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Does the quality of political institutions matter for the effectiveness of environmental taxes? An empirical analysis on CO_2 emissions

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Abstract

We empirically investigate the existence of the Environmental Kuznets Curve (EKC) focusing on a sample of 39 countries in the period 1996-2014. Using an interaction model, we also analyze whether the effectiveness of environmental taxes in reducing CO_2 emissions depends on the quality of political institutions. Our results show that the inverted U-shaped relationship between environmental stress and economic development holds independently of the quality of political institutions and environment related taxes. Moreover, an increase in the environmental tax revenue has the expected reducing effect on environmental degradation only in countries with more consolidated democratic institutions, higher civil society participation and less corrupt governments. Our findings also show that the effects on environmental stress of revenue neutral shifts to different tax sources depend not only on the quality of political institutions, but also on the kind of externality the policymaker aims at correcting.

Keywords: Environmental tax revenue, Environmental tax mix, Environmental Kuznets Curve, CO_2 emissions.

JEL classification: H23, P16, Q50, Q53, Q38.

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1 Introduction

The Environmental Kuznets Curve (EKC) is widely used in the environmental economic literature to describe an inverted U-shaped relationship between per capita income and environmental degradation. The intuition behind the EKC is very appealing: during the early stage of development, when the level of per capita income is low and the economy is undergoing the process of industrialization, environmental quality rapidly deteriorates. Then, when a higher stage of development is achieved, this trend reverses.[1] This implies that the best policy recommendation for reducing environmental stress is economic growth.

However, Panayotou (1997) underlines that '*the EKC, in its reduced form, is a 'black box' that hides more than it reveals. [...] Without an explicit consideration of the underlying determinants of environmental quality, the scope for policy intervention is unduly circumscribed*'. Starting from this, Matsuo (1998), Rentz (1998), Dinda (2004) and Tamazian and Bhaskara Rao (2010) highlight the importance of governance and, more generally, institutional values, as crucial determinants of the economic growth-environmental quality relationship. It is also widely acknowledged that economic growth often goes hand in hand with political development (Acemoglu and Robinson, 2006; Persson and Tabellini, 2006 and 2007; Papaioannou and Siourounis, 2008).

A stream of empirical literature investigating the influence of political institutions on both environmental performance and environmental policy adoption has thus flourished. These studies use different indicators to proxy the quality of political institutions, generally considered as the institutions that shape policy decisions by constraining the possible choices of the policy-makers. Corruption is probably the most common variable used to measure political values (Lopez and Mitra, 2000; Cole, 2007; Fredriksson et al., 2004; Lægreid and Povitkina, 2018), but measures of democracy and civil and political freedom, such as civil society participation, and freedom of expression and information, are also widely used (Bernauer and Koubi, 2009; Halkos and Tzeremes, 2013; Hosseini and Kaneko, 2013; Aasen and Vatn, 2018; Lægreid and Povitkina, 2018).

The most usual environmental performance indicators used as dependent variables are pollutants, such as per capita carbon dioxide (CO_2) emissions. And in the field of environmental policy implementation, given that the world economy is moving towards an era of cleaner energy, there is increasing attention to climate change and energy policies (Durakoğlu, 2011; Nepal and Jamasb 2012; Bhattacharya et al., 2017; RISE, 2018).

Although there is mixed evidence on the relationship between various indicators of political institution quality and environmental performance, almost all empirical studies find that high quality political institutions foster the implementation of environmental policies. (For a survey, see Bernauer and Koubi, 2009; Dasgupta and De Cian, 2016.)

Within these existing strands of the literature, this paper focuses on political institu-

[1] See Dinda (2004) for an exhaustive survey.

tions and environmental tax policy. To our knowledge, no studies to date have focused on these two issues jointly. The paper has three aims: (*i*) to test whether the EKC hypothesis holds independently of the quality of political institutions and independently of environmental related taxes; (*ii*) to check whether and how the quality of political institutions affects the effectiveness of environmental tax revenue in lowering environmental degradation; (*iii*) to assess whether and how the quality of political institutions influences the effect of *revenue neutral shifts* to different environmental tax sources on environmental stress.

To do this, we perform an empirical analysis on a sample of 39 countries characterized by different levels of economic development, in the period 1996-2014. We proxy environmental degradation by using per capita CO_2 emissions. Levels of democracy, civil society participation and political corruption are used to capture the quality of the political institutions of our sample countries (Dasgupta and De Cian, 2016; Lægreid and Povitkina, 2018). We also collect data on environmental taxes, considering both the level of environmental tax revenue and its structure, i.e. energy, transport, pollution and resources taxes. We exploit the fact that these data are broken down into distinct environmental domains, i.e. Total Environment, Air Pollution and Climate Change, representing the environmental externalities on which each tax has a direct effect.

Our results show that the inverted U-shaped relationship between environmental stress and per capita income holds independently of the quality of political institutions and independently of environmental related taxes. In other words, regardless of the development of political institutions and the level of environmental tax revenue, economic growth is necessary for CO_2 emissions to be reduced.

However, we also find that, when the quality of political institutions is low, an increase in the environmental tax revenue worsens environmental quality. Environmental taxation completely fails in this political context, since it increases pollution, rather than reducing it. Only when the quality of political institutions is high, does an increase in the environmental tax revenue have the expected effect of reducing environmental stress. In particular, the strongest reduction in CO_2 emissions is observed when political corruption is at its lowest level. So as well as reinforcing economic development, consolidating democratic values, promoting freedom of thought and participation and fighting political corruption are determinant to effectively improving environmental quality through the environmental tax revenue.

Lastly, our estimates show that the effects on environmental stress of revenue neutral shifts to different tax sources depend not only on the quality of political institutions, but also on the kind of externality the policymaker aims at correcting. Tax structure matters, because the effects of revenue neutral shifts to different tax sources can reduce environmental stress even where the quality of political institutions is low, and vice versa. At the same time, environmental domains also matter. For the same quality of political institutions, shifting to a specific tax, while keeping constant the environmental tax revenue, can have different effects on CO_2 emissions according to the kind of externality the policymaker aims at correcting.

The rest of the paper is organized as follows. Section 2 presents the empirical model. Section 3 introduces the data used in the empirical analysis and provides an overview of them. Section 4 describes the main empirical results. Section 5 discusses the most significant policy implications of our findings. Finally, Section 6 briefly concludes.

2 The empirical model

The traditional specification of the inverted U-shaped relationship between environmental stress and economic development is the following:

$$p_{it} = a_i + b_0 y_{it} + b_1 y_{it}^2 + b_2 X_{it} + \epsilon_{it} \tag{1}$$

where, for each country i in each year t, p_{it} is the environmental stress, y_{it} is per capita GDP and X_{it} is a set of control variables. Equation (1) describes a quadratic inverted U-shaped relationship between pollution and economic development when the coefficient b_0 is positive ($b_0 > 0$) and the coefficient b_1 is negative ($b_1 < 0$) respectively. In this case, the EKC is verified.

From an empirical point of view, the main shortcoming of estimating Equation (1) is that it involves per capita GDP and its square as key explanatory variables. Generally, these series are integrated, and consequently nonlinear transformations of integrated variables may lead to biased and inconsistent estimates (Wagner, 2008).

In order to overcome this drawback, Bradford et al. (2005) provided the following empirical specification of the EKC which has been used in many papers in the existing environmental literature (Leitão, 2010, Baiardi, 2014; Zhang and Meng, 2019):

$$p_{it} = \alpha_i + \beta_0 y_i g_i t + \beta_1 g_i t + \beta_2 X_{it} + \theta_i + \eta_t + \xi_i \tag{2}$$

where y_i is the average GDP for each country i and g_i is its average GDP growth rate, t is a linear time trend, θ_i and η_t are country- and time-specific effects respectively, and ξ_i is the error term. If the coefficient β_0 is negative, the hypothesis of an inverted U-shaped relationship between environmental stress and economic development is verified. No assumptions are imposed on the sign of the coefficient β_1.[2] As noted by Bradford et al. (2005, p. 5), the main advantage of estimating Equation (2) is that it '*is not subject to the unresolved problems arising in panel regression with nonlinear transformations of potentially nonstationary regressors*'.

Starting from Equation (2), we introduce our baseline estimation model by means of the following equation:

$$p_{it} = \alpha_i + \beta_0 y_i g_i t + \beta_1 g_i t + \beta_2 X_{it} + \beta_3 POL\_INST_{it} + \beta_4 REV_{it} + \theta_i + \eta_t + \tau_i \tag{3}$$

[2] See Appendix A for further details.

where POL_INST_{it} and REV_{it} are the political and fiscal variables, i.e. the quality of political institutions and the environmental tax revenue, respectively, while τ_i is the error term, clustered at country level. In this way, we test the existence of the EKC independently of the quality of political institutions and the level of environmental tax revenue.

Then, we rewrite Equation (3) as follows:

$$p_{it} = \alpha_i + \beta_0 y_i g_i t + \beta_1 g_i t + \beta_2 X_{it} +$$
$$\beta_3 POL\_INST_{it} + \beta_4 REV_{it} + \beta_5 POL\_INST_{it} \times REV_{it} + \theta_i + \eta_t + \zeta_i \quad (4)$$

where the interaction term $POL\_INST_{it} \times REV_{it}$ makes it possible to assess whether there is any effect of the level of environmental taxes on environmental degradation that changes with the quality of the political institutions. Thus, by differentiating Equation (4) with respect to REV_{it}, we obtain

$$\frac{\delta p_{it}}{\delta REV_{it}} = \beta_4 + \beta_5 POL\_INST_{it} \quad (5)$$

which is the marginal effect of environmental tax revenue on environmental degradation for different values of the quality of political institutions, i.e. the effect that we are specifically interested in.

Lastly, it is worth noting that, the structure as well as the level of environmental tax revenue can affect environmental stress. Thus, we test whether the effect on environmental degradation of revenue neutral shifts to different environmental tax sources depends on the quality of political institutions by means of the following equation:

$$p_{it} = \alpha_i + \beta_0 y_i g_i t + \beta_1 g_i t + \beta_2 X_{it} +$$
$$\beta_3 POL\_INST_{it} + \beta_4 REV_{it} + \beta_5 TAX_{it} + \beta_6 POL\_INST_{it} \times TAX_{it} + \theta_i + \eta_t + \psi_i \quad (6)$$

where the vector TAX_{it} alternatively refers to the mutually exclusive tax categories composing the environmental tax structure in each country, while the interaction term $POL\_INST_{it} \times TAX_{it}$ captures the conditional effect of revenue neutral shifts to a specific environmental tax category on environmental stress.[3] In this case too, by differentiating Equation (6) with respect to TAX_{it}, we obtain

$$\frac{\delta p_{it}}{\delta TAX_{it}} = \beta_5 + \beta_6 POL\_INST_{it} \quad (7)$$

which defines the marginal effect that we are interested in.

[3]Since we control for the level of environmental taxes, any change in revenues from a given tax category affects the amount of taxes that need to be collected from the other categories to keep the same overall tax revenue. Given the significant differences in the level of environmental taxes across countries, not controlling for these differences can be misleading. See Baiardi et al. (2019) for a similar approach.

3 Data

3.1 Data description

We perform a panel data analysis with annual observations of 39 countries in the period 1996-2014. Following the World Bank classification, our sample is composed of high income countries (Australia, Austria, Canada, Chile, Croatia, Czech Republic, Denmark, France, Germany, Greece, Hungary, Israel, Italy, Japan, Netherlands, New Zealand, Poland, Slovak Republic, Slovenia, Spain, United Kingdom, the United States), upper middle income countries (Argentina, Bulgaria, China, Colombia, Guatemala, Kazakhstan, Peru, Romania, South Africa, Turkey), and lower middle income countries (Bolivia, Cameroon, Côte d'Ivoire, Egypt, India, Morocco and Philippines).[4]

3.1.1 Environmental degradation and economic development

The proxy for environmental pollution used as dependent variable in our econometric estimation is carbon dioxide (CO_2) emissions, measured in metric tons per capita. Carbon dioxide is classified as a global pollutant, since its marginal damage does not depend on the location of emission and reception (Lehmann, 2012), and it is one of the key indicators used for monitoring environmental conditions worldwide. Indeed it has been widely studied in the empirical literature (Fodha and Zaghdoud, 2010; Wang, 2012; Balando-Naves et al., 2018; Lægreid and Povitkina, 2018).

The proxy for economic development is GDP per capita, in constant 2011 international dollars. We compute the average value of real per capita GDP (y_i) and the average growth rate of real per capita GDP (g_i) for each country i. Following Bradford et al. (2005), these variables are then employed to obtain the key independent variables $y_i g_i t$ and $g_i t$ in all our estimated equations, where t is a linear time trend.

Data on CO_2 emissions and on GDP per capita are retrieved from the World Bank Development Indicators, 2019 Edition.

3.1.2 The quality of political institutions

From an economic perspective, political institutions are those which shape policy decisions by constraining the possible choices of the decision-makers (Dasgupta and De Cian, 2016). They can be defined as '*the traditions and institutions by which authority in a country is exercised. This includes the process by which governments are selected, monitored and replaced; the capacity of the government to effectively formulate and implement sound*

[4]The World Bank classification identifies countries on the bases of the level of their 2018 per capita gross national income (GNI) as follows: high countries have a per capita GNI equal to or greater than \$12,375, upper middle income countries have a per capita GNI between \$3,996 and \$12,375, and lower middle income countries have a per capita GNI between \$1,026 and \$3,995.

policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them' (Kaufmann and Kraay, 2008, p.6).

We therefore use three different proxies to measure the quality of political institutions in each country: the first captures the level of democracy, the second the level of civil society participation and the third the level of corruption (Dasgupta and De Cian, 2016; Lægreid and Povitkina, 2018). All these series are country-variant and retrieved from the Varieties of Democracy (V-Dem) database.

More specifically, the electoral democracy index is a holistic variable measuring the degree of democracy characterizing each country. It captures freedom of association and expression, the extent to which elections are free and fair, whether suffrage is universal, and whether the executive is elected through popular elections or through a popularly elected legislature. This variable is called *v2x_polyarchy* in the V-Dem dataset and answers the question '*To what extent is the ideal of electoral democracy in its fullest sense achieved?*'. It shows values between 0 (low level of democracy) and 1 (high level of democracy).

