Energy Market Liberalisation and Renewable Energy Policies in OECD Countries

Francesco Nicolli[1] and Francesco Vona[2]

Abstract

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JEL: Q42, Q48, D72, O38

Keywords: Renewable Energy Policy, Energy Market Liberalisation, Instrumental Variables, Applied Political Economy

[1] Corresponding author at: Department of Economics and Management, University of Ferrara, Italy and European University Institute, Florence School of Regulation - Climate, Fiesole, (Florence), Italy. Via Giovanni Boccaccio, 121. 50133 Firenze, FI. Italy. Tel. +39 055 4685878. Fax +39 0532 205349. Mail: francesco.nicolli@unife.it

[2] OFCE Sciences Po, SKEMA Business School, Université Côte d'Azur. Mail: francesco.vona@sciences-po.fr.

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Abstract

This paper investigates the effect of energy liberalisations, as compared to the one of other drivers, on policies that support renewable energy in a long panel of OECD countries. We estimate this effect accounting for the endogeneity of liberalisation related to joint decisions within a country's energy strategy. Using regulation in other industries as instruments, we find that energy liberalisation increases the public support to renewable energy. The effect of liberalisation is the second largest after the effect of per-capita income and is mostly driven by reductions in entry barriers, while the effect of privatisation is unclear. This finding suggests that a reduction in the monopolistic power of state-owned utilities has a positive effect on renewable energy policies when various types of actors are ensured access to the grid instead of it being provided to only a few large private firms.

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1. Introduction

Environmental problems typically call for government interventions to address the market failures associated with pollution and investment in green technologies. Although international policy agreements such as the Kyoto Protocol have acquired prominence in the public debate, national policies still represent the main tools to fight climate change and global warming. Compared to other environmental policies, policies that support renewable energy (REPs henceforth) affect several targets other than pollution abatement, such as energy security, technological change and energy efficiency, because REPs are often combined with measures that promote energy efficiency. For instance, technological learning is particularly important to reduce the cost of energy production from renewable sources relative to that of traditional ones. Energy security is also a long-term and uncertain objective of REP because renewables are difficult to store and require backup capacity from fossil-fuel plants.[1]

To the best of our knowledge, only a few papers have empirically investigated the determinants of REPs (see, e.g., Lyon and Yin 2010, Jenner et al. 2012). However, by focusing on the adoption of a specific REP, these papers have neglected the fact that each country uses an array of policy instruments to promote renewable energy (RE). Recent research has shown that an appropriate policy mix that combines policies to reduce pollution (e.g., emission trading schemes) with policies for learning (e.g., RE production subsidies) and innovation (e.g., R&D subsidies) stimulates the search for new technological solutions rather than mere compliance with existing standards (see, e.g., Fisher and Newell, 2008; Midttun and Gautesen, 2007; Acemoglu et al., 2012; Nesta et al., 2018). Following on this argument, we examine the determinants of REP indicators that combine various policy measures using different methodologies; in doing so, we complement previous studies by analysing the overall country's commitment to RE rather than the intensity of a single REP.

Our empirical analysis contributes to the growing empirical literature on environmental political economy. A well-established result in this literature is that policy stringency is negatively associated with the level of corruption, which is interpreted as a proxy for the brown lobby's ability to influence environmental policies (e.g., Fredriksson and Svensson, 2003; Zhang et al., 2016). Although corruption is certainly a good measure of the quality and independence of the political system, it does not capture the sector-specific features of the

[1] An evaluation of the welfare effects of REPs is beyond the scope of this paper. See Schmalensee (2012) and Moselle et al. (2010) for comprehensive overviews of the problems associated with the development of renewable energy sources. Jenner et al. (2013) for EU states and Yin and Powers (2009) for US states evaluate the impact of, respectively, feed-in-tariffs (FITs) and renewable portfolio standards (RPSs) on RE electricity generation. The former paper finds that FITs have a positive effect on solar but not on wind development, and the latter finds a positive effect of RPSs on RE deployment. Several papers find that RE policies have a positive effect on RE innovation and diffusion (e.g. Johnstone et al., 2010; Popp et al., 2011; Nesta et al., 2014).

political process that are highlighted in the literature on lobbying (Helpman and Grossman, 1994). The recent wave of energy market liberalizations offers a unique opportunity to investigate the effect of a decrease in the incumbents' lobbying power, which is proportional to their market power, on a sectoral policy aimed at improving citizens' welfare. This paper shows that liberalization has a large effect on the adoption of REPs by controlling for corruption, a proxy for the influences of the green lobby and a wide range of other characteristics.

The new mechanism highlighted here is not obvious: even if the adoption of REPs and liberalizations went hand-in-hand in the last two decades, the two policies were implemented for different reasons. The former had the main objective of reducing electricity prices, while the latter's primary targets were environmental externalities through the support of cleaner but more expensive energy sources. However, there are two reasons for liberalizations to have an independent and perhaps unintended effect on REP.

First, granting free access to the grid to new and often smaller players is likely to favour decentralized energy production, which is highly compatible with RE generation (see the discussion in section 2). Because large utilities have a comparative advantage in centralized energy production, they will contest the approval of REPs to avoid jeopardising their investments. Conversely, new players are likely to invest in small-scale productions, including renewable ones. Lowering entry barriers reduces the capacity of utilities to influence energy policies and favours the emergence of new green actors. Therefore, we expect a positive effect of liberalization on REPs.

Second, the typical state-owned monopoly that characterizes the energy sector before liberalization internalizes the pollution externalities stemming from traditional energy sources. As a result, it may be easier to implement REPs in a market with widespread public ownership than in a market dominated by private utilities. Overall, which effect prevails is an empirical issue that we investigate by exploiting variation in policies in 27 OECD countries over 28 years (1980-2007).[2]

The identification of the effect of liberalization on REPs is problematic because the two variables are co-determined within a country's energy strategy. Moreover, our index of regulation, which is the product market regulation (PMR henceforth) in the energy sector developed in the OECD, is an imperfect proxy for the effective incumbents' market power, on which the capacity to capture policies depends. Because controlling for country fixed effects and country-specific trends may alleviate but not fully solve this problem, we use regulation in other sectors, specifically in telecommunication, to instrument regulation in electricity. The idea is that widespread liberalizations are implemented to pursue general goals and reflect the diffusion of a liberal political ideology, which can be considered independent on the direct lobbying power of incumbents and potential entrants (i.e., solar companies) in the energy sector. The sequence of reforms across sectors validates our instrument choice, as early liberalizations in telecommunications have paved the way for energy liberalizations (Høj et al., 2006).

Three main findings stand out clearly from our analysis. First, we find that a higher degree of regulation in electricity undermines the approval of ambitious REPs. Second, the effect of liberalization is fully driven by reductions in entry barriers, while privatization has no effect on REPs. Third, the effect of entry barrier reductions is particularly strong on feed-in tariffs,

[2] List of countries: Australia; Austria; Belgium; Canada; Czech Republic; Denmark; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Japan; Netherlands; New Zealand; Norway; Poland; Portugal; Slovak Republic; Spain; Sweden; Switzerland; United Kingdom; United States.

consistent with our interpretation stressing the linkage between entry barrier reduction and decentralized energy production.

The paper is organized as follows. The next section reviews the drivers of environmental and energy policies in greater detail. Section 3 describes our instrumental variable (IV) strategy and the REP indicators used as dependent variables. In Section 4, we present the main results for various indicators and various features of the liberalization process using a dynamic specification. The final section concludes the paper.

2. *Drivers of Renewable Energy Policies*

Theoretical and empirical studies on the determinants of environmental policy agree on the prominent role of private and public interest in affecting policy outcomes (e.g., Peltzman 1976). Formal politico-economy models are generally inspired by the seminal paper of Grossman and Helpman (1994), in which multiple lobbies attempt to capture sector-specific policies by offering perspective bribes to politicians. 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 (see, e.g., Fredriksson, 1997; Aidt, 1998). In turn, this difference 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. Empirically, the weight assigned to brown lobby bribes has been approximated by the level of corruption, which has been shown to negatively affect the stringency of environmental regulation (e.g. Damania and Fredriksson, 2000; Fredriksson et al., 2004; Zhang et al., 2016). Although the negative effect of corruption on environmental policy is a consolidated result, using a sectoral measure of the brown lobby appears more appealing when the policy of interest is also sector specific, as in the case of renewable energy policies.

