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Francesco Vona, Francesco Nicolli

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Francesco Vona
OFCE Sciences-Po and SKEMA Business School

Francesco Nicolli
CERIS/CNR and University of Ferrara

ofce

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Abstract

We analyse the impact of market liberalisation on renewable energy policies in OECD countries. To this end, we first develop an aggregated indicator of renewable energy policies using principal components analysis and then examine its determinants through panel data techniques. Our results are consistent with the predictions of political-economy models of environmental policies, as brown lobbying, proxied by entry barriers in the energy sector, and citizens' preferences have the expected effects on policy. Brown lobbying has a negative effect on the policy indicator, even when accounting for endogeneity in its effects in a dynamic panel specification and using different policy indicators. Reducing income inequality, the ratification of the Kyoto protocol and stronger green parties all positively affect the approval of more ambitious policies but with less robust results.

JEL Codes : Q42, Q48, D72, O38.

Keywords: Renewable Energy Policy, Energy Market Liberalisation, Political Economy.

1. Introduction

Environmental problems typically call for government interventions to address the market failures associated with pollution and investment in green technologies. The current consensus is that an appropriate combination of policies should be developed to stimulate the search for new solutions, rather than mere compliance with technological standards or fixed pollution targets. In this vein, recent policy strategy combines interventions to correct pollution externalities (e.g., carbon taxes) with policies to stimulate learning (e.g., renewable energy production subsidies) and innovation (e.g., R&D subsidies). Such sophisticated policy instruments particularly characterise the field of renewable energy, which represents the most promising option to jointly mitigate greenhouse gas emissions and emerging oil scarcity.

The main data source to study Renewable Energy Policy (REP henceforth) is the rich dataset provided by the International Energy Agency, which contains time-varying information on several types of REPs for OECD countries. Thus far, this dataset has been employed to examine the impact of REPs on technology or investments in renewable energy (Johnstone et al., 2010; Popp et al., 2011) but has yet to be employed to study the determinants of the policy per se. Understanding the determinants of REPs is particularly important, as renewable energies, especially solar and biomass, are still not cost-competitive with traditional sources of electricity generation (IEA, 2003). More in generally, the identification of the institutional and political constraints that prevent the adoption of ambitious REPs is crucial to design appropriate strategy for a clean energy transition. The novelty of our paper is that it is the first to analyse the impacts of such institutional constraints, in particular that of energy market regulation, on REPs. Moreover, while existing studies primarily focus on cross-sectional analysis of environmental policy (an exception being Fredriksson et al., 2004), our paper analyses policy determinants in a dynamic setting where we can fully control for unobservable country characteristics.

The political-economy literature on the determinants of environmental policies (e.g., Fredriksson, 1997; Lopez and Mitra, 2000) represents the natural point of departure for our empirical investigations. In political-economy models, politicians maximise the probability of being re-elected by setting environmental policy to balance the interests of citizens and sector-specific lobbies, including that of environmental activists. The well-established result in both the empirical and theoretical literature is that the weights assigned to these (potentially conflicting) interests depend on the level of corruption, and this effect may be amplified or mitigated depending on other institutional factors (e.g., Fredriksson and Svensson, 2003; Damania et al., 2003). We show that for REPs, the degree of entry barriers and market regulation in the energy sector, our proxy for incumbents' lobbying power, undermines the approval of ambitious REPs. Together with the ratification of the Kyoto protocol in 1998, energy market liberalisation is the factor with the largest and most robust impact on REPs. A one standard deviation change in our regulation indicator (the PMR index developed by the OECD) explains more than 2/5 of a standard deviation in the REP index over a longer time span (1975-2005) and more than 3/5 in a shorter and more recent time span (1990-2005), where most of the policy variation is concentrated. In turn, the positive impact of reducing inequality with respect to per capita income implies that citizens' preferences for a clean environment are better captured using both the first and the second moment of the income distribution, which is consistent with models where the median voter decides on environmental policy (Magnani, 2000; Kempf and Rossignol, 2007).

[FIG.1 ABOUT HERE]

From an empirical perspective, the central problem concerns the construction of an aggregate measure of REPs. Absent a commonly accepted method for aggregating heterogeneous policies, the construction of a synthetic indicator involves a choice over which methodological disagreement might easily emerge. Figure 1 presents a visual snapshot of the degree of policy heterogeneity in the IEA dataset by detailing the types of policies applied in various countries. As is clear from the figure, policy diversification increased substantially over time, as previous were often remained in use together with new ones. This increasing diversification makes it exceedingly difficult to provide an aggregate measure of the effort delivered by each country in support of the adoption of renewable energy. Moreover, aggregation of heterogeneous policies through a single indicator is not immediate because the available policies are measured either as binary outcomes or on a continuous scale, e.g., feed-in tariffs. For these reasons and to mitigate concerns regarding the validity of the principal component analysis used to construct our preferred indicator, we conduct extensive robustness checks of our results using different aggregation methods.

The paper is organised as follows. The next section describes the testable predictions derived from political-economy models of environmental policy in greater detail. This section is followed by one presenting the principal component analysis used to extract synthetic information from our heterogeneous set of policies. In Section 4, we detail our empirical strategy and perform an econometric analysis of the determinants of the policy. The final section presents our conclusions.

2. Uncovering the link between energy market liberalisation and renewable energy policies

Policy plays a central role in fostering innovative responses to environmental problems. In the case of renewable energy, technological learning is especially important to reduce the cost of energy production from renewable sources relative to that of polluting energy sources. Thus, renewable energy policies are intrinsically related to innovation policies, both through learning and formal R&D. Recent contributions emphasise this connection through the concept of a 'double externality' on knowledge and pollution (Jaffe et al., 2005; Fisher and Newell, 2008; Acemoglu et al., 2012). From this perspective, a policy targeting an environmental externality alone is likely to reduce firms' competitiveness without fostering innovation, while combining it with a R&D or production subsidy could be a means of meeting competitiveness and sustainability targets alike.

However, a precise evaluation of the effect of renewable energy policies on innovation and diffusion remains primarily an empirical issue. The effect of the IEA policies considered in this paper has been addressed in three recent studies covering OECD countries for the period from the mid-1970s to the mid-2000s. In general, these policies seemed to have a strong effect on renewable energy technology with a remarkably stronger effect on high quality inventions (Nesta et al., 2012) and a weaker one on per-capita investments in renewable capacity (Popp et al., 2011). Moreover, the various policy instruments have displayed heterogeneous effects across different technologies (Johnstone et al., 2010).

In light of these findings, it may prove useful to take a step back to examine the political-economy determinants of renewable energy policy. Existing research builds on the Grossman and Helpman model (1994), where multiple lobbies attempt to capture sector-specific policies by offering perspective bribes to politicians (Fredriksson, 1997; Aidt, 1998). As in the case of many environmental policies, the incumbent firms in the energy sector prefer less stringent policies, while environmentalists support the approval of ambitious ones. The basic model's prediction is that the extent to which the chosen level of environmental tax differs from the optimal Pigouvian tax depends on the lobbies' capacity to influence policy. This, in turn, depends on the weights the politician assigns to social welfare and citizens' preferences on the one hand and to the lobbies' bribes on the other. The weight assigned to brown lobby bribes has generally been interpreted as being dependent on the level of corruption, as confirmed by substantial empirical research[1]. Regarding the green lobby, recent works by Fredriksson et al. (2007) and List and Sturm (2004) show that it can have substantial influence on the approval of ambitious environmental policies.