The civil society participation index shows whether society enjoys autonomy from the state, and whether citizens freely and actively pursue their political and civic goals, and their collective interests and ideals. The series is called *v2x_cspart* in the V-Dem dataset and answers the questions '*Are major civil society organizations (CSOs) routinely consulted by policymakers; how large is the involvement of people in CSOs; are women prevented from participating; and is legislative candidate nomination within party organization highly decentralized or made through party primaries?*'. It varies from 0 (low level of civil society participation) to 1 (high level of civil society participation).

Finally, the political corruption index answers the question '*How pervasive is political corruption?*' in the public and legislative sector, the judicial system, and among the members of the executive. It also distinguishes between corruption pertaining to bribery and embezzlement. This index is labeled *v2x_corr* in the V-Dem dataset and ranges from 0 (the least corrupt situation) to 1 (the most corrupt situation). Thus, in this case, the quality of political institutions decreases for higher values of the index itself.

3.1.3 Environmental taxation

Data on environmental taxes are retrieved from OECD Stats.[5] We collect data on the level of tax revenue as percentage of GDP and on its structure composed by four mutually exclusive tax-base categories: energy, transport, pollution and resources taxes which are expressed as percentage of tax revenue. The sum of the revenue shares of these four tax categories is thus equal to one.

[5] These data belong to a database of Policy Instruments for the Environment (PINE), originally developed by OECD and the European Environment Agency (EEA). The policy instruments in this database are environmentally related taxes, fees and charges, tradable permits, deposit-refund systems, environmentally motivated subsidies and voluntary approaches over and above legal obligations.

Energy taxes cover all taxes on energy products for transport and for stationary purposes. They also include all CO_2 taxes. Transport taxes are taxes on motor vehicles, recurrent taxes on ownership, registration or use of motor vehicles, and other transport-related taxes.[6] Pollution taxes are those on non-energy related carbon content, emissions not related to energy, discharge of wastewater, taxes on packaging, and on final disposal of solid waste and other waste-related taxes, while resources taxes are those on water extraction, forest products, hunting and fishing, excavation and mining royalties.

A *breakdown* of these data by environmental domains is also available. Environmental domains are the environmental externalities covered by a policy instrument. They are: Total Environment, Air Pollution, Climate Change, Biodiversity and Ocean. The Total Environment domain covers all environmentally related taxes, while the other domains cover only taxes that aim to address specific environmental topics, i.e. air pollution, climate change, biodiversity and oceans. A single tax can belong to multiple environmental domains, so revenue should not be aggregated across domains because of the risk of double counting. Our analysis focuses on the first three environmental domains because we use a global air pollutant to proxy environmental stress.[7]

Lastly, note that for the environmental domains of Air Pollution and Climate Change, available data for each tax source are expressed as percentage of Total Environment tax revenue. The sum of the available revenue shares related to the different tax categories is therefore not equal to one. We thus compute the shares of energy taxes, transport taxes, pollution taxes and resources taxes as percentages of *air pollution* tax revenue and *climate change* tax revenue respectively. In this way, the sum of these computed revenue shares related to different tax categories, used in our estimates, becomes exactly one.

3.1.4 Control variables

The existing literature finds that there are many factors potentially impacting on the inverted U-shaped relationship between environmental degradation and economic development. The first set of variables that we consider in our analysis includes trade openness, population density and the level of financial development, which relate to the main economic characteristics of a country. They are retrieved from the World Bank Development Indicators, 2019 Edition.

In particular, trade openness is computed as the ratio between the sum of total export and import and GDP in each country. As noted by Dinda (2004), free trade has conflicting impacts on environment. On one hand, it increases environmental degradation because it may increase the size of the economy with negative repercussions in terms of pollution. On the other hand, trade constitutes an opportunity for high-income countries to shift polluting industries to other (generally poorer) nations.

[6]Excise taxes on automotive fuels are excluded.

[7]Moreover, there are few available data on the domains of Biodiversity and Ocean.

Population density is midyear population divided by land area in square kilometers. Its expected sign is positive, since a higher population density leads to greater social awareness of environmental problems and thus favors the introduction of more severe environmental regulations (Selden and Daqing, 1994; Hosseini and Kaneko, 2013).

To proxy the stage of development of financial markets, we use data on claims on central government, computed as a percentage of national GDP.[8] In this case, the expected sign is negative, since in the long run, if the EKC exists, advanced financial markets play a positive effect on economic development with positive repercussions on environmental quality (Tamazian and Bhaskara Rao, 2010).

We also control for oil and gas production, measured in metric tons per capita. These data are collected from the Ross Oil and Gas Dataset (Ross and Mahdavi, 2015). Following Lægreid and Povitkina (2018), per capita oil and gas production are proxies for energy lobbies that might stand in the way of proactive climate politics. Moreover, the availability of these traditional energy sources makes renewable energy development less advantageous, with negative consequences in terms of environmental degradation.

3.2 Stylized facts

3.2.1 Environmental degradation and economic development

Figure 1 shows the relationship between average GDP per capita and average CO_2 emissions for each country in our dataset. As shown by the size of the bubbles, a process of decoupling between GDP per capita and CO_2 emissions is underway worldwide, since production-based emissions are higher in developing countries, and lower in advanced economies.

Figure 1 about here

In most countries of the world, this decoupling has recently been boosted by the contraction of the manufacturing sector caused by the 2008 financial crisis and by the energy supply mix shifting towards higher energy efficiency and higher energy saving in line with the 2015 Paris Agreement.

However, at the same time, Figure 1 shows that per capita CO_2 emissions are positively correlated with higher standards of living. In other words, most advanced countries are 'net-importers' of CO_2 emissions, implying that, within the nation, the emissions from domestic final demand exceed those from production.

This can be explained by the '*displacement hypothesis*' (Dinda, 2004), which states that changes in the structure of production are not accompanied by equivalent changes in the structure of consumption. This is mainly because pollution intensive industries migrate from countries with stronger environmental regulations to those where environmental

[8] The development of financial markets is often measured using domestic credit to the private sector, but unfortunately many values are missing for this variable in our sample countries.

policies are less stringent. This has also important implications in terms of changes in international specialization and production patterns across countries (OECD, 2017).

3.2.2 The quality of political institutions and economic development

Figure 2 shows that the quality of political institutions is positively correlated with higher levels of economic development. This evidence holds independently of the proxy of political values used in the empirical analysis. In fact, high income countries are, on average, characterized by the *highest* scores for electoral democracy and civil society participation, and, at the same time, by the *lowest* levels of political corruption, with Germany and Denmark as the most noticeable examples.

Figure 2 about here

The lowest values for the electoral democracy index are for China (0.10) and Egypt (0.21). The civil society participation index on the other hand does not show on average differences among upper and lower middle income countries. Bolivia and South Africa stand out for their very good performance in both of these indicators, with scores on average higher than 0.73 and 0.85 in the time period.

However, it is worth noting that, an increasing number of countries around the world have seen a decline in democratic standards since 2001, with worrying consequences in terms of civil society participation, freedom of expression, and quality of political elections (V-DEM, 2020). An example is the crisis in Hungary, which is the first nation in the European Union to have elected an authoritarian government. A substantial decline in the level of democracy has been also observed in India, Turkey and in the USA during recent years.

Lastly, Cameroon and Egypt are the countries with the highest levels of corruption in the sample (0.93 and 0.85, on average, respectively), followed by Kazakhstan and Guatemala (0.84 and 0.81, respectively). Croatia and Greece are the most corrupt high income countries (0.46 and 0.44, respectively). For additional details, see Table B.1 in Appendix B.

3.2.3 The environmental tax burden

Figure 3 shows the average values of environmental tax revenue as a percentage of GDP for each country of our sample in the time period 1996-2014.

Figure 3 about here

The *greenest* economy is Denmark (4.99 per cent), followed by Slovenia, Croatia, Netherlands, Turkey and Italy, where the indicator is on average higher than 3 per cent. The lowest values, under 0.5 per cent of GDP, are on average observed in Egypt, Philippines and Côte d'Ivoire. The picture is similar for Air Pollution and Climate Change domains (see Figures B.1 and B.2 in Appendix B, respectively).

Figure 4 about here

The tax structure is dominated by taxes on energy and transport, as shown in Figure 4. In fact, these two tax sources are very important, accounting on average for 70 and 25 per cent of the revenue in the Total Environment domain, since energy and transport sectors are the main source of the rise in CO_2 emissions worldwide (OECD, 2017).[9] Revenue from pollution and resources taxes are low, particularly in the domains of Air Pollution and Climate Change (see Figures B.3 and B.4 in Appendix B).

Nevertheless, using a different mix of environmental tax sources has become common practice for the policymaker, since many of these taxes are highly elastic. This implies that a tax source can have important environmental benefits even if its weight on overall revenue is limited (OECD, 2017).

4 Estimation results

4.1 Baseline model results

Table 1 reports the estimation results of Equation (3) for all the environmental domains considered.

Table 1 about here

Firstly, the coefficient of $y_i g_i t$ is negative and highly significant in all the estimates, while the coefficient of $g_i t$ is positive and highly significant. According to Bradford et al. (2005), this is robust evidence of the existence of an inverted U-shaped relationship between GDP per capita and environmental stress in our sample.

At the same time, the estimated coefficients of population density and the proxy of financial markets show the signs predicted by the literature and are statistically different from zero.

The proxies for the quality of political institutions, i.e. electoral democracy, civil society participation and political corruption are alternatively introduced in columns (a), (b) and (c). Their coefficients are always not statistically different from zero.

Lastly, the coefficient of the environmental tax revenue is generally negative but not statistically significant, with the only weak exception of columns (a) and (b) for the domain of Air Pollution.

These findings show that the EKC holds independently of the level of environmental taxation as well as the quality of the political institutions (Lopez and Mitra, 2000; Leitão, 2010). In other words, regardless of the development of political institutions and the level of the environmental tax revenue, economic growth is necessary to reduce CO_2 emissions.

[9] In fact, global energy-related CO_2 emissions reached a record high of 32.38 billion tonnes in 2014, an increase of more than 58 percent compared to 1990 (OECD, 2017).

Equation (3) however does not clarify whether and how political institutions steer the effects of environmental taxation in the EKC framework. This issue is investigated in the next subsection.

4.2 Interaction model results: environmental tax revenue

Table 2 reports the estimates of Equation (4) for all the environmental domains under consideration.

Table 2 about here

Similarly to the results shown in Table 1, the inverted U-shaped relationship between per capita income and CO_2 emissions is confirmed. The same findings also hold with respect to the coefficients of population density and, less strongly, of the development of financial markets.

The estimated coefficient of the environmental tax revenue is now positive and statistically significant when the electoral democracy and civil society participation indexes are alternatively introduced (Columns *a* and *b*, respectively), while it is negative and statistically significant when the political corruption index is considered (Column *c*). This means that in a country characterized by the absence of electoral democracy or civil society participation, an increase in the environmental tax revenue in fact raises CO_2 emissions. On the contrary, in a country where political corruption does not exist, an increase in the environmental tax revenue leads to a reduction in CO_2 emissions. These situations are however unrealistic, and thus these parameters are *substantially meaningless* (Brambor et al., 2006). Indeed none of the political variables in our dataset are ever equal to zero.

Focusing on the interaction term, its estimated coefficient always shows the opposite sign with respect to the coefficient of the environmental tax revenue itself. This means that it weakens, or even reverses, the effect of the environmental taxation on environmental stress. More precisely, the coefficient of the interaction term is negative and statistically significant with respect to the electoral democracy and the civil society participation indexes (Columns *a* and *b*). But with respect to the political corruption index (Column *c*), the coefficient is positive and statistically significant, with the sole exception of the Air Pollution domain.

However, the interaction term alone does not show whether environmental taxes have a significant conditional effect on environmental stress (Brambor et al., 2006). It is in fact necessary to focus on the marginal effects of environmental tax revenue on environmental degradation, which are computed by means of Equation (5). In particular, as shown in Table 3, Equation (5) is estimated by considering the minimum and the maximum values that the three political variables used in our analysis show in our sample.

Table 3 about here

When the quality of political institutions is low, an increase in the environmental tax revenue worsens environmental quality. These results for the Total Environment domain are almost perfectly in line with those for the Climate Change domain. This means that where there are low quality political institutions, environmental taxation completely fails, since it increases pollution, rather than reducing it.

A possible explanation of this result is that environmental taxes can show a lot of exemptions and special treatments. This is the case of China, where energy and trade-intensive sectors are fully exempted, and all unexempted sectors are subsidized, with the consequence that CO_2 emissions rise in exempted industries (Liang et al., 2007). Moreover, policymakers can set these taxes not only to favor the competitiveness of specific economic sectors, but also to mainly generate revenue rather than improve environmental quality (Ciocirlan and Yandle, 2003).

On the other hand, when the quality of political institutions is high, an increase in the environmental tax revenue is related to a decrease in CO_2 emissions. This finding holds independently of the kind of externality the policymaker aims at correcting.

Thus, beyond the EKC-based policy recommendation of reinforcing economic development, consolidating democratic values, promoting freedom of thought and participation and contrasting political corruption should be the priority in order to effectively improve environmental quality through environmental tax revenue.

In general, in each environmental domain, the strongest detrimental effect of tax revenue is observed when electoral democracy is at its lowest value, while the strongest reduction effect is observed when political corruption is at its lowest value.[10] In this latter case, an increase in the *climate change* tax revenue is particularly effective. Furthermore, when political institutions are consolidated, i.e. democracy and civil society participation are at their highest values and political corruption is at its lowest value, the estimated marginal effects are the highest for taxes in the Climate Change domain.

Figure 5 about here

Lastly, given that our political variables are continuous series, Figure 5 shows the marginal effects of the environmental tax revenue across the range of values they take. It is clear that the effect of an increase in environmental tax revenue on CO_2 emissions becomes the expected one (i.e. a reducing effect) as the quality of political institutions increases.

