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IS THERE A LEVIATHAN BEHIND ENVIRONMENTAL TAXATION?

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ABSTRACT

The paper empirically verifies whether countries that use environmental taxes relatively more are also more engaged in environment policies or, alternatively, that they use such taxes for general expenditures purposes – a situation revealing at worst a Leviathan behavior by the government or, at least, an inefficiency inherent to the instrument. We examine the EU-27 countries that have committed themselves to attain a set of individual targets of reduction of greenhouse gas emissions by 2020. A dynamic system of simultaneous equations shows that neither such commitment positively affects the resort to environmental taxation, nor that these taxes help attaining the GHG reduction targets. To bring evidence to bear on the Leviathan vs. inefficiency interpretation of these results we further examine whether countries that use environmental taxes more also spend more for the protection of the environment. As a negative correlation instead emerges, our analysis leans towards the interpretation that there is a Leviathan behind environmental taxes.

Keywords: Environmental taxes, environmental policy goals, Leviathan government, dynamic simultaneous equations model.

JEL classification codes: Q28, H54, H87, D72, D73, D78

1. *Introduction*

Are the countries that resort more to environmental taxation also more engaged in the protection of the environment? If this is the case - even without imposing the strong restriction that environmental taxes be earmarked for environmental protection expenditures only - we can conclude that governments use the environmental taxes in a way consistent with the stated goal. If, instead, no correlation is found between the use of environmental taxes and the level of environmental protection, we can deduce either that governments act as Leviathans, in that they exploit the citizens' favorable outlook on the protection of the environment (EU Commission, 2014) for purposes of revenue maximization; or that there is an inefficiency inherent into the instrument.

To address this issue, we examine the sample of the EU countries that in 2009 have formally chosen to commit themselves to the attainment of a specific environmental protection target: the reduction of Green House Gases (henceafter, GHG). Decision 406/2009 of the EU Parliament and Council of the EU collectively obligates the EU member countries to reduce GHG to 70% of their 1990 levels by the year 2020. In addition to this EU wide target, the Decision sets also country-specific targets, to account for the different economic and environmental starting situations of each country, especially those of the former Eastern European nations. Figure 1 illustrates the distance from the target of GHG emissions that each country has committed itself to attain (Annexe II to Decision 4006/2009).

[Figure 1 about here]

Since the variable in Figure 1 is constructed as GHG target emissions minus the observed value (in the year 2012), a negative value indicate that the country is under-achieving its target, as their observed emissions are greater than the target ones; they can therefore be interpreted as evidence that these countries must still produce a policy effort to meet their engagement in the protection of the environment, at least in the domain of GHG reduction. The opposite holds for positive values. It is manifest that most Western countries of the EU still have to attain their target, while the EU effectively allows most of its Eastern members to pollute more (Benjamin et al. 2015).

On the other hand, the share of environmental tax revenues over total revenues indicates the intensity with which the country uses this environmental instrument. Figure 2 reports these values for the EU countries in 2012.

[Figure 2 about here]

We interpret a negative correlation between the country's distance from the target and the recourse to environmental taxation as evidence of consistency between the environmental goal and the environmental fiscal means. If, instead, no correlation is found between the distance from the target and the use of environmental taxation, we conclude that the government employs these taxes in ways disconnected from their presupposition, i.e., just like any other revenue source; in this case, either the government acts as a revenue-maximizing Leviathan or the environmental tax is inherently inefficient or inefficiently used. To bring evidence to bear on these alternative interpretations, we also check whether the countries that use environmental taxes more spend also more for the protection of the environment. The negative correlation found is rather more consistent with a Leviathan like behavior in environmental policy.[1]

This type of analysis faces two potential, yet fundamental, difficulties. The first is an obvious endogeneity problem between our measures of engagement in environmental protection and resort to environmental taxation. A larger negative distance from the environmental protection target justifies a greater effort in environmental taxation; at the same time, a more intensive resort to this type of taxes may reduce the distance from the target. To overcome this problem, we estimate a system of simultaneous equations, one with the distance from the target as the dependent variable, the other with the share of environmental tax revenues over total revenues as the regressand; moreover, we also use instruments for these two variables. The second problem – seemingly ignored in the literature so far – is that the distance from the environmental target can be either negative or positive. In other words, as figure 1 shows, countries can either fall short of their target, and be therefore supposed to intensify their environmental policies; or they can go beyond their target, and could in principle "relax" their fiscal efforts aimed at protecting the environment. The negative and positive value that the target variable may assume of course conditions the interpretation of the estimated coefficients on the explanatory

[1] We acknowledge that theory states that that Pigouvian taxes, such as the environmental ones, are supposed to correct the inefficiency by themselves, without the requirement that revenues be earmarked to the attainment of the same goal. Hence, if we consider the issue from a purely theoretical point of view, a lack of correlation between the resort to environmental taxation and the attainment of environmental targets could be interpreted as inefficiency of the environmental taxes; in turn, the lack of correlation between environmental taxes and environmental expenditures is consistent with the prescription that Pigouvian tax revenues should not be spent to correct the market inefficiency. Yet, in the actual world of environmental policy, it is unrealistic to conceive that a country can achieve such a broad goal like the reduction of GHG emissions by using environmental taxes only; a combination of environmental taxes, expenditures, regulation and other instruments is normally adopted, with all these instruments coordinated to the achievement of the GHG reduction target (Fouquet and Johanson, 2008). As our empirical model controls for country specific policy instruments and are not environmental taxes and expenditures, it is more plausible to interpret the lack of the correlation between environmental taxes and expenditures as evidence that the government uses the environmental taxes for purposes of revenue maximization rather than to pursue environmental goals.

variables. To sort out this problem, we distinguish between the countries with a positive difference with respect to the target, i.e., those that have already done better than it, from those with a negative difference, i.e., those which have still to attain their target.

Additionally, our analysis aims at shedding light on the transmission mechanism between the resort to environmental fiscal means and the attainment of environmental goals. Specifically, we aim to ascertain the factors that make environmental taxation more or less effective in reaching the environmental goals. To this end, we first estimate the system of simultaneous equations with the standard economic and environmental variables considered in the literature. Then we progressively control for a series of political and institutional variables that may condition the "stringency" with which the environmental taxes are effectively directed to support the protection of the environment. These control variables are the ideology of government, its degree of centralization, the type of institutional framework in which it operates, the presence of lobbies etc. We are also conscious that countries dispose of other policy instruments, different from environmental taxes, which can be adopted to achieve environmental goals, like regulation, the creation of market for externalities and so on. Quantitative measures of the countries' resort to these alternative instruments are difficult to obtain (Farmer, 2010); furthermore, important differences exist between the adoption and the application of environmental regulation, which makes the available proxies poorly informative. As the resort to these alternative instruments by each country is likely to remain constant over the time interval of the analysis, they are accounted for in the country fixed effects.

Overall, our analysis shows that environmental taxes are used for general budget purposes, and that there is no correlation between the country's performance in attaining the environmental target and its resort to environmental taxes. The estimated system of simultaneous equations shows that, at least in the group of the underachieving countries, the distance from the target does not affect the recourse to environmental taxation; nor does a more intense use of this instrument bring the countries – actually, any country - closer to their environmental target. This result is robust to changes in the estimation method. Furthermore, once we analyze the determinants of expenditures for the protection of the environment, we find that countries that resort to environmental taxation more tend to spend less for the protection of the environment. No pattern is detected with respect to the other expenditures items. This set of results, without being fully conclusive, still lead us to lean in favor of the interpretation that governments use environmental taxation in a Leviathan style way.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 illustrates the dataset, the variables and the specification of the model. The results of the estimates are presented and discussed in section 4. In section 5 we examine the determinants of the expenditures for environmental protection to double-check the legitimacy of a Leviathan interpretation of the results. Section 6 concludes.

2. *Literature review*

To the best of our knowledge, little, if any, research has been carried out on the political economy of the environmental taxes, namely, on the issue of why certain governments tend to use the instrument of environmental taxation relatively more than others. Several closely related issues have been explored, however.