The influence of lobbies on REPs has also been documented by a growing strand of empirical literature. On the one hand, small local producers, environmental NGOs and potential entrants in the business of RE technologies will support the approval of ambitious REPs. For instance, Michaelowa (1998) reports the lobbying effort of the wind German association to maintain feed-in tariffs in Germany, while the European Committee of Environmental Technology Suppliers Associations (EUCESTA) acts as a lobbyist at the European level (Canton, 2008). Similarly, small-scale utilities, often owned by municipalities and cooperatives, and producers of wind energy technology have played an important role in promoting renewable electricity policy in Denmark and Germany (Agnolucci, 2007; Lipp, 2007). Obviously, small producers support renewable energy policies that favour small- rather than large-scale generation, such as tax credits, feed-in tariffs and investment support schemes (Lipp, 2007). Fredriksson et al. (2007) and List and Sturm (2004) show that green lobbies may have substantial influence on the approval of ambitious environmental policies, while Jacobsson and Lauber (2006) provide anecdotal evidence of the role played by both the green party and the parliamentary group of the social democratic party (SPD) in promoting the development of REPs in Germany.[3] Finally, Aylett (2015) shows that civil society groups can speed up the adoption of new renewable energy systems, by creating economic niches and catalyzing market transformation.[4]

[3] For a theoretical treatment, see also Canton (2008), while for a political science perspective see, e.g, Aklin and Urpelainen (2013) and Cheon and Urpelainen (2013).

[4] A recent review on the intersection between renewable energy adoption, political factors and REPs can be found in Neves Sequeira and Serra Santos (2018).

On the other hand, the opposition of energy utilities to REPs is documented both in single-country case studies (e.g., Jacobsson and Bergek, 2004; Nilsson et al., 2004; Lauber and Mez, 2004), in some recent econometric analyses for the US states (Chandler, 2009; Lyon and Yin, 2010), for OECD countries (Cadoret and Padovano, 2016) and for EU countries (Jenner et al., 2012). This opposition is primarily related to the intrinsic comparative advantage of large utilities in centralized energy production. Whereas the production of energy from renewable sources is decentralized in small to medium-sized units, the competencies of utilities are tied to large-scale plants using coal, nuclear power or gas as the primary energy inputs. The high sunk costs (in terms of both tangible and intangible capital) of large-scale generation further exacerbate the technological lock-in of incumbents and fuel their political opposition to the distributed generation paradigm involving the diffuse use of RE. At the same time, however, the mere replacement of public utilities with private ones will not result in more political support for REPs as long as large private players are less willing to internalize the negative externalities generated by fossil-fuel plants.

Overall, the relationship between energy market liberalization and renewable energy policies crucially depends on the effective design and outcome of the liberalization process. In countries where liberalization mostly favoured the entry of small players and decentralized energy production, we expect a positive effect on RE policies. Conversely, we expect a weaker and even negative effect of liberalization on the adoption of RE policies in countries where liberalization mostly benefited large players. While the main contribution of this paper is to focus on the overall effect of liberalization on RE policies, in Section 4.2 we try to disentangle the effects of the different features of the liberalization process. Although we do not have direct empirical counterparts that allow to capture the incidence of small vs. large producers in the post-liberalization scenario, we claim that this exercise can shed some light on the issue of how the design of the liberalization process affected REPs adoption.

We also consider the direct influence of green lobbies, proxied with the share of votes for green parties in parliamentary elections, which is expected to be positive on the approval of REPs. The inclusion of this variable allows to strengthen the causal interpretation of the effect of liberalization on REP. Specifically, if the green party is against pro-market reforms and in favour of REPs, the inclusion of the green party's share is necessary to be sure that the effect of PMR is not affected by confounding factors.

Obviously, including a proxy for the green lobby is not enough to identify our effect of interest. In next section, we will discuss an instrumental variable strategy designed to directly address the endogeneity of the PMR index.

The paper of Jenner et al. (2012) is closely related to ours as it estimates the effects of the green and brown lobbies, which they also proxied with the PMR, on the probability of adopting feed-in tariffs (FITs) or renewable energy certificates (RECs). Our work extends and complements this work in four directions. First, we address the issue of endogeneity in the effect of energy market liberalization (see Section 3.1). Second, we build an indicator of policy commitment to capture various dimensions of public support for RE (see Section 3.2). Clearly, this requires the use of a linear model rather than an hazard rate model, as in the work by Jenner et al. (2012), since we are interested in the country commitment to REPs rather than in the timing of adoption of a specific RE policy. Third, we disentangle two aspects of the liberalization process that are expected to have different effects on REPs: entry barrier reduction and privatization. Finally, we modify the set of controls to better account for environmental preferences. In particular, following a simple median voter argument, citizens' willingness to pay for higher environmental quality depends on both the GDP per capita and income inequality. Because environmental quality is a normal good, wealthier households demand more stringent environmental policies (e.g., the literature on the environmental Kuznets curve, see Carson, 2010). In turn, for a given level of income per capita, a lower level of inequality implies a richer median voter and thus greater support for ambitious policies, as recent theoretical and empirical studies have shown (Magnani, 2000; Kempf and Rossignol, 2007; Vona and Patriarca, 2011). Besides looking at the effect of liberalization on REPs, our empirical analysis allows to compare this effect with the one of preferences for cleaner energy.

3. Empirical Protocol

3.1 Empirical Strategy

Exploiting the panel dimension of our data, we are interested in estimating the effect of an index of energy market regulation (PMR , or PMR_{ener}[5] when we wish to distinguish energy regulation from regulation in other sectors) on an indicator of REP commitment for country *i* at time *t*, conditional to a set of controls:

$$\mathrm{REP}_{\mathrm{it}} = \beta \mathrm{PMR}_{ener,\mathrm{it-1}} + \vartheta green_{\mathrm{it-1}} + \boldsymbol{\gamma}\mathbf{X}_{\mathbf{it-1}} + trend_i + \mu_i + \mu_t + \varepsilon_{it}. \quad (1)$$

We include country $\boldsymbol{\mu_i}$ and time effects $\boldsymbol{\mu_t}$ to eliminate, respectively, time-invariant unobservable factors affecting REP, such as wind and solar endowments, and common time shocks. The resulting unbalanced panel dataset includes 28 countries over the years 1979 to

[5] The index PMR_{ener} is the weighted average of the PMR_{elect} and PMR_{gas}. As renewable energy is mainly used to produce electricity, we weigh 0.75 PMR_{elect} and 0.25 PMR_{gas}. In what follows, we will show that our results do not change if we consider PMR_{elect}.

2007.[6] To be sure that the estimated effect of $\boldsymbol{PMR_{ener}}$ is not plagued by unobservable country attributes, (e.g., institutional quality) affecting both PMR and REPs, we also consider a demanding specification with country-specific time trend $(\boldsymbol{trend_i})$. This specification provides us a lower bound of our effects of interest. Finally, the right-hand-side variables are lagged one year to capture the retard in the effect of policy drivers.

Our second variable of interest is the share of votes for green parties in parliamentary elections.[7] We use this variable rather than, as in Jenner et al. (2012), a dummy equal to one since the year in which a solar association began. While we believe that our proxy for the green lobby is more general when all renewables are concerned, the inclusion of the solar dummy does not have any significant effect on the REP indicator (results available upon request). We acknowledge, however, that $\boldsymbol{green}$ is an imperfect proxy for green lobby. First, green parties are often heterogeneous across OECD countries; second, in the last two decades, they have been subject to an increasing lack of consensus and their platforms have been often absorbed by long-standing socialist or new democratic parties. A recent work by Cadoret and Padovano (2016), for instance, shows that governments supported by a left-wing majority promoted the adoption of REPs more than their right wing counterparts. Finally, the right- or left-wing orientation of the ruling parties may also have an influence in the liberalisation process. In order to account for these issues, we perform various checks proving the

[6] GDP is missing for the Czech Republic for 11 years and for the Slovak Republic for 8 years, the Gini coefficient is missing in Austria for two years, and in Switzerland for one year. Mexico and Turkey have been dropped from the original sample because of many missing values in $\boldsymbol{green}$ (share of green deputies in parliament).

[7] Data source: Armingeon et al. (2015), Comparative Political Data Set (CPDS).

robustness of our results to the inclusion of additional proxies of the country's political orientation.[8]

The vector of controls $\boldsymbol{X_{it-1}}$ is composed of variables that depict the evolution of preferences and other institutional constraints that are likely to affect REPs.[9] A first set of controls used in this study includes the usual proxy of the brown lobby, i.e., an index of the perception of corruption, and the three variables to account for environmental preferences, i.e., GDP per capita, its square and income inequality. A second set of controls includes three features of a country's energy system, i.e., the share of energy produced from nuclear power, energy dependency and the industrial energy consumption per capita as proxy of the energy intensity of the economy.[10] However, these three variables are likely to be affected by liberalization and weakly correlated with REPs, thus they are bad controls in the sense of Angrist and Pischke (2009). To cope with this issue, we measure these variables before the initial year of our analysis, i.e. 1979, and interact them with a time trend. The associated coefficients can be interpreted as the incidence of the initial characteristics of the country's energy system on REP adoption.