To sum up, regardless of the environmental domain investigated, the high quality of political institutions ensures that an increase in environmental tax revenue leads to the expected reduction of CO_2 emissions. Only under high quality political institutions is environmental tax revenue effective in lowering environmental stress.

[10]The political corruption index ranges from 0 (the least corrupt situation) to 1 (the most corrupt situation).

4.3 Interaction model results: environmental tax structure

In this subsection, we test whether the effects of revenue neutral shifts to different tax sources on environmental degradation depend on the quality of political institutions. In fact, not only the environmental tax revenue, but also its composition can play a role in affecting environmental stress in countries with different political institutions.

Tables 4, 5 and 6 report the estimates of Equation (6) for the Total Environment, Air Pollution and Climate Change environmental domains, respectively.[11]

Tables 4, 5 and 6 about here

Similarly to Tables 1 and 2, all estimation results in Tables 4, 5 and 6 support the existence of the inverted U-shaped relationship between per capita income and CO_2 emissions. Previous findings on the coefficients of the control variables are also confirmed. Therefore, economic growth remains mandatory to reduce CO_2 emissions even in this context too.

With reference to Tables 4, the estimated parameter of energy taxes is positive and statistically significant when we control for the electoral democracy and the civil society participation indexes, while it is negative and statistically significant when the political corruption index is used. The opposite is true for the coefficient of resources taxes, and for the coefficient of transport taxes, but only when the electoral democracy and the political corruption indexes are taken into account.

Our results thus suggest that a revenue neutral shift to energy taxes increases CO_2 emissions, but this happens in the unrealistic cases in which electoral democracy or civil society participation are equal to zero. In such unrealistic situations, a revenue neutral shift to resources taxes is instead recommended to reduce environmental degradation. For both energy and resources taxes, the opposite findings hold when there is no political corruption.[12] Furthermore, a revenue neutral shift to transport taxes is positive in terms of environmental goals only in countries where electoral democracy is zero, while it is negative in completely uncorrupted political contexts.

Similar conclusions for energy and transport taxes are also found for the Climate Change domain (Table 6), while no statistically significant results are observed for the Air Pollution domain (Table 5).[13]

Starting from this and remembering that the interaction terms do not make it possible to infer whether a revenue neutral tax shift has a significant conditional effect on envi-

[11]For the sake of completeness, we also estimate Equation (6) without the interaction term. When focusing on the Total Environment or the Climate Change domain, we find no statistically significant results on the effects of revenue neutral shifts to an environmental tax category from the others on CO_2 emissions. But for the environmental domain of Air Pollution, we find that a revenue neutral shift to pollution taxes leads to an increase in CO_2 emissions. Full results are available upon request.

[12]This means that, in completely uncorrupted countries, a revenue neutral shift to energy taxes reduces CO_2 emissions, while a revenue neutral shift to resources taxes increases CO_2 emissions.

[13]For the domain of Air Pollution, in fact, we find that a revenue neutral shift to resource taxes is not recommended only when civil society participation is zero.

ronmental stress (Brambor et al., 2006), we compute the meaningful marginal effects by means of Equation (7) using the minimum and the maximum values of the three political variables employed in the empirical analysis.

Table 7 about here

Findings shown in Table 7 refer to the Total Environment domain. In this case, when the quality of political institutions is low, a revenue neutral shift to energy taxes is detrimental for the environment, while a revenue neutral shift to transport or resources taxes leads to a reduction of CO_2 emissions. On the contrary, when the quality of political institutions is high, a revenue neutral shift to resources taxes is not the most effective environmental policy to implement. When political corruption is at its lowest value, a shift to energy taxes is effective, while a shift to transport taxes appears to increase CO_2 emissions. Lastly, results reported in Table 7 do not provide statistically significant evidence on the effects of a revenue neutral shift to pollution taxes.[14]

Analyzing the effectiveness of revenue neutral increase in the different tax sources aimed at fighting air pollution and climate change, further interesting points emerge.

Tables 8 and 9 about here

In fact, when considering the Air Pollution domain (Table 8), a revenue neutral shift to resources taxes leads to higher CO_2 emissions when civil society participation is the lowest and political corruption is the highest. In this last case an increase in pollution taxes is not recommended, whereas an increase in energy taxes can be useful. On the other hand, when democracy and civil society participation levels are the highest, a revenue neutral increase in pollution taxes is not recommended, and when civil society participation is the highest, the most effective environmental policy is shifting to energy or resources taxes.

With regard to Climate Change domain (Table 9), the effects of a revenue neutral shift to energy and transport taxes are the same as those for the Total Environment domain (Table 7). At the same time, a shift to pollution taxes should not be implemented when the quality of political institutions is low (i.e. the civil society participation is at its minimum value and the political corruption is at its maximum value). A shift to resources taxes is advisable but only in countries with the lowest level of political corruption.

To sum up, consider countries where the quality of political institutions is low. A shift to *all* energy taxes is not recommended, and a shift to *all* transport taxes should be implemented instead. These results are both driven by *climate change* energy and transport taxes. At the same time, a revenue neutral increase in *all* resources taxes should lead to a better environmental quality, but for *climate change* resources taxes,

[14] In order to provide a complete picture, Figure B.5 in Appendix B shows the marginal effect of revenue neutral tax shift on CO_2 emissions across the range of values assumed by each political variable in our dataset.

and for *air pollution* resources taxes at least where low quality political institutions is measured by (low) civil society participation and (high) political corruption.[15]

Now, consider countries where the quality of political institutions is high. In this case, a revenue neutral increase in *all* resources taxes is not recommended, but this result is not driven by either *air pollution* or *climate change* resources taxes. Moreover, when the high quality of political institutions is specifically measured by low political corruption, a shift to *all* energy taxes is a good environmental policy, while the opposite holds for a shift to *all* transport taxes. These last two findings are driven by *climate change* energy and transport taxes.

It is not surprising that the most robust results are those relating to energy and transport taxes. Indeed, as shown in Subsection 3.2.3, energy and transport are the most significant tax sources in all the environmental domains under consideration. A further discussion on these tax sources is thus in order.

Energy taxes are mainly used to make the transition from an intensive use of fossil energy sources, such as oil, natural gas and coal, to a more efficient use of the existing energy resources and to obtain cost-effective energy savings. In particular, energy taxes also include revenue from the auctioning of trade-able permits, which are used to allocate emissions or resource exploitation rights. The proceeds are invested in consumer benefit programmes to foster energy efficiency and renewable energy, which are the frontier in advanced economies for shifting to less greenhouse gas-intensive and more efficient methods of production. Greater attention has recently been given to applying of these energy sources in different sectors such as heating, cooling, electricity and transport in many economies worldwide. However, energy taxes are actually effective when political corruption is very low. In fact, as noted by Fredriksson et al. (2004), greater corruptibility of policymakers reduces the stringency of tax energy policy. This is the case in both the Total Environment and the Climate Change domains.

Together with energy taxes, transport taxes are also particularly relevant in the process of transition from fossil fuels to cleaner energy. Our estimates suggest that they are an effective environmental tax policy when the quality of political institutions is low, again in the Total Environment and Climate Change domains. More specifically, transport taxes affect the marginal cost of transport and thus production and operating costs. These latter in turn depend on public expenditure on infrastructures, essential for the extension and the maintenance of the public transport network.[16] Consequently, in countries with weak political institutions, fostering public investment in infrastructures together with the implementation of transport taxes should be the policy to pursue. A good example in this direction is the 'One Belt & One Road Initiative', a global strategy adopted by China in 2013 involving infrastructure development and investments in nearly 70 countries

[15]Note that *all* here refers to specific taxes in the Total Environment domain. Similarly, *air pollution* and *climate change* refer to specific taxes in these specific domains.

[16]Transport taxes can be also used as budgetary transfers to cover the cost of the infrastructure.

between East and West. This initiative should foster regional economic development and coordination (Huang, 2016), which, as we discuss in the following section, implies positive spillovers on the quality of political institutions and on environmental conditions internationally (Hosseini and Kaneko, 2013).

Furthermore, it is interesting to note that a revenue neutral shift to transport taxes does not reduce environmental stress in countries with consolidated political institutions.[17] This may be because these countries generally apply higher excise tax rates on petrol rather than on diesel, even though diesel is more dangerous in terms of CO_2 emissions.[18]

All these findings show that even in low quality political contexts, CO_2 emissions can be reduced by closely targeted tax policy that shifts to particular tax sources while keeping constant the total environmental tax revenue. At the same time, even in high quality political contexts, shifting to the *wrong* tax source while keeping constant the total environmental tax revenue appears to increase emissions. This evidence contributes to solving the shortcomings in the empirical literature about the influence of institutional quality on environmental degradation (Bernauer and Koubi, 2009; Hosseini and Kaneko, 2013).[19] Furthermore, our results underline that for the same quality of political institutions, shifting to a specific tax, while keeping constant the total environmental tax revenue, can have different effects on CO_2 emissions according to the kind of externality the policymaker aims at correcting.

5 Policy implications

Several policy implications can be gathered from the results drawn in the previous section.

Our findings show that the EKC holds independently of the quality of political institutions and independently of the application of environmental tax policies. This implies that economic growth is always necessary in order to reduce environmental stress.

However, this is just a part of the story. As underlined by the literature and as shown in Subsection 3.2.2, improvements in terms of economic development generally go hand in hand with improvements in the quality of political institutions. Indeed, we empirically demonstrate that high quality political institutions are the driving force for the preservation of the environment through an increase in the environmental tax revenue.

Thus, in countries with undemocratic governments, where citizen participation in public decision making is low and the level of corruption is very high, environmental taxation completely fails in its goal, since it increases pollution, rather than reducing it. In this

[17] Transport taxes can even increase CO_2 emissions when political corruption is at its lowest value.

[18] In the OECD area, only Switzerland and the USA have a higher excise tax rate per litre on diesel (OECD, 2019).

[19] Bernauer and Koubi (2009) and Hosseini and Kaneko (2013) identify five distinct theories supporting the idea that well developed political institutions foster environmental condition, and four other theories reaching precisely the opposite conclusions.

respect, beyond the EKC policy recommendation of reinforcing economic development, it is clear that consolidating democratic values, promoting freedom of thought and participation and contrasting political corruption needs to be the priority in order to effectively improve environmental quality through environmental tax revenue.

Furthermore, when political corruption is low, an increase in tax revenue used to fight the negative externalities caused by climate change is particularly effective. This point is also supported by the existing empirical literature: Fredriksson and Neumayer (2016) find that, countries' historical experience as well as their current level of corruption is a determinant for the effectiveness of climate change policies. This reflects the fact that adaptation and mitigation policies on climate change generally require large-scale and financial initiatives such as financial incentives, micro-finance and cash transfers, as well as the coordination of public-private partnerships (IPCC, 2014). Indeed, these policies work only when corruption is low, since even well designed market-based policies can be ineffective in the presence of poor institutions and heavy bureaucracies (Gennaioli and Tavoni, 2016).

When moving to consider the environmental tax structure, our findings show that a revenue neutral shift to specific tax sources can reduce environmental stress in the presence of low quality political institutions, and vice versa. The policy implication is that tax structure also matters. For a certain quality of political institutions, rearranging the tax mix while keeping constant the tax revenue can affect environmental conditions in exactly the opposite way compared to increasing the tax revenue.

The last policy implications we can draw from our investigation into the composition of the tax burden is that environmental domains also matter. In fact, for the same quality of political institutions, shifting to a specific tax, while keeping constant the environmental tax revenue, can have different effects on CO_2 emissions according to the kind of externality the policymaker aims at correcting. More precisely, the Air Pollution domain shows different results from the Total Environment and Climate Change domains. This may be because CO_2 emissions are mainly responsible for the negative externalities related to climate change, while the negative externalities due to air pollution are less correlated to greenhouse gases.

6 Conclusions

This paper finds that beyond reinforcing economic development, consolidating democratic values, promoting freedom of thought and participation and fighting political corruption need to be the priority in order to effectively improve environmental quality through environmental tax revenue.

The paper also contributes to solving the current shortcomings in the empirical literature on the influence of political institution quality on environmental degradation. In fact it shows that changing the structure, but not the level, of environmental taxation can increase (decrease) the environmental quality even in the case of low (high) quality political institutions. Moreover, for the same quality of political institutions, shifting to a specific tax, while keeping constant the environmental tax revenue, can have different effects on CO_2 emissions according to the kind of externality the policymaker aims at correcting. Policymakers would be well-advised to take into account these implications when using tax revenue or shaping tax structure in order to achieve environmental goals.

Lastly, it is worth recalling that the effectiveness of environmental taxes depends many factors not included in our empirical analysis, such as the presence of large energy-consuming industries, which influences domestic demand in the energy and transport sectors, and the participation in international environmental treaties and/or multilateral organizations. Furthermore, higher levels of environmental awareness and environmental-friendly behaviors are crucial for increasing public support for emission-reducing policies that can lead to an era of cleaner energy. Indeed there is much space for further research on this topic.

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References

[1] Acemoglu, D., Robinson, J.A., (2006). *Economic origins of dictatorship and democracy.* Cambridge University Press.

[2] Andreoni, J., Levinson, A., (2001). The simple analytics of the environmental Kuznets curve. *Journal of Public Economics* 80: 269–286.

[3] Aasen, M., Vatn, A., (2018). Public attitudes toward climate policies: the effect of institutional contexts and political values. *Ecological Economics* 146: 106–114.

[4] Baiardi, D., (2014). Technological progress and the environmental Kuznets curve in the twenty regions of Italy. *The B.E. Journal of Economic Analysis & Policy* 14: 1501-1542.

[5] Baiardi, D., Profeta, P., Puglisi, R., Scabrosetti, S., (2019). Tax policy and economic growth: does it really matter? *International Tax and Public Finance* 26: 282–316.

[6] Balando-Naves, R., Banos-Pino, J., F., Mayor, M., (2018). Do countries influence neighboring pollution? A spatial analysis of the EKC for CO_2 emissions. *Energy Policy* 123: 266–279.

[7] Bernauer, T., Koubi, V., (2009). Effects of political institutions on air quality. *Ecological Economics* 68: 1355-1365.

[8] Bhattacharya, M., Churchill, S.A., Paramati, S.R., (2017). The dynamic impact of renewable energy and institutions on economic output and CO2 emissions across regions. *Renewable Energy* 111: 157–167.