In the case of energy, first note that the high polluting sectors are expected to have a greater incentive to form lobbies to influence environmental policies (Damania and Fredriksson, 2000). Fredriksson et al. (2004) provide empirical support for this prediction, showing that the effect of corruption, i.e., as a proxy for lobbying power, on energy intensity is greater in more energy-intensive sectors. More closely related to REP, case study evidence shows that the incumbent firms tend to oppose the approval of ambitious renewable energy policies (e.g., Neuhoff, 2005; Jacobsson and Bergek, 2004; Nilsson et al., 2004; Lauber and Mez, 2004). As REP primarily entails subsidies and incentives, the opposition of existing lobbies is, in this case, related to technological comparative advantages rather than to the costs of complying with regulations. Whereas the production of energy from renewable sources is decentralised in small-medium sized units, the competences of incumbents are tied to large-scale plants using coal, nuclear or gas as the primary energy inputs. The high sunk

1. Fredriksson and Svensson (2003) extend the Helpman and Grossman (1994) and Fredriksson (1997) models to include also political instability. Their model shows that the effect of corruption decreases when political instability increases, as incumbent officeholders can less credibly commit to a policy. This prediction is confirmed in their empirical analysis of the stringency of environmental regulation in agriculture. Other aspects of the impact of corruption on environmental policies are considered in variants of the same models and tested empirically by Fredriksson et al. (2004), who consider multiple lobbies and their organizational costs, Fredriksson and Vollebergh (2009), who show that the effect of corruption is lower in federal systems, and Damania et al. (2003), where the effect of corruption greatly depends on the degree of trade openness.

costs of large-scale generation further exacerbate the technological lock-in of incumbents and should fuel their political opposition to the distributed generation paradigm involving the diffuse use of renewable energy. As a result, we expect that the recent liberalisation of energy markets, and in particular opening access to the grid for new producers, should have been accompanied by a reduction in the incumbents' capacity to influence energy policies, and hence favouring the adoption of ambitious REPs.

Energy policies are also the result of citizens' preferences and their willingness to pay for a cleaner environment. As environmental quality is a normal good, wealthier households demand more stringent environmental policies– a prediction that is consistent with the empirical evidence at both the micro and macro levels[2]. The second moment of the income distribution also matters, as recent theoretical and empirical studies have shown[3]. The effect of inequality hinges on the fact that, given a level of per capita income, a lower level of inequality implies a richer median voter and therefore greater support for ambitious policies.

Whether the increasing willingness to pay for cleaner energy has been more important than the liberalisation process in explaining the rapid adoption of REPs remains an unresolved issue that we attempt to address in what follows.

3. An aggregated Indicator of Renewable Energy Policy

The dataset made available by the IEA contains detailed country fact sheets to construct dummy variables reflecting the adoption time of selected REPs for most OECD countries. A drawback of this dataset is that it provides information on the year of adoption but does not specify the degree of intensity of the policy adopted. We hence integrate this information using other data sources in all those cases for which policies measured on a continuous scale are available. To the best of our knowledge, this is possible for the following three policy instruments: public renewable R&D expenditures, feed-in tariff schemes and renewable energy certificates (see Table 1 for a full description of the policies). Information on the first is also available in the joint IEA-OECD dataset, whereas the main references for feed-in tariffs are two reports compiled by the IEA (2004) and Cerveny and Resch (1998). Our measure of the stringency of renewable energy certificates (RECs) is the variable constructed by Johnstone et al. (2010) and reflects the share of electricity that must be generated by renewables.

For renewable energy, both theory and empirical evidence provide strong justification for the use of diversified policy portfolio rather than of specific policy instrument. In particular, a diversified policy portfolio is the best way to target the multiple externalities associated with renewable energy (e.g. Fisher and Newell 2008, Acemoglu et al. 2012). Midttun and Gautesen (2007) show that the combination of RECs,

2. See: Arrow et al. (1995), Diekmann and Franzen (1999), Dasgupta et al. (2001), Esty and Porter (2005) and OECD (2008). At the micro level, several studies have also shown that wealthier and more educated households are generally more willing to pay higher prices for renewable energy (Roe et al. 2001, Wiser 2007) and voluntarily participate in clean energy programs (Rose et al. 2002, Kotchen and Moore 2007, Kotchen 2010).

3. See, e.g., Magnani (2000), Eriksson and Persson (2003), Kempf and Rossignol (2007), McAusland (2003), Magnani (2000) and Vona and Patriarca (2011).

feed-in and R&D subsidies is the best way to deal with technology at different level of maturity. Nesta et al. (2012) suggest that each policy is often targeted to a specific actor (i.e. RECS for large incumbents, feed-in for small plants, investment incentives for specialized suppliers of electric equipment) and combination of several policies are a better way to deal with uncertainty.

The construction of a synthetic policy indicator based on these specific REPs alone may be misleading for several reasons. First, some countries may be under-represented if they decide not to adopt feed-in tariffs or REC targets but instead rely on other instruments for which we have only binary information[4], i.e., tax credits, investment incentives, obligations, voluntary agreements, etc. (Table 1). Second, feed-in tariffs or RECs have been frequently adopted in recent years, and hence relying on them to characterise the long-term evolution of policy efforts could prove misleading[5]. Therefore, the complete exclusion of the other instruments would offer a rather incomplete picture of the overall policy effort both across countries and over time.

[TABLE 1 ABOUT HERE]

For these reasons, the appropriate policy indicator should include both the signalling effect of policy dummies and the stringency of continuous policies. Previous research on aggregate policy indicators attempts to address heterogeneous information in a variety of ways. Mazzanti and Zoboli (2009) weight policy signals to account for the cross-country differences in the intensity of the main policy instrument for which they have quantitative information, i.e., landfill taxes. Using survey data, Dasgupta et al. (2001) assign weights to each policy on a Likert scale, built by converting the responses provided to specific questions in the survey into numeric values. Also using survey-based data, Esty and Porter (2005) summarise several policy indicators using common factor analysis to collapse the substantial set of indicators into two main ones.

Given the lack of consensus on the appropriate way to aggregate heterogeneous policies, we follow Esty and Porter (2005) and propose an indicator based on principal component analysis (PCA henceforth), while the robustness section contains a sensitivity analysis conducted using alternative policy indicators derived from literature. PCA is interesting because of its ability to extract a small number of uncorrelated sub-indexes (called principal components) from a wide set of variables. The first principal component is the linear combination of the original variables that explains the greatest amount of the overall variance. With

4. An important example is Japan, which during the period analysed did not adopt any feed-in tariff schemes but adopted many other REPs, and had the largest energy RD&D budget of the OECD countries (approximately 3.4 billion dollars) in 2001. The same is true for Canada and Norway.
5. Especially for RECs, and in some cases also for feed-in tariff schemes, the adoption time is around the year 2000, when many European countries experimented with these instruments to meet the target set by Directive 2001/77/CE. As a result, an indicator based on this information alone can either present too many zeros or be composed of only a single variable, e.g., public R&D. Identifying the factor affecting the adoption time of these policies represents an interesting extension of our analysis, but is beyond the scope of this paper.

sequential application of PCA, it is possible to identify a second linear combination of the original variables that explains a greater share of the residual variance, and so on[6]. To construct aggregate indicators, the general rule of thumb is to use only those components that account for a sufficient amount of variance, i.e., generally those associated with eigenvalues greater than one.

In our case, we construct our preferred PCA indicator *(FACT_MAIN)* using the three available continuous policies (feed-in tariffs, RECs and public R&D), and six dummy variables for the other policy instruments. The analysis produces three relevant components that have been used to construct a single indicator taking the simple mean. Table 2 provides an in-depth summary of the main variables that 'load' each relevant component entering the indicator *FACT_MAIN*. This step is important to clearly interpret each principal component, as it is usually desirable for variables exhibiting greater similarity to be clustered together. Supporting our methodological choice, similar original policies are typically clustered together in the same component. For instance, the component with the greatest explanatory power (40%) is primarily a combination of market-based policies, while the second is a combination of quantity-based instruments. The last principal component in terms of explanatory power is strongly correlated with innovation policies (i.e., R&D intensity).

[TABLE 2 ABOUT HERE]

The evolution of *FACT_MAIN,* is depicted in Figure 2 for selected years. As expected, Scandinavian and, to a lesser extent, Central European countries are those with persistently higher policy support (see Appendix A for details on the country rankings for several policy indicators). The indicator displays a monotonically increasing pattern for nearly all countries, with the exception of Sweden and Greece, which experience a relative decline between 1985 and 1995. From figures 1 and 2, it also appears evident that the two main policy drivers of renewable energy occurred in the 1970s and especially from the mid-1990s on. The two oil crises of the 1970s stimulated policy responses in nearly all developed countries, whereas an abrupt halt in the expansion of these policies occurred when oil prices began to decline in the early 1980s. A second wave of REP was implemented in the 1990s in response to increasing concerns related to climate change mitigation. With respect to the policy adopted, certain cross-country regularities clearly emerge. A first phase focusing on RD&D (Research, Demonstration and Development) subsidies and grants is followed by a second phase characterised by the greater use of market-based instruments such as taxes, incentives, feed-in tariffs, and more recently, tradable permits and RECs (see fig. 1).

