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EXPLORING THE DETERMINANTS AND CONSEQUENCES OF THE STRINGENCY OF ENVIRONMENTAL POLICIES[1]

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ABSTRACT

Public choice models of environmental policies suggest that governments arbitrage between the conflicting interests of consumers/voters and of producers organized in lobbies. Governments minimize the political costs of these policies by approving those that voters demand without pushing for their implementation, to save cost increases to producers. Environmental policies thus become far reaching but not "stringent". This paper provides a model where the stringency of environmental policies is the endogenous result of a political arbitrage between conflicting interests of producers and voters; the model also identifies the channels through which these policies affect energy intensity. We test the model in a sample of 16 OECD countries for the period 1995-2012, using a new system of equations and a set of proxies of the stringency of market and non-market based policies. The estimates find that voters demand greater stringency of market based policies only, while lobbies oppose both types. Quality of regulation has a positive impact on market based policy stringency, while left wing governments push for greater stringency in non market based policies. Finally, greater stringency especially in non-market based policies appears to reduce energy intensity.

Keywords: Environmental policy stringency, energy intensity, political arbitrage, regulatory quality, corruption, voters, special interest groups.

JEL classification codes: D78, H23, Q52, Q58, D72

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1. *Introduction*

Probably the most significant contribution that public choice and political economy have made to environmental economics is the idea that the reciprocal nature of externalities creates the possibility for re-election seeking governments to arbitrage between the conflicting interests of consumers and producers. To the extent that voters are unorganized, whereas polluting producers are organized in special interest groups, governments tilt this arbitrage in favor of the latter, away from a "socially optimal" environmental policy (Bocher, 2012; Eerola, 2004; Demania et al. 2003; Aidt, 1998; Fredriksson, 1997). The early public choice literature argued that deviations of political equilibria from social optimality may take place at two different levels: that of *legislation* of the environmental policy, and that of the *implementation and administration* of the policy itself. In other words, governments may approve the environmental policies that voters demand, to show them that "they are doing something" for the environment, without actually implementing them to a point that proves too costly for polluting firms and interest groups. Likewise, governments may prefer highly visible but poorly effective policy instruments, such as command and control measures, rather than others that produce immediate results, like Pigouvian taxes (Buchanan and Tullock, 1975; Hahn, 1989; Schneider and Weck-Hanemann, 2005). As a result of these political incentives, environmental policies tend to be far reaching but not stringent.

The more recent research about the political economy of environmental policy, both theoretical and empirical, has not fully developed this insight. At least three shortcomings appear still to be dealt with. First measures of policy stringency are usually based on proxies that are quite indirect, varied and mainly driven by the data availability. Damania et al. (2003) for instance proxy environmental policy stringency as grams of lead per gallon of gasoline, whereas Fredriksson et al. (2004) adopt a measure energy intensity. Measures such as these are actually end results of a variety of environmental policies, as different countries can achieve these results through different policy routes; hence they do not make clear which policy stringency is being evaluated. Damania et al. (2003) consider also alternative indicators used in the literature, such as environmental R&D expenditures as a

percentage of GDP, or country per capita memberships in environmental organizations. A potentially better proxy is the Dasgupta index of policy stringency, based on a series of expert evaluations of environmental policies, but that index is highly aggregate and available for 1990 only.

A second shortcoming is that neither these indexes, nor others adopted in the literature, are apt to examine the differences in the stringency of legislated policies and implemented policies, as they treat as equivalents indicators based on policy evaluations – better suited to assess the stringency of legislated policies - and on policy results – which rather refer to the stage of policy implementation.

Third, and finally, most empirical studies have not jointly examined the two issues of the efficiency and of the stringency of environmental policies. The joint analysis of these two issues is crucial to verify whether governments arbitrage in environmental policies between the conflicting interests of producers and voters. That because if policies were ineffective, re-election seeking governments would have no incentive to implement them, as they would represent a political cost for both voters, who would see that the government is not protecting the environment, and producers, who would have to bear the burden of costly and useless environmental regulations. Only if environmental policies are effective then the problem of arbitraging the interests of voters and producers emerges for politicians; in this case they will have to decide the optimal degree of stringency of the environmental policies. Hence the two issues of the efficiency and the stringency of policies are essentially intertwined, and they must be jointly addressed in the same analytical framework and sample. So far, all papers in the literature has dealt with either policy efficiency or policy stringency, without recognizing the link between them.

This paper tries to address the issue of whether and how governments arbitrage between the conflicting interests of consumers/voters and producers/interest groups in environmental policy. First, we propose a stylized theoretical model that describes the incentives and constraints of politicians in legislating and implementing policies in favor of the environment. We then examine the stringency and the efficiency of environmental policies of 18 OECD countries for the period 1995-2012 using a system of simultaneous

equations. We innovate on the empirical literature referred to so far in that we use two indexes of environmental policy stringency provided by OECD (Botta and Kozluk, 2014), one for non-market based polices (mainly regulatory emission limits and subsidies for R&D), the other for market-based policies that pass through the price system (Pigouvian taxes, FITs, and trading schemes). On these indexes of stringency, we examine the impact of a set of political determinants that may condition the extent to which politicians arbitrage among the conflicting interests of voters and producers. These are indicators of the costs for producers to get organized as a lobby, of the sensitivity of governments to lobbying activities and of the importance that voters attribute to environmental issues on the other. To verify whether politicians resort to institutional arrangements to optimize the stringency of environmental policies, we also consider the impact of regulatory quality. Finally, the analysis is conducted controlling for economic and energy related factors that could affect the stringency of environmental policy, like energy prices, energy intensity and trade liberalization, which have usually received the greatest attention by environmental policy analysts so far.

To evaluate then the efficiency of the environmental policies – the second side of the research question of the paper - we take the industry energy intensity (i.e. the industry energy consumption per unit value of output produced in the country) as target variable, and examine it as a function of economic and energy controls, and, of course, of the indexes of environmental policy stringency.

To ensure that the two components of our research questions are jointly analyzed, we resort to a system of equations estimated via a two-stages least squares model with instrumental variables to account for the endogeneity of the two dependent variables. To anticipate the main outcomes of the analysis, in the equation for energy intensity we find that the stringency of non-market environmental policies has a greater impact on the reduction of the intensity of energy consumption in productive processes than marked based ones, all other things being equal. Furthermore, analyzing the determinants of the stringency environmental policies is indeed relevant, since they do appear to have distributional consequences; politicians can then derive political advantages by optimally

setting their degree of stringency. In this respect, the analysis shows that a) the impact of the proxies for lobbying activities opposes environmental policy stringency, where indicators of voters preferences have the opposite effect; b) voters concentrate mainly on market based policies, whereas lobbying by producers negatively affect both policy types; c) countries characterized by better regulatory quality receive higher scores in the stringency indexes of market based policies, whereas those that are governed by left-wing majorities reach higher level of stringency of non-market based policies.

The rest of the paper is organized as follows. Section 2 presents the theoretical model. The data, the testable hypothesis and the empirical strategy are illustrated in section 3. Section 4 discusses the results. Section 5 presents the main conclusions of the analysis.

2. *The model*

The stylized model we propose is divided in two sections. The first section shows how government endogenously decide environmental policy; government's permanence in power depends on the support of consumers/voters and of producers organized in a lobby[2]. That model is inspired to those of Friedriksson et al. (2004), Eerola (2003) and others in the same vein, yet it innovates on them in that we distinguish the policy goals from the policy instruments, to allow the possibility that governments declare far reaching environmental goals without actually pursuing them with maximal rigor – the arbitrage hypothesis. The second section of the model verifies how the equilibrium policy choice emerged from the first section actually affects the target variable, here energy intensity in production, characterizing the transmission mechanisms and presenting the main conditioning factors, along the lines of Fisher Vanden et al. (2016).