[9] Bradford, D. F., Fender, R., Shore, S. H., Wagner, M., (2005). The environmental Kuznets curve: exploring a fresh specification. *Contributions to Economic Analysis and Policy* 4(1): Article 5.

[10] Brambor, T., Clark, W. R., Golder, M., (2006). Understanding interaction models: improving empirical analyses. *Political Analysis* 14: 63-82.

[11] Ciocirlan, C. E, Yandle, B., (2003). The Political Economy of Green Taxation in OECD Countries. *European Journal of Law and Economics* 15: 203-218.

[12] Cole, M., A., (2007). Corruption, income and the environment: an empirical analysis *Ecological Economics* 62: 637-647.

[13] Dasgupta, S., De Cian, E. (2016). Institutions and the environment: existing evidence and future directions. *Nota di Lavoro* 41, Fondazione ENI Enrico Mattei.

[14] Dinda, S., (2004). Environmental Kuznets curve hypothesis: a survey. *Ecological Economics* 49: 431–455.

[15] Durakoğlu, S. M., (2011). Political institutions of electricity regulation: The case of Turkey. *Energy Policy* 39: 5578-5587.

[16] Fodha, M., Zaghdoud, O., (2010). Economic growth and pollutant emissions in Tunisia: an empirical analysis of the environmental Kuznets curve. *Energy Policy* 30: 1150–1156.

[17] Fredriksson, P. G., Vollebergh, H. R., Dijkgraaf, E. (2004). Corruption and energy efficiency in OECD countries: theory and evidence. *Journal of Environmental Economics and Management* 47: 207-231.

[18] Fredriksson, P., G., Neumayer, E., (2016). Corruption and climate change policies: do the bad old days matter? *Environmental and Resource Economics* 63: 451-469.

[19] Gennaioli, C., Tavoni, M. (2016). Clean or dirty energy: evidence of corruption in the renewable energy sector. *Public Choice* 166: 261-290.

[20] Halkos, E., G., Tzeremes, N., G., (2013). Carbon dioxide emissions and governance: A nonparametric analysis for the G-20. *Energy Economics* 40: 110-118.

[21] Hosseini, H., M., Kaneko, S., (2013). Can environmental quality spread through institutions? *Energy Policy* 56: 312-321.

[22] Huang, Y., (2016). Understanding China's Belt & Road Initiative: motivation, framework and assessment. *China Economic Review* 40, 314-321.

[23] IPCC, (2014). In: Core Writing Team, Pachauri, R.K., Meyer, L.A. (Eds.), Climate Change 2014. Synthesis Report, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.

[24] Kaufmann, D., Kraay, A., (2008). Governance indicators: where are we, where should we be going? *Policy Research Working Paper* n. 4370, World Bank.

[25] Lehmann, P., (2012). Justifying a policy mix for pollution control: a review of economic literature. *Journal of Economic Survey* 26: 71-97.

[26] Lopez, R., Mitra, S., (2000). Corruption, pollution and the environmental Kuznets curve. *Journal of Environmental Economics and Management* 40, 137-150.

[27] Lægreid, O., M., Povitkina, M., (2018). Do political institutions moderate the GDP-CO_2 relationship? *Ecological Economics* 145: 441-450.

[28] Leitão, A., (2010). Corruption and the environmental Kuznets curve: empirical evidence for sulfur. *Ecological Economics* 69: 2191-2201.

[29] Liang, Q., M., Fan, Y., Wei, Y.M., (2007). Carbon Taxation Policy in China: How to Protect Energy-and Trade-Intensive Sectors? *Journal of Policy Modeling* 29: 311-333.

[30] Matsuo, N., (1998). Key elements related to the emissions trading for the Kyoto protocol. *Energy Policy* 26: 263-273.

[31] Nepal, R., Jamasb, T., (2012). Reforming the power sector in transition: do institutions matter? *Energy Economics* 34: 1675-1682.

[32] OECD, (2017). *Green Growth Indicators 2017.* OECD Publishing, Paris.

[33] OECD (2019). *Taxing Energy Use 2019: Using Taxes for Climate Action*, OECD Publishing, Paris.

[34] Panayotou, T., (1997). Demystifying the environmental Kuznets curve: turning a black box into a policy tool. *Environmental and Development Economics* 2: 469-484.

[35] Papaioannou, E., Siourounis, G., (2008). Democratization and growth. *The Economic Journal* 118: 1520-1551.

[36] Persson, T., Tabellini, G., (2006). Democracy and development: the devil in the details. *American Economic Review, Papers and Proceedings* 96: 319-324.

[37] Persson, T., Tabellini, G., (2007). The growth effect of democracy: is it heterogeneous and how can it be estimated. NBER Working Papers, 13150.

[38] Rentz, H., (1998). Joint implementation and the question of 'additionality' proposal for a pragmatic approach to identify possible joint implementation projects. *Energy Policy* 26: 275-279.

[39] RISE (2018). *Policy matters. Regulatory indicators for sustainable energy.* 2018 International Bank for Reconstruction and Development / The World Bank, Washington DC 20433, USA.

[40] Ross, M., L., Mahdavi, P., (2015). *Oil and gas data, 1932-2014*. Network, Harvard Dataverse.

[41] Selden, T., M., Daqing, S., (1994). Environmental quality and development: is there a Kuznets curve for air pollution emissions? *Journal of Environmental Economics and Management* 27: 147-162.

[42] Tamazian, A., Bhaskara Rao, B., (2010). Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies *Energy Economics* 32: 137-145.

[43] V-DEM, (2020). *Autocratization surges resistance grows DEMOCRACY REPORT 2020*. V-Dem Institute, University of Gothenburg.

[44] Wagner, M., (2008). The carbon Kuznets curve: a cloudy picture emitted by bad econometrics? *Resource and Energy Economics* 30, 388–408.

[45] Wang, K.M., (2012). Modeling the nonlinear relationship between CO2 emissions from oil and economic growth. *Economic Modelling* 29: 1537-1547.

[46] Zhang, Z., Meng, X., (2019). Internet penetration and the environmental Kuznets curve: a cross-national analysis. *Sustainability* 11, 1358.

Tables

Table 1: Estimation results of Equation (3) for all the environmental domains

	Total Environment			Air Pollution			Climate Change		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
$y_i g_i t$	-0.131***	-0.130***	-0.137***	-0.137***	-0.135***	-0.143***	-0.1271***	-0.1253***	-0.1311***
	(0.0431)	(0.0424)	(0.0452)	(0.0434)	(0.0428)	(0.0458)	(0.0422)	(0.0416)	(0.0441)
$g_i t$	0.230***	0.227***	0.229***	0.236***	0.233***	0.234***	0.2323***	0.2297***	0.2310***
	(0.0228)	(0.0235)	(0.0231)	(0.0221)	(0.0228)	(0.0222)	(0.0230)	(0.0235)	(0.0231)
Trade openness	0.0222	0.0149	0.0143	0.0274	0.0190	0.0191	0.0246	0.0177	0.0177
	(0.0259)	(0.0251)	(0.0246)	(0.0266)	(0.0260)	(0.0254)	(0.0262)	(0.0256)	(0.0250)
Population density	1.198***	1.170***	1.131***	1.232***	1.199***	1.163***	1.2167***	1.1933***	1.1599***
	(0.286)	(0.283)	(0.282)	(0.287)	(0.285)	(0.280)	(0.2897)	(0.2863)	(0.2847)
Development of financial markets	-0.0175**	-0.0157**	-0.0142**	-0.0185**	-0.0166**	-0.0154**	-0.0188**	-0.0173**	-0.0160**
	(0.00702)	(0.00650)	(0.00702)	(0.00729)	(0.00682)	(0.00714)	(0.0072)	(0.0067)	(0.0071)
Per capita oil production	-0.0102	-0.0112	-0.0102	-0.0111	-0.0114	-0.0115	-0.0099	-0.0108	-0.0100
	(0.0252)	(0.0250)	(0.0257)	(0.0278)	(0.0269)	(0.0276)	(0.0251)	(0.0248)	(0.0255)
Per capita gas production	-0.00432	-0.00590	-0.00563	-0.00399	-0.00566	-0.00590	-0.0044	-0.0057	-0.0057
	(0.0300)	(0.0294)	(0.0302)	(0.0284)	(0.0277)	(0.0285)	(0.0287)	(0.0279)	(0.0287)
The electoral democracy index	0.234	-	-	0.257	-	-	0.2210	-	-
	(0.180)			(0.180)			(0.1768)		
The civil society participation index	-	0.0767	-	-	0.0889	-	-	0.0849	-
		(0.163)			(0.164)			(0.1647)	
The political corruption index	-	-	0.0700	-	-	0.0659	-	-	0.0480
			(0.145)			(0.152)			(0.1525)
Environmental tax revenue	-0.00639	-0.00539	-0.00486	-0.0240*	-0.0241*	-0.0227	-0.0168	-0.0183	-0.0178
	(0.0205)	(0.0211)	(0.0205)	(0.0131)	(0.0138)	(0.0138)	(0.0200)	(0.0210)	(0.0205)
Obs	524	524	524	524	524	524	525	525	525
R^2	0.6158	0.6104	0.6102	0.6252	0.6186	0.6180	0.6155	0.6110	0.6102
Number of id	39	39	39	39	39	39	39	39	39

Notes: OLS estimates with the inclusion of country- and time- fixed effects. For the sake of parsimony, the estimates of the constant terms are not reported. The dependent variable is per capita CO_2 emissions. With reference to Equation (3), the electoral democracy index, the civil society participation index and the political corruption index alternatively stand for POL_INST_{it}, while REV_{it} is proxied with the environmental tax revenue, computed as a percentage of national GDP. With the sole exception of the environmental tax revenue and the three proxies for the quality of political institutions, all the variables have been standardized. Standard errors clustered at country level are reported in brackets. *** significance at 1%, ** significance at 5%, * significance at 10%.

Table 2: Estimation results of Equation (4) for all the environmental domains

	Total Environment			Air Pollution			Climate Change		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
$y_i g_i t$	-0.163***	-0.154***	-0.155***	-0.152***	-0.143***	-0.152***	-0.1601***	-0.1507***	-0.1568***
	(0.0391)	(0.0402)	(0.0411)	(0.0425)	(0.0435)	(0.0450)	(0.0385)	(0.0393)	(0.0409)
$g_i t$	0.216***	0.216***	0.229***	0.226***	0.227***	0.234***	0.2195***	0.2191***	0.2316***
	(0.0220)	(0.0233)	(0.0234)	(0.0211)	(0.0217)	(0.0215)	(0.0226)	(0.0236)	(0.0234)
Trade openness	0.0225	0.0146	0.0227	0.0243	0.0177	0.0208	0.0273	0.0220	0.0243
	(0.0237)	(0.0251)	(0.0232)	(0.0249)	(0.0256)	(0.0240)	(0.0242)	(0.0246)	(0.0231)
Population density	0.972***	0.954***	0.955***	1.085***	1.094***	1.033***	1.0230***	1.0027***	0.9432***
	(0.294)	(0.309)	(0.291)	(0.303)	(0.306)	(0.313)	(0.2861)	(0.2928)	(0.2989)
Development of financial markets	-0.0103	-0.0117*	-0.0106	-0.0157**	-0.0157**	-0.0142*	-0.0112	-0.0128**	-0.0115
	(0.00746)	(0.00616)	(0.00807)	(0.00769)	(0.00674)	(0.00775)	(0.0072)	(0.0062)	(0.0079)
Per capita oil production	-0.00951	-0.00527	-0.00804	-0.00266	-0.000988	-0.000877	-0.0089	-0.0022	-0.0051
	(0.0245)	(0.0224)	(0.0242)	(0.0257)	(0.0240)	(0.0256)	(0.0241)	(0.0226)	(0.0250)
Per capita gas production	3.33e-05	-0.00557	0.00390	-0.000253	-0.00658	0.00290	-0.0010	-0.0047	0.0043
	(0.0260)	(0.0264)	(0.0245)	(0.0278)	(0.0274)	(0.0267)	(0.0241)	(0.0247)	(0.0216)
The electoral democracy index	0.773***	-	-	0.630***	-	-	0.6733***	-	-
	(0.191)			(0.204)			(0.1622)		
The civil society participation index	-	0.600**	-	-	0.358	-	-	0.5669**	-
		(0.255)			(0.236)			(0.2306)	
The political corruption index	-	-	-0.361	-	-	-0.201	-	-	-0.3436*
			(0.225)			(0.252)			(0.1845)
Environmental tax revenue	0.138***	0.178***	-0.0997***	0.116**	0.106*	-0.0852**	0.1397***	0.1829***	-0.1280***
	(0.0299)	(0.0593)	(0.0323)	(0.0565)	(0.0620)	(0.0362)	(0.0287)	(0.0578)	(0.0282)
Interaction terms									
The electoral democracy index × Environmental tax revenue	-0.228***	-	-	-0.197**	-	-	-0.2479***	-	-
	(0.0507)			(0.0759)			(0.0441)		
The civil society participation index × Environmental tax revenue	-	-0.263***	-	-	-0.174*	-	-	-0.2887***	-
		(0.0859)			(0.0893)			(0.0810)	
The political corruption index × Environmental tax revenue	-	-	0.176***	-	-	0.132	-	-	0.2047***
			(0.0598)			(0.0799)			(0.0542)
Obs	524	524	524	524	524	524	525	525	525
R^2	0.6571	0.6403	0.6433	0.6389	0.6261	0.6285	0.6623	0.6435	0.6504
Number of id	39	39	39	39	39	39	39	39	39

Notes: OLS estimates with the inclusion of country- and time- fixed effects. For the sake of parsimony, the estimates of the constant terms are not reported. The dependent variable is per capita CO_2 emissions. With reference to Equation (4), the electoral democracy index, the civil society participation index and the political corruption index alternatively stand for POL_INST_{it}, while REV_{it} is proxied with the environmental tax revenue, computed as a percentage of national GDP. The three interaction terms alternatively introduced stand for $POL\_INST_{it} \times REV_{it}$. With the sole exception of the environmental tax revenue and the three proxies for the quality of political institutions, all the variables have been standardized. Standard errors clustered at country level are reported in brackets. *** significance at 1%, ** significance at 5%, * significance at 10%.