[FIGURE 2 ABOUT HERE]

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6. Principal components are generally normalized and have mean equal to zero and variance equal to one, which provides a better interpretation of the resulting values, especially. The components obtained in the analysis are generally rotated to produce more readily interpretable results. The tables presented below refer to an orthogonal (VERIMAX) rotation, but an oblique rotation, not presented in the paper, yields similar results.

4. Econometric Analysis of the Determinants of Renewable Energy Policy

4.1 Econometric Strategy

We use standard panel data techniques to estimate the impact of our variables of interest on the policy indicators. More precisely:

$POLICY_{it} = \beta X_{it-1} + t + \mu_i + \varepsilon_{it,}$ *eq.1,*

where **Xs** are our time-varying covariates lagged one year to mitigate problems associated with reverse causation, t is a time trend, μ_i a country effect and ε_{it} is a purely random effect. As usual in cross-country panel data regressions, the critical choice is between Random Effects (RE) and Fixed Effects (FE) models. The first is consistent only if country-specific effects are not correlated with the covariates, which is unlikely to occur when there are omitted variables. The FE model, however, tends to eliminate all cross-country variability, thereby substantially reducing efficiency. The Hausman test allows the researcher to select between the two models. Specifically, if the null hypothesis is not rejected, the two models deliver similar results and the RE model is also consistent. Particularly in cross-country regressions, a standard strategy for mitigating this trade-off consists of comparing an FE model with an RE model that includes fixed effects for homogeneous geographical areas, e.g., Scandinavian countries (e.g., Caselli and Coleman, 2001). This is the approach followed in this paper.

Furthermore, the relationship between energy liberalisation and environmental policies may be plagued by reverse causality and time-varying omitted variable bias. With respect to the former, a self-reinforcing feedback loop can emerge because reducing barriers to entry not only decreases the lobbying power of incumbents but also strengthens new green players who will support more ambitious policies later on. Furthermore, technological improvements may represent an indirect source of endogeneity, as suggested in the seminal paper by Downing and White (1986). Omitted variable bias can be an issue here, as we cannot account for changes in the factors that affect lobbying efforts such as coordination costs (Fredriksson et al., 2004). Moreover, lobbies can continue affecting energy policy if incumbents remain sufficiently strong after liberalisation. Overall, even if we control for time-invariant country effects, there may still be unobservable time-varying characteristics affecting both REP policies and the level of the PMR, such as a change in institutional and political factors.

We use a time-varying measure of corruption (CORR), taken from the Transparency Index (Transparency International, 1996)[7], as an instrument for the level of PMR. The notion that corruption dampers the liberalisation process is consistent with previous use of corruption as a proxy for the lobbies' capacity to

7. As in Friedrikson and Vollebergh (2009), the existing data have been interpolated using the Hodrick-Prescott filter. Data for corruption is only available from 1980, and we elected to not interpolate backward.

affect environmental policy (e.g., Fredriksson and Svensson, 2003). A relatively corrupted country is more likely either to conduct liberalisation in the interest of private lobbies rather than that of its citizens, or not to liberalize energy markets at all. For instance, depending on the quality of political institutions, new firms co-owned by municipalities can either improve the match between citizens' interests and public policies, as is the case for the Scandinavian countries, or simply be aligned with the local vested interests, as in Italy.
While from a statistical point of view corruption has all the desirable properties (see below), we recognize that it is not fully justifiable from a theoretical point of view. In particular, it is not straightforward why corruption should affect liberalisation but not the REP index. A weaker claim is that corruption hampers the implementation of reforms that hit vested interests, especially when the damage is expected to be high and highly concentrated as for the case of liberalisation. In fact, the harmful effect of liberalisation on, often state-owned, monopolies is much larger than the one of renewable energy policies. Put it differently, the negative effect of liberalisation on vested interests through the approval of more ambitious REPs is a second-order effect that, we claim, was not expected by the brown lobby when the liberalisation process started.

To reinforce our causal interpretation of the effect of PMR on REP, we use other political and institutional factors that influence the regulatory process in the energy sector, but not REPs. Empirical evidence shows that left-wing governments are associated with greater regulation in the electricity and gas sectors (Chang and Berdiev, 2011), while market-oriented and right-wing governments favour privatisation and deregulation (Bortolotti et al., 2003; Potrafke, 2010). Moreover, Chang and Berdiev (2012) and Pitlik (2007) show that more homogeneous governments face fewer political obstacles and, consequently, are more willing to deregulate, while the political fragmentation typical of heterogeneous governments may hamper the approval of long-term policy reforms. We follow these works and include as additional instruments the share of right-wing deputies in parliament[8] and the Herfindhal index of government, a proxy for government fragmentation calculated as the sum of the squared seat shares of all parties in government. Data are obtained from the Comparative Political Data Set I and the World Bank Database on Political Institutions, respectively.

With these caveats in mind, our IV estimates should be seen still as a way, although a second best one, to support a causal interpretation of the effect of PMR on REP rather than an ideal identification strategy.
Not only endogeneity may bring about a bias in the estimated effect of PMR, three issues should be discussed to elaborate on our empirical strategy. First, given the low variability over time that characterises the policy indicator during the 1970s and 1980s, we estimate the model in eq. 1 for a sub-sample covering the period 1990-2005. In this case, rather than using either an FE or RE estimator, we control for country effects using the pre-sample mean (PSM, henceforth) of the dependent variable as is standard in the literature

8. Note that, even if the share of right wing deputies would be the perfect instrument from a theoretical point of view, it has a poor first-stage performance in term of explanatory power of PMR. Therefore, in the trade-off between a good instrument from a statistical point of view and a good theoretical instrument, we decide to include both in our IV estimates.

(e.g., Blundell et al., 1995). Secondly, we always compute cluster-robust standard errors to control for heteroskedasticity in the residuals. Third, it is reasonable to assume that past decisions to implement REPs affect the present behaviour of national policy makers. For this reason, we check the robustness of our results using the bias-corrected least square dummy variable (LSDV) model developed in Nickell (1981) and Kiviet (1995, 1999), which allow us to include both dynamics and unobserved individual heterogeneity in our analytical framework. This estimator generally outperforms IV and GMM estimators in contexts, such as the present one, in which N is small and T is long (Judson and Owen, 1999).

4.2 Explanatory Variables

Section 2 identifies three main determinants of REP: GDP per capita (GDP_pc), income inequality (INEQ) and market regulation. For the latter two, we use standard data sources (see appendix). For the former, we use the index of Product Market Regulation (PMR) in the electricity sector provided by the OECD. This index is also constructed using common factor analysis by combining objective sector-specific policies and regulations from different data sources (see Conway et al., 2005 for details). The PMR index for electricity aggregates three sub-indexes ranging from 0 to 6 (maximum anti-competitive regulation). The first is ownership, which assumes five values: private, mostly private, mixed, mostly public and public. The second is an index of entry barriers that employs information on third party access to the grid (regulated, negotiated, no access) and minimum consumer size to freely choose suppliers (from 'no threshold' to 'no choice'). The third component is vertical integration, ranging from unbundling to full integration. Access to each sub-index allows for the evaluation of the importance of each particular aspect of the liberalisation process. The PMR indicator has three main advantages over alternative indexes of market regulation: reliability[9], the fact that it is time-varying and based on objective measures of regulation.

Figure 3 displays the evolution of PMR for selected countries. As is well known, a widespread reduction in PMR is observed beginning in the early 1990s in parallel with a general process of deregulation in many other markets. Despite this common trend, differences in the time of adoption (the Scandinavian countries and the UK take the lead) and the final values of the index are quite remarkable.