2.1. The model economy. The analysis presupposes a small open economy where many firms produce a private good Q for a perfectly competitive international market. The price setting behavior of firms allows setting the price of Q to $p_Q = 1$. The technology of

[2] Especially for environmental concerns, consumers too may act organized in special interest groups (Eerola, 2004). Our analysis then can be interpreted as considering the differential lobbying efficiency of the more concentrated lobbies of producers over the more dispersed lobbies of consumers, according to the standard logic of collective action by Olson (1970).

production F, common to all firms, exhibits constant returns to scale, is concave and increasing in all inputs, and is twice continuously differentiable. Moreover, output Q is obtained using three inputs, capital K, labor L and energy θ, according to the following production function:

$$Q = F(K, L, \theta(1-\sigma)) \quad (1)$$

where $0 \leq \sigma \leq 1$ is an indicator of the stringency of the government's environmental policy. While K is in fixed quantity internationally, energy can be imported free of import duties at a price p_θ. By linear homogeneity, for a given amount of K we have:

$$Q = Kf(\mathrm{l}, \alpha(1-\sigma)) \quad (2)$$

where $l = \frac{L}{K}$ is the inverted capital/labor ratio and the variable $\alpha = \frac{\theta}{K}$ defines the government energy policy goal, specified as a given amount of energy per units of capital. Differently from Fredriksson et al. (2004), Eerola (2003) and the rest of the theoretical literature, we explicitly assess the stringency of the government's environmental policy through the parameter σ; this enables us to distinguish the policy goal α, which, as already explained in the introduction, politicians can proclaim in far reaching terms, from the rigor with which they in fact pursue such a goal; higher values of σ denote greater policy stringency.

The marginal products of factors of production are positive and decreasing: $f_l > 0, f_\alpha > 0, f_{ll} < 0, f_{\alpha\alpha} < 0$. Furthermore, we suppose, quite realistically, that $f_{l\alpha} > 0$, namely, an increase of the energy/capital ratio increases the marginal product of labor, for a given level of capital. This assumption plays an important role in our political model, as it aligns the interests of workers to those of capital owners *vis à vis* the government. Rearranging terms, the marginal product of capital is given by:

$$\frac{\partial Q}{\partial K} = f - lf_l - \alpha f_\alpha > 0$$

The marginal product of labor and of energy are, instead:

$$\frac{\partial Q}{\partial L} = K\left(\frac{\partial f}{\partial l}\frac{\partial l}{\partial L}\right) = Kf_l\frac{1}{K} = f_l > 0$$

$$\frac{\partial Q}{\partial \theta} = K\left(\frac{\partial f}{\partial \alpha}\frac{\partial \alpha}{\partial \theta}\right) = Kf_\alpha\frac{1}{K} = f_\alpha > 0$$

The aggregate profit function of the firms operating in each country can be expressed as:

$$\pi = Kf\big(l, \alpha(1-\sigma)\big) - rK - wL - p_\theta\theta(1-\sigma) \quad (3)$$

where r represents the cost of capital and w the wage rate. Just like for the price of the output good Q, the presence of many small firms leads to assume that they take both r and w as given. Differentiating (3) with respect to the use of energy we obtain:

$$\frac{\partial \pi}{\partial \theta} = f_\alpha - p_\theta(1-\sigma) = 0 \quad (4)$$

Rearranging (4) one observes that $f_\alpha = p_\theta(1-\sigma) < p_\theta$. This is already a first result of the theory: when the government policy σ is a binding constraint, namely, when (and to the extent that) the policy is stringent, the firms' use of energy is restricted to a lower level than the optimal for production purposes.

There are four sets of agents in the economy: workers W, capital owners K (which, combined with workers, constitutes the class of producers), consumers S and the government. The first three compose the total mass of the population of the country, which for convenience is normalized to 1. Of this total, β^S represents the share of consumers, $\beta^W = L$ that of workers and β^K that of capital owners. The utility of all individuals increases with the consumption of the produced good Q, but consumers in addition suffer a damage D that corresponds to the emissions generated by the production process of Q. In particular, emissions are assumed to be in proportion $0 \leq \Omega \leq 1$ to the production of Q. The additively separable utility functions of consumers can be described as:

$$U^S = c^S(Q) - \Omega Q \quad (5)$$

whereas those of workers and of capital owners are:

$$U^W = c^W(Q) \quad (6)$$

$$U^K = c^K(Q) \quad (7)$$

The income Y^S of each consumer is supposed to be exogenously determined, i.e., earned from employment in jobs non affected by environmental policy.

2.2. The political process. The producers, i.e., capital owners and workers combined together, form a single special interest group; the condition $f_{l\alpha} > 0$ ensures that workers

gain from an increase of the energy/capital ratio, i.e., from a less stringent environmental policy, just like capital owners. This identity of interests allows assuming, for simplicity and with no loss of generality, that capital owners lobby the government also for the workers. In particular, capital owners offer to the government a "payment schedule" $C^K(\sigma)$, which relates the amount transferred to a given level of stringency of the environmental policy that the government decide to implement. Note that lobbying affects the implementation stage of the policy, regardless of what may have been already decided. Lobbying engenders a cost of coordination λ for workers and capital owners, which makes the total cost of lobbying (payments included) equal to $(1+\lambda)C^K(\sigma)$. Following Olson (1970) and Laffont and Tirole (1994), we suppose that larger special interest groups, or those where the alignment of interests between workers and capital owners is not seamless, face greater coordination problems, reflected in larger values of λ.

The indirect (gross of lobbying costs) utility functions of consumers, workers and of capital owners are, respectively:

$$V^S = \beta^S(Y^S - \Omega Q) \tag{8}$$

$$V^W = Lf_l \tag{9}$$

$$V^K = K(f - lf_l - \alpha f_\alpha) \tag{10}$$

For capital owners engaged in lobbying activities, the net indirect utility function is:

$$V_N^K(\sigma) = K(f - lf_l - \alpha f_\alpha) - (1+\lambda)C^K(\sigma) \tag{11}$$

The additive the social welfare function equals

$$V = V^S + V^W + V^K \tag{12}$$

In order to remain in power, the government *G* maximizes a weighted sum of the gross indirect utility functions of the three groups, plus the contributions from the lobby, using the energy policy σ as the control variable:

$$V^G = a_1 V^K + a_2\, \gamma \beta^S V^S + a_3 V^W + C^K(\sigma)$$

where a_1, a_2 and a_3 represent the exogenous weights that the government attributes to, respectively, the support of capital owners, of β^Sconsumers and of workers. In particular we posit that a_1, a_2 >0 but that a_3 =0. This means that the government is responsive to capital owners because of their lobbying efforts and to consumers who manifest their support through the elections; yet, as workers delegate the representation of

their (coinciding) interests to capital owners, for simplicity we treat them as if they do not participate to the political process. Finally, $\gamma \geq 0$ is an electoral accountability parameter, which reveals to what extent the country's institutions (rather than the government's political inclinations and/or ideology) allow the government to open a wedge between what it proclaims to do for the environment and what it actually does. Greater values of γ denote that the government find it more difficult to open such a wedge. In empirical analysis γ can be proxied through an indicator of government regulatory quality. The government indirect utility function can therefore be stated as follows:

$$V^G \equiv a_1 V^K + a_2\, \gamma \beta^S V^S + C^K(\sigma) \tag{13}$$

The equilibrium energy policy is the outcome of a two-stage non-cooperative game. In the first stage the lobby of capital owners offers to the government a bribe schedule $C(\sigma)$, as a monetary reward for selecting policy σ. In the second stage, the government selects an energy policy and collects the associated payment from the lobby. The lobby is assumed not to renege on its promises in the second stage. Following Bernheim and Whinston (1986), Grossman and Helpman (1994) and Eerola (2004), the characterization of the political equilibrium is given by:

$$\sigma^* \in argmax_\sigma\, [V^G(\sigma)] \tag{14.1}$$

$$\sigma^* \in argmax_\sigma\, [V^K(\sigma) - (1+\lambda)C^K(\sigma) + V^G(\sigma)\,] \tag{14.2}$$

$$\sigma^* \in argmax_\sigma\, [V^S(\sigma) + V^G(\sigma)\,] \tag{14.3}$$

$$\sigma^* \in argmax_\sigma\, [V^W(\sigma) + V^G(\sigma)\,] \tag{14.4}$$

The FOC (14.2) implies that $V_\sigma^k(\sigma) = (1+\lambda)C_\sigma^K(\sigma)$ [3]; in other words, the marginal change in total lobbying cost (i.e., the amount of the payment *C* and the organizational costs λ) induced by a change of policy σ equals the marginal change in the gross welfare of the lobby, i.e., of capital owners. Rearranging terms we obtain the characterization of σ^*:

$$V_\sigma^G = a_1 V_\sigma^K(\sigma) + a_2 \gamma \beta^S V_\sigma^S(\sigma) + C_\sigma^K(\sigma) = 0$$

$$a_1 V_\sigma^K(\sigma) + a_2 \gamma \beta^S V_\sigma^S(\sigma) + \frac{1}{(1+\lambda)} V_\sigma^K(\sigma) = 0$$

$$\left(a_1 + \tfrac{1}{(1+\lambda)}\right) V_\sigma^K(\sigma) = -\gamma \beta^S (a_2 V_\sigma^S(\sigma)) \tag{15}$$

[3] That because $V_\sigma^K - (1+\lambda)C_\sigma^K(\sigma) + V_\sigma^G(\sigma) = 0$. Hence the FOC (14.1) yields $V_\sigma^G(\sigma) = 0$.

Equation (15) is the standard result in lobbying models: the government equates at the margin the marginal support of producers and of consumers (Grossman and Helpman, 1994). The fact that consumers are not lobbying the government generates an unequal representation of the combined interests of producers with respect to those of consumers themselves. Equation (15) indeed shows that, while the government assigns a (positive) weight of $a_1 + 1/(1+\lambda)$ to producers' interests, consumers' interests receive a weight of only a_2. Voters' interests are better represented when, all other things being equal, the government is more ideologically aligned to their demands (larger a_2) or when the difference between the legislated decisions and their actually implementation is narrower (higher γ) or when the share of the voting population concerned by environmental policy is large β^S. It is also to be noted that, as $\lim_{\lambda} \to \infty$, for instance because the coordination between capital owners and workers is no longer effective, the weight that the government associates to the interests of producers converges to a_1. Moreover, the greater the organizational costs involved with transfer of the contribution *C* to the government, the lower the influence of the producers' special interest group.

To find an explicit expression for the equilibrium policy σ^*, we need to find the effects of σ on the gross welfare of the politically active groups, capital owners and consumers. These effects are given by, respectively:

$$V_\sigma^K(\sigma) = K(f_\sigma - l f_{l\sigma} - \alpha f_{\alpha\sigma}) < 0 \tag{16}$$

$$V_\sigma^S(\sigma) = -\gamma \beta^S \, \Omega K f_\sigma > 0 \tag{17}$$

Substituting (16) and (17) in (15) yields the equilibrium condition for σ^*:

$$\left(a_1 + \frac{1}{(1+\lambda)}\right) K(f_\sigma - l f_{l\sigma} - \alpha f_{\alpha\sigma}) - \; a_2 \gamma \beta^S \, \Omega K f_\sigma \; = 0$$

which, simplifying for *K*, can be rewritten as:

$$\left(a_1 + \tfrac{1}{(1+\lambda)}\right)(f_\sigma - l f_{l\sigma} - \alpha f_{\alpha\sigma}) - \; a_2 \gamma \beta^S \, \Omega f_\sigma \; = 0 \tag{18}$$

The first term $\left(a_1 + \frac{1}{(1+\lambda)}\right)(f_\sigma - l f_{l\sigma} - \alpha f_{\alpha\sigma})$ denotes the influence of the lobby; the second $a_2 \gamma \beta^S \, \Omega f_\sigma$reflects the government's consideration for voters. The two terms have opposite signs, so the government must arbitrage between the conflicting interests of the two groups.

2.3. Predictions. To derive the predictions of the model, we must totally differentiate equation (18) under the simplifying assumption that all third-order conditions are approximatively zero:

$$(f_\sigma - lf_{l\sigma} - \alpha f_{\alpha\sigma})da_1 - \frac{1}{(1+\lambda)^2}(f_\sigma - lf_{l\sigma} - \alpha f_{\alpha\sigma})d\lambda - \gamma\beta^S\,\Omega f_\sigma da_2 - a_2\beta^S\,\Omega f_\sigma d\gamma +$$

$$\left(a_1 f_{\sigma\sigma} + \frac{1}{(1+\lambda)}f_{\sigma\sigma} - a_2\gamma\beta^S\,\Omega f_{\sigma\sigma}\right) + \left(a_1 f_{\sigma\sigma} + \frac{1}{(1+\lambda)}f_{\sigma\sigma} - a_2\gamma\beta^S\,\Omega f_{\sigma\sigma}\right)d\sigma = 0 \quad (19)$$

From equation (19) we can derive the following predictions of the model:

$$\frac{d\sigma}{da_1} = \frac{f_\sigma - lf_{l\sigma} - \alpha f_{\alpha\sigma}}{a_1 f_{\sigma\sigma} + \frac{1}{1+\lambda}f_{\sigma\sigma} - a_2\gamma\beta^S\Omega f_{\sigma\sigma}} \quad (20)$$

$$\frac{d\sigma}{da_2} = \frac{-\gamma\beta^S\Omega f_\sigma}{a_1 f_{\sigma\sigma} + \frac{1}{1+\lambda}f_{\sigma\sigma} - a_2\gamma\beta^S\Omega f_{\sigma\sigma}} \quad (21)$$

$$\frac{d\sigma}{d\gamma} = \frac{-a_2\beta^S\Omega f_\sigma}{a_1 f_{\sigma\sigma} + \frac{1}{1+\lambda}f_{\sigma\sigma} - a_2\gamma\beta^S\Omega f_{\sigma\sigma}} \quad (22)$$

$$\frac{d\sigma}{d\lambda} = \frac{-\frac{1}{(1+\lambda)^2}(f_\sigma - lf_{l\sigma} - \alpha f_{\alpha\sigma})}{a_1 f_{\sigma\sigma} + \frac{1}{1+\lambda}f_{\sigma\sigma} - a_2\gamma\beta^S\Omega f_{\sigma\sigma}} \quad (23)$$

Since $f_\sigma < 0$, $f_{\sigma\sigma} < 0, f_{\alpha\sigma} < 0$, and under the plausible assumptions that $a_1 + \frac{1}{(1+\lambda)} < a_2\gamma\beta^S\,\Omega$ we can state the following signs and the ensuing Propositions:

$\frac{d\sigma}{da_1} < 0$; $\frac{d\sigma}{da_2} > 0$; $\frac{d\sigma}{d\gamma} > 0$; $\frac{d\sigma}{d\lambda} > 0$.