Table 3: Marginal effects of environmental tax revenue on CO_2 emissions for all the environmental domains

	Total Environment	**Air Pollution**	**Climate Change**
Low quality of political institutions			
The electoral democracy index - *Minimum*	0.1169***	0.0972*	0.1166***
	(0.0255)	(0.0496)	(0.0248)
The civil society participation index - *Minimum*	0.1066**	0.0589	0.1050**
	(0.0369)	(0.0385)	(00365)
The political corruption index - *Maximum*	0.0634**	0.0369	0.0614**
	(0.0321)	(0.0426)	(0.0269)
High quality of political institutions			
The electoral democracy index - *Maximum*	-0.0784***	-0.0715***	-0.0953***
	(0.0212)	0.0205	(0.0169)
The civil society participation index - *Maximum*	-0.0823**	-0.0665**	-0.1026**
	(0.0299)	(0.0295)	(0.0259)
The political corruption index - *Minimum*	-0.0986**	-0.0844**	-0.1267***
	(0.0320)	(0.0357)	(0.0279)

Notes: Findings derived from the results shown in Table 2. When political institutions take their average values in our sample, the sign and the statistical significance of the marginal effects of environmental tax revenue are the same as those shown for high quality political institutions. These results are available upon request. Standard errors are reported in brackets. *** significance at 1%, ** significance at 5%, * significance at 10%.

Table 4: Estimation results of Equation (6) for the Total Environment domain

	The electoral democracy index				The civil society participation index				The political corruption index			
$y_i g_i t$	-0.150***	-0.144***	-0.134***	-0.123***	-0.145***	-0.140***	-0.131***	-0.121***	-0.164***	-0.169***	-0.147***	-0.128***
	(0.0405)	(0.0420)	(0.0433)	(0.0380)	(0.0396)	(0.0426)	(0.0428)	(0.0369)	(0.0436)	(0.0441)	(0.0469)	(0.0415)
$g_i t$	0.237***	0.251***	0.239***	0.184***	0.231***	0.248***	0.233***	0.176***	0.238***	0.243***	0.235***	0.184***
	(0.0284)	(0.0267)	(0.0292)	(0.0400)	(0.0258)	(0.0282)	(0.0297)	(0.0402)	(0.0267)	(0.0257)	(0.0303)	(0.0378)
Trade openness	0.0308	0.0241	0.0264	0.0226	0.0352	0.0194	0.0191	0.0230	0.0129	0.0120	0.0149	0.0103
	(0.0230)	(0.0231)	(0.0265)	(0.0240)	(0.0216)	(0.0225)	(0.0251)	(0.0224)	(0.0189)	(0.0201)	(0.0256)	(0.0209)
Population density	1.178***	1.230***	1.223***	1.056***	1.215***	1.215***	1.181***	1.118***	0.960***	1.031***	1.163***	0.910***
	(0.295)	(0.300)	(0.311)	(0.299)	(0.250)	(0.280)	(0.308)	(0.277)	(0.299)	(0.290)	(0.297)	(0.291)
Development of financial markets	-0.0149**	-0.0162**	-0.0177**	-0.0170**	-0.0132**	-0.0142**	-0.0158**	-0.0176**	-0.00920	-0.00908	-0.0135*	-0.0139**
	(0.00689)	(0.00698)	(0.00752)	(0.00691)	(0.00635)	(0.00635)	(0.00694)	(0.00666)	(0.00693)	(0.00736)	(0.00732)	(0.00675)
Per capita oil production	-0.0102	-0.0110	-0.0106	-0.0104	-0.0102	-0.0148	-0.0102	-0.00130	-0.00652	-0.00277	-0.0201	-0.00992
	(0.0253)	(0.0244)	(0.0242)	(0.0271)	(0.0235)	(0.0250)	(0.0242)	(0.0194)	(0.0253)	(0.0206)	(0.0255)	(0.0277)
Per capita gas production	-0.00386	-0.00668	-0.00802	-0.00272	-0.00147	-0.00508	-0.00893	-0.00829	0.00545	0.00665	-0.00735	-0.00150
	(0.0272)	(0.0291)	(0.0313)	(0.0292)	(0.0249)	(0.0284)	(0.0313)	(0.0290)	(0.0256)	(0.0258)	(0.0306)	(0.0278)
The electoral democracy index	0.740***	0.164	0.247	0.158	-	-	-	-	-	-	-	-
	(0.211)	(0.225)	(0.180)	(0.192)								
The civil society participation index	-	-	-	-	0.969**	-0.0305	0.0727	0.0760	-	-	-	-
					(0.366)	(0.206)	(0.165)	(0.141)				
The political corruption index	-	-	-	-	-	-	-	-	-0.565***	0.367**	0.0678	0.186
									(0.178)	(0.162)	(0.146)	(0.126)
Environmental tax revenue	-0.0165	-0.0126	-0.00705	-0.0128	-0.0120	-0.0108	-0.00491	-0.00917	-0.0192	-0.0164	-0.0106	-0.00712
	(0.0158)	(0.0169)	(0.0165)	(0.0183)	(0.0171)	(0.0178)	(0.0179)	(0.0206)	(0.0178)	(0.0170)	(0.0160)	(0.0182)
Energy taxes	0.00448***	-	-	-	0.00876***	-	-	-	-0.00442**	-	-	-
	(0.00115)				(0.00277)				(0.00177)			
Transport taxes	-	-0.00304*	-	-	-	-0.00422	-	-	-	0.00700**	-	-
		(0.00156)				(0.00260)				(0.00279)		
Pollution taxes	-	-	0.00416	-	-	-	0.000478	-	-	-	-0.00791	-
			(0.00904)				(0.0147)				(0.0107)	
Resources taxes	-	-	-	-0.00754***	-	-	-	-0.0149***	-	-	-	0.0105***
				(0.00171)				(0.00417)				(0.00229)
Interaction terms												
Political institutions × Energy taxes	-0.00657**	-	-	-	-0.0116**	-	-	-	0.00895***	-	-	-
	(0.00254)				(0.00456)				(0.00216)			
Political institutions × Transport taxes	-	0.00370	-	-	-	0.00486	-	-	-	-0.0144***	-	-
		(0.00309)				(0.00427)				(0.00453)		
Political institutions × Pollution taxes	-	-	-0.00218	-	-	-	0.00315	-	-	-	0.0231	-
			(0.0120)				(0.0183)				(0.0179)	
Political institutions × Resources taxes	-	-	-	0.0154***	-	-	-	0.0219***	-	-	-	-0.0150***
				(0.00391)				(0.00662)				(0.00331)
Obs	522	522	516	505	522	522	516	505	522	522	516	505
R^2	0.6101	0.6232	0.6022	0.4738	0.6130	0.6169	0.5960	0.4814	0.6229	0.6499	0.6034	0.4752
Number of id	39	39	39	38	39	39	39	38	39	39	39	38

Notes: OLS estimates with the inclusion of country- and time- fixed effects. For the sake of parsimony, the estimates of the constant terms are not reported. The dependent variable is per capita CO_2 emissions. With reference to Equation (6), the electoral democracy index, the civil society participation index and the political corruption index alternatively stand for POL_INST_{it}, while REV_{it} is proxied with the environmental tax revenue, computed as a percentage of national GDP. The four taxes alternatively introduced stand for TAX_{it}; consequently the four interaction terms alternatively introduced stand for $POL\_INST_{it} \times TAX_{it}$. With the exceptions of the environmental tax revenue, of the three proxies for the quality of political institutions and of the four tax sources, all the variables have been standardized. Standard errors clustered at country level are reported in brackets. **** significance at 1%, ** significance at 5%, * significance at 10%.

Table 5: Estimation results of Equation (6) for the Air Pollution environmental domain

	The electoral democracy index				The civil society participation index				The political corruption index			
$y_i g_i t$	-0.144***	-0.139***	-0.142***	-0.142***	-0.143***	-0.140***	-0.142***	-0.130***	-0.153***	-0.142***	-0.156***	-0.144***
	(0.0409)	(0.0434)	(0.0414)	(0.0483)	(0.0414)	(0.0439)	(0.0413)	(0.0449)	(0.0430)	(0.0456)	(0.0458)	(0.0475)
$g_i t$	0.217***	0.235***	0.237***	0.237***	0.214***	0.231***	0.234***	0.231***	0.220***	0.231***	0.237***	0.234***
	(0.0319)	(0.0318)	(0.0230)	(0.0221)	(0.0346)	(0.0327)	(0.0248)	(0.0228)	(0.0313)	(0.0312)	(0.0269)	(0.0221)
Trade openness	0.0269	0.0267	0.0370	0.0274	0.0188	0.0181	0.0247	0.0211	0.0198	0.0173	0.0251	0.0198
	(0.0252)	(0.0271)	(0.0260)	(0.0273)	(0.0250)	(0.0264)	(0.0256)	(0.0260)	(0.0238)	(0.0254)	(0.0250)	(0.0255)
Population density	1.164***	1.232***	1.226***	1.236***	1.130***	1.186***	1.200***	1.226***	1.126***	1.161***	1.165***	1.171***
	(0.280)	(0.292)	(0.291)	(0.305)	(0.272)	(0.282)	(0.287)	(0.293)	(0.271)	(0.287)	(0.277)	(0.290)
Development of financial markets	-0.0183**	-0.0188**	-0.0171**	-0.0197**	-0.0168**	-0.0166**	-0.0157**	-0.0173**	-0.0161**	-0.0165**	-0.0136*	-0.0161**
	(0.00735)	(0.00740)	(0.00734)	(0.00801)	(0.00715)	(0.00710)	(0.00690)	(0.00745)	(0.00676)	(0.00696)	(0.00713)	(0.00779)
Per capita oil production	-0.00855	-0.00974	-0.0148	-0.0127	-0.00665	-0.00795	-0.0164	-0.0122	-0.0199	-0.0124	-0.0191	-0.0122
	(0.0266)	(0.0280)	(0.0269)	(0.0286)	(0.0260)	(0.0273)	(0.0262)	(0.0273)	(0.0291)	(0.0285)	(0.0281)	(0.0278)
Per capita gas production	0.00121	-0.00349	-0.00204	-0.00437	0.00553	0.00197	-0.00483	-0.00561	-0.00728	-0.00733	-0.00629	-0.00578
	(0.0262)	(0.0281)	(0.0282)	(0.0284)	(0.0237)	(0.0254)	(0.0267)	(0.0284)	(0.0289)	(0.0299)	(0.0275)	(0.0290)
The electoral democracy index	0.286	0.245	0.276	0.259	-	-	-	-	-	-	-	-
	(0.304)	(0.204)	(0.179)	(0.188)								
The civil society participation index	-	-	-	-	0.446*	0.0147	0.116	0.0966	-	-	-	-
					(0.231)	(0.206)	(0.163)	(0.164)				
The political corruption index	-	-	-	-					0.542	0.0321	0.0790	0.0627
									(0.389)	(0.167)	(0.152)	(0.152)
Environmental tax revenue	-0.0211	-0.0231*	-0.0282**	-0.0235*	-0.0208	-0.0217	-0.0284**	-0.0236*	-0.0227	-0.0216	-0.0259*	-0.0221
	(0.0133)	(0.0133)	(0.0130)	(0.0132)	(0.0129)	(0.0134)	(0.0137)	(0.0137)	(0.0137)	(0.0137)	(0.0141)	(0.0138)
Energy taxes	-0.00176	-	-	-	-6.10e-05	-	-	-	0.00151	-	-	-
	(0.00209)				(0.00278)				(0.00311)			
Transport taxes	-	-0.000112	-	-	-	-0.00198	-	-	-	-0.000976	-	-
		(0.00128)				(0.00173)				(0.00343)		
Pollution taxes	-	-	0.000143	-	-	-	-0.00142	-	-	-	0.00265	-
			(0.00192)				(0.00374)				(0.00803)	
Resources taxes	-	-	-	-0.364	-	-	-	1.094**	-	-	-	-0.0411
				(1.008)				(0.435)				(0.0483)
Interaction terms												
Political institutions × Energy taxes	-0.000516	-	-	-	-0.00392	-	-	-	-0.00540	-	-	-
	(0.00332)				(0.00387)				(0.00396)			
Political institutions × Transport taxes	-	0.000791	-	-	-	0.00480	-	-	-	0.00253	-	-
		(0.00289)				(0.00340)				(0.00583)		
Political institutions × Pollution taxes	-	-	0.0121*	-	-	-	0.0101	-	-	-	0.000826	-
			(0.00654)				(0.00721)				(0.00986)	
Political institutions × Resources taxes	-	-	-	0.382	-	-	-	-1.242**	-	-	-	0.311
				(1.134)				(0.509)				(0.189)
Obs	519	518	519	518	519	518	519	518	519	518	519	518
R^2	0.6405	0.6274	0.6520	0.6295	0.6387	0.6250	0.6441	0.6252	0.6404	0.6208	0.6409	0.6226
Number of id	38	38	38	38	38	38	38	38	38	38	38	38

Notes: OLS estimates with the inclusion of country- and time- fixed effects. For the sake of parsimony, the estimates of the constant terms are not reported. The dependent variable is per capita CO_2 emissions. With reference to Equation (6), the electoral democracy index, the civil society participation index and the political corruption index alternatively stand for POL_INST_{it}, while REV_{it} is proxied with the environmental tax revenue, computed as a percentage of national GDP. The four taxes alternatively introduced stand for TAX_{it}; consequently the four interaction terms alternatively introduced stand for $POL\_INST_{it} \times TAX_{it}$. With the exceptions of the environmental tax revenue, of the three proxies for the quality of political institutions and of the four tax sources, all the variables have been standardized. Standard errors are clustered at country level reported in brackets. **** significance at 1%, ** significance at 5%, * significance at 10%.