Combined with country fixed effects, our set of controls should in principle eliminate the time-varying sources of unobservable heterogeneity that affect both REPs and PMR_{ener}. However, there remain good reasons to believe that the effect PMR_{ener} is not estimated consistently because it remains correlated with future policy shocks ε_{it}. First, PMR_{ener} is an imperfect measure of the lobbying power of incumbents in the electricity sector because entry barriers are at least partially endogenous. If large utilities maintain sufficient market power to

[8] In particular, Table A6 controls for the votes to democratic parties in parliament; Table A7 controls for the percentage of social-democratic and other left parties in the cabinet (GOV LEFT); Table A8 for the share of left, social-democratic and center parties in the cabinet (GOV CENT).
[9] The data sources are standard and hence reported in Table 1. For our two main variables of interest, REPs and PMR, the data sources are discussed in greater details in the Appendix.
[10] Results are unchanged if we use total (residential and industrial) energy consumption per capita.

block the approval of REPs after liberalization, the coefficient associated with PMR_{ener} may be reduced in absolute terms as a result of successful and unsuccessful reductions in incumbents' market power. Second, reductions in entry barriers may be induced by certain REPs, such as FITs, that mandate the provision of priority access to the grid to energy produced from renewable sources. Therefore, after FITs are approved, the power of incumbents is *de facto* reduced, new green players enter the market, and the support for further reductions in entry barriers is stronger, which leads to a reverse causality problem.

Our IV strategy is designed to solve these potential sources of bias in the effect of PMR_{ener}. We argue that liberalizations are more likely to be successful and hence effective in reducing the market power of existing incumbents if an ambitious liberalization plan is pursued. The underlined politico-economic logic is that liberalizations are first carried out in sectors where the benefits clearly exceed the costs and then in sectors where the outcomes are more doubtful in terms of welfare (Høj et al. 2006). By way of example, the model of Blanchard and Giavazzi (2003) shows that labour market deregulation becomes more politically acceptable after product markets have been deregulated, which increases investments and employment opportunities. A similar argument applies to liberalization in telecommunication compared to the one in electricity, with the latter having less clear welfare effects.[11] The empirical analysis of Høj et al. (2006) provides evidence on the existence of these spillovers between product market reforms, especially in sectors that were deregulated later, such as electricity.[12]

[11] Høj et al. (2006) document the sequence of reform across sectors. Sectors characterized by elements of a natural monopoly such as electricity have been generally liberalized after sectors where new technologies allow for more competition (telecommunications) or the natural monopoly argument was simply absent (air transportation). An evaluation of the effect of liberalization on welfare is beyond the scope of this paper. The general consensus is that liberalization did not reduce electricity prices (e.g., Fiorio and Florio, 2013), but has a negative effect on energy R&D expenditures (e.g., Jamasb and Pollitt, 2008).

[12] A related argument is that partial liberalizations may have a completely different effect on REP than full liberalization. Chick (2011) and Pollitt (2012) suggest that partial liberalization is likely to emerge because governments wish to maintain their ability to subsidize favoured interest groups. In this case, an external

Provided that the incumbents (and in general all lobbies) in the energy sector do not have any influence on the liberalization process in other sectors, the bias in the estimated effect of energy market liberalization should disappear when we use other sectors' liberalizations as instruments for PMR_{ener}. Specifically, we use the instances of PMR in telecommunication because in most countries deregulation occurred earlier than in the energy sector and thus gave a positive initial push to the promotion of liberalizations in other sectors.

Our instrument fulfills the three crucial conditions for being a good instrument. First, it is exogenous provided that lobbies in the energy sector do not have any influence in the liberalization process of telecommunication. One can still argue that this condition is violated in presence of a political constituency that has strong interests in actively lobbying both in favour of renewable energy policies and against pro-market reforms in the telecommunication sector. As already anticipated, the only case of this kind is the one of a green party actively engaged against pro-market reforms in all sectors. This concern is, however, minimal as green parties are usually small and unlikely to devoted active effort in affecting regulation in sectors other than energy and highly polluting ones. In addition, any residual concern is by the inclusion of the green (and democratic) party electoral share in our empirical model. We believe that these arguments are strong enough to confidently consider deregulation in telecommunication as exogenous conditional to our set of controls, i.e. $E\left(\text{PMR}_{tel,it-1}, \varepsilon_{it} \middle| \mathbf{X_{it-1}}, green_{\text{it}-1}, \mu_i\right) = 0$. The second condition is that the instruments predict well the endogenous variable. Standard statistical tests confirm the strength (see Section 4) and exogeneity of our instruments (Appendix). Third, as shown in Figure 1, the sequence of liberalisations that we assume in our IV strategy is respected for 80% of the

instrument that captures a country's willingness to liberalize in other sectors should convey more information on the true level of regulation in the electricity sector than the observed measure of regulation in electricity.

countries included in the sample. The only exceptions are: Ireland, Norway, Portugal, Spain and Switzerland, where the energy market was liberalised together with telecommunications. In Appendix 5 we test the robustness of our results by re-estimating our favourite specifications of Table 3 for a sub-sample which excludes these five countries. Results are consistent with the findings of Section 4 (See Table A9). Before presenting the main results of the paper, the next sub-section describes the policy indicators we use to measure a country's commitment to RE.

[FIGURE 1 ABOUT HERE]

3.2 Policy Indicators

In the case of renewable energy, both theory and empirical evidence provide strong support for the use of a diversified policy portfolio rather than a specific policy instrument. In particular, a diversified policy portfolio is the best way to target the multiple externalities associated with RE (e.g., Fisher and Newell 2008, Acemoglu et al. 2012). Midttun and Gautesen (2007) show that the combination of RECs, FITs and R&D subsidies is the best means of managing technology at a different level of maturity, while Nesta et al. (2014) suggest that each policy often targets a specific actor (i.e., RECs for large incumbents, FITs for small plants, investment incentives for specialized suppliers of electric equipment).

Figure 2 presents a visual snapshot of the degree of policy heterogeneity in the International Energy Agency (IEA) dataset by detailing the types of policies applied in various countries. As is evident from the figure, policy diversification increased substantially over time because previous policies were often maintained in conjunction with new ones.[13] 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 RE. As a further complication, the IEA dataset provides information on only the year of adoption of a specific policy and not on the degree of intensity of the adopted policy. We thus integrate this dataset using other data sources in all cases for which policies measured on a continuous scale are available. Intensity measures are available for the following three instruments: public R&D expenditures in renewable energy, FITs and RECs (see Table 1 for a full description of the policies and data sources). [14]

[TABLE 1 ABOUT HERE]

[FIGURE 2 HERE]

To offer a complete picture of a country's commitment to RE, we build an indicator that consider both the signalling effect of policy dummies and the stringency of continuous policies. Previous research on policy indicators attempts to cope with heterogeneous information through the use of a variety of weighting schemes and aggregation methods.[15] Following Esty and Porter (2005), our favourite indicator is based on the robust and widely used technique of principal component analysis (PCA henceforth). PCA is interesting due to its ability to extract a small number of orthogonal sub-indexes (called principal components,

[13] As expected, Figure 1 also shows that the two main policy drivers of RE occurred in the 1970s (i.e. oil crises) and especially from the mid-1990s on (i.e. Kyoto protocol). This phenomenon justifies the inclusion of time effects in our econometric specification to capture these common shocks.

[14] Notice that in some countries, notably the US and Canada, environmental policies differ across states. Although the variables we employed in the analysis have been calculated as weighted average of state policies, the measure of REP commitment is likely to be affected by measurement error (weights are each state's share of total national electricity consumption, as in Johstone et al., 2010). The study of the determinants of state level environmental policies, despite interesting, is beyond the scope of this work, and left to further research.

[15] For instance, Dasgupta et al. (2001) assign weights to each policy on a Likert scale that is built by converting the responses provided to specific questions in the survey into numeric values. See also Mazzanti and Zoboli (2009) for waste policies and Galeotti et al. (2018) for energy efficient policies.

PCs). The PCs are linear combinations of the wider set of original variables that maximize the explained covariance of the data. In our case, we construct our preferred PCA indicator (REP_fact) using the three available continuous policies (FITs, RECs and public R&D) and six dummy variables for the other policy instruments (see Table 1). The analysis produces three relevant PCs that together explain approximately 65% of the policy variance. Interesting, each relevant PC reflects a different policy-type, i.e., quantity, price and innovation (Menanteau et al., 2003), and has been used to construct REP_fact by taking the simple mean.

To mitigate concerns about the validity of the PCA used to construct our preferred indicator, we conduct extensive robustness checks of our results by using two different aggregation methods. Our second-favourite indicator (REP_poly) was developed by Kolenikov and Angeles (2009) to generalize PCA when both discrete and continuous variables are present. This method derives the correlation matrix used to build the PCA by estimating the latent continuous variable that corresponds to each discrete or categorical variable. Accordingly, the first PC explains a greater share of the variance compared to a standard PCA (58% in our case) and is the only one we use to build the second indicator: REP_poly. However, the first PC obtained with the Kolenikov and Angeles's procedure has no clear economic interpretation, and thus we prefer to retain a traditional PCA for our favourite indicator. The third indicator (REP_div) rewards policy diversity and is the sum of policy dummies, which take the value 1 if any policy is adopted, including the one for which we have continuous information. The simple justification of REP_div is that because each policy generally targets a different actor, policy diversification reflects a country's commitment to RE (see Nesta et al., 2014). Finally, we consider two continuous policies that received particular attention in the debate: feedin tariffs in support of solar and wind energy (the two most promising renewable sources) and public R&D per capita. We do not consider RECs, the other policy for which we have intensity, because it has very little time variation.