Proposition 1: *When the government is more (less) sensitive to producers' interests, the marginal stringency of the policy decreases (increases), as pointed out by (20).*

Proposition 2: *When the government is more (less) sensitive to consumers' interests, the marginal stringency of the policy increases (decreases), as pointed out by (21).*

Proposition 3: *Greater quality of regulation raise the stringency of the policy, as pointed out by (22)*

Proposition 4: Greater coordination costs for the lobby raise the stringency of the policy, as pointed out by (23).

2.4. Determinants of energy intensity. To bring the theoretical model as close to the data as possible, we need to examine how policy σ affects the energy intensity θ in production of *Q*. This enables to characterize the transmission mechanisms and to

highlight the main conditioning factors that must be taken into account in the empirical analysis. Since energy θ is an input of the production function $Q = F(K, L, \theta(1-\sigma))$, we have to derive its demand by the firms. From the previous section we know that firms are competitive profit maximizers, so input demand can be derived from a problem of cost minimization. For simplicity it is useful to define $E \equiv \theta(1-\sigma)$, the actual amount of energy used in the production function, once the effects of the implemented policy σ are taken into account; and $k = \frac{K}{L}$, the capital/labor ratio. Assuming an explicit Cobb-Douglas cost function with constant returns to scale, so that the weights $a + b = 1$, we have:

$$C(p_k, p_E) = A p_k^a p_E^b Q \tag{24}$$

Where *A* is total factor productivity, p_k is the price of non-energy inputs and p_E is the price of energy, including the application of policy σ. From Shephard Lemma we know that the factor demand for the energy input is given by the derivative of the cost function with respect to the price of energy $\frac{\partial C}{\partial p_E}$, namely:

$$E = \frac{b}{p_E} A p_k^a p_E^b Q \tag{25}$$

Having set $p_Q = 1$ in the first section of the model, and supposing that $p_Q = p_k^a p_E^b = 1$, we can rearrange (25) to obtain:

$$\frac{E}{Q} = \frac{b}{p_E} A \tag{26}$$

In order to obtain an equation that we can estimate empirically, we can express equation (25) in its log linear form, taking into account that $E \equiv \theta(1-\sigma)$ and $p_Q = 1$:

$$\ln\left(\frac{\theta}{Q}\right) = \beta_1 + \beta_2 \ln\sigma + \beta_3 \ln Trade + \beta_4 Trend + \beta_5 \ln p_\theta + \varepsilon \tag{27}$$

where p_θ is the real price of energy and $\beta_4 < 0$. As it is standard in the empirical literature (Demania et al. 2003; Fredriksson et al., 2004) we proxy the determinants of *A* as openness to international trade and technological progress, represented by a linear trend.

3. Empirics

3.1. Dependent variables. In order to bring the theory presented above to the data, we need proxies of the theoretical variables for energy policy stringency σ and for energy

intensity θ/Q, the policy target; these are the two dependent variables to be estimated simultaneously in the empirical analysis. Botta and Kozluk (2014) have recently proposed two indexes for environmental policy stringency that overcome the shortcomings of the proxies used in the literature so far and discussed in section 1. Their advantages are twofold: first, they constitute direct assessments of the stringency of the main types of environmental and energy policies that the various countries are enacting; second, these indexes provide a fairly comprehensive dataset, because they cover most OECD countries for the 1990-2012 time interval. They are[4]: 1) *meps*, which measures the stringency of "market-based" policies, i.e., policies that have a direct impact on the price system. This index varies between 0 and 6 and evaluates the stringency of three main market based policies: feed in tariffs, trading schemes and Pigouvian taxes. Within the index, each of these policies receives an equal weight (0.33). 2) *nmeps*, which proxies the stringency of non-market-based policies, namely emission limits and subsidies for R&D, each one entering with a 0.5 weight in the index; also this index increases from 0 to 6. Figure 1 and 2 illustrate the evolution of these indexes between countries (figure 1, means over periods) and over time (figure 2, means over countries) for the sample of countries for which we can assemble a complete data set. Our sample, spanning over the time interval 1995-2012, includes the following countries: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Poland, Portugal, Slovak Republic, Spain, Sweden, United Kingdom.

[Figure 1 about here]

As the figures show, the scores that evaluate the stringency of non-market based instruments are higher than those of market based ones in all countries. Spain, France, Denmark, Austria, Sweden reach the highest values for the index of market based instruments, whereas Finland, Denmark, Japan, Austria, Germany and Sweden do the same for non-market based instruments. The two indicators however appear rather

[4] Appendix 1 explains in greater detail the composition and construction of these indexes.

correlated to each other (correlation coefficient equals 0.43) suggesting that certain countries tend to be overall more rigorous in environmental policy than others.

Looking at the means over countries of the same indicators, it appears that, predictably, the 2008 crisis affected the stringency of market based indicators more than non-market based ones. Whatever their efficiency as policy instruments (to be evaluated in this paper), non-market based policies seem to be more resilient to economic fluctuations than their marked based counterparts.

[Figure 2 about here]

The policy target that we consider is instead quite standard in the literature and it is a close proxy for the theoretical variable θ/Q, namely the energy intensity of the industry, defined as final industry energy consumption in physical quantities (*Ktoe*) over real GDP, expressed in 2010 euro and labelled *EI* [5] (Fisher-Vanden et al., 2016). Figures 3 respectively reveal the variation across countries (means over periods) and over time (means across countries) of this indicator. The considerable cross country and time wise variation of this indicator confirms its appropriateness as benchmark for the environmental impact of production.

[Figure 3 about here]

The correlation between the overall measure of energy intensity and each indicator of policy stringency is always negative, and higher for the market based index (-0.56) than for the non-market based one (-0.30).

3.2. Explanatory variables for policy stringency. Starting with the equations that explain the market and non-market stringency of environmental policies, we consider two sets of explanatory variables: political variables, as specified in the first section of the theoretical model; and economic and energy controls, to validate some fundamental hypotheses of the model.

[4] Data on energy consumption comes from International Energy Agency and data on industrial output from OECD (Stan Database).

Among the political variables that may affect politicians' arbitrage between the conflicting interests of consumers and producers in environmental policy, the first to be proxied are the costs of lobbying λ. In this case we have followed the literature (Fredriksson, 1997; Cadoret and Padovano, 2016), which usually uses the value added in the manufacturing industry (variable *Industry_VA*)[6]. The motivation for this choice is that the greater the value added of an industry, the higher are the producers' incentives to overcome the costs of getting organized as a lobby in order to defend such a value added. Hence λ and *Industry_VA* should be closely and negatively correlated. According to Proposition 4, the expected sign on this proxy in the equations explaining policy stringency is negative.

Next, the parameter γ, which measures the country's institutional accountability to the interests of voters, is captured by the World Bank's indicator of regulatory quality *rq*, which assess to what extent the institutions of a country ensure that legislated policies get actually implemented. In the arbitrage model of section 2, politicians may underweight consumers interests by limiting themselves to legislate, rather than actually implement environmental policies. Hence, higher scores of regulatory quality correspond to a lower slack between legislated and implemented policies, i.e., more stringent energy and environmental policies, as stated in Proposition 3. This also implies that *rq* indirectly measures the weight that politicians attribute a larger weight to voters' demands.