Table 6: Estimation results of Equation (6) for the Climate Change environmental domain

	The electoral democracy index				The civil society participation index				The political corruption index			
$y_i g_i t$	-0.1412***	-0.1453***	-0.1280***	-0.1300***	-0.1379***	-0.1426***	-0.1297***	-0.1299***	-0.1466***	-0.1512***	-0.1323***	-0.1364***
	(0.0400)	(0.0420)	(0.0395)	(0.0471)	(0.0404)	(0.0434)	(0.0389)	(0.0445)	(0.0413)	(0.0428)	(0.0412)	(0.0468)
$g_i t$	0.2430***	0.2509***	0.2197***	0.2323***	0.2414***	0.2509***	0.2180***	0.2305***	0.2427***	0.2421***	0.2177***	0.2315***
	(0.0310)	(0.0290)	(0.0261)	(0.0232)	(0.0294)	(0.0291)	(0.0264)	(0.0235)	(0.0280)	(0.0256)	(0.0260)	(0.0232)
Trade openness	0.0340	0.0295	0.0237	0.0222	0.0333	0.0236	0.0165	0.0150	0.0122	0.0122	0.0158	0.0146
	(0.0267)	(0.0268)	(0.0292)	(0.0276)	(0.0262)	(0.0265)	(0.0287)	(0.0264)	(0.0202)	(0.0209)	(0.0281)	(0.0257)
Population density	1.2520***	1.2631***	1.2999***	1.2087***	1.2831***	1.2590***	1.2601***	1.1798***	1.1227***	1.1334***	1.2422***	1.1444***
	(0.3014)	(0.3051)	(0.2533)	(0.2975)	(0.2666)	(0.2815)	(0.2526)	(0.2888)	(0.2977)	(0.2931)	(0.2503)	(0.2853)
Development of financial markets	-0.0145**	-0.0148**	-0.0183**	-0.0169**	-0.0137**	-0.0133**	-0.0155**	-0.0152**	-0.0084	-0.0084	-0.0151**	-0.0138*
	(0.0068)	(0.0067)	(0.0070)	(0.0069)	(0.0062)	(0.0061)	(0.0064)	(0.0063)	(0.0066)	(0.0065)	(0.0069)	(0.0068)
Per capita oil production	-0.0084	-0.0113	-0.0213	-0.0099	-0.0117	-0.0144	-0.0237	-0.0110	-0.0092	-0.0119	-0.0208	-0.0100
	(0.0261)	(0.0263)	(0.0275)	(0.0256)	(0.0243)	(0.0250)	(0.0284)	(0.0253)	(0.0263)	(0.0266)	(0.0272)	(0.0260)
Per capita gas production	-0.0102	-0.0083	0.0432	-0.0034	-0.0036	-0.0038	0.0433	-0.0046	-0.0065	-0.0060	0.0434	-0.0044
	(0.0229)	(0.0236)	(0.0359)	(0.0295)	(0.0217)	(0.0239)	(0.0375)	(0.0287)	(0.0213)	(0.0209)	(0.0368)	(0.0295)
The electoral democracy index	0.7515**	0.1663	0.2206	0.2184	-	-	-	-	-	-	-	-
	(0.2854)	(0.1975)	(0.1774)	(0.1849)								
The civil society participation index	-	-	-	-	1.0389**	-0.0311	0.0152	0.0755	-	-	-	-
					(0.4932)	(0.1891)	(0.1699)	(0.1647)				
The political corruption index	-	-	-	-	-	-	-	-	-0.6656***	0.2493	0.0529	0.0602
									(0.1787)	(0.1669)	(0.1346)	(0.1524)
Environmental tax revenue	-0.0214*	-0.0234*	-0.0208	-0.0160	-0.0189	-0.0224	-0.0232	-0.0175	-0.0321***	-0.0334***	-0.0218	-0.0168
	(0.0121)	(0.0124)	(0.0172)	(0.0200)	(0.0139)	(0.0145)	(0.0172)	(0.0209)	(0.0114)	(0.0118)	(0.0175)	(0.0204)
Energy taxes	0.0036**	-	-	-	0.0076**	-	-	-	-0.0042***	-	-	-
	(0.0018)				(0.0034)				(0.0010)			
Transport taxes	-	-0.0026*	-	-	-	-0.0046	-	-	-	0.0040***	-	-
		(0.0013)				(0.0028)				(0.0009)		
Pollution taxes	-	-	0.0156***	-	-	-	0.0280	-	-	-	-0.0054	-
			(0.0056)				(0.0172)				(0.0119)	
Resources taxes	-	-	-	-0.7106	-	-	-	-4.6053	-	-	-	-0.2009*
				(1.0728)				(5.6258)				(0.1006)
Interaction terms												
Political institutions × Energy taxes	-0.0062*	-	-	-	-0.0110*	-	-	-	0.0092***	-	-	-
	(0.0031)				(0.0057)				(0.0016)			
Political institutions × Transport taxes	-	0.0047	-	-	-	0.0068	-	-	-	-0.0087***	-	-
		(0.0029)				(0.0051)				(0.0015)		
Political institutions × Pollution taxes	-	-	-0.0206	-	-	-	-0.0354	-	-	-	0.0184	-
			(0.0186)				(0.0327)				(0.0146)	
Political institutions × Resources taxes	-	-	-	0.4858	-	-	-	4.5138	-	-	-	0.7098
				(1.1930)				(5.7581)				(0.9374)
Constant	-0.4950**	-0.1613	-0.1903	-0.1970	-0.7824**	-0.0245	-0.0319	-0.0931	0.3290***	-0.0861	-0.0330	-0.0429
	(0.2309)	(0.1825)	(0.1738)	(0.1910)	(0.3216)	(0.1663)	(0.1606)	(0.1591)	(0.1128)	(0.0996)	(0.0901)	(0.1032)
Obs	521	521	511	522	521	521	511	522	521	521	511	522
R^2	0.6119	0.6356	0.6481	0.6208	0.6127	0.6307	0.6428	0.6161	0.6451	0.6709	0.6440	0.6158
Number of id	39	39	39	39	39	39	39	39	39	39	39	39

Notes: OLS estimates with the inclusion of country- and time- fixed effects. For the sake of parsimony, the estimates of the constant terms are not reported. The dependent variable is per capita CO_2 emissions. With reference to Equation (6), the electoral democracy index, the civil society participation index and the political corruption index alternatively stand for POL_INST_{it}, while REV_{it} is proxied with the environmental tax revenue, computed as a percentage of national GDP. The four taxes alternatively introduced stand for TAX_{it}; consequently the four interaction terms alternatively introduced stand for $POL\_INST_{it} \times TAX_{it}$. With the exceptions of the environmental tax revenue, of the three proxies for the quality of political institutions and of the four tax sources, all the variables have been standardized. Standard errors clustered at country level are reported in brackets. *** significance at 1%, ** significance at 5%, * significance at 10%.

Table 7: Marginal effects of revenue neutral tax shifts on CO_2 emissions for the Total Environment domain

	Total Environment			
	Energy taxes	Transport taxes	Pollution taxes	Resources taxes
Low quality of political institutions				
The electoral democracy index - *Minimum*	0.0038***	-0.0027*	0.0040	-0.0051***
	(0.0010)	(0.0014)	(0.0081)	(0.0012)
The civil society participation index - *Minimum*	0.0056***	-0.0029*	0.0013	-0.0090***
	(0.0016)	(0.0016)	(0.0101)	(0.0024)
The political corruption index - *Maximum*	0.0039***	-0.0064**	0.0135	-0.0033**
	(0.0009)	(0.0019)	(0.0081)	(0.0012)
High quality of political institutions				
The electoral democracy index - *Maximum*	-0.0018	0.0005	0.0021	0.0071***
	(0.0017)	(0.0021)	(0.0060)	(0.0023)
The civil society participation index - *Maximum*	-0.0027	0.0006	0.0036	0.0068**
	(0.0021)	(0.0022)	(0.0061)	(0.0025)
The political corruption index - *Minimum*	-0.0044**	0.0069**	-0.0078	0.0105***
	(0.0018)	(0.0028)	(0.0106)	(0.0023)

Notes: Findings derived from the results shown in Table 4. When political institutions take their average values in our sample, the sign and the statistical significance of the marginal effects of revenue neutral tax shifts are generally the same as those shown for high quality political institutions. These results are available upon request. Standard errors are reported in brackets. *** significance at 1%, ** significance at 5%, * significance at 10%.

Table 8: Marginal effects of revenue neutral tax shifts on CO_2 emissions for the Air Pollution domain

	Air Pollution			
	Energy taxes	Transport taxes	Pollution taxes	Resources taxes
Low quality of political institutions				
The electoral democracy index - *Minimum*	-0.0018 (0.0019)	0.0000 (0.0012)	0.0013 (0.0013)	-0.3288 (0.9023)
The civil society participation index - *Minimum*	-0.0011 (0.0019)	-0.0007 (0.0011)	0.0013 (0.0018)	0.7589** (0.2982)
The political corruption index - *Maximum*	-0.0032*** (0.0012)	0.0012 (0.0023)	0.0034*** (0.0008)	0.2322* (0.1335)
High quality of political institutions				
The electoral democracy index - *Maximum*	-0.0023 (0.0020)	0.0006 (0.0024)	0.0116** (0.0043)	-0.0024 (0.0762)
The civil society participation index - *Maximum*	-0.0039** (0.0018)	0.0028 (0.0021)	0.0085** (0.0034)	-0.1341* (0.0779)
The political corruption index - *Minimum*	0.0015 (0.0031)	-0.0010 (0.0034)	0.0027 (0.0080)	-0.0392 (0.0474)

Notes: Findings derived from the results shown in Table 5. When political institutions take their average values in our sample, the sign and the statistical significance of the marginal effects of revenue neutral tax shifts are generally the same as those shown for high quality political institutions. These results are available upon request. Standard errors are reported in brackets. *** significance at 1%, ** significance at 5%, * significance at 10%.

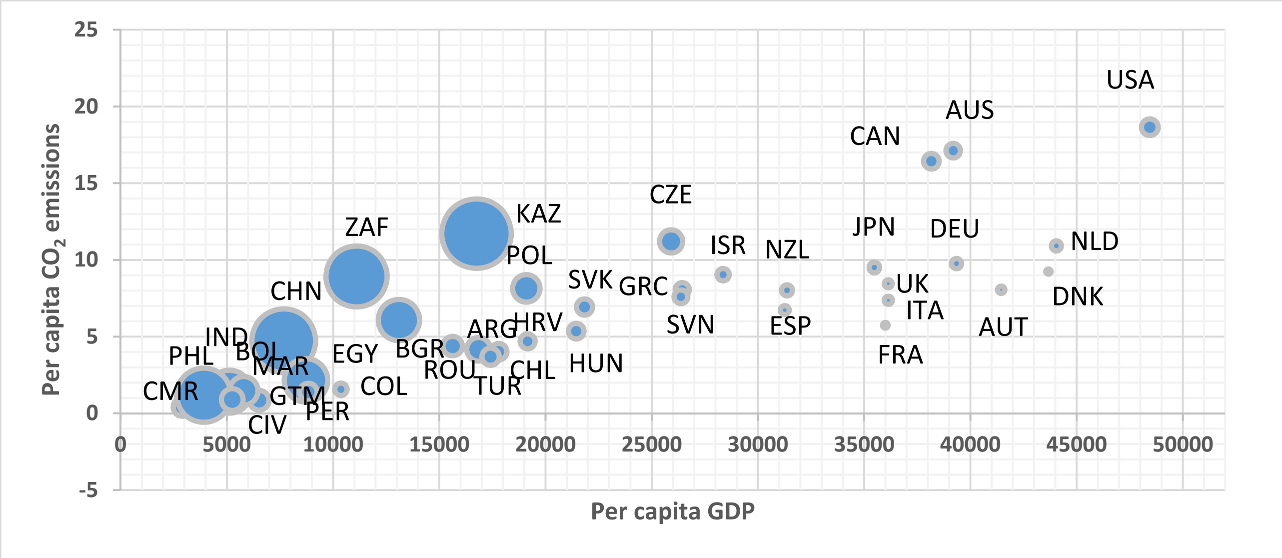
Table 9: Marginal effects of revenue neutral tax shifts on CO_2 emissions for the Climate Change domain

	Climate Change			
	Energy taxes	Transport taxes	Pollution taxes	Resources taxes
Low quality of political institutions				
The electoral democracy index - *Minimum*	0.0030**	-0.0022*	0.0137	-0.6654
	(0.0015)	(0.0012)	(0.0039)	(0.9623)
The civil society participation index - *Minimum*	0.0047**	-0.0028*	0.0185**	-3.3866
	(0.0021)	(0.0016)	(0.0084)	(4.0715)
The political corruption index - *Maximum*	0.0043***	-0.0040***	0.0116***	0.4557
	(0.0009)	(0.0007)	(0.0025)	(0.8807)
High quality of political institutions				
The electoral democracy index - *Maximum*	-0.0023	0.0018	-0.0039	-0.2501
	(0.0018)	(0.0020)	(0.0124)	(0.1125)
The civil society participation index - *Maximum*	-0.0032	0.0021	-0.0070	-0.1412
	(0.0027)	(0.0027)	(0.0154)	(0.1369)
The political corruption index - *Minimum*	-0.0041***	0.0040***	-0.0053	-0.1966*
	(0.0010)	(0.0009)	0.0118	(0.1012)

Notes: Findings derived from the results shown in Table 6. When political institutions take their average values in our sample, the sign and the statistical significance of the marginal effects of revenue neutral tax shifts are generally the same as those shown for high quality political institutions. These results are available upon request. Standard errors are reported in brackets. *** significance at 1%, ** significance at 5%, * significance at 10%.