[TABLE 2 ABOUT HERE]

[FIGURE 3 and 4 ABOUT HERE]

Descriptive statistics for the main variables used in the analysis are presented in Table 2, while the evolution of REP_fact and PMR_{ener} is depicted in Figure 3 for selected countries. The REP_fact indicator displays a monotonically increasing pattern, while PMR_{ener} tends to converge towards very low values almost everywhere, which depicts the widespread liberalization process.

Figure 4 presents a cross country comparison of REP_fact for selected years. As expected, Scandinavian and, to a lesser extent, Central European countries show a persistently higher policy support, but the indicator displays a monotonically increasing pattern nearly everywhere. From Figures 1 and 4, it also appears evident that the two main policy pushes occurred in the 1970s and especially from the mid-1990s on. The two oil crises of the 1970s stimulated policy responses in almost all developed countries, whereas an abrupt halt in the expansion of these policies occurred when oil prices began to decline in the early 1980s. Finally, a second wave of REP was implemented in the 1990s in response to increasing concerns related to climate change mitigation.

This preliminary unconditional evidence reinforces our expectation about the positive effect of market liberalization on the adoption of REPs. For instance, Scandinavian and Anglo-Saxon countries lead the process of market liberalization and have persistently high

REP policy support, while transition economies are generally characterised by lower policy levels and a less liberalized energy market.

The Appendix provides further details on the construction of the indicators, the country rankings for the three policy indicators, their cross-correlations and their correlation with an external policy indicator of sustainable development.

4. Analysis

4.1 Main Results

Table 3 reports the main results for our preferred indicator, REP_fact. For the sake of comparison, the policy indicators are standardized to have a mean of 0 and a unitary standard deviation.

Column 1 presents the FE model as in equation (1). The first important result concerns the effect of energy market liberalisation on renewable energy policies. Our point estimate of PMR_{ener} shows that a more stringent regulation of energy markets has a negative and significant influence on REPs. In line with previous evidence, large utilities contrast the approval of ambitious REPs to retain their *raison d'etre*, which is intimately related to centralized energy production. Second, our estimates unravel a positive correlation between the green party's share and the adoption of ambitious REPs. This result is not so obvious given the inclusion of variables correlated with the green share, such as inequality, energy dependency or corruption.

Before presenting the main IV results, it is interesting to briefly discuss the effect of the other controls. It is worth noting that they all have also the expected effects on REP. The positive coefficient for the corruption index implies that institutional quality has a positive effect on REPs. The combined effect of GDP per capita and its square is positive and significant, as it is positive the one of lowering inequality. To reiterate our previous argument, if environmental quality is a normal good, policies that support it should be more ambitious in richer countries. In turn, conditional on a country's wealth, a lower inequality implies a more affluent median voter and thus an increased support for REPs. Finally, higher initial levels of energy dependency and share of nuclear power represent positive stimuli for the development of RE, while a higher initial energy use per capita is negative correlated with the future development of REPs, possibly reflecting a country's comparative advantage in energy intensity production. Note that the positive effect for initial nuclear share is likely to reflect a political reaction to the Chernobyl accident.

[TABLE 3 ABOUT HERE]

Column 2 presents our favourite specification where we instrument PMR in energy with the PMR in telecommunication. The chosen instrument has the expected signs and a high explanatory power (the F-test for the first stage is 114.7, which is well above the usual cut-off level of 10, Stock et al., 2002).[16] When comparing the results of Columns 1 and 2, the effect of liberalising the electricity market appears larger in the IV specification. This finding suggests that PMR is positively correlated with an unobservable factor that dampers the public support for renewable energy policies. Such a bias may be due to the fact that an exogenous index of regulation understates the lobbying power of incumbents in highly concentrated sectors such as energy. As would be expected, the effect of liberalization is

[16] See Table A4 in the Appendix for detail on the first stage results. Table A5 also in the Appendix replicates Table 3 adding PMR in roads as additional exclusion restriction to compute the Hansen exogeneity test. The p-values of the Hansen test presented there corroborate our theoretical claim on the exogeneity of our instruments.

larger when the commitment of public authorities to liberalization is more credible and widespread across sectors.

We evaluate the magnitude of our effect of interest using coefficients estimated through the specification of Column 2, which -we contend- offers the most accurate representation of the factors that affect REPs. Because the two variables of interest, REP_fact and PMR, are indexes, our preferred metric for quantification is an inter-quartile change. First, the inter-quartile increase in REP_fact explained by an inter-quartile decrease in PMR is about two third (i.e. 0.63). To provide a concrete example of this effect, Greece and Czech Republic would have ranked just below United States in REP_fact with an energy market, on average, regulated to the same extent as the German one (see Table 2A in the Appendix). Second, green shows a relatively smaller effect with an IQR increase in the green share generating a modest 0.12 IQR change in REP_fact. Third, the remaining variables also have a considerable influence on REP_fact and especially GDP_pc. The explained inter-quartile deviation is 1.52 for GDP_pc, 0.25 for inequality and for the index of corruption. Note that the good scores of Nordic countries in terms of inequality and corruption explain a large fraction of their high scores in REPs.

Column 3 addresses the issue of unobservable time-varying institutional factors potentially affecting both PMR_{ener} and REP_fact by including country-specific time trend. Because these trends capture most of the within country variation in the dependent variable, the precision of the estimated coefficients should decline across the board. Given this exceedingly stringent conditions imposed for the identification of the effects of interest, it is thus worth to emphasize that PMR_{ener} is one of the few variables that remains nearly significant at conventional levels (p-value=0.133). In turn, the effects of most other variables disappear including the one of the green share. However, since including these trends does not allow to retrieve a precise estimate for all our effects of interest, the specification in Column 2 remains favourite and we consider the estimates obtained through specification in Colum 3 as a lower bound for the PMR effect. Even considering this lower bound, an IQR increase in PMR would still generate an IQR change in REP by 0.24 IQR, which corresponds to the difference between Spain and Austria.

Columns 4 and 5 replicate Columns 2 and 3 using PMR in electricity rather than in energy. This addresses the potential concern that renewable energies are mostly used for electricity generation and thus that liberalisations in electricity capture the bulk of the PMR effect. In fact, this is what happens: comparing Columns (4) and (2) the effect of PMR is only reduced by 18.5%. Similar reductions in the PMR effects are obtained in the comparison for the highly demanding specification with country trend, i.e. Columns (3) and (5). In sum, the effect of liberalization in electricity captures the bulk of the PMR effect, but also the conditions in the gas market affects the political willingness to adopt ambitious RE policies.

4.2 Various Features of the Liberalization Process

The design of liberalizations varies substantially across countries and is the result of three distinct processes: granting freedom of access and choice to producers and consumers, privatising public utilities and unbundling network services from power generation. Table 4 assesses which particular component of the liberalization process creates a friendlier environment for REPs, focussing in particular on the effects of entry barrier reductions and privatization for which we have clearer theoretical expectations. We use analogous components of the regulatory indexes in telecommunication as exclusion restrictions for PMR_{entry} and $PMR_{public\ own}$.

In relation to the discussion of section 2, observe that, conditional on $PMR_{public\ own}$ (which captures large-scale privatization), a lower PMR_{entry} implies the entry of small players such as municipalities, independent power producers, cooperatives and households that have favoured the emergence of lobbies supporting renewable energies. These small players are often classified as public enterprises (or joint ventures private-public). On the other hand, the mere privatization of energy utilities, i.e. the replacement of a large public monopoly with few private companies, may have reduced or left unchanged the support for REPs. Therefore, we expect that a country with a low PMR_{entry} and a high $PMR_{public\ own}$ (like Sweden, Denmark or the Netherlands) is more keen to adopt RE policies than a country with a low PMR_{entry} and a small $PMR_{public\ own}$ (like Spain or Belgium). However, following the discussion of section 2, this interpretation should be taken with caution as we cannot observe the effective size and characteristics of new entrants.

[TABLE 4 ABOUT HERE]

We report in Table 4 regression results for Columns 1 and 2 of Table 3, associated with the different components of the PMR index estimated alone (Columns 1 to 4) and jointly (Columns 5 and 6). The picture that emerges is fairly clear. The effect of liberalization is fully driven by reductions in entry barriers, while privatisation is never statistically significant. The effects are again economically meaningful: if Canada had the same level of entry regulation as Sweden, it would have climbed 11 positions in the REP_fact's ranking, reaching a level similar to that of Germany (see the ranking of Table A2).[17]

To recap, a reduction in the monopolistic power of state-owned utilities has a positive effect on REPs when various types of actors are ensured access to the grid instead of it being

[17] More formally, a change from the 3rd to the 1st quartile in PMR_{entry} explains about 0.5 IQR in REP_fact.

provided to only a few large private firms. For instance, Sweden, Denmark and, to a lesser extent, the Netherlands are well recognized as having low entry barriers for small players, strong public ownership and ambitious REPs (Pollitt, 2012).