The first is the issue of the choice of the policy instrument. Following the seminal paper of Buchanan and Tullock (1975), a few papers on the public choice/political economy of environmental policy have analyzed the choice of environmental taxes versus the 'command and control' approach (see, among others, Schneider and Volkeit, 1999 and Kirchgassner and Schneider, 2003). Kirchgassner and Schneider (2003) in particular argue that governments propose and apply environmental taxes for purposes different from the correction of externalities. By opposing the mainstream argument that environmental taxes create more incentives to innovate in emissions abatement technology than the command and control approach (Oates, 2000), they maintain that the application of market-oriented instruments in environmental policy is neither in the interest of the public bureaucrats nor in that of the industries to be regulated. The 'command and control' approach, instead, receives greater support from both sides of the political market: on the demand side of environmental policies, command and control instruments generally favor firms that are incumbent in the market, by introducing a barrier to entry; on the supply side, it produces visible political benefits and hidden political costs and leaves greater discretionary control to administrative agencies.

The second issue that has been explored is whether environmental policies can be best explained by electoral models, like the median voter (Congleton, 1992) or by lobbying models based on the influence of special interest groups (see, among others, Fredriksson, 1997; Aidt, 1998; Conconi, 2003; Riddel, 2003). Others have broadened the scope by examining the relationship between democracy (or lack thereof) and environmental protection. Congleton (1992), for instance, demonstrates that authoritarian regimes confront a higher relative price for pollution abatement than democracies; they consequently adopt less stringent domestic environmental standards and are less willing to sign environmental international treaties. He finds empirical evidence that liberal democracies are relatively lower sources of air pollution because of their higher income and their greater willingness to sign international treaties about environmental protection. Fredriksson et al. (2005) investigate how environmental lobbies, citizens' participation and the degree of electoral competition affect the determination of environmental policy in developed and developing countries. In their paper they also explore the interaction between democratic participation and electoral competition. They find that both environmental lobbies and political competition, in particular where citizens' participation in the democratic process is widespread, positively affect the stringency of environmental policy. Farzin and Bond (2006) empirically investigate the relationship between several local and global air pollutants and economic development, allowing for a set of sociopolitical-economic features of the countries in the sample. Their results support the hypothesis that democracy, and the freedoms it usually engenders, allow agents to exercise their preferences for environmental quality more effectively than autocratic regimes, thus leading to a reduction of concentrations or emissions of pollution. Yet additional factors such as urbanization, income inequality, age structure of the population, education mitigate or exacerbate the net effect of the type of political regime on pollution.

Another strand of research that has received considerable attention has examined the relationship between government ideology and environmental policies. Some papers suggest that left-wing parties have a tendency to consider environmental demands from the society more than other parties with different political orientation. Horbach (1992), for example, shows that in Germany the Green Party received fewer votes in the elections in the *lander* characterized by high employment rates than in the other *lander*. Moreover, the Green party had worse electoral outcomes in lander where the chemical and steel industries are relatively more diffused. Through a content analysis of party manifestos from 25 OECD countries over the period 1945-1998, Neumayer (2004) suggests that left-wing parties declare to be more pro-environment than their right-wing counterparts. Neumayer (2003) however argues that leftist governments may find themselves in a difficult position with respect to environmental policy because it can be costly in terms of employment in heavilypolluting industrial sectors (Neumayer, 2003). Potrafke (2010) provides empirical evidence that right wing governments have been more active at deregulating product markets and, among them, the market for energy. More recently Chang and Berdiev (2011) as well as Biressieloglu and Karaibrahimoglu (2012) show that left-wing governments favor regulation in the energy sector, while right-wing governments endorse energy deregulation, even though in the latter the link between environmental policy and government ideology in this case is less evident.

The quality of institutions too apparently plays an important role in the politics of the environmental protection. Fredriksson and Svensson (2003), for example, examine theoretically and empirically the effects of political instability and corruption on the efficiency of environmental policies. They find that corruption reduces the stringency of environmental regulations, while political instability offset this effect by lowering the rate of return on corrupt practices. Fredriksson et al. (2004) extend this analysis to the combined effects of corruption and industry size – a proxy for lobbying efficiency - on the outcomes of energy policies in the OECD countries. They provide empirical support to the hypotheses that greater corruptibility reduces the stringency of energy policies while higher costs of lobby coordination increase their stringency. Additionally, when the effect of energy policies on wages is large (small), the influence of worker coordination costs on the stringency of energy policies is also large (small), whereas the effect on capital owners' coordination costs is small (large). A number of other empirical studies (Welsch, 2004; Morse, 2006; Fredriksson and Vollebergh, 2009) broadly confirm these theoretical predictions using different samples, measures of governance quality and estimating techniques. Lopez and Mitra (2000) argue that corruption and rent-seeking behavior influence the relationship between income and the environment causing the turning points of the U-shaped Kuznets curve which defines the relation between economic growth and environment protection to rise above the socially optimum level. Magnani (2000) suggests that well-defined property rights, democratic voting systems, and respect of human rights can create synergies that lead to increased levels and efficiency of environmental policies. Finally, Cadoret and Padovano (2015) analyze how political factors affect the deployment of renewable energy sources and compare it to other economic, energy and environmental drivers that have received greater attention in the literature so far. Their analysis shows that lobbying by the manufactural industry negatively affect renewable energy deployment, whereas standard measures of government quality show a positive effect; furthermore left-wing parties promote the deployment of renewable energy more than right wing ones.

To our knowledge, in analyzing the reasons behind the use of environmental taxation, little if no attention has been devoted either to the relative importance of economics vs. political factors, or to the consistency between environmental goals and fiscal means. This is what the present paper is set out to do.

3. *Empirics*

<u>3. 1. Sample.</u> The sample encompasses all the EU-27 countries affected by Decision 406/2009; precisely Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom. The time interval covers the period 1995-2012, for which Eurostat provides coherent data for the dependent variables. Each variable thus features a maximum of 18*27=486 observations, quite enough to obtain efficient estimates; furthermore, the matrices of the variables are fairly balanced in their time series and cross sectional dimensions.

<u>3.2. Dependent variables.</u> To examine the relationships that relate the use of environmental taxation with the reduction of GHG, we use a system of equations where the two dependent variables are: 1) the share of environmental taxes[2] in total taxes (measured in revenue terms), labelled ENV_TAX; and 2) the difference between the GHG emissions target and the observed emissions, GHG_TARGET. The first is a standard indicator of the intensity with which a country is using the instrument of environmental taxation, and it is specified as the percentage of the revenues from all environmental taxes over total revenues of taxes and social contributions. The GHG_TARGET variable, instead, measures the distance separating the country from the target assigned by Decision 406/2009 – Annexe II. For consistency with the Decision, both the target and the observed values of GHG are specified as an index with respect to the base year of 1990. [3]

Two are the essential advantages of considering the GHG emission targets with respect to other possible indicators of environmental protection. The first is that this

[2] According to Eurostat, our data source, "…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". Hence environmental taxes fall within the following economic sectors: energy, transport, pollution, resources. Eurostat data are compatible with the concepts used in the system of national accounts. Throughout the paper, we stick to this definition and to this source of official data.

[3] See the text of Decision 406/2009 for the precise specification of this index.

target is precisely specified in quantitative terms[4] and can therefore be readily employed for statistical analyses. The second, and more important, is that the EU-27 member countries have committed themselves to attain these targets, by an official act of will, stated by Decision 406/2009. This frees the analyst from the subjective, and therefore always questionable, task of selecting an indicator of the country's engagement to pursue environmental protection goals. Here the general goal is common to all countries and it is specified in a country specific way that all countries have unanimously subscribed. The interference of the analyst is thus minimized. Finally, when necessary, this variable is separated in two groups, one for the countries that are doing better than their specific target and have thus a positive difference (variable GHG_TARGETp); the other for the countries that are underscoring their specific target and have thus a negative difference, (variable GHG_TARGETn).

3.3. Explanatory variables. Following the literature, the explanatory variables can be categorized in three vectors of variables: economic variables **X**, energy characteristics and environmental policy variables **W,** and politico-institutional variables **Z**. The first two are commonly used in the literature on the attainment of environmental protection goals. The third vector is a rather novel addition of the present analysis. All these three sets of variables have been included in both equations that compose the system illustrated in section 3.4.