Following Fredriksson et al. (2004) we represent a_1, the government sensitivity to the interests of producers, through the variable *cc*, the World Bank's indicator for control of corruption. Larger values of this indicator reflect a greater corruptibility (i.e., lobbying accountability) of the government, which reflects a greater attention to the demands of

[6] As an alternative specification, we have also proxied λ using the energy intensity of alternative energy types (*EI_oil, EI_gas, EI_coal, EI_elec*). The idea is that the more important is energy as an input in the productive process, the more producers will react negatively to environmental measures that could increase their costs and reduce their competitiveness. They will therefore lobby harder against such measures. The results obtained with these alternative indicators do not qualitatively change with respect to the specification using the industry value added. We have preferred the latter specification because it is more parsimonious and it is less similar to the policy target variable *EI*. Nevertheless, these alternative estimates are available upon request.

producers/lobbysts with respect to those of consumers/voters. According to proposition 1, the expected sign on this variable is negative.

Conversely, a battery of indicators is used to capture government sensitivity to voters' demands in the domain of environmental issues, the theoretical variable a_2. The first refers to the ideology of government. According to the literature, left-wing governments should prefer more market regulation, also in the domain of the environment, which makes left wing governments more sensitive to the environmental interest of voters with respect to those of producers, whose interests should instead be better represented by right wing ones (Chang and Berdiev, 2011; Biressieloglu and Karaibrahimoglu, 2012)[7]. Our measure of ideology comes from the DPI and consists of a dummy, *left*, which discriminates between governments supported by a left-wing majority, and those that express a right-wing or a center ideology[8]. A second proxy is consumers' income per capita (variable *gdp*, measured at purchasing power parity and constant 2011 US$). According to the well-known Kutznets curve, voters' sensitivity towards environmental issues increases with their income per capita, especially beyond the minimum vale of the function. To verify this, we include the squared value of *gdp*, also to verify that the relationship between the dependent variable and per capita income is actually nonlinear (Arrow et al. 1995); the expected signs are negative on *gdp* and positive on its squared value. Finally, we consider a third direct measure of voters' sensitivity to the quality of the environment, their urbanization rate *urban.* Higher values of this variable imply that a larger share of the country's population will be exposed to the risks associated with poor environmental

[7] Neumeyer (2003) however points out that tougher environmental controls might negatively affect employment levels, thus creating a conflict among two typical concerns of left-wing parties. Left-wing governments should therefore be more likely to arbitrage and compromise between conflicting interests than right wing ones, for which maximization of productivity is ideologically paramount. We therefore leave the evaluation of the overall sign of the correlation to the empirical analysis.

[8] The DPI classifies governments as "right-wing" when they are supported by parties defined as conservative, Christian democratic, or right-wing; as "left-wing" when they are supported by parties defined as communist, socialist, social democratic, or left-wing; and as center, when the supporting parties advocate strengthening private enterprise in a social-liberal context. As there are very few center governments in our sample, we adopt a more parsimonious specification of the ideology variable and join the center and right wing governments into a single group. The results do not change qualitatively. Incidentally, the DPI considers green and environmentalist parties as left-wing.

quality; they will therefore pay greater attention to what the government actually does in this domain. In a democratic setting, this should be reflected in higher values of a_2. According to proposition 2, the expected signs on these three proxies are positive.

Coming to the controls, we include two economic determinants of environmental policy stringency because they allow to verify two fundamental hypotheses of the model of section 2, namely that economies are open and energy is traded freely across countries. Furthermore, these variables are often included in the empirical literature as controls (Fredriksson et al. 2004; Demania et al., 2003; Cadoret and Padovano, 2016). The first is *E_imports,* which measures the share of imported energy on the total energy use. Higher energy dependence from foreign sources pushes governments to implement energy saving measures, like the promotion of renewable energy sources, which should increase policy stringency σ. The second control is *trade*; specified as the ratio of total imports and exports over GDP, it captures the country's openness to international trade. The impact of this variable on policy stringency is ambiguous. On the one hand, greater openness can make industries more fearful of the higher costs and the loss of competitiveness that environmental policies engender, resulting in a negative correlation with the indicators of σ. On the other hand, greater openness raises productivity, which can make environmental-friendly productive processes less costly.

Finally, we control for the level of energy intensity in production, to account for the fact, illustrated in Figure 3, that different countries in the sample are characterized by different degrees of energy intensity. These differences may in turn affect the countries' needs to implement stringent environmental policies.

2.3. Explanatory variables for energy intensity. The proxies used to estimate equation (28) are, of course, the indicator of energy intensity *EI*, our proxy for the theoretical variable θ/Q; and the two indicators of environmental policy stringency σ, namely, *meps* and *nmeps*. We consider *meps* and *nmeps* together, to assess which type of policies is more effective at reducing energy intensity. To control for the real price of energy p_θ we adopt as a proxy the real price of oil *p-oil,* measured as the nominal price index of oil price at the industrial level, normalized by the deflator of gross output. Again, we include in the

specification the variable *trade*; greater openness to international trade should negatively affect the use of energy, through the productivity growth that exposure to international competition engenders. The linear *trend* accounts for the impact that changes in total factor productivity may have on the use of energy in production.

Table 1 summarizes the description of the variables used in the analysis and specifies their sources, while table 2 reports the descriptive statistics.

[Table 1 and 2 about here]

3. Estimates

4.1. Choice of estimators and model specification. In order to jointly test the determinants of the stringency of the environmental policy and its efficiency in reaching its objective as the political arbitrage requires we must resort to a system of three equations, where *EI*, *nmeps* and *meps* are in turn the endogenous variable. Moreover, the theory clearly identifies a problem of endogeneity between the stringency of the environmental policy and energy intensity, as they both appear as the explanatory variable of the other. To solve this endogeneity problem, we estimate each equation of the system by an IV_2SLS method. In the equations for *meps* and *nmeps*, where the variable *EI* is endogeneous, we use the lagged value of *EI* as instrument, checking the validity of the instrument with the first stage estimation. Similarly, in the equation explaining energy intensity the variables *meps* and *nmeps* are endogeneous, and there too we resort to their lagged variables, checking the validity of instrument through the Cragg Donald Wald Statistic. The system of simultaneous equations is specified as follows:

$$\ln meps_{it} = \alpha_{1,i} + \beta_{1,0t} + \beta_{1,1}\ln gdp_{i,t} + \beta_{1,2}(\ln gdp_{it})^2 + \beta_{1,3} urban_{it} + \beta_{1,4} left_{it} + \beta_{1,5} rq_{1t} + \\ + \beta_{1,6} Industry\_VA_{it} + \beta_{1,7} cc_{it} + \beta_{1,8} trade_{it} + \beta_{1,9}\ln EI_{it} + \beta_{1,10} E\_imports_{it} + \varepsilon_{1it} \quad (28.1)$$

$$ln\, nmeps_{it} = \alpha_{2,i} + \beta_{2,0t} + \beta_{2,1}\ln gdp_{i,t} + \beta_{2,2}(\ln gdp_{it})^2 + \beta_{2,3} urban_{it} + \beta_{2,4} left_{it} + \\ \beta_{2,5} rq_{1t} + + \beta_{2,6} Industry\_VA_{it} + \beta_{2,7} cc_{it} + \beta_{2,8} trade_{it} + \beta_{2,9}\ln EI_{it} + \beta_{2,10} E\_imports_{it} + \varepsilon_{2it} \quad (28.2)$$

$$\ln EI_{it} = \alpha_{3,i} + \beta_{3,2}\ln meps_{it} + \beta_{3,3}\ln nmeps_{it} + \beta_{3,4} trend_{it} + \beta_{3,5}\ln p\_oil_{it} + +\beta_{3,5} trade_{it} + +\varepsilon_{3it} \quad (28.3)$$

α_{1i}, α_{2i} and α_{3i} are the country fixed effects and $\beta_{10,t}$ and $\beta_{20,t}$ are year fixed effects. For the variables in logs, the coefficients can be interpreted as elasticities; the exceptions are the variables expressed in percentage terms (namely, *trade*, *urban* and *e_imports*), which we interpret as semi-elasticities, and the dummy variables *rq*, *cc* and *left*. Finally, ε_{1it} , ε_{2it} and ε_{3it} are the disturbance terms.