4.3 Different Policy Indicators

Absent a widely accepted methodology to aggregate heterogeneous policies, one may argue that REP_fact imperfectly describes policy support for RE. We thus re-estimate Column 6 of Table 4 using the alternative indicators described in Section 3.2.

[TABLE 5 ABOUT HERE]

For the sake of comparison, column 1 presents the benchmark results for REP_fact. Results are qualitatively unchanged when we use either REP_poly, which is the indicator that maximizes the share of the variance explained by the first PC (column 2), or REP_div that rewards policy diversification (column 3). For both these alternative indicators, the effects of GDP_pc decrease by about a half compared to the benchmark, while the effect of inequality declines considerably for REP_poly and the one of corruption for REP_div. Observe also that countries with lower initial energy consumption per capita have a stronger support to RE policies, irrespective of the indicator used.

The second part of Table 4 addresses the issue of specific RE policies, i.e. feed-in tariffs in wind and solar (column 4), only solar (column 5) and public R&D in support of RE per capita (column 6). In comparison with column 1, the effect of PMR_{entry} is stronger on feed-in tariffs than on other REPs (feed-in tariffs are also standardized for sake of comparison). Interestingly, our results for feedin tariffs indicate that the positive and significant effect of lowering entry barriers is partially offset by a negative and significant effect of privatization.

Because feed-in tariffs have a strong effect on renewable energy innovations (Johnstone et al. 2010), this result lends support to the idea that the incumbents' opposition to REPs is linked to technological competition (e.g., Dosi, 1982). Results in column 6 confirm previous findings on the negative effect of liberalization on public R&D expenditures (Jamasb and Pollitt, 2008). This result resonates with the classical appropriability effect of competition on innovation and suggests the existence of complex trade-offs in the effect of liberalization on renewable energy innovation (see Popp, 2006; Jamasb and Pollitt, 2008).

4.4 Persistency in Renewable Energy Policies

Renewable energy policies are changing slowly over time and display high persistency with an estimated autoregressive coefficient of approximately 1. This finding does not come unexpectedly, as past decisions to implement REPs affect the present behaviour of policy makers through learning and lobby formation. However, accounting for dynamics is not straightforward in our case because we must address the endogeneity of both the lagged dependent variable and our main variable of interest (Nickell, 1981).

We propose two methodologies to address these issues. First, we include the lagged REP among the covariates. To fix endogeneity for the lagged dependent variable, we use its own lags and lagged differences as instruments, and PMR is instrumented as above. However, our external instruments for PMR become weaker in this dynamic setting. We thus propose a second, preferred approach to consider dynamics. In particular, we take the five-year average and then first-difference our variables of interest. Our main specification is thus re-estimated for this shorter 5-year panel using the differenced-PMR in telecommunication as instrument for the differenced-PMR in energy. This methodological choice is validated by the fact that the 5-year averaged REP index, conditioned to time effects, does not display serial correlation. In both cases we estimate our favourite specification (i.e. Column 2 of Table 3).

Column 1 of Table 6 presents the first approach. The point estimates are qualitatively similar to those of the static specification, although all the effects are remarkably smaller than the point estimates of Column 2 in Table 3. Note however that in this case, the point estimates should be interpreted as short-term effects. The long-term effects are instead nine times larger, and a persistent interquartile reduction of PMR_{ener} triggers a considerable interquartile increase of 2.3 in REP_fact.

Column 2 presents the results for the alternative first-difference 2SLS estimator. Observe first that the main results are qualitatively unchanged. Obtaining this result in a first-difference specification further corroborates our causal interpretation of the effect of PMR on REP. Among the other effects, the share of greens and inequality are far from being statistically significant. To summarize, we may conclude that liberalization, GDP_pc, corruption and initial electricity consumption are the four variables that remain significant determinants of REPs in these demanding dynamic specifications.

[TABLE 6 ABOUT HERE]

5. Conclusions

The recent academic debate has stressed how pressure from the energy-intensive industries (Cadoret and Padovano, 2016) and corruption (Zhang et al., 2016) provide a significant resistance to the adoption of energy and environmental policies, thus hindering the deployment of renewables. Contextually, Cadoret and Padovano (2016) have shown that political ideology plays a role, and left-wing government are more likely to promote REPs.

Against this backdrop, we investigate the effect of energy market liberalization on REPs's adoption, building a new aggregate indicator of RE policy support. 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 energy market liberalization has a positive and perhaps unintended impact on REPs. Remarkably, the effect of PMR is the second largest after that of GDP_pc, with an interquartile decrease in PMR explaining roughly 2/3 of an interquartile increase in our favourite REP indicator. Considering the effects of inequality, corruption and green lobbying, our results suggest that a hybrid politico-economic model, where both citizens' preferences and lobbying power are important, offers the most accurate explanation of REP determinants.

To provide a more transparent interpretation of the effect of liberalization, we split the PMR index into its components and find that a reduction in entry barriers mostly captures the effect of PMR on REP. This finding suggests that a reduction in the monopolistic power of state-owned utilities has a positive effect on REPs when various types of actors are ensured access to the grid instead of it being provided to only a few large private firms. We are inclined to explain this finding with the competition between two rival technological paradigms. The development of RE will increase decentralized and small-scale energy production and thus reduce the profits of large-scale generators, which fuels their opposition to REPs.

Our results are important for future and on-going research on energy markets. First, assessments of the effect of liberalization on energy prices may be incomplete and misleading when not accounting for REPs as long as the cost of these policies are, at least partially, passed to consumers and REPs are affected by the liberalization. Second, the welfare consequences of both liberalizations and REPs should be jointly assessed by accounting for the interaction highlighted by our paper. The explicit inclusion of these effects in energy modelling seems a promising avenue for illustrating the trade-offs between various objectives, i.e., energy security vs. price reductions, and the full consequences of specific market reforms. This is especially relevant in Europe, where the creation a fully integrated energy market is one the pillar of the Energy Union, and liberalisations represented an essential step in this direction.