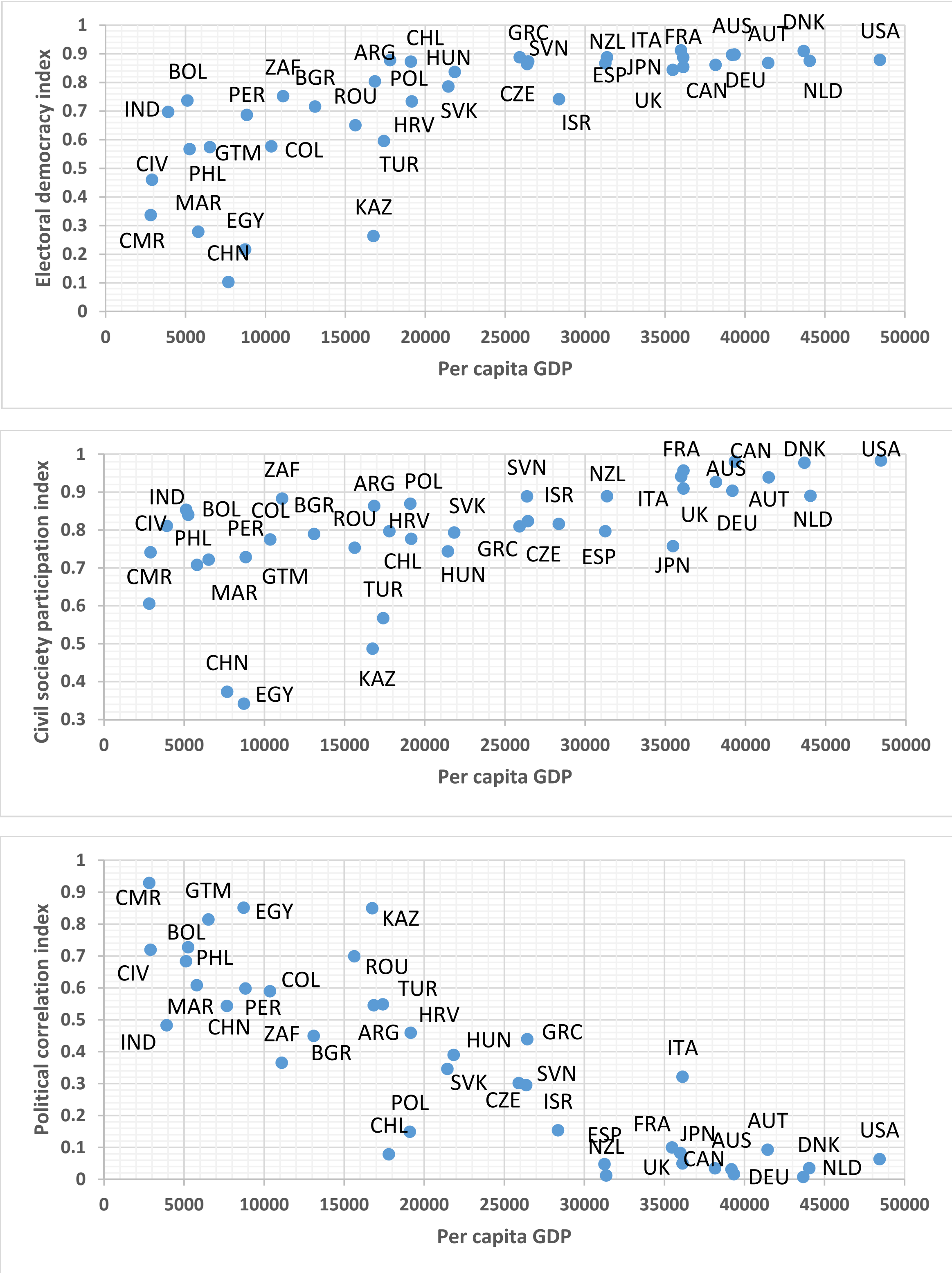
Figures

Figure 1: Per capita CO_2 emissions and per capita GDP



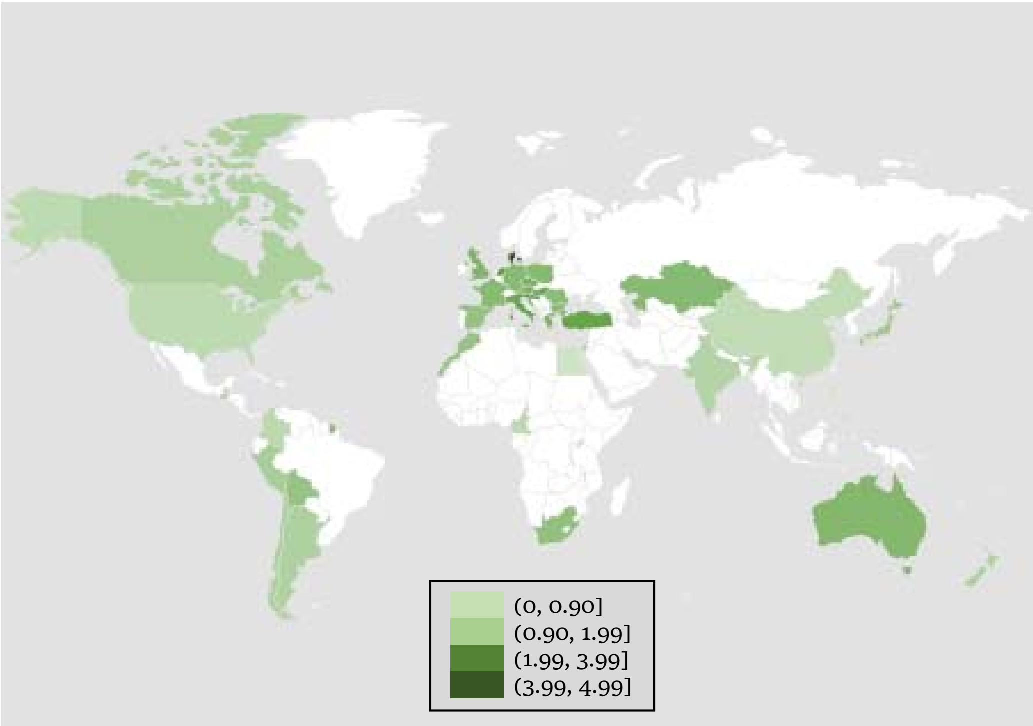
Notes: In each country, average values have been computed in the period 1996-2014. The size of the bubble is obtained by considering the average values of CO_2 emissions computed in kg per 2010 US$ of GDP, which include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring and are those stemming from the burning of fossil fuels and the manufacture of cement. Authors' elaborations on Word Bank data.

Figure 2: The quality of political institutions and GDP per capita



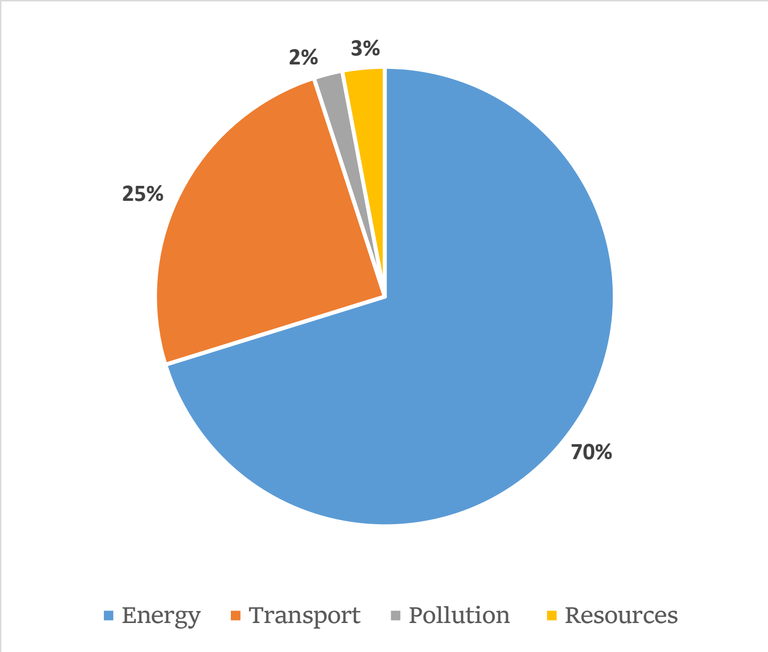
Notes: In each country, average values have been computed in the period 1996-2014. Authors' elaborations on V-Dem and Word Bank data.

Figure 3: Environmental tax revenue as percentage of GDP in the Total Environmental domain



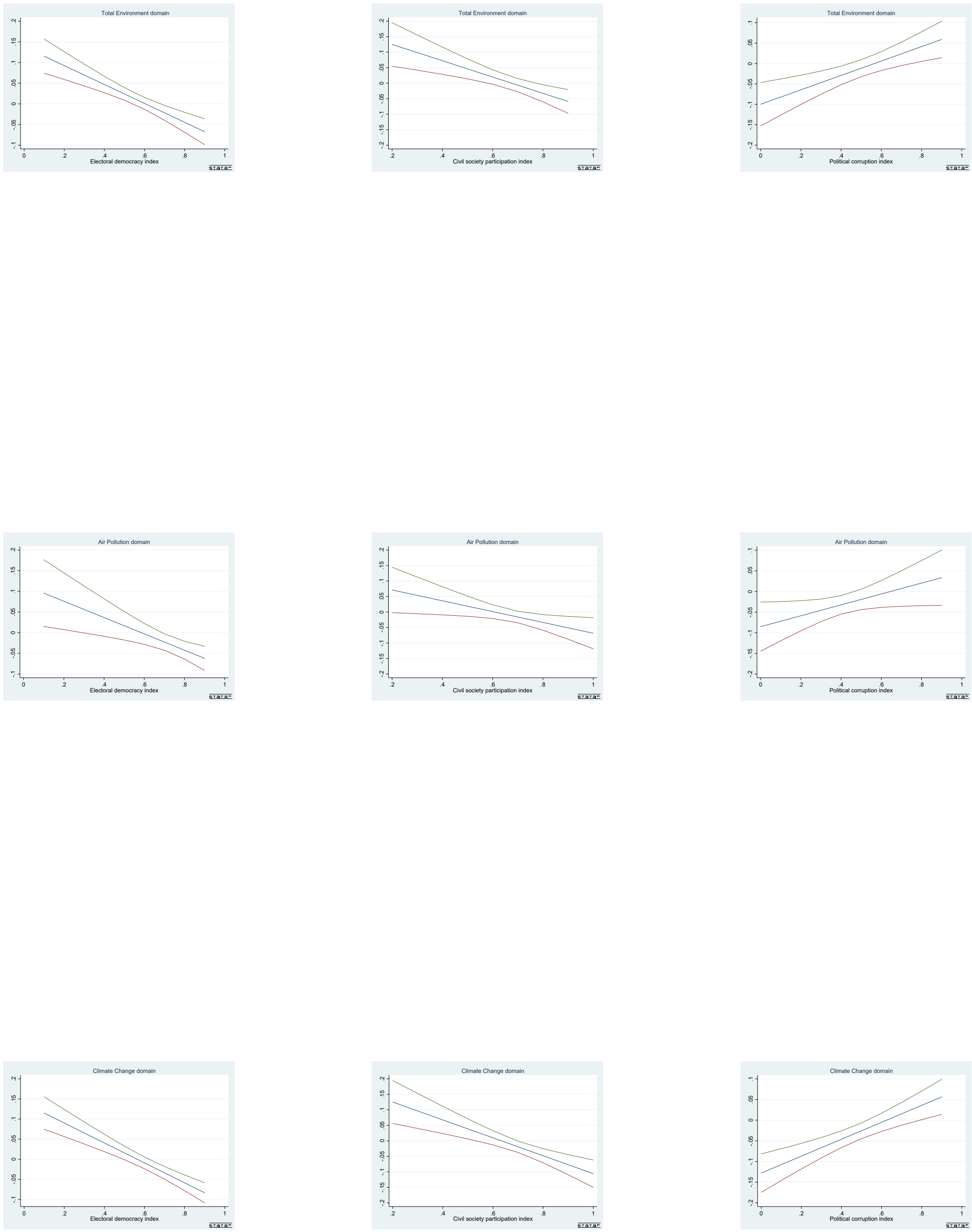
Notes: In each country, average values have been computed in the period 1996-2014. Authors' elaborations on OECD data.

Figure 4: The tax structure in the Total Environment domain



Notes: Average values in the period 1996-2014. Authors' elaboration on OECD data.

Figure 5: Marginal effect of environmental tax revenue on CO_2 emissions: the role of political variables



Notes: The blue lines correspond to the estimated values of Equation (5), while the red and green lines identify the upper and the lower bounds of 95% confidence intervals respectively. When they are both above (or below) the zero line, environmental tax revenue has a statistically significant effect on CO_2 emissions.

Appendix A

Following Bradford et al. (2005), we differentiate Equation (1) with respect to time t in order to obtain

$$\frac{\delta p_{it}}{\delta t} = (b_0 + 2b_1 y_{it})\frac{\delta y_{it}}{\delta t} \tag{A.1}$$

Moreover, by differentiating Equation (1) with respect to y and after some computations, we get that

$$y^{\star}_{it} = -\frac{b_0}{2b_1} \tag{A.2}$$

Then, we substitute Equation (A.2) into Equation (A.1), and by omitting the subscript t for sake of simplicity, we obtain

$$\frac{\delta p_{it}}{\delta t} = \gamma(y_i - y^{\star}_i)g_i \tag{A.3}$$

that corresponds to the specification of the EKC proposed by Bradford et al. (2005). Equation (A.3) shows that, in each country i, the instantaneous change in pollution depends on the distance of income y_i to the turning point $y^{\star}_i$, and to the average income rate of growth, g_i, given that $g_i = \frac{\delta y_{it}}{\delta t}$. Given that g_i is positive, environmental stress increases when $y_i < y^{\star}_i$, while decreases in the opposite case, i.e. when $y_i > y^{\star}_i$. Moreover, the coefficient $\gamma = 2b_1$ is expected to be negative, since $b_1 < 0$.

Then, we integrate Equation (A.3) with respect to time and we obtain

$$p_{it} = \alpha_i + \gamma(y_i - y^{\star}_i)g_i t \tag{A.4}$$

where α is a constant of integration and t is a linear time trend. Lastly, by adding the set of control variables X_{it} and country- and time-specific effects θ_i and η_t, we obtain the Equation (2), which is at the basis of our estimation strategy. The coefficient $\beta_0 = \gamma$ is thus expected to be negative. If this occurs, the hypothesis of an inverted-U-shaped relationship between environmental stress and economic development is verified.