4.2. Results. Table 3 and table 4 present the IV-2SLS and the Within estimates of the system of equations (28)

[Table 3 and 4 about here]

The results reported in table 3 (equation 28.1 and 28.2) show that different factors drive the stringencies of the market and the non-market based policies. Regardless of the estimation technique adopted, the data always lend support to the nonlinear relationship posited by the environmental Kuznets curve; in particular, as all countries in the sample are on average over the time interval beyond the minimum conversion point estimated at 9.2, in all of them an increase of per capita income results in a demand of greater stringency in the implementation of energy and environmental policies. This especially applies for the market based type, i.e., those that consumers perceive more directly: the estimated coefficents on *meps* are generally higher than those for *nmeps*. The positive coefficients on the variable *urban* corroborate this result, which is positive and highly significant in all the models explaining the stringency of market based policies; conversely, the coefficient on *urban* has the correct sign but it is never significant in the equations explaining non marked based policies. Conversely, the fact that the government has a left wing ideology seems to have an effect only on non-market based policies, which then seem to be more strictly implemented. A possible explanation is that governments have superior information than voters and therefore, moved by their ideology, adopt also environmental policies that voters do not necessarily demand. All in all, the combination of these results confirms Proposition 2.

Furthermore, better quality of regulation is associated with greater market based policies stringency, as Proposition 3 states; this result, however, does not extend to non market based policies.

As for the prediction that $\frac{d\sigma}{da_1} < 0$, the estimated coefficients on the regressor *cc* (our proxy for a_1) confirm that, when the government is more sensitive to lobbying, then whichever policy, be it market or non-market based, is applied in a less stringent manner. This is in line with the interpretation of the findings on the variables about voters' demands, which suggest that voters have higher information costs than the other two agents of the political model, namely the lobby of producers and the government itself. In any event, the data lend support also to Proposition 1.

Finally, the estimates seem to confirm also the prediction of Proposition 4; the negative coefficient on *industry_VA* reveals that, as producers face lower costs of lobbying, namely, when the value added of industries is higher, governments appear to give more weight to their demands with respect to those of consumers.

As for the control variables, *trade* and *e_imports* are never significant in the equations for the stringency of non-market based policy instruments; they are, instead, and with a positive semi-elasticity in the equation for the market based instruments. In the case of *trade* this result suggests that the greater competitiveness that international trade engenders pushes producers to make more environmental-friendly investments and, consequently, to demand greater respect of environmental regulation. In the case of *e_imports*, instead, greater dependency from foreign energy sources leads governments to implement energy saving measures, which should increase policy stringency. The negative coefficients on the level of energy intensity, highly significant in all models, point out that economies that use larger quantities of energy per unit of output tend to resist the implementation of energy saving policies.

Coming now to the estimates of the determinants of energy intensity, reported in table 4 (equation 28.3), as expected both market and non-market based indexes of environmental policy stringency have a negative impact on industry energy intensity; both policies are effective at reducing the use of energy in productive activities, but the

non-market based ones seem to have the greater impact on *EI*; in the within-estimator models, the semi-elasticity for *nmeps* is twice as large than that of *meps*, whereas for the IV-2SLS estimates the ratio goes up to 3:1. Interestingly, the greater positive influence that individual voters exert on the stringency of market-based policies raises their absolute scores relative to non-market based ones; in a situation of diminishing marginal returns, this implies that the marginal effect of an increase of the stringency of non-market based ones on energy intensity is larger.

Finally, in both the IV-2SLS and the within estimator models, increases in the price of oil have the expected substitution effect on energy intensity and so does the *trend*, which controls for technological progress. The variable *trade* has a negative coefficient, confirming that greater openness to international trade increases productivity through greater exposure to international trade; this eventually reduces the use of energy per unit of output.

All estimated models, including country and time fixed effects, explain a very large share of the variation of the endogenous variables.

5. Conclusion

The empirical analysis has found evidence that governments do arbitrage between the conflicting interests of consumers/voters and of producers organized in special interest groups when they have to decide and implement environmental policies. The estimated coefficients on the proxies for the weights that governments associate to the demands of producers and consumers have consistently the opposite signs. To the extent that these policies prove effective at reducing the energy intensity of productive processes, they increase actual costs and reduce (at least in the short run) the competitiveness of firms; this generates an optimal level of stringency in the implementation of legislative acts aimed at protecting the environment, precisely to balance at the margin the benefits and costs of environmental policy. These policies may thus be characterized by a far reaching legislation but by a rather ineffective implementation.

Holding economic and energy controls constant, the political factors that can tilt the political arbitrage in favor of unorganized voters are their degree of urbanization, which increases the share of the population similarly affected by the same environmental negative externalities, voters per capita income, which reduces the marginal utility of an additional unit of income but raises that of a better environment, and the general quality of country's governance system, which raises the likelihood that voters' demands be reflected in government decisions. Conversely, a higher value added in the industry, as a proxy of the opportunity costs for firms to get organized as a lobby, and a greater corruptibility of government increase the possibility that industries obtain less stringent environmental policies.

Finally, both market and non-market based indexes of environmental policy appear to be effective at reducing industry energy intensity in production but, for any equally scored level of stringency, the analyses reveal that non-market based ones appear to have a much greater impact on *EI*.

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EXPLORING THE DETERMINANTS AND CONSEQUENCES
OF THE STRINGENCY OF ENVIRONMENTAL POLICIES