To account for the influence of international factors on countries' policies, we include a dummy equal to 1 for the year in which the Kyoto protocol was first ratified (in 1998). Previous studies show that the Kyoto dummy has a strong effect on investment in renewable capacity and technology diffusion (Popp et al., 2011; Johnstone et al., 2010). Here, we claim that its effect should be partially mediated by an inducement effect on REP at the national level. Energy prices (ENERGY) are also considered in the set of explanatory variables because consumers typically pay for REPs in terms of higher prices (e.g., in the case of feed-in

9. The cross-country rankings of the PMR indicator appear substantially unchanged when using different specifications of the weighting scheme (Conway and Nicoletti, 2006) and are in line with rankings derived from other indicators of market competition (Nicoletti and Pryor, 2006).

tariffs) or energy taxes are jointly decided with policies[10]. Moreover, especially in the 1970s, exogenous changes in oil prices represented the first impulse for REPs. Interestingly and consistent with previous findings (e.g., Pollitt, 2012), ENERGY and PMR are not negatively correlated in our sample, and hence the inclusion of both does not create problems of interpretation. A lack of correlation can also be observed between GINI and GDP_pc, likely because of the substantial homogeneity in the country sample. Finally, the share of green deputies in the parliament (GREEN) is a time-varying measure of the public's preferences for environmental quality and political voice for environmental issues, i.e., the green lobby. A time trend is also included to depurate from a common trend correlated with the policy.

The resulting dataset is a fairly balanced dynamic panel of OECD countries for the period from 1970 to 2005 (although data on PMR are available from 1975). Turkey and Mexico are excluded from the main regressions, as they are outliers in GDP_pc, while for the Slovak Republic and the Czech Republic, we only have data on income since 1989. Korea is also excluded due to missing data on INEQ. Finally, note that missing values for PMR, GREEN and ENERGY are particularly highly concentrated in the middle-income and transition countries. Table 3 presents the data sources and basic descriptive information for each variable.

[TABLE 3 ABOUT HERE]

[FIGURE 3 ABOUT HERE]

4.3 Main Results

In Table 4, we present the main results for our preferred indicator *FACT_MAIN*. Columns 1 - 5 report full sample estimates from the FE and RE models, while the last column presents results for the shorter 1990-2005 panel using the PSM estimator. Comparing the RE model augmented with area dummies and the FE model, the Hausman test rejects the null hypothesis that the RE model is also consistent, and thus the FE model should be considered as the baseline. However, the difference between the two models is generally negligible, especially concerning the statistical significance of the estimated coefficients.

The estimates from model I show that the lagged value of PMR negatively influences REPs. Moreover, the lagged INEQ and Kyoto variables are both statistically significant with the expected signs, whereas the lagged GREEN variable exhibits a nearly significant coefficient associated with the expected positive effect. The lagged GDP_pc variable, on the contrary, has the expected positive effect on REPs, which never proves statistically significant, primarily due to the inclusion of the time trend. In model II, the inclusion of lagged

10. The energy price variable has numerous missing values, particularly in Sweden, Belgium, the Czech Republic and the Slovak Republic. In the first two cases, they were mainly internal values in the time series, which have been imputed as the average of the two adjacent years. For the other two countries, this was not always the case and we preferred not to reconstruct the series before 1989 due to the extensive lack of data.

energy prices in logarithm for, does not alter the core results, and the effect of ENERGY is not statistically significant. With respect to model I, the sizes of the effects of the Kyoto, lagged INEQ and lagged PMR variables remain virtually unchanged.

We contend that these results suggest that the bias in the politicians' behaviour has to be interpreted as depending on the capacity of the incumbents to influence the country's energy strategy, which is in turn proportional to the monopolistic rents in the energy sector. Moreover, the ratification of the Kyoto protocol and an equal income distribution, reflecting international pressure for climate change mitigation and a wealthier median voter, respectively, both increase the political support for the approval of ambitious REPs.

Quantifying the estimated effects reveals that they are quite sizeable. For the PMR, a one-unit std. dev. decrease leads to an increase of between 0.33 and 0.43 of a std. dev. in FACT_MAIN. For instance, France would have had ranked just below the Nordic countries and the US in FACT_MAIN with an electricity market, on average, regulated to the same extent as the German one. The upper bound in the PMR effect, obtained in the FE model, captures the average effect of a change in PMR within a country, whereas the RE estimate is plagued by the positive correlation between country effects and the level of PMR. Interestingly, the Kyoto dummy also exerts a sizable effect, leading to a 0.7 std. dev. increase in the dependent variable. Finally, inequality also displays a remarkable effect where a one std. dev. increase in INEQ leads to a 0.4 std. dev. decrease in policy support[11].

Model III replicates our preferred FE specification with the PMR indicator divided into its three sub-indexes to assess which particular element of liberalisation tends to create a friendlier environment for REPs. While, unsurprisingly, the main results for Kyoto and inequality are confirmed, among the PMR sub-indexes, only entry barriers significantly affect policy support. On the contrary, public ownership shows a statistically insignificant effect. This result suggests that a reduction in the monopolistic power of state-owned utilities has a positive effect on REPs when various types of actors, i.e., municipalities, cooperatives, and households, are ensured access to the grid instead of it only being provided to a few large private firms. Sweden, for instance, is well-recognised as having low entry barriers, strong public ownership and ambitious REPs (Pollitt, 2012).

In model IV, we restrict the sample to the period 1990-05 and include the PSM of the dependent variable, a proxy for the initial policy level. As expected, the effect of the initial level of REP is positive and highly statistically significant. A one std. dev. increase in the PSM accounts for a 0.34 std. dev. increase in the REP index, precisely as in the case of a one std. dev. decrease in entry barriers. The different estimation strategy

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11. Regarding the magnitudes of the effects of the remaining variables, they are slightly lower in size: a one std. dev. change in ENERGY, resp. GREEN, leads to a 0.24, resp. 0.16, std. dev. change in the policy index. Despite not being statistically significant, the effect of a 1 std. dev. increase in GDP_pc is substantially larger, and equal to approximately a 0.36 std. dev. in policy.

and the reduction of the time period only slightly alter the sizes of three components of the PMR coefficients. Moreover, reducing the time period particularly affects a slowly changing variable such as INEQ, the effect of which nearly disappears.

[TABLES 4 ABOUT HERE]

4.4 Endogeneity and Dynamic Specification

The first extension of our analysis consists of addressing the endogeneity in the effect of PMR. In Table 5, we present the results of our IV estimates with the caveat that the time period considered changes, as corruption data are only available from 1980 on. We use corruption as main instrument for PMR, while government fragmentation and the share of right wing deputies in parliament are additional exclusion restrictions. The chosen instruments all have the expected signs, high explanatory power (the F-test for the first stage is well-above the usual cut-off level of 10) and appear exogenous as suggested by the Hansen tests presented in Table 5 (detailed results are available on request).

The main effects remain of similar size when we compare results for the just identified IV estimate (model II) and the core FE model in column I (re-estimated here for the shorter 1980-2005 time period). In both the perfectly identified and the over-identified IV specifications (col. II & III), PMR has negligibly smaller effect compared to the simple FE estimates (col. I). In column 4 of Table 5, we further restrict the sample to the time period 1990-2005, where the temporal variation in REPs and PMR is concentrated. Qualitatively, our results remain in line with the previous estimates. However, the quantitative effects change substantially: the effect of the PMR increases by a remarkable 50% with respect to model II in the same Table.

In sum, the lower coefficient in the IV estimates suggests that in more corrupt countries, the process of liberalisation has likely only been partial and has favoured existing lobbies rather than consumers. Chick (2011) and Pollit (2012) show that governments often failed to implement complete energy market liberalisation to maintain their ability to subsidise favoured interest groups. Our result suggests that this is more likely to occur in countries with a higher degree of corruption or those with more fragmented governments. Incidentally, this result contributes to the literature on the determinants of environmental policies (Lopez and Mitra, 2000; Fredriksson and Svensson, 2003), suggesting that the effect of corruption on REPs is entirely mediated by its indirect effect on the PMR index. Notice also that the effect of CORR on REP conditional on the covariates is statistically insignificant.

