]**	[1.027]
TETAX $_{it-1}$	0.047	0.238	0.288	0.068	0.055
[t-stat]	[2.656]*	[1.986]**	[2.354]*	[3.263]*	[2.074]**

Dependent Variable	GNI	ETAX	GCF	HCE	GCE
GNI $_{it-1}$	0.197	0.760	1.142	0.159	0.155
[t-stat]	[1.850]**	[2.556]*	[2.731]*	[1.276]	[1.467]***
GCF $_{it-1}$	0.005	-0.045	0.061	0.013	-0.002
[t-stat]	[0.220]	[0.586]	[0.828]	[0.654]	[0.120]
HCE $_{it-1}$	0.437	-0.185	-0.123	0.368	0.109
[t-stat]	[3.978]*	[0.546]	[0.242]	[2.612]*	[0.908]
GCE $_{it-1}$	-0.010	-0.369	-0.198	0.096	-0.114
[t-stat]	[0.136]	[1.481]***	[0.922]	[2.324]*	[0.992]
ETAX $_{it-1}$	0.041	0.190	0.230	0.073	0.051
[t-stat]	[2.555]*	[2.022]**	[2.186]**	[4.600]*	[1.917]**

Dependent Variable	GNI	TTAX	GCF	HCE	GCE
GNI $_{it-1}$	0.159	-0.043	0.918	0.091	0.107
[t-stat]	[1.348]***	[0.022]	[1.734]**	[0.571]	[1.142]
GCF $_{it-1}$	0.025	0.794	0.191	0.052	0.024
[t-stat]	[0.977]	[1.726]**	[1.767]**	[2.228]**	[1.017]
HCE $_{it-1}$	0.455	-1.717	0.047	0.413	0.140
[t-stat]	[3.757]*	[0.948]	[0.096]	[2.552]*	[1.256]
GCE $_{it-1}$	0.004	1.958	-0.107	0.124	-0.094
[t-stat]	[0.618]	[1.882]**	[0.527]	[2.814]*	[0.798]
TTAX $_{it-1}$	-0.000	0.012	-0.040	-0.008	-0.005
[t-stat]	[0.748]	[0.130]	[0.662]	[1.113]	[0.412]

Note: t-ratios in the square parenthesis. *,**, and *** indicate significance at the 1%,5% and 10% level respectively.

Table 6: Variance Decomposition Analysis

Variance for TETAX						
	s	**GNI**	**TETAX**	**GCF**	**HCE**	**GCE**
GNI	10	0.866621	0.058757	0.002514	0.071482	0.000626
GCF	10	0.484113	0.118739	0.384747	0.008047	0.004353
HCE	10	0.449678	0.119821	0.015272	0.40811	0.00712
GCE	10	0.072634	0.02745	0.004921	0.008558	0.886437
TETAX	10	0.068659	0.916586	0.001643	0.005138	0.007974
GNI	20	0.86659	0.05878	0.002514	0.071489	0.000626
GCF	20	0.48412	0.118745	0.384728	0.008053	0.004353
HCE	20	0.449704	0.119838	0.01527	0.408069	0.007119
GCE	20	0.072647	0.027455	0.004921	0.008561	0.886415
TETAX	20	0.068669	0.916574	0.001643	0.00514	0.007974
GNI	30	0.86659	0.05878	0.002514	0.071489	0.000626
GCF	30	0.48412	0.118745	0.384728	0.008053	0.004353
HCE	30	0.449704	0.119838	0.01527	0.408069	0.007119
GCE	30	0.072647	0.027455	0.004921	0.008561	0.886415
TETAX	30	0.068669	0.916574	0.001643	0.00514	0.007974
Variance for ETAX						
	s	**GNI**	**ETAX**	**GCF**	**HCE**	**GCE**
GNI	10	0.87124	0.046683	0.005815	0.075817	0.000445
GCF	10	0.496077	0.080669	0.410612	0.009249	0.003394
HCE	10	0.458833	0.097305	0.025086	0.411369	0.007408
GCE	10	0.076786	0.025901	0.007294	0.010308	0.87971
ETAX	10	0.045918	0.928464	0.003686	0.004991	0.016941
GNI	20	0.871196	0.046711	0.005816	0.075831	0.000445
GCF	20	0.496087	0.080678	0.410582	0.00926	0.003393
HCE	20	0.458873	0.097327	0.025083	0.411311	0.007406
GCE	20	0.076808	0.025908	0.007295	0.010314	0.879676
ETAX	20	0.045931	0.928448	0.003686	0.004994	0.016941
GNI	30	0.871196	0.046711	0.005816	0.075831	0.000445
GCF	30	0.496087	0.080678	0.410582	0.00926	0.003393
HCE	30	0.458873	0.097327	0.025083	0.411311	0.007406
GCE	30	0.076808	0.025908	0.007295	0.010314	0.879676
ETAX	30	0.045931	0.928448	0.003686	0.004994	0.016941
Variance for TTAX						
	s	**GNI**	**TTAX**	**GCF**	**HCE**	**GCE**
GNI	10	0.88404	0.001878	0.026159	0.085968	0.001956
GCF	10	0.523666	0.015782	0.445263	0.013826	0.001464
HCE	10	0.489015	0.010055	0.065557	0.423056	0.012316
GCE	10	0.088214	0.004935	0.011356	0.01572	0.879776
TTAX	10	0.057156	0.853462	0.034336	0.014999	0.040047
GNI	20	0.884008	0.001877	0.026169	0.085989	0.001956
GCF	20	0.523677	0.015781	0.445239	0.01384	0.001464
HCE	20	0.489053	0.010053	0.065562	0.423017	0.012315
GCE	20	0.088234	0.004934	0.011359	0.015727	0.879746
TTAX	20	0.057158	0.85346	0.034336	0.014999	0.040047
GNI	30	0.884008	0.001877	0.026169	0.085989	0.001956
GCF	30	0.523677	0.015781	0.445239	0.01384	0.001464
HCE	30	0.489053	0.010053	0.065562	0.423017	0.012315
GCE	30	0.088234	0.004934	0.011359	0.015727	0.879746
TTAX	30	0.057158	0.85346	0.034336	0.014999	0.040047