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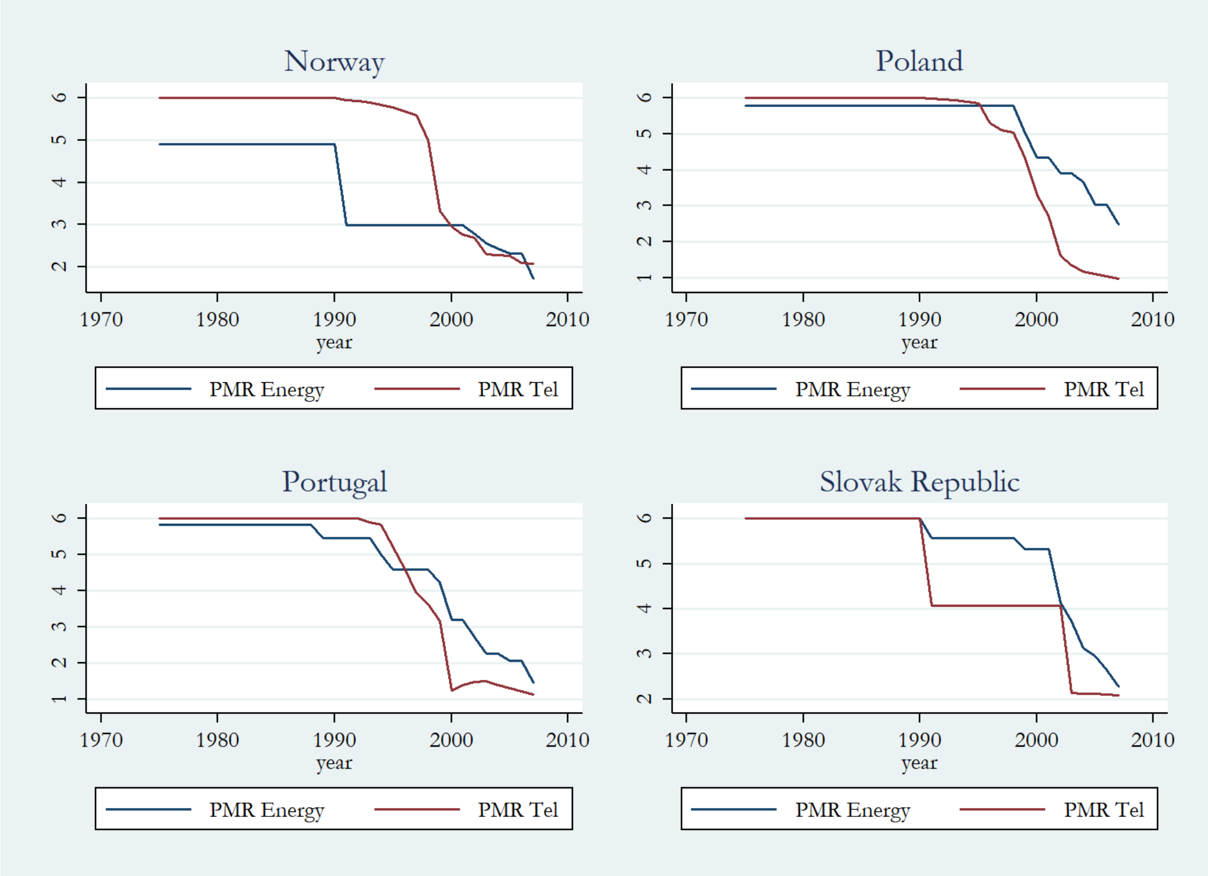
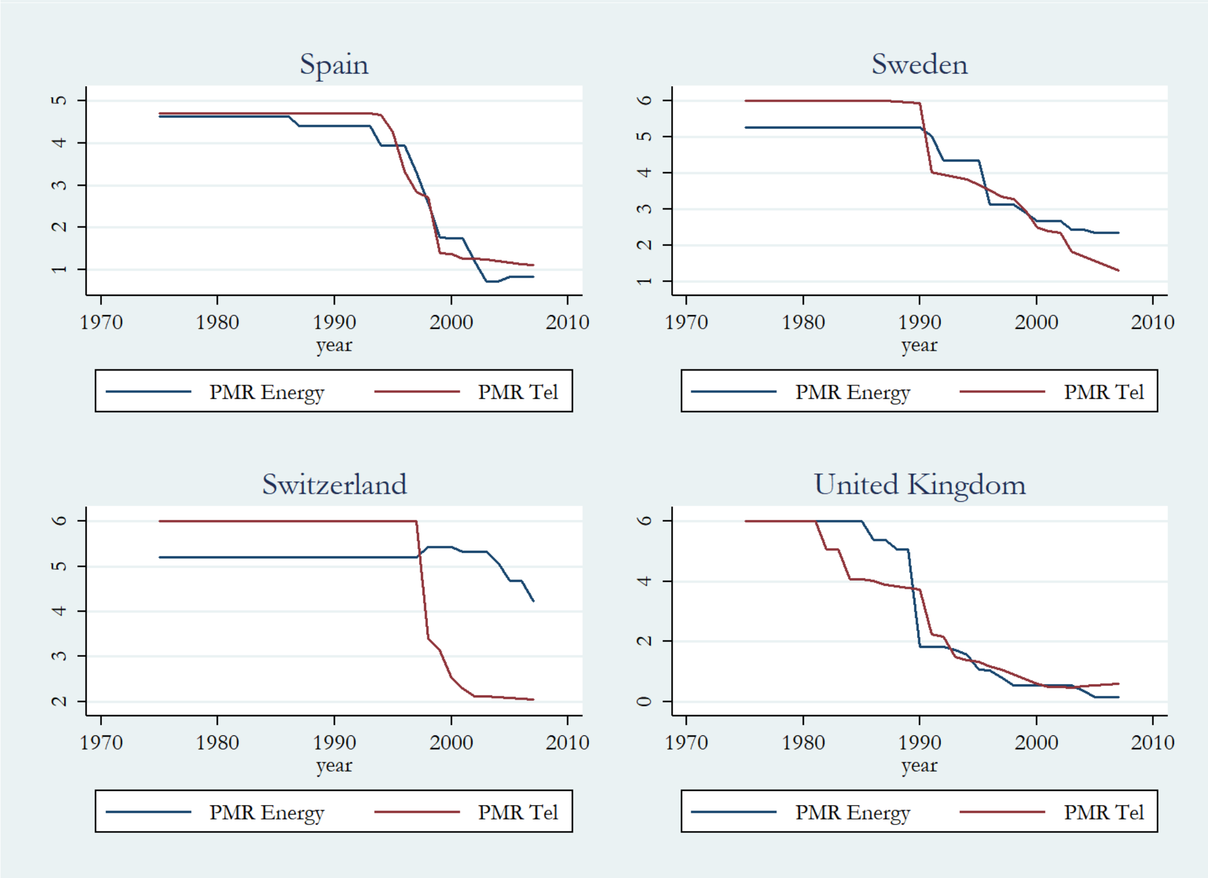
Figure 1. Sequencing of liberalisation. Product Market Regulation in the energy sector (PMR_{ener}) and in telecommunication (PMR_{tel}).


Germany
Greece
Hungary
Ireland
Italy
Japan
Netherlands
New Zealand
1 2 3 4 5 6
1970 1980 1990 2000 2010
year
PMR Energy
PMR Tel


Norway
Poland
Portugal
Slovak Republic
1970 1980 1990 2000 2010
year
PMR Energy
PMR Tel


Spain
Sweden
Switzerland
United Kingdom
1970 1980 1990 2000 2010
year
PMR Energy
PMR Tel

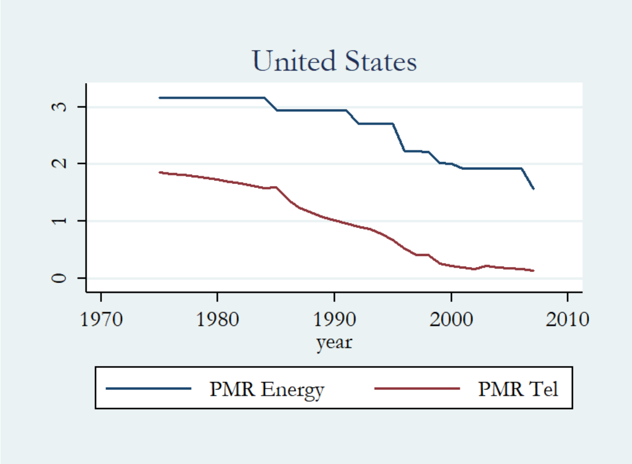
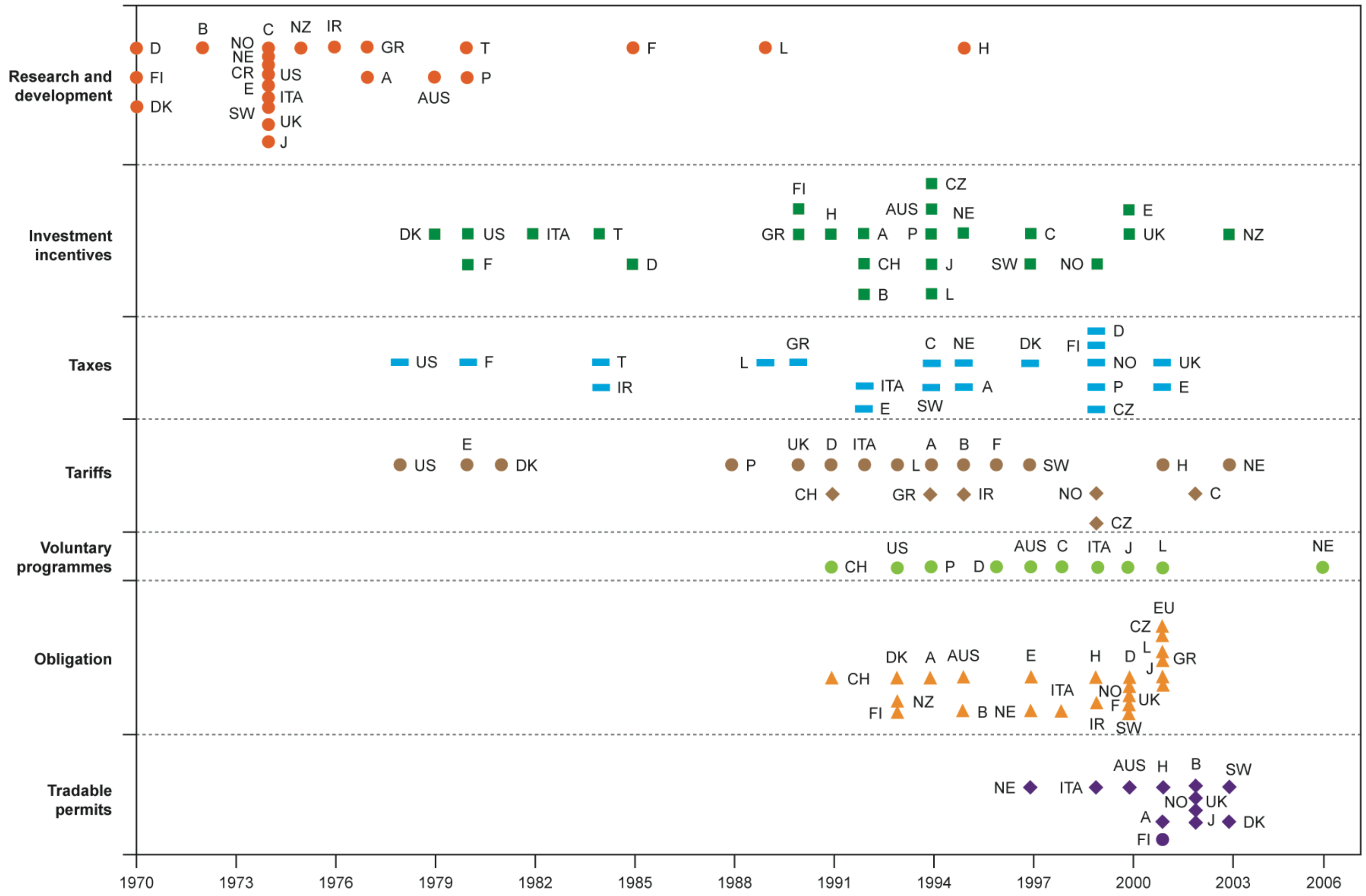

United States
3
2
1
0
1970
1980
1990
2000
2010
year
PMR Energy
PMR Tel

Figure 2. Patterns of policy adoption in selected OECD countries.