The last column of Table 5 presents the results of a dynamic panel model specification where the lagged dependent variable is included to account for persistency in the adoption of REPs. The results for KYOTO and PMR remain robust, even if the magnitudes of the coefficients are substantially reduced. This is an expected result, as the estimated coefficients in dynamic models represent short-term effects and should be multiplied by $1/(1-\rho)$, where ρ is the estimated effect of the lagged REP index, to obtain long-term effects.

Interestingly, the estimated coefficient for the lagged dependent variable is not very far from one, denoting high persistency in the political process even when conditioning on several time-varying controls.

4.5 Different Policy Indicators

To test the robustness of our results to the particular policy indicator employed, we estimate our preferred FE specification from models II and III of Table 4 using three different policy indicators. Similar to Mazzanti and Zoboli (2009), the first is the average value of the policy dummies, taking the value 1 if any policy, including the one for which we have continuous information, is adopted (*POL_DIV*). The second, instead, only considers the three policies for which we have intensity measures (R&D expenditures, feed-in tariffs and RECs), standardises them and then takes the un-weighted average *(CONT_POL)*. These two indexes reflect, respectively, diversity of the policy portfolio and the intensity of the most relevant instruments. The third index (*FACT_ROB*) is also constructed using PCA, and specifically combines: continuous data on RECs, public R&D and average feed-in tariff; feed-in tariff adoption dummies for waste, solar, wind and biomass (the three most promising renewable energy sources); and an adoption dummy for the remaining policies. Appendix A presents detailed descriptive statistics for the three new indicators and compares them with those of our main indicator.

The results of this sensitivity analysis are presented in Table 6, where all indicators are normalised to have mean 0 and standard deviation 1 to facilitate comparison with our main indictor, FACTOR_MAIN. In general, PMR and KYOTO are statistically significant with the expected signs for all indicators. However, three important differences emerge. First, the effect of INEQ is generally lower and usually significant at the 10-15% levels for *CONT_POL* and *FACT_ROB*, while its effect completely disappears for *POL_DIV*. This implies that the median voter cares more about the intensity of key policy instruments than the number of available options. The opposite holds for the impact of GREEN, the proxy for direct green lobbying, which is stronger when using *POL_DIV*. Second, regarding the *POL_DIV* indicator, PMR has the expected sign, but the associated coefficient is no longer significant. However, when examining the individual components of the PMR index (column 4), a negligible aggregate effect masks a negative and significant effect of barriers to entry counterbalanced by a positive and significant effect of vertical integration. Third, our covariates have remarkably lower explanatory power in regressions with the indicator *CONT_POL*. This result may reflect that two of the policies included in *CONT_POL*–i.e., REC and average feed-in—were implemented quite recently in many countries, further reducing the temporal variability to be explained.

As a final robustness check, Appendix B presents that the central message of the paper when we exclude groups of countries, i.e., Scandinavian or Anglo-Saxon, sharing similar political and institutional frameworks.

[TABLES 5-6 ABOUT HERE]

5. Conclusions

This paper employs principal component analysis to aggregate heterogeneous policies designed to promote renewable energy. In undertaking this analysis, we test whether it is possible to identify a set of variables that is able to account for the evolution of this indicator. We draw inspiration from political economy models of environmental policies and adapt the predictions of these models to the case of REP. Our main result is that three main variables can be identified: inequality, Kyoto and product market regulation. The first variable reflects the preference of the median voter given the country's level of development, the second reflects the role of international cooperation in climate change mitigation and the third reflects the capacity of energy lobbies to capture policies. Of the components of the PMR index, barriers to entry fully capture the effect of PMR on REP, while privatisation does not display any significant effect. The results for PMR remain robust when instrumenting market regulation, in more demanding dynamic panel specifications, adopting alternative policy indicators and restricting the sample to different sub-groups of countries. Interestingly, the IV estimator for PMR shows that corruption only has an indirect effect on policy mediated by barriers to entry, while the negative effect of inequality is quite large and much stronger for the richer countries.

Overall, these results suggest that a hybrid political-economy model of environmental policy, where both competition and lobbying power are important, seems to offer the most accurate explanation of policy determinants. Moreover, our paper amends Pollitt's claim that the liberalisation of the energy market plays a secondary role in the green energy transition compared to citizens' preferences (Pollitt, 2012). We show that removing the obstacles to the entry of new actors in the market plays a role that is at least as important as that played by increasing concerns among the public regarding climate change and pollution. Finally, our results are important for future and on-going research, where we will analyse the effectiveness of our policy indicators on the diffusion and development of renewable energy technologies.

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Appendix A - Descriptive evidence of the alternative policy indicators

In this appendix, we present some descriptive statistics for our alternative policy measures. The results from the PCA analysis employed to derive the alternative indicator *FACT_ROB* are summarised in Table A1 below. The analysis yielded four relevant principal components. The first primarily refers to price based instruments; the second is a combination of quantity-based instruments and the third is primarily correlated with REC and a 2001 EU directive, while obligations equally load on the second and the third. The last principal component in terms of explanatory power is instead strongly correlated with innovation-oriented policies. As seen in the correlations presented in Table A2, the differences between the two PCA based indicators are small. However, these differences are statistically significant, motivating the use of all indicators to validate our results.

The two average based indicators (*COM_POL, CONT_POL*) display trends across countries and time similar to those of the main indicator *FACT_MAIN*. The country ranking presented in Table A2 is fairly consistent across indicators. Transition economies are generally those with lower policy levels, together with Greece and New Zealand. Denmark, Switzerland, the Netherlands, Sweden and the US have higher policy levels. In last 15 years, policy support in Austria, Germany, Finland and Italy approached the levels of the best performing countries, while Sweden and the US experienced substantial declines in their rankings.

There are, however, some discrepancies across indicators. In particular, the absence of feed-in tariff schemes in certain countries (which accounts for a third of the total variability in *CONT_POL* and has a high loading in the first principal component) altered the ranking between *DIV_POL*, on the one hand, and the three remaining indicators, on the other. For instance, Japan ranks second in *POL_DIV* and only 18th in *FACT_MAIN*. Moreover, the US has a lower rank in indicators that place the largest weight on feed-in tariffs, such as *CONT_POL*. However, countries such as the Netherlands and Sweden have much better rankings in indicators employing information from continuous variables because of their higher than average levels of REC targets and public R&D expenditures. Denmark represents another important exception. Its high value in both average feed-in level and REC targets makes it the leader across all indicators that place greater weight on these variables.

These considerations also explain the correlation matrices presented in Table A2, which, although confirming the high correlation among the indicators, underline the differences, especially between *CONT_POL* and *DIV_POL*.

[TABLES A1 – A3 ABOUT HERE]

Appendix B

As a final exercise, in this appendix we present a robustness check for the omission of groups of countries. The results are presented in Table B1, using the baseline specification of model I (FE) in Table 4. Main evidence is confirmed across different subsamples: lagged PMR, lagged INEQ and Kyoto are always statistically significant and associated with the expected signs. Consistent with theoretical predictions, the effect of inequality is only stronger when rich countries are considered (Vona and Patriarca 2011). When excluding the Scandinavian or Anglo-Saxon countries, the coefficient for lagged INEQ drops by approximately ¼. In turn, the effect of Kyoto is similar across the different subsamples, with the exception of the Mediterranean group, the inclusion of which tends to reduce the average effect. The Scandinavian countries also inflate the size of the PMR coefficient, while Anglo-Saxon and Eastern European countries tend to reduce it.

Table 1. Summary of the individual REP policies.