Starting from the economic variables **X**, for all countries *i* and years *t*, we examine first the role of the growth of GDP per capita (G_GDP), measured in millions of euro at constant 2005 prices (as well as exchange rates, for the countries that do not belong to the Eurozone). GDP growth affects taxes as it is a proxy for the variation of the tax base; furthermore, economic growth pushes a country further towards the downward sloping portion of the Kutznets curve, thus positively influencing the citizens-taxpayers' preferences for environmental taxation with respect to alternative fiscal instruments (Arrow et al. 1995). A similar reasoning can be applied to citizens-taxpayers' support for environmental protection, including the reduction of GHG emissions. While the curve in principle posits a nonlinear relationship, our sample includes only countries that are either developed or highly developed ones, and therefore likely to be already positioned on the downward sloping portion of the

[4] Article 2.1 of decision 406/2009 defines the GHG emissions as "…the emission of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6), […] expressed in terms of tonnes of carbon dioxide equivalent".

curve. Nonetheless, the relationship between economic growth and the GHG_TARGET variable is difficult to specify *a priori*, because the targets set by the Decision account for the level of economic development of each country. Next we consider the country's terms of trade for goods and service (variable TTRADE), measured as the ratio of the prices of exports over the price of imports. As a measure of the country competitiveness on international markets, this variable influences the willingness to introduce environmental taxes, which typically fall on intermediate goods, thus increasing the actual production costs and reducing competitiveness. In a similar fashion, and at the risk of multicollinearity, we consider a standard measure of the country's revenues requirements, the deficit-to-GDP ratio (variable DEFICIT), measured as the country's net lending (+) or net borrowing (-), at the general government level. [5]

Vector **W** includes the energy and environmental policy variables. We have considered, beyond the environmental taxes and the total taxes defined by the dependent variable ENV_TAX, the non-environmental taxes (variable OTHER_TAX), measured as the difference between total tax revenues and environmental tax revenues, both normalized by GDP [6]. This variable aims to detect Leviathan-style behaviors by the government, which typically substitutes alternative fiscal instruments regardless of their end use. Another important variable that the literature often uses in this context [7] is the interaction between the price of oil and the energy dependency ratio (variable OIL_PRICE*DEP). Energy dependence shows the extent to which an economy relies on imports to meet its energy requirements. The indicator is calculated as net imports divided by the sum of gross inland energy consumption plus bunkers. The (crude) oil price is specified as the average spot price Brent, Dubai and West Texas Intermediate, equally weighed, in US$ per barrel at 2010 prices. Ultimately, this is another measure of the country's competitiveness, as it refers to the weight of the imported energy on the actual costs of domestic products; as such it should be correlated with the country's propensity to introduce environmental taxes. Yet, as this variable includes also the price of oil, it is also correlated with the country's willingness to reduce GHG emissions. This composite

[5] This measure includes the one-off proceeds relative to the allocation of mobile phone licenses. We have also considered the country's debt-to-GDP ratio, measured as the general government consolidated gross debt. The results were quite similar to those obtained using the DEFICIT variable.

[6] The normalization by GDP avoids the possibility that the variables ENV_TAX and OTHER_TAX sum to 1.

[7] See for instance Chang et al. (2009) and Marques et al. (2010).

structure makes the variable potentially difficult to interpret; we hence elect to examine also the energy intensity (variable ENERGY_INT), specified as the kilogram of oil equivalent per 1000 euros worth of products. This is an alternative, but non-interacted, measure of the country's propensity to substitute oil with other energy sources, thus reducing GHG emissions.

Finally, vector **Z** features the politico-institutional variables that characterize the transmission mechanism from the recourse to environmental taxation and the attainment of the environmental goals. It includes a series of variables that describe either the preferences of the political agents that take environmental policy decisions concerning the use of environmental taxation as an instrument to protect the environment; or the political and institutional framework where these decisions are actually taken. Hence, holding constant the covariates in vectors **W** and **X**, the variables of vector **Z** tell us why, for a given use of environmental taxation, some countries are more efficient than others in reducing their GHG reduction target. Starting from the proxies for political preferences, we consider the variable LEFT, a dummy from the Database of Political Institutions, which equals 1 if the country's sitting government is supported by parties defined as communist, socialist, social democratic, left-wing or altogether green, and 0 otherwise. The idea is that left wing governments place a larger weight on goals of environmental protection, like the reduction of GHG emissions, and are thus relatively more likely to resort to environmental taxes (Neumayer, 2003; Potrafke, 2010). Another preference indicator is the variable MAN_VA, which measures the share of value added from the manufacturing industry on total GDP. This variable aims at capturing the diffusion of lobbies from the manufacturing sector, which have been shown to oppose the pursuit of environmental goals that increase production costs (Fredriksson et al. 2004; Fredriksson and Vollenbergh, 2009; Cadoret and Padovano, 2015). In one specification we have also considered the diffusion of lobbies from the agricultural sector, with the same theoretical presuppositions. Furthermore, we consider four proxies for the institutional constraints under which environmental policy decisions are taken. The first is SYS_PARL, a dummy from the Database of Political Institutions, which equals 1 if the country has a parliamentary system and 0 otherwise. The idea, from the political economy literature (Persson and Tabellini, 2003), is that parliamentary countries tax more than presidential ones; this fact might influence the resort to environmental taxation. The second is the country's decentralization of expenditure decisions (variable DECENTR), specified, in percentage terms of GDP, as the difference between the general and the central government total expenditures, divided by the general government total expenditures. This variable checks the efficiency with which the central government can direct the country's policy of reduction of GHG emissions, including the resort to environmental taxation. Because considerable geographical spillovers characterize this policy target, countries with more centralized policy decision making processes should perform better in the attainment of the GHG target. Additionally, these countries should also be more liable, all other things being equal, to use the environmental taxation in a way consistent with its stated goal (Ashworth et al. 2013). Finally, we control for two measures of government policy efficiency. The first is the "quality of regulation" index (variable REG_QUAL), a World Bank indicator that reflects the perceptions of the ability of the government to formulate and implement sound policies and regulations promoting private sector development. The second is the government effectiveness indicator (GOV_EFF), another highly aggregated World Bank indicator that compounds the perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

Table A.1 in the appendix reassumes the characteristics of the variables and their data sources, while table 1 provides the descriptive statistics.

[Table 1 about here]

<u>3.4. Specification of the model.</u> In order to model the likely bivariate interactions between the resort to environmental taxes and the attainment of the GHG emissions targets, we have estimated, via 2SLS, a simultaneous equation model with two endogenous variables: the share of environmental taxes in total taxes (measured in revenue terms) ENVTAX and the difference between the GHG emissions target and the observed emissions GHG. The system is dynamic, as it includes the one lagged values of the dependent variable for each equation of the system. This enables us to see, first, how variations in environmental taxation produce changes in the country's attainment of the environmental goals; and, second, whether the progressive attainment of these goals determines variations in the recourse to environmental taxation. Moreover, we have adopted an additional measure to tackle the potential problems of endogeneity, namely we have instrumented the lagged environmental taxes with further lags of the ENV_TAX variable and of the overall GHG_TARGET variable. We have proceeded likewise when the dependent variable is the distance

from the GHG target[8]. Finally, for robustness checks, we have estimated the model via GMM and system-GMM to verify whether the results remain stable under alternative estimating techniques.

Besides these three vectors of exogenous variables, the model also includes country fixed effects φ, to account for country's idiosyncratic characteristics, chiefly among them the resort to environmental instruments other than taxes, such as regulations etc.

The model of two equations that we estimate can be expressed as follows:

$$\begin{cases} ENVTAX_{it} = \alpha_1 ENVTAX_{it-1} + \beta_1 GHG_{TARGET\,it} + \gamma_1 \mathbf{X}_{1it} + \delta_1 \mathbf{W}_{1it} + \theta_1 \mathbf{Z}_{1it} + \varphi_{1i} + \varepsilon_{1it} & (1) \\ GHG\_TARGET_{it} = \alpha_2 GHG\_TARGET_{it-1} + \beta_2 ENVTAX_{it} + \gamma_2 \mathbf{X}_{2it} + \delta_2 \mathbf{W}_{2it} + \theta_3 \mathbf{Z}_{2it} + \varphi_{2i} + \eta_{2it} & (2) \end{cases}$$

where i identifies the country, t the year and 1 and 2 the equation of the system.

4. *Results of the estimates*

4.1. 2SLS estimates. Tables 2 and 3 report the results of the 2SLS estimates of the system of equations 1. In particular, table 2 shows the results of the equation for environmental taxes, and table 3 those for the distance from the target.