Appendix B

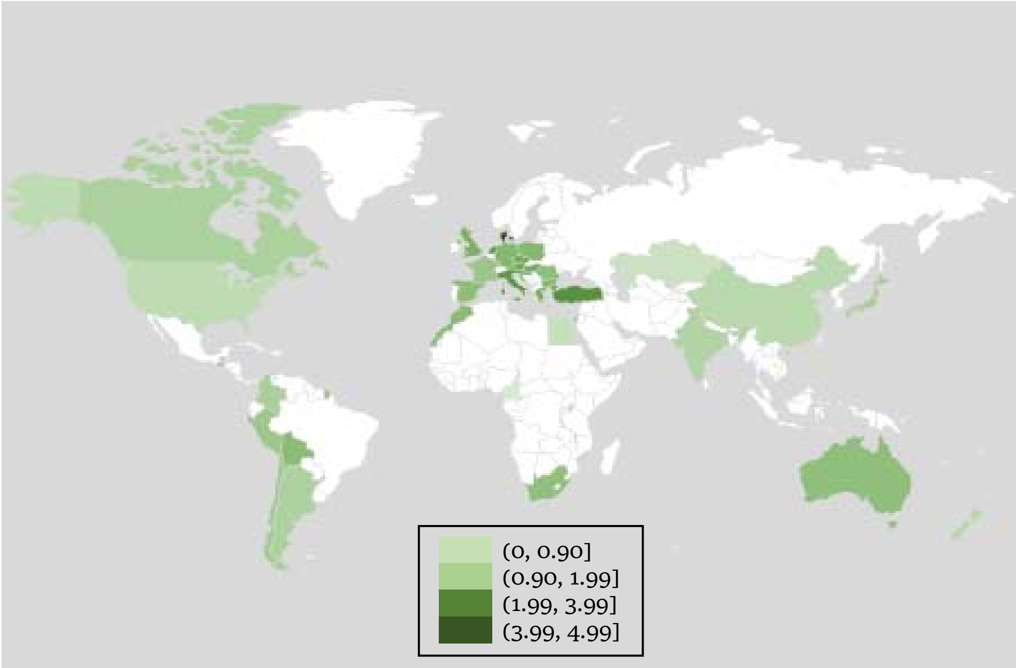
Table B.1: The tax structure in the Air Pollution domain

	The electoral democracy index	The civil society participation index	The political corruption index
High income countries			
Australia (AUS)	0.8961	0.9031	0.0311
Austria (AUT)	0.8679	0.9386	0.0927
Canada (CAN)	0.8607	0.9265	0.0343
Chile (CHL)	0.8773	0.7965	0.0780
Croatia (HRV)	0.7332	0.7765	0.4588
Czech Republic (CZE)	0.8872	0.8091	0.3015
Denmark (DKN)	0.9092	0.9770	0.0072
France (FRA)	0.9117	0.9407	0.0824
Germany (DEU)	0.8970	0.9804	0.0156
Greece (GRC)	0.8728	0.8231	0.4390
Hungary (HUN)	0.7853	0.7434	0.3456
Israel (ISR)	0.7412	0.8160	0.1532
Italy (ITA)	0.8537	0.9090	0.3210
Japan (JPN)	0.8435	0.7570	0.0997
Netherlands (NL)	0.8874	0.8887	0.0116
New Zealand (NZL)	0.8874	0.8887	0.0116
Poland (POL)	0.8725	0.8692	0.1488
Slovak Republic (SVK)	0.8360	0.7930	0.3899
Slovenia (SVN)	0.8638	0.8883	0.2950
Spain (ESP)	0.8664	0.7965	0.0475
United Kingdom (GBR)	0.8872	0.9563	0.0492
United States (USA)	0.8783	0.9830	0.0631
Average	*0.8598*	*0.8709*	*0.1580*
Upper middle income countries			
Argentina (ARG)	0.8034	0.8630	0.5453
Bulgaria (BGR)	0.7156	0.7892	0.4491
China (CHN)	0.1025	0.3730	0.5432
Colombia (COL)	0.5765	0.7749	0.5891
Guatemala (GTM)	0.5739	0.7217	0.8141
Kazakhstan (KAZ)	0.2631	0.4867	0.8495
Peru (PER)	0.6863	0.7280	0.5978
Romania (ROU)	0.6503	0.7530	0.6986
South Africa (ZAF)	0.7515	0.8824	0.3650
Turkey (TUR)	0.5953	0.5670	0.5480
Average	*0.5718*	*0.6939*	*0.6000*
Lower middle income countries			
Bolivia (BOL)	0.7367	0.8531	0.6832
Cameroon (CMR)	0.3364	0.6056	0.9284

Cote d'Ivoire (CIV)	0.4596	0.7410	0.7191
Egypt (EGY)	0.2162	0.3415	0.8509
India (IND)	0.6967	0.8106	0.4824
Morocco (MAR)	0.2781	0.7076	0.6079
Philippines (PHL)	0.5669	0.8397	0.7268
Average	*0.4701*	*0.6999*	*0.7141*

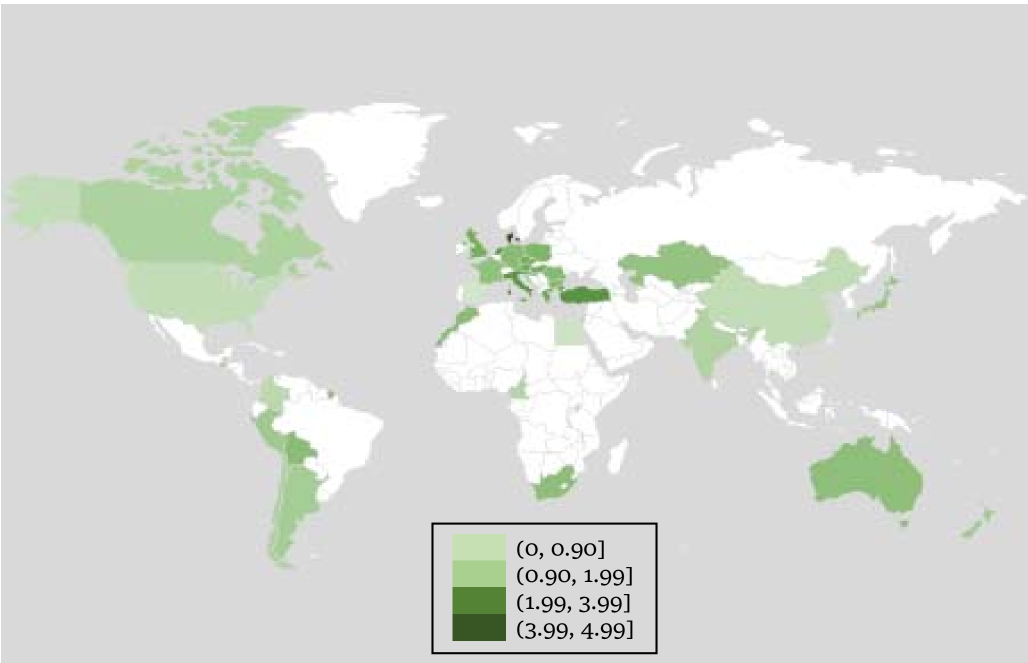
Notes: For each country, average values have been computed in the time period 1996-2014. Authors' elaborations on V-Dem and Word Bank data.

Figure B.1: Environmental tax revenue as percentage of GDP in the Air Pollution domain



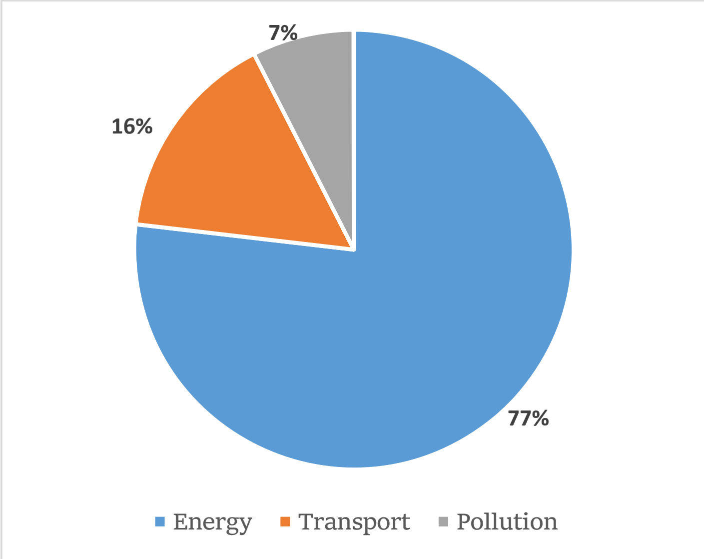
Notes: In each country, average values have been computed in the period 1996-2014. Author's elaborations on OECD data.

Figure B.2: Environmental tax revenue as percentage of GDP in the Climate Change domain



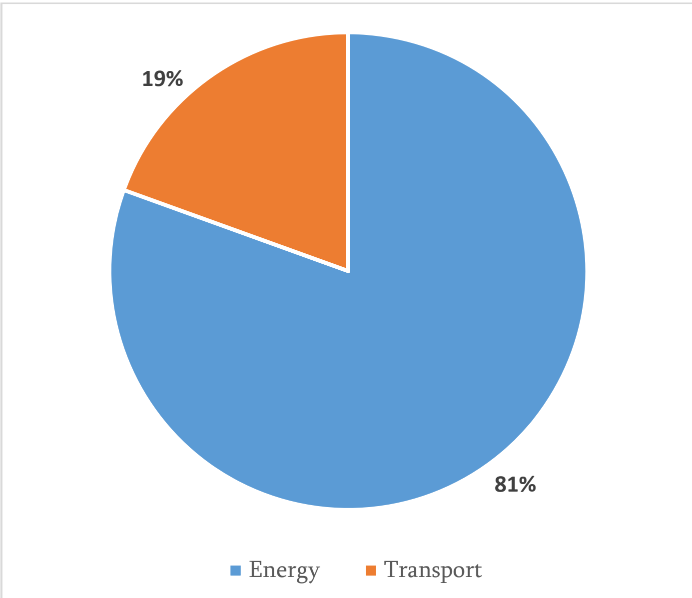
Notes: In each country, average values have been computed in the period 1996-2014. Author's elaborations on OECD data

Figure B.3: The tax structure in the Air Pollution domain



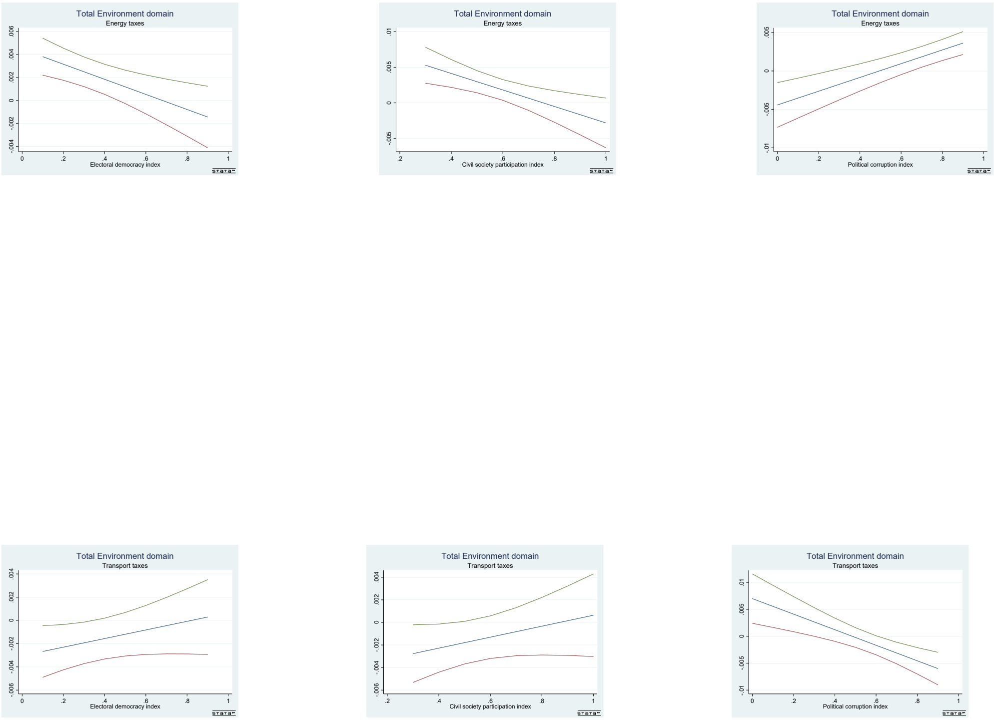
Notes: Average values in the period 1996-2014. Resources taxes are not reported, since their share is very low (on average 0.02 per cent). Authors' elaboration on OECD data.

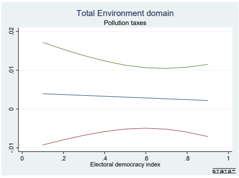
Figure B.4: The tax structure in the Climate Change domain

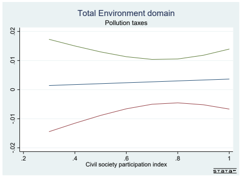


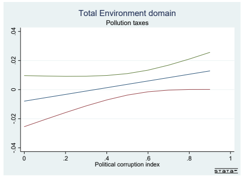
Notes: Average values in the period 1996-2014. Pollution and resources taxes are not reported, since their shares are very low (on average 0.4 and 0.09 per cent, respectively). Authors' elaboration on OECD data.

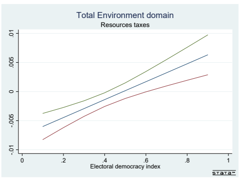
Figure B.5: Marginal effect of of revenue neutral tax shifts on CO_2 emissions: the role of political variables

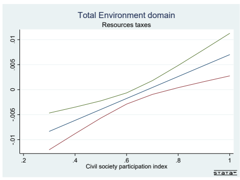


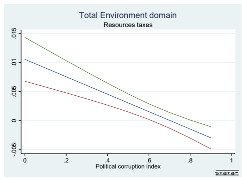












Notes: The blue lines correspond to the estimated values of Equation (7), while the red and green lines identify the upper and the lower bounds of 95% confidence intervals respectively. When they are both above (or below) the zero line, revenue neutral tax shifts have a statistically significant effect on CO_2 emissions.