Instrument	Brief explanation	Variable Construction	Source
Investment incentives	Capital grants and all other measures aimed at reducing the capital cost of adopting renewables. May also take the form of third party financial arrangements, where governments assume part of the risk or provide low interest rates on loans. They are generally provided by State budgets.	Dummy Variable	International Energy Agency
Tax Measure	Economic instruments used either to encourage production or discourage consumption. They may take the form of investment tax credits or property tax exemptions, to reduce tax payments for the project owner. Excises are not directly accounted for here unless they were explicitly created to promote renewables (for example excise tax exemptions).	Dummy Variable	International Energy Agency
Incentive tariff	Through guaranteed price schemes, the energy authority obliges energy distributors to feed in the production of renewable energy at fixed prices varying according to the various sources. This system is considered one the main factors in the development of renewable technologies, especially thanks to the advantage of reducing uncertainty, offering investors long-term security (Reiche et al., 2002). Some countries (UK, Ireland) developed so-called bidding system schemes in which the most cost-effective offer is selected to receive a subsidy. This last case is also accounted for in the dummy, due to its similarity to the feed-in systems.	Level of price guaranteed (USD, 2006 prices and PPP)	International Energy Agency Cerveny and Resch (1998) Country specific sources
Voluntary program	These programs generally operate through agreements between the government, public utilities and energy suppliers, where they agree to buy energy generated from renewable sources. One of the first voluntary programs was in Denmark in 1984, when utilities agreed to buy 100 MW of wind power.	Dummy Variable	International Energy Agency
Obligations	Obligations and targets generally take the form of quota systems that place an obligation on producers to provide a share of their energy supply from renewable energy. These quotas are not necessarily covered by a tradable certificate.	Dummy Variable	International Energy Agency
Tradable Certificate	Renewable energy Certificates (REC) are used to track or document compliance with the quota system and consist of financial assets, issued by the regulating authority, which certify the production of renewable energy and can be traded among the actors involved. Along with the creation of a certificate scheme, more generally a separate market is established where producers can trade the certificates, creating certificate "supply", while the demand depends on political choices. The price of the certificate is determined through relative trading between the retailers.	Share of electricity that must be generated by renewables or covered with a REC.	Data made available by Nick Johnstone, OECD Environment Directorate
Public Research and Development	Public financed R&D program disaggregated by type of renewable energy.	Public sector per capita expenditures on energy R&D (USD, 2006 prices and PPP).	International Energy Agency
EU directive *2001*/77/EC	Established the first shared framework for the promotion of electricity from renewable sources at the European level.	Dummy Variable	European Commission

Table 2. Principal Component Analysis results.

FACT_MAIN	Variables included	Eigenvalue	Share of variance Explained
First	Average Feed-in tariff (Value) Tax Measure (Dummy) Investment incentive (Dummy) Voluntary program (Dummy) Incentive tariff (Dummy)	3.633	0.403
Second	Obligation (Dummy) EU Directive 2001 (Dummy) REC target (Value)	1.159	0.128
Third	Public R&D (Value)	1.0209	0.113

Table 3. Descriptive statistics and sources.

Acronym	Description	Obs.	Mean	St. Dev.	Min	Max	Source
FACT_MAIN	Policy index based on factor analysis (standardised)	936	0	1	-0.769	6.427	
FACT_ROB	Policy index based on factor analysis (standardised)	936	0	1	-1.044	4.267	
POL_DIV	Policy index based on dummy variables (standardised)	936	0	1	-0.953	3.184	
CONT_POL	Policy index based on continuous variables (standardised)	936	0	1	-0.600	8.448	
PSM	FACT_MAIN pre-sample mean (years 1970-1990)	936	-0.426	0.399	-0.769	0.794	
GDP_pc	GDP per capita, thousands US 1990 Dollars, ppp. (Missing data for Czech and Slovak republic before 1990)	899	23.272	8.971	6.045	71.16	OECD
Ineq	Gini Coefficient	889	27.571	4.377	15.061	38.72	Standardized World Income Inequality Database (SWIID)
Kyoto Dummy	Dummy variable that takes on a value of 0 prior to the approval of the Kyoto protocol and 1 thereafter	936	0.25	0.433	0		
Green	Share of green deputies in parliament	792	1.311	2.623	0	13.33	World bank
Energy Prices	Energy end use price, USDppp/unit (Households). Log in the analysis.	753	0.1085	0.046	0.0190	0.256	International Energy agency
PMR Electr.	Product Market regulation in the energy sector	798	4.613	1.586	0	6	OECD
PMR Entry	Product Market regulation in the energy sector sub-index: Entry barriers	798	4.685	2.182	0	6	OECD
PRM Public Own.	Product Market regulation in the energy sector sub-index: Public ownership	806	4.464	1.821	0	6	OECD
PMR Vertical Int.	Product Market regulation in the energy sector sub-index: Vertical integration	806	4.719	1.940	0	6	OECD
Corruption	Corruption index that ranges from 0 (highly corrupt) to 10 (highly clean). (Available from 1980)	676	7.235	1.831	1.497	9.959	World Resource Institute dataset
Govern. fragmentation	Herfindhal index of governments, calculated as the sum of the squared seat shares of all parties in the government	785	0.7293	0.2695	0.181	1	World Bank database of Political Institutions.
Right party	Share of right-wing deputies in parliaments	776	0.2463	3.4257	0	48.3	Comparative Political Data Set I

Table 4. Dependent variable: FACT_MAIN.

Specification	I (RE)	I (FE)	II (RE)	II (FE)	III	IV
Lagged GDP_pc	0.0231	0.0356	0.0337	0.0404	0.0372	0.0200
	(0.0228)	(0.0299)	(0.0273)	(0.0320)	(0.0297)	(0.0196)
Lagged Ineq	-0.0667*	-0.1001**	-0.0670**	-0.0891**	-0.0828**	-0.0300
	(0.0355)	(0.0405)	(0.0341)	(0.0379)	(0.0367)	(0.0255)
Kyoto Dummy	0.6632***	0.5982***	0.7497***	0.7092***	0.6203***	0.7095***
	(0.1329)	(0.1415)	(0.1272)	(0.1303)	(0.1347)	(0.1211)
Lagged Green	0.0567	0.0602	0.0613	0.0643	0.0655	0.0425
	(0.0417)	(0.0424)	(0.0427)	(0.0442)	(0.0436)	(0.0471)
Lagged PMR Electr.	-0.2074***	-0.2638***	-0.2286***	-0.2701***		
	(0.0730)	(0.0826)	(0.0756)	(0.0827)		
Lagged Energy Prices (log)			5.4717	5.7709	5.6866	5.0309
			(5.0579)	(5.1367)	(4.6303)	(3.0515)
Lagged PMR Entry					-0.1748***	-0.1560**
					(0.0531)	(0.0579)
Lagged PMR Public Ownership					-0.0077	0.0149
					(0.0715)	(0.0325)
Lagged PMR Vertical Integration					-0.0320	0.0287
					(0.0936)	(0.0534)
Pre-Sample Mean						0.8882***
						(0.1438)
Country FE	No	Yes	No	Yes	Yes	No
Area FE	Yes	No	Yes	No	No	No
Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.33	0.47	0.32	0.47	0.48	0.46
Observation	638	638	621	621	621	352
Hausman test		26.62 (0.000)		20.04 (0.002)		

Cluster-robust standard errors, cluster unit is the country. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively.

Table 5. Endogeneity and dynamic: dependent variable, FACT_MAIN.

Specification	I (FE)	II (FE2SLS)	III (FE2SLS)	IV (FE2SLS)	IV (LSDVC)
Lagged GDP_pc	0.0394	0.0399***	0.0452***	0.0102	0.0068
	(0.0340)	(0.0154)	(0.0143)	(0.0124)	(0.0078)
Lagged Ineq	-0.0824*	-0.0792***	-0.0724***	-0.0348	-0.0107
	(0.0427)	(0.0260)	(0.0243)	(0.0233)	(0.0114)
Kyoto Dummy	0.7039***	0.7213***	0.7519***	-0.1161	0.2085***
	(0.1382)	(0.1435)	(0.1406)	(0.1164)	(0.0756)
Lagged Green	0.0678	0.0669***	0.0755***	-0.0049	0.0198*
	(0.0477)	(0.0209)	(0.0193)	(0.0185)	(0.0113)
Lagged PMR Electr.	-0.2833***	-0.2626***	-0.2502**	-0.3927***	-0.0533**
	(0.0873)	(0.1010)	(0.0982)	(0.0933)	(0.0232)
Lagged Energy Prices (log)	4.4144	4.4796	3.0303	5.9433*	-1.4527
	(5.7591)	(2.8942)	(2.3424)	(3.4020)	(1.3993)
Lagged Dependent Variable					0.8802***
					(0.0301)
Country FE	Yes	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes	Yes
Observation	567	567	567	352	621
R^2	0.46	0.46	0.46	0.64	
Sample	year >=1980	year >=1980	year >=1980	year >=1990	Full Sample
F First step		93.00 (7, 413)	106.58 (7, 413)	95.40 (7, 308)	
Hansen test		0.000	0.703	0.000	
Instruments	FE Estimation	Corruption	Corruption, Right Party, Gov Frag	Corruption	

Cluster-robust standard errors, cluster unit is the country. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively.
In column IV, we used the Stata routine xtlsdvc with the bootstrapped standard errors implemented by Bruno (2005), initialising the bias correction using standard one-step Arellano-Bond (1991) estimator with no intercept and, following Kiviet (1999), we forced a bias approximation up to $N^{-1}T^{-2}$.