[Table 2a about here]

In table 2a we have considered just the economic variables **X** and the energy and environmental policy variables **W**. In model (1) the distance from the target is considered for all the countries lumped together, without distinguishing those that are bettering the target from the under-achieving ones. The coefficient is not statistically significant. Only the lagged share of environmental taxes positively influences the dependent variable, showing the expected persistence in the use of this policy instrument. The deficit to GDP variable, a standard measure of the government's revenue requirement, is not correlated to the resort to environmental taxes, as the lack of statistical significance of the estimated coefficient reveals. The negative sign on the economic growth variable G_GDP suggests that an increase of the tax base augments the revenue share of the non-environmental taxes only – possibly because their tax bases are more directly related to personal income than those of the environmental ones. The "growth dividend" is not spent on taxes aimed

[8] The precise specification of the instruments adopted in each model is reported at the bottom of tables 2 and 3.

– at least nominally – at achieving environmental goals. An alternative explanation is that economic growth pushes countries further on the downward sloping portion of the inverted Kutznets curve; the more environmental friendly technologies adopted reduce the need to impose environmental taxes (Benjamin et al., 2015). The terms of trade variable has always a negative sign, although it is weakly significant only in model (1), where all countries are lumped together with respect to their position from the target. This suggests that, if the price of exports rises with respect to that of imports, the country is losing competitiveness, reducing its likelihood to resort to environmental taxation. The interactive term of oil dependency and price is always negatively and significantly correlated with the use of environmental taxes. This sign is expected because, for a stable oil price, a greater dependency pushes environmental taxes down to avoid a loss of competitiveness. Similarly, for a stable degree of oil dependency, an increase of the price of oil leads countries to reduce environmental taxation, again for fear of loss of competitiveness. Finally, the negative and statistically significant sign on the regressor OTHER_TAX indicates that governments treat environmental and non-environmental taxes as substitute fiscal instruments. This substitutability is a first piece of evidence that governments use environmental taxes for general revenue purposes – in a Leviathan way – rather than exclusively for environmental purposes. The rate of substitution is far from being perfect though, as a 10 percentage points increase of the non-environmental tax pressure reduces the resort to environmental taxes by 1,24 percentage points, circa one eightieth. This is another sign that governments actually aim at maximizing revenues.

Most of these results are in line with the theoretical hypotheses; the most problematic one appears the lack of statistical significance of the target variable, which would imply that countries do not bother to reach the target of GHG emission reduction that they have formally committed themselves to. In models (2)-(4) of table 2a we investigate whether this lack of statistical significance is due to an aggregation bias, by distinguishing the countries with a positive difference (i.e;, those that have already done better than their target) from those with a negative one (the underachievers). For the first group of countries the estimated coefficient is indeed negative and statistically significant, confirming that these countries can reduce the tax pressure from environmental taxation and that, at the same time, they are characterized by a consistency between the fiscal end and the fiscal means. Conversely, model (2) shows that the countries that under-achieve the environmental target, mostly the Western European ones, do not correlate the resort to environmental taxation with the distance from their target. These contradictory signs suggest, however, that there is no stable relationship between the target of GHG reduction and the use of environmental taxes. This reinforces the interpretation that environmental taxes are used, especially in Western European countries, for general purposes of taxation, but is, at least also at this stage of the analysis, also compatible with a scenario where environmental taxes are inherently ineffective.

[Table 2b about here]

The estimates reported in table 2b include the explanatory variables from vector **X** and **W** that have consistently turned out significant in models (1)-(5) and add to them the political and institutional drivers of vector **Z**. Most of these variables are specified so to separate out countries which have surpassed the target from those still lagging behind. Among these institutional factors, only parliamentary systems (regardless of the position of the country with respect to the target) positively affect the share of environmental taxation. The political economy literature (Persson and Tabellini, 2003) has long established that parliamentary systems tend to spend more, and therefore tax more, than presidential ones. Here it appears that they recourse more to environmental taxes as well. Leftwing governments seem more committed to reaching the target than right wing ones. The coefficients on the LEFT dummies show a positive and statistically significant sign when the country is below the target (variable LEFTn) – and must therefore use more Pigouvian taxes to close the distance from it – while it turns negative and again significant in countries where the target is already attained (variable LEFTp). The other political and institutional factors seem not to play a relevant role in the relationship between environmental goals and means.

[Table 3a and 3b about here]

In table 3 we report the estimates of equation (2) of the system, with the target for GHG reduction as the dependent variable. Following the same procedure as for the first equation, in table 3a we consider only the economic and environmental policy variables, while in table 3b we include also institutional factors.

The results of this second equation provide a picture altogether consistent with the one emerged from the estimates of the equation with ENV_TAX as the regressand. The lagged dependent variable is highly significant and with a positive sign: this means that all countries with a negative distance (the under-achievers) are getting closer to their target, while those that have already surpassed their assigned target are polluting even less. The most striking result is however the lack of statistical significance for the environmental taxes. This strongly confirms what already emerged in the first equation, namely that either environmental taxes are not used for environmental purposes, certainly not for the reduction of GHG emissions or that they are inherently ineffective, as no country within our sample has managed to use them successfully to correct the negative externality caused by GHG emissions. As it is rather absurd that all countries in the sample consistently insist in using an instrument that has been shown ineffective, we lean towards the first interpretation, namely that environmental taxes are just another instrument for Leviathan governments to raise more revenues. A similar lack of correlation regards also the other types of taxes.

The other regressors mostly show the expected signs. The oil dependency/oil price interactive term is negatively related with the distance from the target, suggesting that when competitiveness decreases, the countries are less interested in achieving their GHG reduction target and in fact move away from it. The same logic applies to the TTRADE variable, at higher levels of statistical significance. The energy intensity of production is actually a measure of pollution, so its negative sign reflects the country's distance from the target.

Among the variables of vector **Z**, we find that countries with parliamentary systems, *ceteris paribus*, tend to under-achieve the GHG reduction target more than countries with different government systems. If we combine this negative relationship with the positive one between parliamentarism and resort to environmental taxation, we might infer that countries with parliamentary systems are the most likely to spend the environmental tax revenues in manners unrelated with environmental goals; in other words, they are the ones that act in the most Leviathan-like way. Finally, government ideology seems to play a role only when governments are left wingers and the country is not attaining the GHG reduction target. The positive sign on this variable suggests that these left wing governments are the ones more engaged in closing the gap from the target.

4.2. System-GMM estimates. To verify whether the results are robust to changes in the estimation techniques, we have estimated the system of equations (1) using the Arellano-Bond model. Table 4 reports the results.

[Table 4 about here]

The GMM estimates yield two main results and a caveat. The first result is that the Arellano-Bond estimator confirms the core outcome of the 2SLS estimates, namely, that there is no correlation between the country's performance in attaining the environmental target and its resort to environmental taxes. If anything, the negative sign on the GHG target for the overachieving countries attains higher levels of statistical significance than in the 2SLS estimates, thus corroborating the interpretation that environmental tax revenues are used for purposes different from the reduction of GHG emissions. In the equation with GHG target as dependent variable, the intensity of use of environmental taxes never turns out statistically significant, and it has been left out from the reported estimates.

The second interesting result is that the political variables pick up statistical significance in the Arellano-Bond estimations. Specifically, in countries with a negative difference from the target, left wing government are associated with better performances in the attainment of the target, a result already found in the 2SLS; likewise, in this group of countries, those with a parliamentary government tend to lag behind the other ones in the attainment of the GHG target, all other things being equal. The other results remain fundamentally unchanged[9], confirming that the results are robust to changes of the estimating techniques.

5. *Estimates on environmental protection expenditures*

So far, the interpretation of the estimates as evidence that governments act as Leviathans with respect to environmental taxation rests on two types of results: first, the imperfect substitutability between environmental and non-environmental taxes; second, and most importantly, the finding that environmental taxes are irrelevant to reducing the country's distance from its target level of GHG emissions. Hence, even controlling for the country specific resort to environmental regulation, governments appear to use environmental tax revenues to finance any type of expenditures.