Isabelle Cadoret - Fabio Padovano

TABLES AND FIGURES

Figure 1. Environmental policy stringency index, between countries

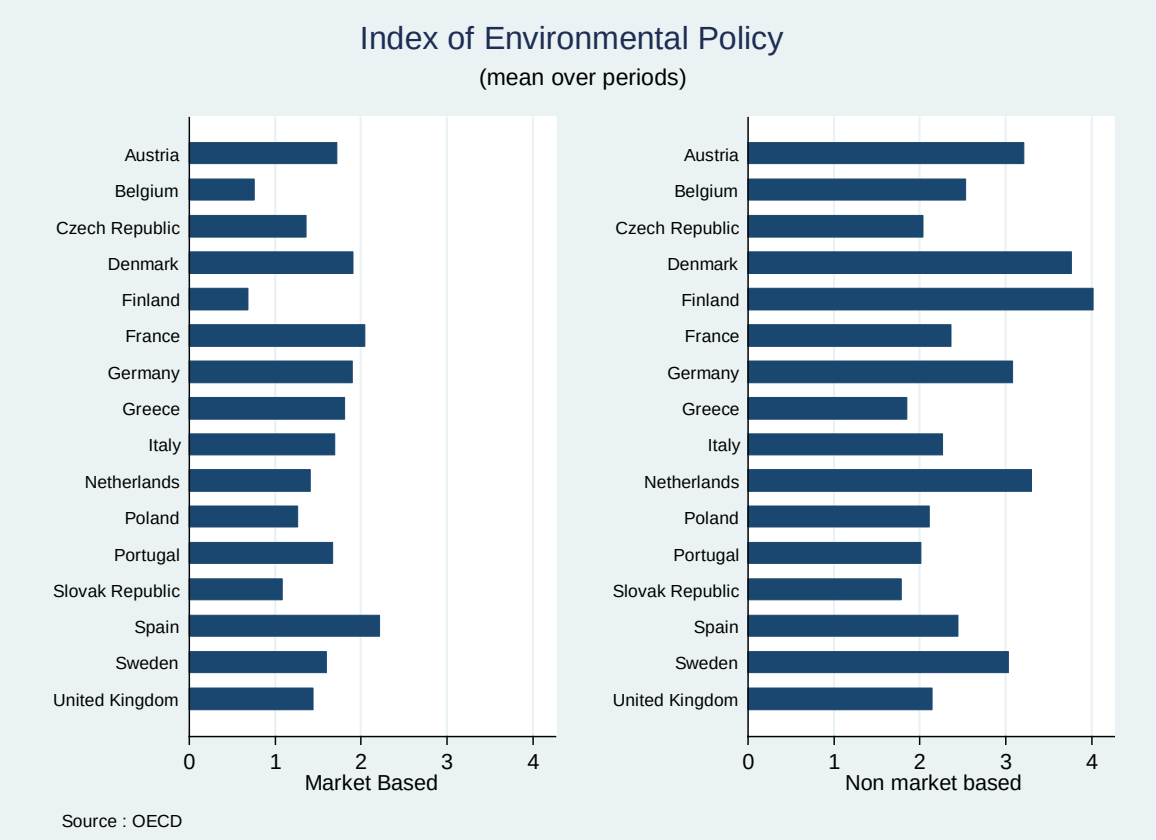

Figure 2. Evolution of environmental policy stringency index, over periods

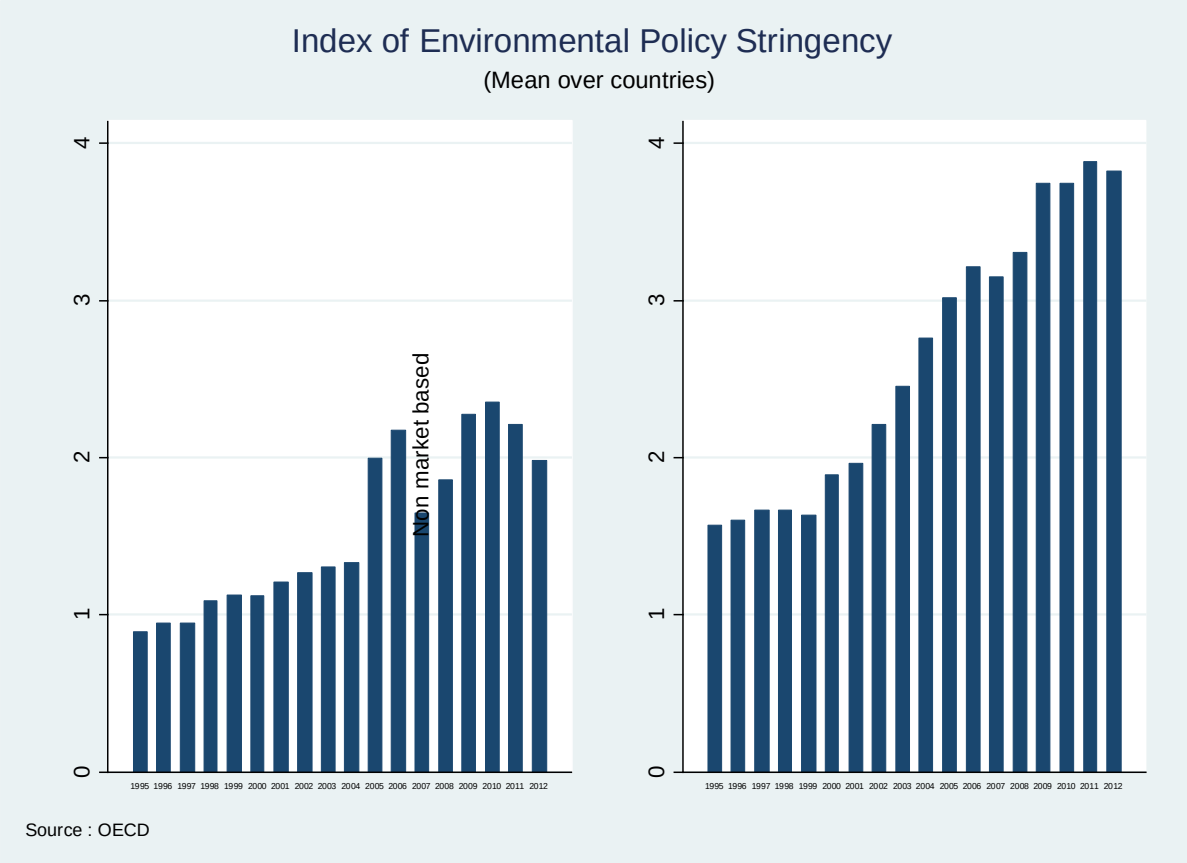

Figure 3. Energy intensity over time (means across countries) and across countries (means over periods).

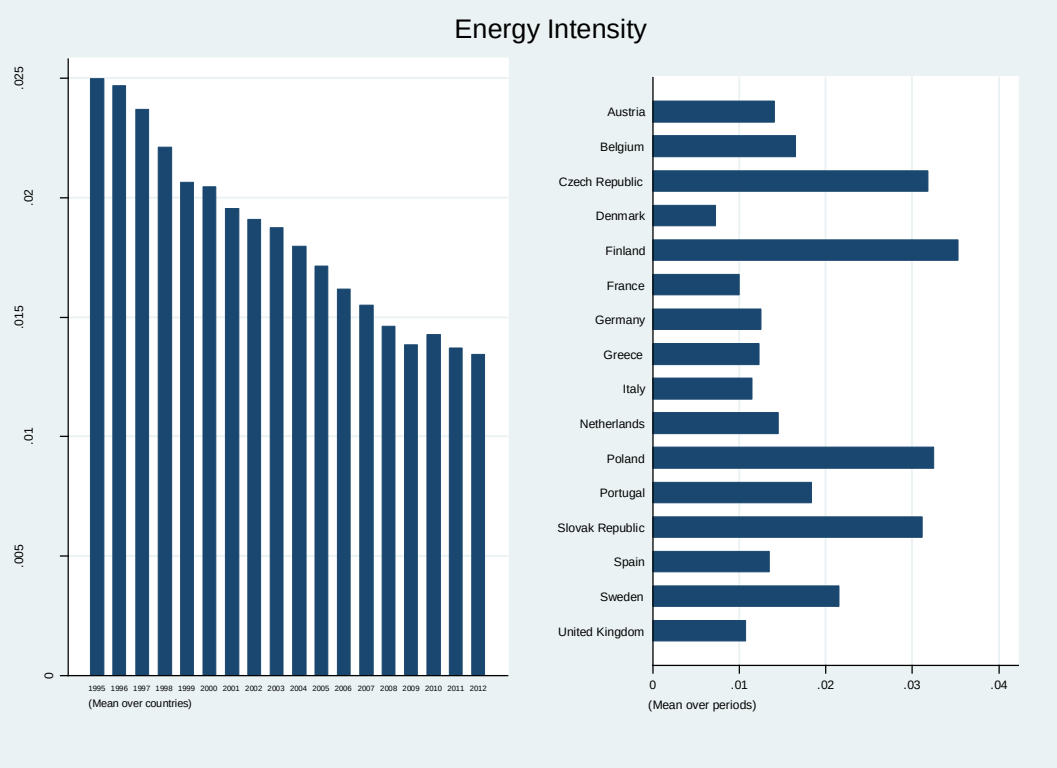

Table 1. Description of the variables

Variable	Description	Source
meps	market based stringency index	OECD
nmeps	non market based stringency index	OECD
EI	industry energy intensity	IAE : energy consumption Kteoe, OECD 8 Stan industry database Gross output in volume
gdp	GDP per capita, PPP (constant 2011 international $)	World Bank, WDI database
Industry_VA	Industry, value added (% of GDP)	World Bank, WDI database
trade	trade (% of GDP)	World Bank, WDI database
urban	urban population (% of total)	World Bank, WDI database
e_imports	energy imports, net (% of energy use)	World Bank, WDI database
p_oil	nominal oil price index for industry divided by industry output deflator	IAE : Nominal price index, OECD : Production (Gross Output), deflator
cc	Control of corruption	World Bank, WGI database
rq	regulatory quality	World Bank, WGI database
left	dummy = 1 if governement is Left; 0 otherwise	World Bank - Database of Political Institutions