Table 6. Other dependent variables: FACT_ROB, POL_DIV, CONT_POL.

Specification	I	II	III	IV	V	VI
Dependent Variable	FACT_ROB	FACT_ROB	POL_DIV	POL_DIV	CONT_POL	CONT_POL
Lagged GDP_pc	0.0321	0.0298	0.0174	0.0119	0.0143	0.0121
	(0.0225)	(0.0226)	(0.0168)	(0.0147)	(0.0303)	(0.0234)
Lagged Ineq	-0.0535*	-0.0484	0.0008	0.0038	-0.0962*	-0.0641
	(0.0306)	(0.0306)	(0.0288)	(0.0260)	(0.0538)	(0.0455)
Kyoto Dummy	0.6206***	0.5517***	0.5947***	0.5202***	0.5383***	0.5529***
	(0.1228)	(0.1296)	(0.1211)	(0.1319)	(0.1257)	(0.1149)
Lagged green	0.0593	0.0603*	0.0521**	0.0523**	0.0637	0.0597
	(0.0349)	(0.0346)	(0.0248)	(0.0235)	(0.0573)	(0.0564)
Lagged PMR Electr.	-0.1459***		-0.0067		-0.2595*	
	(0.0509)		(0.0390)		(0.1306)	
Lagged Energy Prices (log)	3.5843	3.4895	0.2950	0.6036	8.5039	8.7684*
	(3.4033)	(3.1081)	(3.2440)	(2.9706)	(6.1215)	(4.9337)
Lagged PMR Entry		-0.1130**		-0.0905**		-0.0771
		(0.0494)		(0.0406)		(0.0483)
Lagged PMR Public Ownership		0.0216		-0.0158		0.0639
		(0.0589)		(0.0488)		(0.0947)
Lagged PMR Vertical Integration		-0.0078		0.0989*		-0.1315
		(0.0678)		(0.0558)		(0.1315)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.62	0.63	0.78	0.79	0.22	0.23
Observation	621	621	621	621	621	621

Cluster-robust standard errors, cluster unit is the country. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively.

Appendix A

Table A1. Second Principal Component (FACT_ROB) Analysis results.

FACT_ROB	**Variables included**	**Eigenvalue**	**Share of variance Explained**
First	Feed-in tariff wind (Dummy) Feed-in tariff solar (Dummy) Feed-in tariff biomass (Dummy) Feed-in tariff waste (Dummy) Average Feed-in tariff (Value) Incentive tariff (Dummy)	6.3606	0.424
Second	EU Directive 2001 (Dummy) Obligation (Dummy) REC target (Value)	2.127	0.141
Third	Tax Measure (Dummy) Investment incentive (Dummy) Voluntary program (Dummy)	1.347	0.089
Fourth	Public R&D (Value) Public R&D (Dummy)	1.124	0.075

Table A2. Correlations among the policy indicators. Years 1970-2005.

	FACT_MAIN	**FACT_ROB**	**POL_DIV**	**CONT_POL**
FACT_MAIN	-			
FACT_ROB	0.9351*	-		
POL_DIV	0.7722 *	0.8822*	-	
CONT_POL	0.8584 *	0.8038*	0.4938*	-

*p<0.05

Table A3. Country ranking according to the different indicators (std. values). Year 2005.

Rank	FACT_MAIN		FACT_ROB		POL_DIV		CONT_POL		FACT_MAIN (1990-2005)	
1	Sweden	0.87	Denmark	0.69	United States	1.04	Sweden	0.84	Denmark	2.24
2	Denmark	0.87	Sweden	0.63	Japan	0.61	Denmark	0.82	Switzerland	1.75
3	Switzerland	0.54	Switzerland	0.57	Denmark	0.60	Switzerland	0.69	Netherlands	1.50
4	United States	0.49	United States	0.55	Germany	0.50	Greece	0.65	Austria	1.36
5	Netherlands	0.46	Netherlands	0.45	Italy	0.44	Austria	0.47	Sweden	1.15
6	Greece	0.35	Austria	0.39	Switzerland	0.35	Portugal	0.44	Germany	0.91
7	Austria	0.30	Italy	0.31	France	0.33	Spain	0.38	Finland	0.91
8	Italy	0.19	Germany	0.30	Finland	0.28	Netherlands	0.33	Italy	0.88
9	Germany	0.14	Belgium	0.28	Belgium	0.28	Italy	0.15	United States	0.79
10	Spain	0.06	Greece	0.20	Netherlands	0.27	United States	0.13	Belgium	0.71
11	Belgium	0.01	Spain	0.16	Austria	0.24	Germany	0.09	Spain	0.50
12	Finland	-	Portugal	0.08	Canada	0.10	Belgium	0.06	France	0.44
13	France	-	Japan	0.01	Spain	0.08	New Zealand	-	Japan	0.42
14	Australia	-	France	-	Sweden	0.07	Luxembourg	-	United	0.39
15	New Zealand	-	United	-	Ireland	0.04	Canada	-	Australia	0.31
16	United	-	Canada	-	United	0.04	Norway	-	Luxembourg	0.27
17	Canada	-	Australia	-	Australia	-	United	-	Norway	0.21
18	Japan	-	Finland	-	Norway	-	Australia	-	Portugal	0.17
19	Ireland	-	Ireland	-	Luxembourg	-	Hungary	-	Ireland	0.15
20	Norway	-	Norway	-	New Zealand	-	Czech	-	Canada	0.04
21	Portugal	-	New Zealand	-	Portugal	-	Finland	-	Czech	-
22	Luxembourg	-	Luxembourg	-	Greece	-	Japan	-	New Zealand	-
23	Czech	-	Czech	-	Czech	-	France	-	Greece	-
24	Poland	-	Hungary	-	Hungary	-	Ireland	-	Poland	-
25	Hungary	-	Poland	-	Poland	-	Slovak	-	Hungary	-
26	Slovak	-	Slovak	-	Slovak	-	Poland	-	Slovak	-