It may be the case, however, that environmental taxes are used for other environmental concerns, not necessarily the reduction of GHG; if so, our interpretation of the estimation results as evidence of a Leviathan like behavior by governments would be unjustified because the chosen dependent variable would be too limited to represent the whole environmental policy of the country. To verify this possibility, we have estimated the same model used to explain the behavior of GHG_TARGET substituting the countries' expenditures for environmental

[9] We have also performed the same estimates using an Arellano-Bover system GMM technique. The results, available upon request, confirm what already found in the 2SLS and the GMM Arellano-Bond estimates. The system-GMM estimates however yield AR(2) statistics that are at the boundary of acceptance for the estimates with ENV_TAX as dependent variable, suggesting that the instruments which this model generates are not fully satisfactory.

protection in percentage of GDP as the dependent variable. Environmental protection expenditures are the most comprehensive aggregate of government outlays for environmental purposes for which Eurostat (and the OECD) collect information. If no correlation can be found between the countries' resort to environmental taxation and either GHG reduction or environmental protection, one can more legitimately conclude that governments collect environmental taxes just for purposes of revenue maximization.

Unfortunately, data limitations prevent us from estimating the same system of equations (1-2). Eurostat actually collects official data about environmental protection in the EU for a more limited sample than that of GHG emissions, as there is no information for Finland and the time series starts in 2002 as opposed to 1995. We therefore estimate the second equation of the system with ENV_PROT as the dependent variable, namely:

$$\text{ENV\_PROT}_{it} = \alpha_3 \text{ENV\_PROT}_{it-1} + \beta_3 \text{ENVTAX}_{it} + \gamma_3 \mathbf{X}_{it} + \delta_3 \mathbf{W}_{it} + \theta_3 \mathbf{Z}_{it} + \varphi_i + \omega_{it} \quad (3)$$

and propose it only as a further check of the interpretation of the estimates of the system of equations (1-2). Equation (3) is therefore estimated using only an Arellano-Bond dynamic panel estimator. The generated instruments are two lags of the dependent variable and of ENV_TAX, as well as the first differences of all regressors. Table 5 illustrates the results.

[Table 5 about here]

Model 1 of table 5 includes all the variables of table 3. Environmental taxes appear negatively and statistically significantly correlated with expenditures for environmental protection; the dynamic structure of the estimating procedure ensures that this result does not depend on the time difference between the moments when revenues are collected and when they are spent. Likewise, other non-environmental taxes are negatively correlated with the dependent variable. Predictably, higher oil prices leave fewer revenues available for environmental concerns; nor there is a growth dividend to be paid in this domain of government intervention. All these results are consistent with the ones obtained with the GHG_TARGET as the dependent variable. Among the political variables of vector $\boldsymbol{Z}$, only the lobbying influence of the manufacturing sector turns out to be negatively and statistically significantly correlated with outlays for environmental protection, just as theory predicts. Model 2 features a more parsimonious specification, limited to the explanatory variables that attained statistical significance in model 1. The negative and statistically significant correlation between the resort to environmental taxation and spending for the protection of the environment persists, while the other results remain qualitatively the same.

These results further increase the amount of evidence in favor of the Leviathan interpretation, especially if we adopt a "real world" vision of environmental policy, whereby all instruments (taxes, expenditures, regulation etc.) must point to the same direction in order to achieve such a broad result like the reduction of GHG emissions. Yet, if one prefers to stick only to the Pigouvian model affirming that taxes are enough to achieve the correction of the externality, the negative correlation between environmental tax revenues and expenditures is in principle compatible with a scenario where governments implement environmental taxes in a "pure Pigouvian" way – notwithstanding the inefficiency of such a policy shown by the regression of tables 3 and 4. Hence, to bring the maximum of evidence possible to bear on these alternative interpretations, we have estimated equation (3) for the remaining expenditure programs for which Eurostat provides data, namely, general services, defense, education, public order, economic services, health care, housing services and social protection. The idea of this test is that a Pigouvian government should spread the revenues of environmental taxes across all expenditure items. This dispersion should result in a lack of statistical significance of the coefficient relating environmental taxes to each expenditure item. The limited share of environmental tax revenues with respect to total fiscal revenues (7% on average throughout our sample) makes this result easier to obtain and actually slants the test in favor of the Pigouvian view. Conversely, if environmental taxes are spent more in a Leviathan style, they should result positively correlated with the more redistributive expenditure items, which are most apt to secure a power base to the government. Table 6 reports the results of the estimates of equation (3) with this wider array of regressands.

[Table 6 about here]

For the sake of brevity we report only the results where the estimated coefficient on the ENV_TAX regressor turned out significant. Out of the ten spending items considered (including environmental protection) environmental taxes appear to be negatively correlated with expenditures on the environment and order and security – two public goods – while positively correlated with expenditures on public administration, on economic affairs and housing services – three highly redistributive programs. For the remaining five spending items the estimated efficient is not statistical significant, with no pattern detected among the signs[10].

All in all, also the estimates of tables 5 and 6 appear rather more consistent with the interpretation that governments use environmental taxation for purposes of revenue maximization, i.e., in a Leviathan style. Controlling for country-specific phenomena like the use of regulation, governments that more intensively resort to environmental taxation do not get closer to their GHG reduction targets; if anything, they appear to spend less for the protection of the environment and more for purposes of strengthening their power base. In fairness, we cannot claim that the empirical analysis has provided conclusive evidence in favor of the Leviathan interpretation; but that would have been in any event most difficult, as literature reviews of the Leviathan model concur in saying that no conclusive empirical test of the presence of a Leviathan government has so far been devised (Persson and Tabellini, 2001; Mueller, 2003) and that the existing evidence must be considered as indicative.

6. Conclusions

This paper has empirically verified whether countries that use environmental taxes relatively more are also more engaged in the protection of the environment – or else, such taxes are used for general purposes – hence presupposing either a Leviathan like behavior by the government or an inefficiency embedded in the instrument. To this end, we have examined the EU-27 countries that have committed themselves to attain a set of individual target of reduction of greenhouse gas emissions by 2020.We have found evidence of the combination of a) greater intensity in the use of environmental taxation, a fiscal instrument that usually benefits of a positive outlook by citizens and thus represents a less politically costly tax to levy; and b) lack of correlation between environmental taxation and the pursuit of the environmental goal, clearly specified as the reduction of GHG emission. Both these results may be interpreted as evidence either of a Leviathan-type behavior in environmental policy or as an inefficient use of the environmental taxes – although it is doubtful that rational governments insist in using a fiscal instrument that has been shown to be ineffective. . , We have also estimated the same model using environmental protection outlays as a further indicator of environmental policies and

10 The results for these last five regressions are available upon request.

found that there is lack of consistency in the use of the two sides of the public budget for environmental purposes. If anything, when the model was estimated on other expenditure items, environmental tax revenues appeared to be directed to a selected set of highly redistributive expenditure items, such as functioning of the public administration and economic affairs. Hence, and with no claim to having provided conclusive evidence, our interpretation of the overall results of the analysis is that it is likely that there is a Leviathan behind environmental taxation.

The estimates of dynamic system of simultaneous equations have shown that the lack of correlation between the GHG reduction targets and the resort to environmental taxation is all the more evident in countries that are actually under-achieving their target, especially in those that feature a parliamentary system, which generally constraints the government less. Likewise, left wing governments seem more committed to the achievement of the environmental goals, regardless of the policy instrument they adopt.

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Tables and figures for the paper "LEVIATHAN , GREEN IS THE COLOUR OF THY SKIN" by Isabelle Cadoret, Emma GalliandFabio Padovano

Figure 1.Distance from country specific targets for GHG emissions set by Decision n. 406/2009 (observed GHG emissions of 2012)