Source: IEA (2004) and www.ren21.net 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 3. Evolution of Product Market Regulation in the Electricity sector and the main renewable energy policy indicator (REP_fact) between 1980 and 2007 in Large Countries (left panel) and Small Countries (right panel).

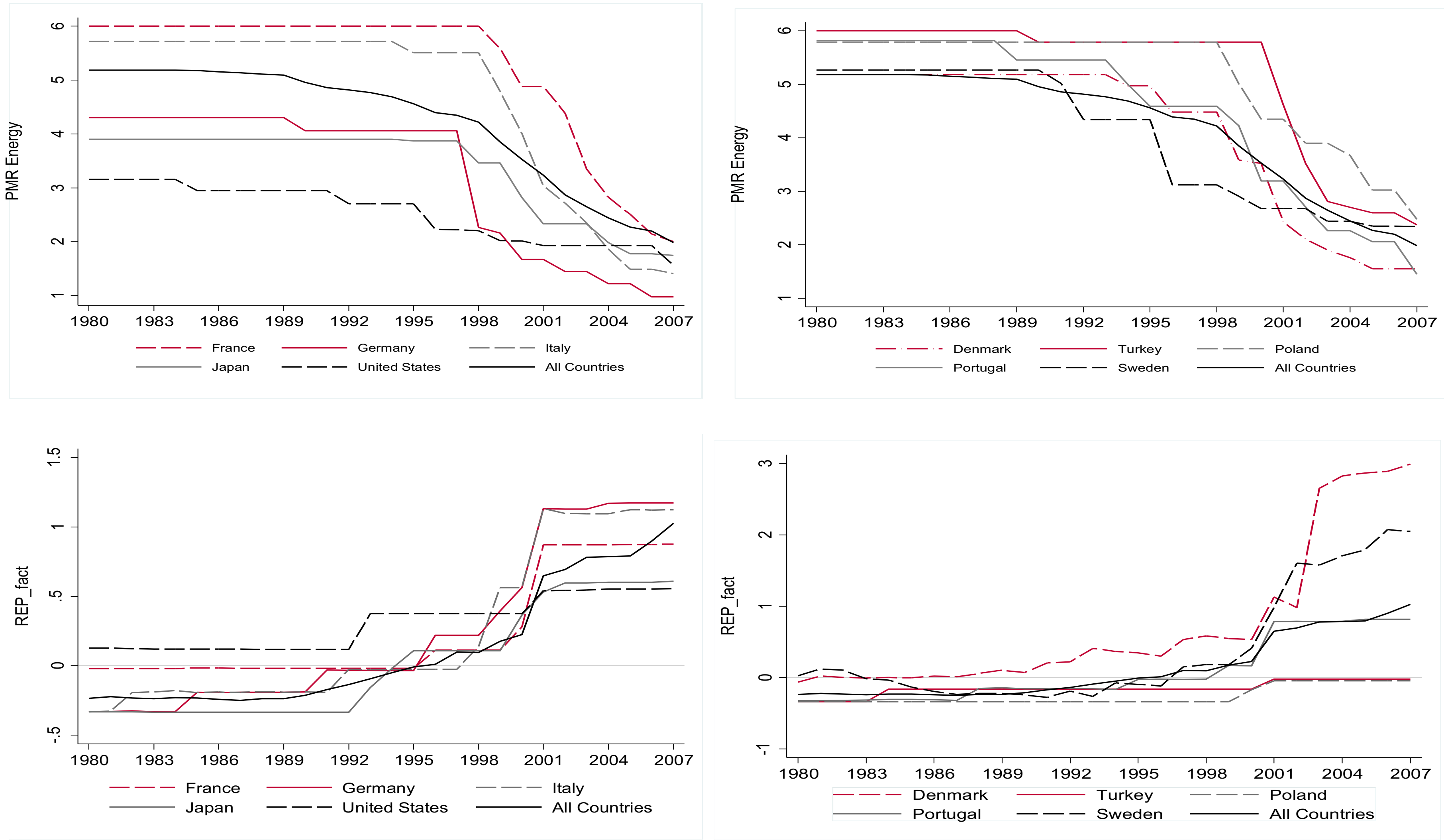


Figure 4. Cross-country comparison of the main renewable energy policy indicator (REP_fact).

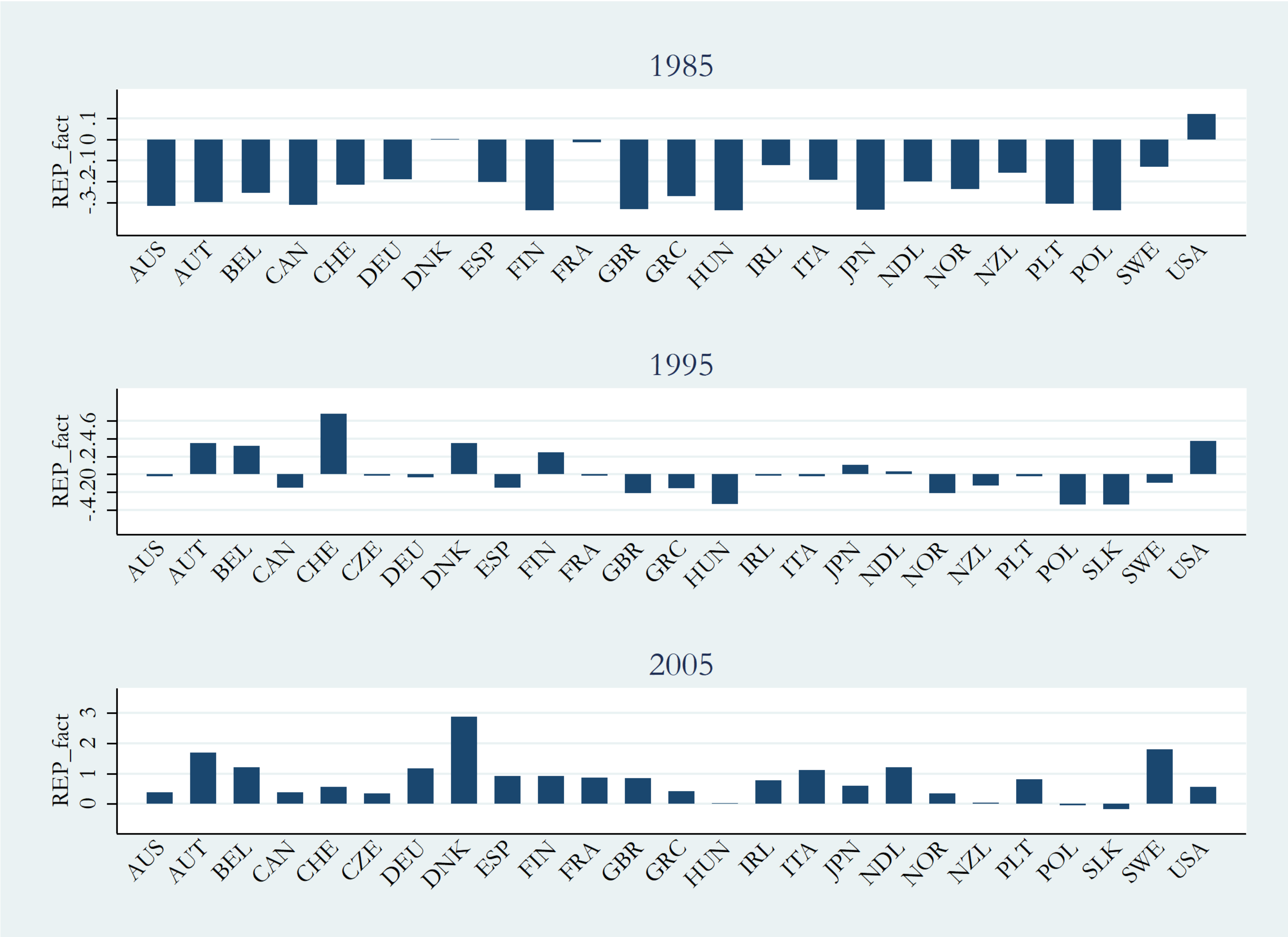


Table 1. Summary of the individual REP policies.