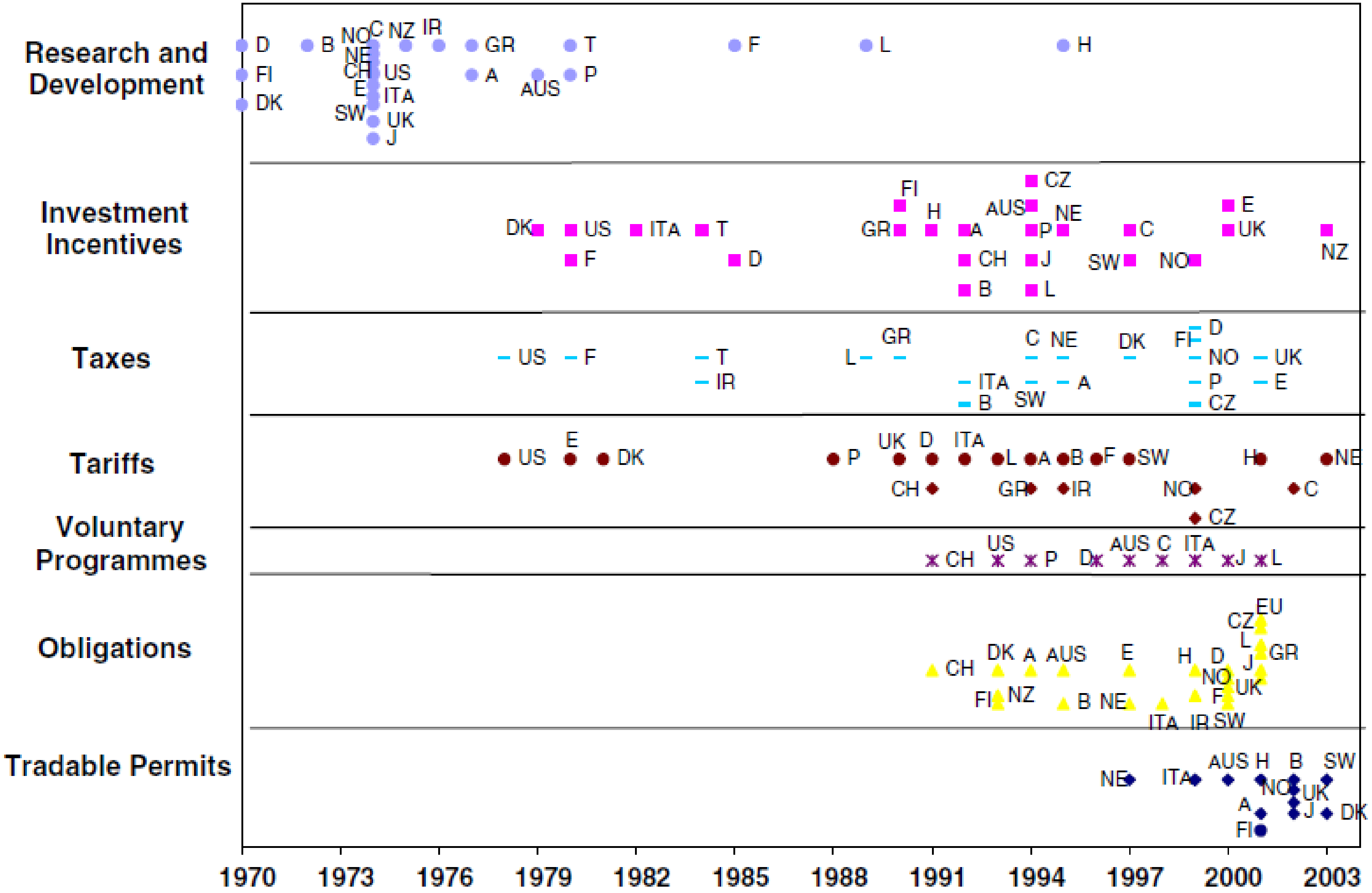
Appendix B

Table B1. Dependent variable: FACT_MAIN.

	All Countries	No Scandinavian	No Anglo	No Cent EU	No Mediterranean	No East	No Denmark	No Slovak Rep	No US
Lagged GDP_pc	0.0356	0.0402	0.0293	0.0580	0.0111	0.0356	0.0376	0.0356	0.0374
Lagged Ineq	-0.1001**	-0.0746**	-0.0748**	-0.1059*	-0.1131**	-0.1001**	-0.0615**	-0.1001**	-0.0922**
Kyoto Dummy	0.5982***	0.5697***	0.5738***	0.5408**	0.6969***	0.5982***	0.6461***	0.5982***	0.6221***
Lagged green	0.0602	0.0796*	0.0695	-0.0237	0.0425	0.0602	0.0770*	0.0602	0.0566
Lagged PMR Electr.	-0.2638***	-0.2384***	-0.3396***	-0.2716**	-0.2210**	-0.2638***	-0.2071***	-0.2638***	-0.253***
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.44	0.45	0.48	0.38	0.53	0.46	0.44	0.46	0.46
Observation	638	518	459	474	493	638	608	638	608

Cluster-robust standard errors, cluster unit is the country. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. We use the specification of model I (FE) in Table 4 as the benchmark. The Scandinavian group is formed by: Finland, Sweden, Denmark and Norway. The Anglo group is formed by: New Zealand, the United Kingdom, Ireland, Australia, Canada and the United States. The Central EU is formed by: Denmark, Belgium, Austria, Netherland, Switzerland and Luxembourg. The Mediterranean group is formed by: Portugal, Greece, Spain, Italy and France. The East group is formed by: Poland, Hungary, the Czech Republic and the Slovak Republic.

Figure 1. Patterns of policy adoption in selected OECD countries



Source: IEA (2004), as in Johnstone et al. (2009). *AUS* Australia, *C* Canada, *FI* Finland, *GR* Greece, *ITA* Italy, *L* Luxembourg, *NO* Norway, *SW* Sweden, *UK* United Kingdom, *A* Austria, *CZ* Czech Rep., *F* France, *H* Hungary, *J* Japan, *NE* Netherlands, *P* Portugal, *CH* Switzerland, *US* United States, *B* Belgium, *DK* Denmark, *DE* Germany, *IR* Ireland, *NZ* New Zealand, *E* Spain, *T* Turkey

Figure 2. Evolution of FACT_AV_FEED

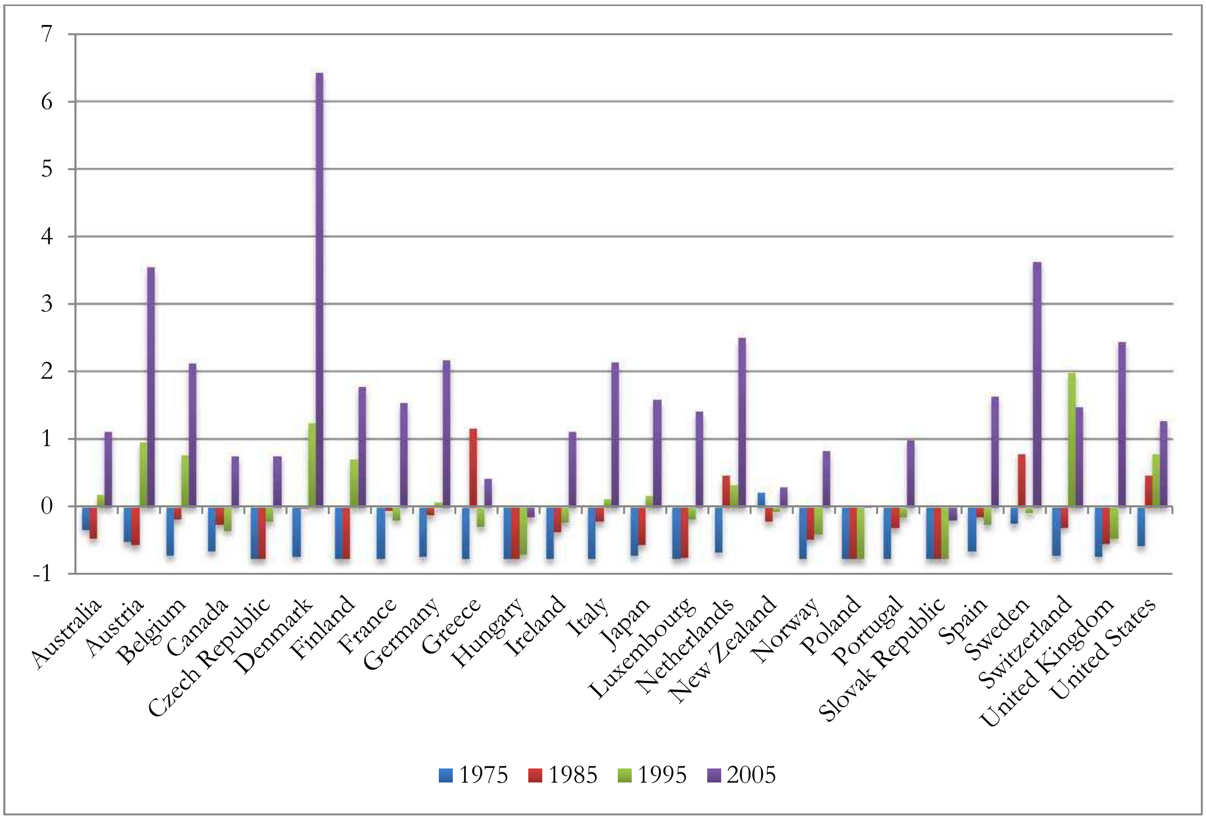


Figure 3. Evolution of Product Market Regulation between 1976 and 2005 (selected countries).