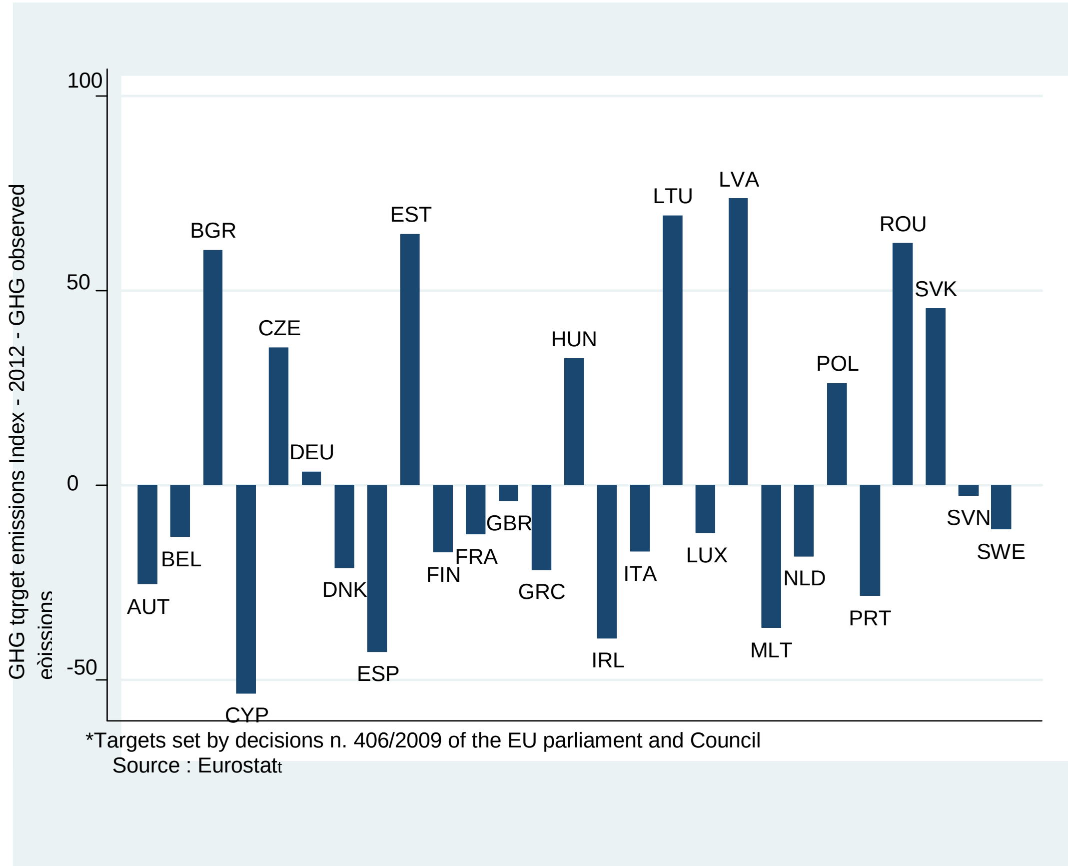

Figure 2.Share of environmental tax revenues over total tax revenues (mean values).

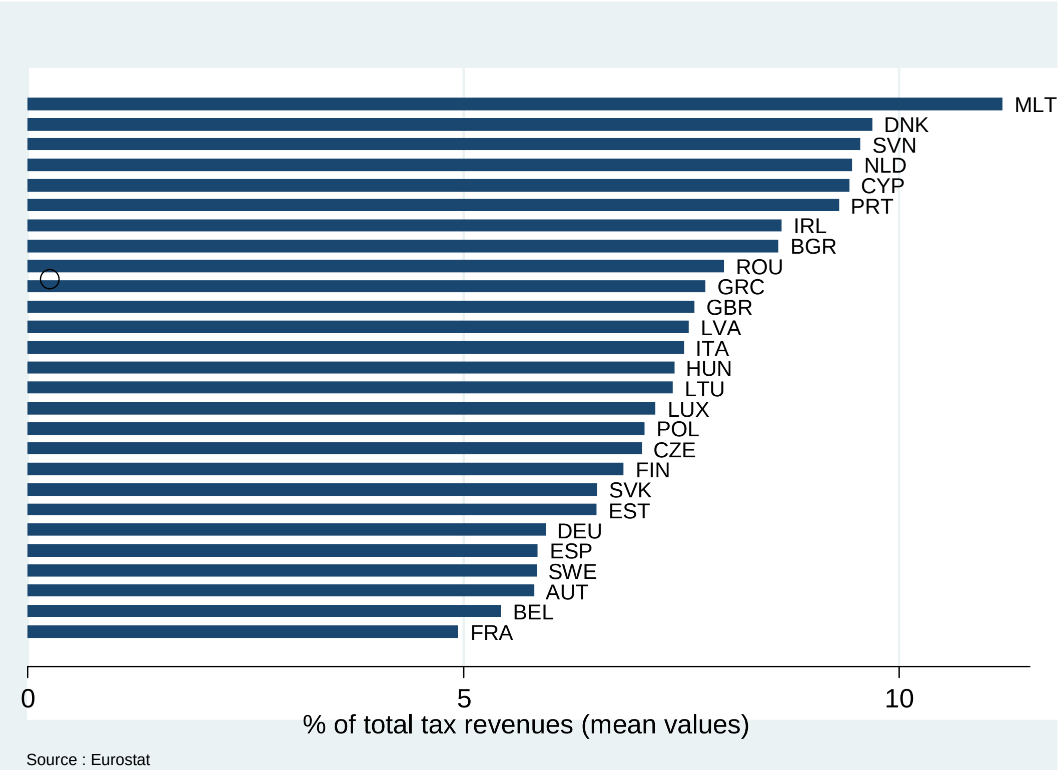

Table 1. Descriptive statistics

Variable		*Mean*	*Std. Dev.*	*Min*	*Max*	*Observations*
ENV_TAX	overall	7.567593	1.8448	2.7	15.39	N = 486
	between		1.526826	4.946111	11.18944	n = 27
	within		1.074151	2.670926	11.98815	T = 18
GHG_TARGET	overall	3.500864	38.37574	-72.66	78.89	N = 486
	between		38.332	-53.59278	73.64222	n = 27
	within		7.406618	-24.40969	29.97364	T = 18
OTHER_TAX	overall	34.67551	6.195756	22.34	49.44	N = 486
	between		6.033776	26.28056	46.01556	n = 27
	within		1.804728	28.65996	42.14496	T = 18
OILPRICE	overall	51.12278	27.88435	15.8991	97.5972	N = 486
	between		7.24e-15	51.12278	51.12278	n = 27
	within		27.88435	15.8991	97.5972	T = 18
DEP	overall	55.48004	29.83609	-49.8	109.5	N = 486
	between		29.37196	-16.50556	100.8333	n = 27
	within		7.597346	22.1856	105.3856	T = 18
G_GHG	overall	2.75488	7.849959	-16.59683	149.2716	N = 459
	between		2.394908	.4202695	11.89454	n = 27
	within		7.489102	-19.68544	140.1319	T = 17

Variable		*Mean*	*Std. Dev.*	*Min*	*Max*	*Observations*
DEFICIT	overall	-3.074454	6.8676	-130.4177	6.855226	N = 486
	between		2.51081	-9.086248	1.996832	n = 27
	within		6.409425	-124.4059	7.143008	T = 18
TTRADE	overall	98.951	6.974166	63.52617	120.2129	N = 486
	between		5.250032	81.72532	109.133	n = 27
	within		4.69492	79.76752	119.0359	T = 18
ENERGY_INT	overall	286.9376	223.7432	82.45876	1810.431	N = 486
	between		205.2663	102.5862	947.3875	n = 27
	within		96.97235	.9282057	1495.274	T = 18
SYS_PARL	overall	.8374486	.3693361	0	1	N = 486
	between		.3636257	0	1	n = 27
	within		.0939157	.2263374	1.226337	T = 18
LEFT	overall	.3703704	.4834015	0	1	N = 486
	between		.2799064	0	.8888889	n = 27
	within		.3975872	-.5185185	1.314815	T = 18
DECENTR	overall	34.65555	15.07439	0	74.50111	N = 485
	between		14.31098	.3419677	67.18395	n = 27
	within		5.485388	-13.45749	66.92296	T-bar = 17.963
REG_QUAL	overall	1.200972	.4398875	-.1184463	2.076635	N = 486
	between		.4207997	.2611139	1.81986	n = 27
	within		.1504505	.6596762	1.596799	T = 18

Variable		*Mean*	*Std. Dev.*	*Min*	*Max*	*Observations*
GOV_EFF	overall	1.177533	.6702878	-.6228861	2.356591	N = 486
	between		.6605725	-.3541682	2.118035	n = 27
	within		.1680021	.6522224	1.660397	T = 18
MAN_VA	overall	17.98509	5.049876	5.1	29.7	N = 486
	between		4.753222	7.933333	24.91111	n = 27
	within		1.923553	10.95731	24.06842	T = 18
ENV_PROT	overall	.6030726	.3848534	.01	3.14	N = 358
	between		.3494376	.2081818	1.9	n = 27
	within		.2161619	0.680726	1.843073	T = 13 .2593

Table 2a. Equation (1). Dependent variable: share of environmental taxes over total taxes