*(General government expenditure-Central government expenditure)/ General government expenditure

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ln meps	288	.2716651	.6133586	-1.098612	1.382119
ln nmeps	288	.857633	.4832767	-.2876821	1.704748
ln EI	288	-4.128116	.4967312	-5.252942	-2.797662
ln gdp	288	10.36082	.3012042	9.332582	10.76076
Industry_VA	288	28.30366	5.128944	15.57164	40.53205
trade	288	80.94941	32.10025	37.10788	179.1939
urban	288	74.55404	10.93939	51.109	97.732
e_imports	288	46.26129	32.3975	-65.69406	86.34024
ln p_oil	288	-.1650723	.2197946	-.7356392	.2768636
cc	288	1.423151	.7581384	-.0995601	2.58558
rq	288	1.299693	.3905069	.436307	2.076643
Left	288	.4791667	.5004354	0	1

Table 3. Estimates of the determinants of policy stringency

	Within	Within	IV_2SLS	IV_2SLS	within	within	IV_2SLS	IV_2SLS	IV_2SLS	IV_2SLS
	ln meps	ln meps	ln meps	ln meps	ln nmeps	ln nmeps	ln nmeps	ln nmeps	ln nmeps	ln nmeps
ln *gdp*	-10.98+	-11.56+	-10.87	-11.85+	-7.820+	-6.901+	-7.742+	-7.270+	-6.798	
	(-1.76)	(-1.86)	(-1.61)	(-1.76)	(-1.86)	(-1.73)	(-1.68)	(-1.66)	(-1.55)	
ln gdp^2	0.597+	0.626*	0.596+	0.643+	0.414+	0.365+	0.403+	0.373+	0.355	
	(1.90)	(2.00)	(1.77)	(1.91)	(1.95)	(1.82)	(1.75)	(1.70)	(1.62)	
urban	0.0575***	0.0610***	0.0611***	0.0653***	-0.0140		-0.0151+	-0.0132		
	(4.28)	(4.65)	(4.55)	(5.00)	(-1.54)		(-1.66)	(-1.48)		
left	-0.0456		-0.0473		0.0513+	0.0667**	0.0501+	0.0576*	0.0659**	0.0594*
	(-1.14)		(-1.25)		(1.91)	(2.62)	(1.95)	(2.30)	(2.69)	(2.44)
rq	0.355*	0.361*	0.376**	0.379**	0.00740		-0.0245			
	(2.40)	(2.44)	(2.66)	(2.67)	(0.07)		(-0.25)			
cc	-0.242+	-0.230+	-0.274*	-0.259*	-0.194*	-0.163*	-0.195*	-0.180*	-0.175*	-0.146+
	(-1.81)	(-1.73)	(-2.17)	(-2.05)	(-2.16)	(-2.03)	(-2.26)	(-2.32)	(-2.24)	(-1.92)
Industry_VA	-0.0840***	-0.0795***	-0.0905***	-0.0855***	-0.0126		-0.0105			
	(-4.27)	(-4.12)	(-4.85)	(-4.67)	(-0.95)		(-0.82)			
trade	0.0129***	0.0127***	0.0141***	0.0138***	0.000330		0.000344			
	(4.22)	(4.16)	(4.81)	(4.71)	(0.16)		(0.17)			
e_imports	0.00693***	0.00666**	0.00744***	0.00714***	0.000924		0.000945			
	(3.37)	(3.25)	(3.69)	(3.55)	(0.67)		(0.69)			
ln *EI*	-0.719**	-0.749**	-0.819**	-0.882**	-0.678***	-0.733***	-0.844***	-0.881***	-0.897***	-0.852***
	(-3.14)	(-3.29)	(-3.02)	(-3.28)	(-4.39)	(-5.07)	(-4.57)	(-5.18)	(-5.26)	(-6.85)
Year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	288	288	272	272	288	288	272	272	272	272
R^2	0.858	0.857	0.864	0.863	0.970	0.970	0.971	0.971	0.971	0.971
Return point Ln *gdp*				9.20 [8.16;10;24]						
First Stage P_Value			0.000	0.000			0.000	0.000	0.000	0.000

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

Table 4. Estimates of the determinants of energy intensity

	Within	IV_2SLS
	ln *EI*	ln *EI*
ln *meps*	-0.0790***	-0.0778**
	(-4.35)	(-3.24)
ln *nmeps*	-0.160***	-0.221***
	(-5.46)	(-4.90)
ln *p_oil*	-0.335***	-0.318***
	(-4.54)	(-4.50)
trade	-0.00424***	-0.00356***
	(-5.17)	(-4.56)
trend	-0.156***	-0.236***
	(-20.00)	(-56.61)
Year fixed effect	yes	yes
Country fixed effect	yes	yes
N	288	272
R^2	0.99	0.97
Cragg-Donald Wald F statistic		56.962

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

Appendix 1. Measures of policy stringency

The measures of policy stringency adopted in the empirical analysis are drawn from Botta and Kozluk (2014). They provide the most comprehensive set of quantitative indicators of the stringency of environmental policies, for most of the OECD countries over the 1990-2012 period. Botta and Kozluk (2014, p. 6) define policy stringency as the "cost that the policy imposes on polluting or on other environmental harmful activities". The correlations obtained with the other, more limited indexes introduced before in the literature are generally high and significant, showing that coverage is the most important advantage of the new indicators. In particular, we use two indicators that are specific for the energy sector, because our policy target variable is energy intensity in production. They are *meps* (market-based energy policy stringency) and *nmeps* (nonmarket-based energy policy stringency). The policy instruments that are being evaluated and scored are:

1. For *meps*:
   1.1. Taxes on CO_2 emissions, NO_x emissions and SO_x emissions;
   1.2. Trading schemes of CO2 emissions, of renewable energy certificates and of energy efficiency certificates;
   1.3. Feed-In-Tariffs for wind energy and solar energy.
2. For *nmeps*:
   2.1. Emission limit standards for CO_2, NO_x and SO_x;
   2.2. Government R&D expenditures on renewable energies.

To each component of the *meps* index an equal weight of 0.33 is applied; those of *nmeps* receive an equal weight of 0,5.

For each of the components the scores applied vary from 0 to 6. The scoring procedure is based on the comparison of the stringency of each policy instrument against the distribution of values for the same type of policy instrument across countries and time. Hence, they reflect the relative stringency of the policy instrument, in other words, the country's position on each instrument relative to the other countries and years. More information about the details of these indexes can be obtained from Botta and Kozluk (2014).