	Model 1 2SLS	Model 2 2SLS	Model 3 2SLS	Model 4 2SLS
ENV_TAX_{t-1}	0.554*** (13.15)	0.584*** (15.02)	0.587*** (15.01)	0.580*** (14.94)
GHG_TARGET_t	-0.0108 (-1.62)			
G_GDP_t	-0.0290*** (-3.36)	-0.0333*** (-3.90)	-0.0318*** (-3.74)	-0.0316*** (-3.71)
$DEFICIT_t$	-0.00477 (-1.17)			
$TTRADE_t$	-0.0116+ (-1.68)	-0.00914 (-1.41)	-0.00782 (-1.21)	
$logOILPRICE_t{}^{\times}DEP_t$	-0.0049*** (-7.15)	-0.00438*** (-6.50)	-0.00418*** (-6.32)	-0.00417*** (-6.27)
OTHER_TAX	-0.124*** (-6;04)	-0.126*** (-6.57)	-0.119*** (-6.40)	-0.123*** (-6.63)
$GHG\_TARGETn_t$		-0.00791 (-1.38)		
$GHG\_TARGETp_t$		-0.0272+ (-1.73)	-0.0298+ (-1.90)	-0.0320+ (-2.03)
N	405	432	432	432
adj. R^2	0.638	0.656	0.653	0.651
F_Cragg-Dowd	101.9	91.63	99.7	99.03
SarganPval	0.447	0.493	0.348	0.329

t statistics in parentheses, + p<0.10, * p<0.05, ** p<0.01, *** p<0.001
Instruments: ENV_TAX_{t-2}, GHG_TARGET_{t-2},GHG_TARGET_{t-3} in model (1),
Instruments: ENV_TAX_{t-2}, $GHG\_TARGETn_{t-1}$, $GHG\_TARGETn_{t-2}$, $GHG\_TARGETp_{t-1}$ and $GHG\_TARGETp_{t-2}$ in model (2), (3) and (4).

Table 2b.First equation. Dependent variable: share of environmental taxes over total taxes

	Model 5 2SLS	Model 6 2SLS	Model 7 2SLS	Model 8 2SLS	Model 9 2SLS	Model 10 2SLS
ENV_TAX_{t-1}	0.551*** (12.97)	0.553*** (13.24)	0.551*** (13.12)	0.545*** (12.88)	0.548*** (13.09)	0.552*** (13.19)
$GHG\_TARGETp_t$	0.339* (-2.06)					
G_GDP_t	-0.0312*** (-3.64)	-0.0333*** (-3.90)	-0.0318*** (-3.74)	-0.0316*** (-3.71)		
$logOILPRICE_t{\times}DEP_t$	-0.00477*** (-6.54)	-0.00435*** (-6.45)	-0.00423*** (-5.51)	-0.00477*** (-6.56)	-0.00452*** (-6.58)	-0.00473*** (-6.82)
$OTHER\_TAX_t$	-0.125*** (-6.69)	-0.130*** (-7.01)	-0.130*** (-6.95)	-0.129*** (-6.96)	-0.131*** (-6.92)	-0.128*** (-6.94)
SYS_PARLp_t	0.797* (2.36)					
$SYS8PARLn_t$	0.707^{+} (1.92)	-0.126*** (-6.57)	-0.119*** (-6.40)	-0.123*** (-6.63)		
SYS_PARLp_t		0.779* (2.33)	0.769* (2.29)	0.898* (2.57)	0.775* (2.26)	0.818* (2.45)
$LEFTn_t$		0.168* (1.99)	0.162^{+} (1.88)	0.177* (2.06)	0.194* (2.28)	0.175* (2.06)
$LEFTp_t$		-0.231* (-2.11)	-0.227* (-2.05)	-0.280* (-2.42)	-0.296* (-2.56)	-0.300* (-2.57)
MAN_VA_t			0.00700 (0.33)			
$DECENTRn_t$				0.00452 (0.44)		
$DECENTRp_t$				0.0108 (1.04)		
REG_QUALn_t					-0.155 (-0.74)	

	Model 5 2SLS	Model 6 2SLS	Model 7 2SLS	Model 8 2SLS	Model 9 2SLS	Model 10 2SLS
REG_QUALp_t					0.0710 (0.33)	
GOV_EFFn_t						-0.284 (-1.64)
GOV_EFFp_t						-0.114 (-0.61)
N	432	432	432	432	432	432
adj. R^2	0.648	0.655	0.654	0.653	0.655	0.656
F_Cragg-Dowd	96.09	94.75	94.12	95.03	90.40	93.81
Sargan_pvalue	0.142	0.141	0.148	0.135	0.0873	0.0955

t statistics in parentheses. + p<0.10, * p<0.05, ** p<0.01, *** p<0.001
Instruments: ENV_TAX$_{t-1}$, ENV_TAX$_{t-2}$, GHG_TARGETn_{t-1}, GHG_TARGETn_{t-2}, GHG_TARGETp_{t-1} and GHG_TARGETp_{t-2}.

Table 3a.Second equation. Dependent variable: GHG TARGET

	Model 1 2SLS	Model 2 2SLS	Model 3 2SLS
GHG_TARGET_{t-1}	0.800^{***} (20.10)	0.799^{***} (20.38)	0.813^{***} (23.50)
ENV_TAX_t	-0.302 (-1.04)	-0.311 (-1.18)	
G_GDP_t	-0.443^{***} (-8.74)	-0.443^{***} (-8.75)	-0.444^{***} (-8.71)
$TTRADE_t$	-0.203^{***} (-4.06)	-0.202^{***} (-4.08)	-0.172^{***} (-3.81)
$logOILPRICE_t{}^{\times}DEP_t$	-0.0110^{+} (-1.67)	-0.0109^{***} (-1.64)	
$OTHER\_TAX_t$	0.181 (0.13)		
$logENERGY\_INT_t$	-8.501^{***} (-3.40)	-8.392^{***} (-3.53)	-5.962^{***} (-3.70)
N	405	405	405
adj. R^2	0.709	0.710	0.708
F_Cragg-Dowd	127.8	130.4	352.1
Sargan_pvalue	0.0899	0.0900	0.989

t statistics in parentheses; + p<0.10, * p<0.05, ** p<0.01, *** p<0.001
Instruments: $GHG\_TARGET_{t-2}GHG\_TARGET_{t-3}$ ENV_TAX_{t-2} ENV_TAX_{t-3} in models (1) and (2).
Instruments: GHG_TARGET_{t-2} GHG_TARGET_{t-3} in model (3).

Table 3b.Second equation. Dependent variable: GHG TARGET

	Model 4 2SLS	Model 5 2SLS	Model 6 2SLS	Model 7 2SLS	Model 8 2SLS	Model 9 2SLS
GHG_TARGET_{t-1}	0.794^{***} (22.14)	0.812^{***} (22.76)	0.810^{***} (22.04)	0.819^{***} (22.70)	0.813^{***} (22.88)	0.813^{***} (22.84)
G_GDP_t	-0.435^{***} (-8.61)	-0.436^{***} (-8.73)	-0.438^{***} (-8.77)	-0.418^{***} (-7.46)	-0.437^{***} (-8.62)	-0.437^{***} (-8.74)
$TTRADE_t$	-0.157^{***} (-3.41)	-0.177^{***} (-3.98)	-0.185^{***} (-3.92)	-0.163^{***} (-3.44)	-0.174^{***} (-3.22)	-0.176^{***} (-3.97)
$logENERGY\_INT_t$	-5.712^{***} (-3.54)	-5.851^{***} (-3.68)	-5.983^{***} (-3.73)	-5.283^{***} (-2.98)	-5.983^{***} (-2.88)	-5.884^{***} (-3.72)
$SYS8PARLp_t$	-1.513 (-0.71)					
SYS_PARLn_t	-4.601^{+} (-1.93)	-3.787^{***} (-3.26)	-4.228^{***} (-2.09)	-3.663^{***} (-3.33)	-3.697^{***} (-3.34)	-3.704^{***} (-3.37)
$LEFTp_t$		-0.161 (-0.22)				
$LEFTn_t$		1.669^{***} (3.05)	1.715^{***} (3.11)	1.751^{***} (3.14)	1.666^{***} (3.03)	1.670^{***} (3.05)
$DECENTRn_t$			-0.0403 (-0.58)			
$DECENTRp_t$			-0.0246 (-0.33)			
MAN_VA_t				-0.0969 (-0.73)		
AGR_VA_t					-0.176 (-0.07)	
N	405	405	405	405	405	405
adj. R^2	0.714	0.719	0.718	0.718	0.719	0.718
F_Cragg-Dowd	332.0	332.1	312.7	326.9	339.0	334.7
Sargan_pvalue	0.843	0.897	0.905	0.804	0.899	0.894

t statistics in parentheses. + p<0.10, * p<0.05, ** p<0.01, *** p<0.001; Instruments:GHG_TARGET_{t-2}andGHG_TARGET_{t-3}.

Table 4.Estimation via Arellano-Bond - GMM. Dependent variables: share of environmental taxes over total taxes and GHG TARGET

Dependent variable	ENV_TAX_t		GHG_TARGET_t	
	Model 1 Arellano-Bond GMM	Model 2 Arellano-Bond GMM	Model 3 Arellano-Bond GMM	Model 4 Arellano-Bond GMM
ENV_TAX_{t-1}	0.706^{***} (18.14)	0.724^{***} (13.98)		
GHG_TARGET_{t-1}			0.633^{***} (25.64)	0.604^{***} (13.41)
G_GDP_t	-0.0254^{***} (-45.81)	-0.0257^{***} (-54.78)	-0.158^{***} (-10.37)	-0.146^{***} (-8.86)
$TTRADE_t$			-0.383^{***} (-12.87)	-0.404^{***} (-5.35)
$logOILPRICE_t \times DEP_t$	-0.00410^{***} (-9.65)	-0.00356^{***} (-5.46)		
$OTHER\_TAX_t$	-0.138^{***} (-7.22)	-0.170^{***} (-5.39)		
$logENERGY\_INT_t$			-11.96^{***} (-4.93)	-15.38^{***} (-4.44)
SYS_PARL_t		0.273 (0.35)		
SYS_PARLn_t				-3.704^{***} (3.59)
$LEFTn_t$		0.251 (1.03)		1.670^{***} (3.05)
$LEFTp_t$		-0.270 (1.52)		
$GHG\_TARGETp_t$	-0.0222^{***} (-3.82)	-0.0324^{***} (-3.91)		
C	8.317^{***} (13.72)	9.047^{***} (5.71)	104.1^{***} (6.78)	126.3^{***} (5.13)
N	432	432	432	432
AR(1)	0.001	0.0013	0.0004	0.0003
AR(2)	0.07	0.10	0.7827	0.7953
Sargan_pvalue	1.0	1.0	1.0	1.0

t statistics in parentheses; + p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Table 5. Dependent variable: Expenditures on environmental protection

	Model 1 Arellano-Bond GMM	Model 2 Arellano-Bond GMM
ENV_PROT_{t-1}	0.511*** (6.5)	0.608*** (11.55)
ENV_TAX_t	-0.0223+ (-1.63)	-0.0126** (-2.11)
G_GDP_t	-0.001* (-1.86)	-0.0004*** (-3.71)
$logOILPRICE_t{}^{\times}DEP_t$	-0.0003** (-2.22)	-0.0001*** (-3.30)
$OTHER\_TAX_t$	-0.0029 (-0.59)	
SYS_PARL_t	-0.0257 (-0.18)	
$LEFTn_t$	0.008 (0.13)	
$LEFTp_t$	0.0619 (1.18)	
MAN_VA	-0.0118* (-2.93)	-0.0084*** (-2.39)
C	0.852*** (4.73)	0.490*** (5.03)
N	293	293
Wald χ^2	482.96***	1788.67***
Sargan_ χ^2	17.19	20.35

t statistics in parentheses; + p<0.10, * p<0.05, ** p<0.01, *** p<0.001
Instruments: $GHG_TARGET_{t-2}$$GHG_TARGET_{t-3}$ ENV_TAX_{t-2} ENV_TAX_{t-3} in models (1) and (2).
Instruments: GHG_TARGET_{t-2} GHG_TARGET_{t-3} in model (3).

Table 6. Dependent variable: Other expenditures items

	Expenditures on general services ENV_PA	Expenditures on housing services ENV_HS	Expenditures on order and security ENV_OS	Expenditures on economic affairs ENV_EA
	Arellano-Bond GMM	Arellano-Bond GMM	Arellano-Bond GMM	Arellano-Bond GMM
ENV_TAX_t	0.113* (2.49)	-0.0282+ (-0.14)	-0.0317*** (-3.39)	0.233*** (3.94)
G_GDP_t	-0.0110*** (-5.30)	0.000301 (0.64)	0.000158** (3.28)	-0.00903*** (-2.81)
SYS_PARL_t	-5.111* (-2.18)	0.502 (0.99)	0.138 (0.56)	-2.051 (-0.91)
$DECENTR_t$	-0.104*** (-6.07)	-0.0148*** (-6.72)	-0.0114*** (-7.15)	-0.151*** (-4.94)
$LEFT_t$	0.457+ (1.87)	0.181+ (1.78)	0.101+ (1.94)	0.252 (0.98)
GOV_EFF_t	-0.554+ (-1.96)	-0.0761 (-0.93)	0.0703 (1.07)	-1.185* (-2.25)
MAN_VA_t	-0.0462 (-0.71)	-0.0075 (-0.66)	-0.0161*** (-5.71)	-0.153** (-3.24)
ENV_PA_{t-1}	0.439*** (9.32)			
ENV_HS_{t-1}		0.239** (2.62)		
ENV_OS_{t-1}			0.516*** (8.90)	
ENV_EA_{t-1}				0.119** (3.26)
C	0.852*** (4.73)	0.490*** (5.03)		14.50*** (6.60)
N	399	399	399	399
Adj. R^2				
Sargan_ χ^2				

t statistics in parentheses; + p<0.10, * p<0.05, ** p<0.01, *** p<0.001
Instruments:
Instruments:

Appendix 1.

Table A1.List of variables: Definition and Sources

Name	*Description*	*Source*
ENV_TAX	Total environmental taxes, Percentage of total revenues from taxes and social contributions	Eurostat
TAX_GDP	Total revenues from taxes and social contributions/GDP	Eurostat
GHG_TARGET	Target – GHG observed	
TARGET	Target 2020, i.e. the level of GHG (base year 1990) actually assigned to the country by the European Commission (decision 406/2009 – Annexe II)	European Commission
GHG observed	Greenhouse gas emissions (base year 1990)	Eurostat
OTHER_TAX	Difference between total revenues from taxes and social contributions/GDP and total revenues from environmental taxes/GDP	Eurostat
OILPRICE	Log of crude oil, average spot price of Brent, Dubai and West Texas Intermediate, equally weighed, expressed in $/bbl (at 2010 constant prices)	World Bank
DEP	Log of net imports of all types of energy divided by the sum of gross inland energy consumption plus bunkers	Eurostat
G_GDP	Growth rate of GDP per capita	Eurostat
GDP	Gross Domestic Product, expressed in millions of euro (at 2005 constant prices)	Eurostat
POPULATION	Resident Population, expressed in millions	Eurostat
DEFICIT	General Government Net lending (+) or net borrowing (-)(based on ESA 2010), expressed as % of GDP	AMECO - European Commission
TTRADE	Ratio of an index of exports prices on the index of import prices (base year 2010)	AMECO - European Commission
ENERGY_INT	kg of oil equivalent per 1 000 EUR	Eurostat
SYS_PARL	Parliamentary versus Presidential System (binary, 0,1)	Database of Political Institutions, Development Research Group - The

Name	*Description*	*Source*
		World Bank
LEFT	Leftist governments (binary 0,1)	Database of Political Institutions, Development Research Group - The World Bank
DECENTR	Central government expenditure/ General government expenditure, both expressed as % of GDP	Eurostat
MAN_VA	Manufacturing, value added expressed as % of GDP	World Bank
AGR_VA	Agriculture, value added expressed as % of GDP	World Bank
REG_QUAL	Perceptions about the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development	World Bank
GOV_EFF	Perceptions about the quality of public services, civil service, independence from political pressures, quality of policy formulation and implementation and the credibility of government's commitment	World Bank
ENV_PROT	Expenditures for environmental protection as a percentage of GDP	Eurostat
ENV_PA	Total expenditures of the Public Administrations as % of GDP	Eurostat
ENV_HS	Total expenditures of the Public Administrations on housing services as % of GDP	Eurostat
ENV_OS1	Total expenditures for Order and Security services as % of GDP	Eurostat
ENV_EA	Total expenditures of the Public Administrations for economic affairs as % of GDP	Eurostat