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. 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 REN21 Database (www.ren21.net)
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 REN21 Database (www.ren21.net) Country Specific sources
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. Descriptive statistics and sources.

Acronym	Description	Obs.	Mean	St. Dev.	Min	Max	Source
REP_fact	Policy index based on principal component analysis (standardized in the analysis)	677	0.12	0.54	-0.3	3	IEA
REP_poly	Policy index based on polychoric principal component analysis (standardized in the analysis)	677	0.47	1.53	-1.0	5	IEA
REP_div	Policy index based on dummy variables (standardized in the analysis)	677	2.55	1.91	0.0	7	IEA
REP_price	Feed-in tariffs in wind and solar (standardized in the analysis)	677	0.03	0.07	0.0	0	IEA
REP_inno	Public R&D in support of RE per capita (standardized in the analysis)	677	0.00	0.00	0.0	0	IEA
REP_price solar	Feed-in tariffs in solar (standardized in the analysis)	677	0.04	0.11	0.0	1	IEA
GDP_pc	GDP per capita, thousands US 1990 Dollars, ppp. (Missing data for Czech and Slovak republic before 1990)	677	25.05	8.17	7.2	51	OECD
INEQ	Gini Coefficient (Missing data for Austria and Switzerland before 1980)	677	28.32	4.32	15.1	37	SWIID
CORR	Corruption index that ranges from 0 (highly corrupt) to 10 (highly clean)	677	7.27	1.81	1.5	10	World Resource Institute dataset
PMR_{ener}	Product Market regulation in the energy sector (0.75* PMR_{elec} + 0.25* PMR_{gas})	677	4.07	1.51	0.1	6	OECD
$PMR_{ener\ entry}$	Product Market regulation in the energy sector sub-index: Entry barriers (0.75* $PMR_{elec\ entry}$ + 0.25* $PMR_{gas\ entry}$)	677	4.07	2.15	0.0	6	OECD
$PMR_{ener\ public\ own}$	Product Market regulation in the energy sector sub-index: Public ownership (0.75* $PMR_{elec\ public\ own}$ + 0.25* $PMR_{gas\ public\ own}$)	677	3.88	1.80	0.0	6	OECD
PMR_{elec}	Product Market regulation in the electricity sector	677	4.17	1.75	0.0	6	OECD
GREEN	Share of green deputies in parliament	677	1.52	2.72	0.0	13	Comparative Political Data Set I
SOCIAL	Share of votes of the party classified as social-democratic	584	27.06	14.69	0.0	51	Comparative Political Data Set I
GOV LEFT	Social-democratic and other left parties in percentage of total cabinet posts, weighted by days.	584	36.01	39.15	0.0	100	Comparative Political Data Set I
GOV RIGHT	Centre parties in percentage of total cabinet posts, weighted by days.	584	21.88	30.15	0.0	100	Comparative Political Data Set I
EN_DEP	Energy imports, net (% of energy use). Initial value*trend in the analysis.	677	14.09	131.49	-842.4	95	IEA
NUKE	Electricity production from nuclear sources (% of total). Initial value*trend in the analysis.	677	19.06	21.12	0.0	79	World bank
ELEC_CONS	Industrial electricity consumption per capita. (Gxh). Initial value*trend in the analysis.	677	3.03	2.26	0.8	11	IEA
PMR_{tel}	Product market regulation in Telecommunications	677	3.84	2.06	0.1	6	OECD
$PMR_{entry\ tel}$	Product market regulation in Telecommunications sub-index: Entry barriers	677	3.18	2.79	0.0	6	OECD
$PMR_{public\ own\ tel}$	Product market regulation in Telecommunications sub-index: Public ownership	677	3.65	2.44	0.0	6	OECD

Table 3. Effect of Product Market Regulation on Renewable Energy Policies, dependent variable: REP_fact.

Specification	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
$PMR_{ener\,-1}$	-0.1823*	-0.2470***	-0.0919		
	(0.0902)	(0.0559)	(0.0612)		
$PMR_{elec\,-1}$				-0.2018***	-0.0749
				(0.0479)	(0.0505)
GREEN $_{-1}$	0.0441	0.0456***	-0.0020	0.0406***	-0.0017
	(0.0269)	(0.0098)	(0.0093)	(0.0102)	(0.0094)
GDP_pc $_{-1}$	-0.1411	-0.1583***	-0.0967***	-0.1585***	-0.0981***
	(0.0833)	(0.0352)	(0.0215)	(0.0353)	(0.0221)
Squared GDP_pc $_{-1}$	0.0030**	0.0032***	0.0020***	0.0032***	0.0020***
	(0.0014)	(0.0006)	(0.0005)	(0.0006)	(0.0005)
INEQ $_{-1}$	-0.0335**	-0.0367***	0.0038	-0.0390***	0.0029
	(0.0159)	(0.0093)	(0.0093)	(0.0098)	(0.0095)
CORR $_{-1}$	0.0730*	0.0594***	0.0155	0.0599***	0.0178
	(0.0366)	(0.0183)	(0.0166)	(0.0185)	(0.0166)
EN_DEP	0.0005***	0.0005***	-0.0018	0.0005***	-0.0021
	(0.0002)	(0.0001)	(0.0077)	(0.0001)	(0.0077)
NUKE	0.0444	0.0353	1.0187	0.0620	1.2252
	(0.1597)	(0.0630)	(3.7097)	(0.0632)	(3.7064)
ELEC_CONS	-0.0061	-0.0061***	-0.0347**	-0.0065***	-0.0374**
	(0.0043)	(0.0018)	(0.0157)	(0.0018)	(0.0150)
N	677	677	677	677	677
Number of countries	25	25	25	25	25
F First step		114.82	102.12	110.16	75.83
Country-trend	No	No	Yes	No	Yes

Notes: In Models 2 to 5 we use PMR in telecommunication as instrument for respectively PMR_{ener} and PMR_{elect}. Details on the first-stage results are available in the Appendix. All regressions include year and country effects. Standard errors are clustered by country. Significant levels: * 10%, ** 5%, *** 1%.

Table 4. Effect of different components of PMR on REP_fact. All columns present results estimated using Model 1 and 2 of Table 3.

Specification	(1)	(2)	(3)	(4)	(5)	(6)
$PMR_{entry\ -1}$	-0.1051**	-0.1253**			-0.1067**	-0.1195*
	(0.0434)	(0.0571)			(0.0402)	(0.0626)
$PMR_{publ\ own\ -1}$			-0.0281	-0.0918	0.0090	-0.0280
			(0.0566)	(0.0577)	(0.0427)	(0.0665)
$GREEN_{-1}$	0.0418	0.0421***	0.0410	0.0429***	0.0415	0.0429***
	(0.0267)	(0.0100)	(0.0282)	(0.0106)	(0.0266)	(0.0102)
GDP_pc_{-1}	-0.1158	-0.1203***	-0.0998	-0.1165***	-0.1138	-0.1263***
	(0.0796)	(0.0339)	(0.0938)	(0.0379)	(0.0814)	(0.0350)
Squared GDP_pc_{-1}	0.0025*	0.0026***	0.0024	0.0027***	0.0025*	0.0027***
	(0.0013)	(0.0005)	(0.0015)	(0.0006)	(0.0013)	(0.0006)
$INEQ_{-1}$	-0.0298*	-0.0308***	-0.0264	-0.0311***	-0.0292	-0.0325***
	(0.0163)	(0.0095)	(0.0179)	(0.0108)	(0.0171)	(0.0105)
$CORR_{-1}$	0.0831**	0.0777***	0.1071***	0.0976***	0.0840**	0.0751***
	(0.0352)	(0.0220)	(0.0361)	(0.0181)	(0.0364)	(0.0204)
EN_DEP	0.0005***	0.0005***	0.0005**	0.0005***	0.0005***	0.0005***
	(0.0002)	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0001)
NUKE	0.0643	0.0632	0.0587	0.0330	0.0678	0.0522
	(0.1543)	(0.0639)	(0.1901)	(0.0722)	(0.1633)	(0.0684)
ELEC_CONS	-0.0066	-0.0067***	-0.0058	-0.0056***	-0.0066	-0.0066***
	(0.0040)	(0.0018)	(0.0044)	(0.0019)	(0.0040)	(0.0018)
N	677	677	677	677	677	677
Number of countries	25	25	25	25	25	25
F First step		43.88		57.61		17.31

Notes: We use PMR in telecommunication (entry and public ownership) as instrument for PMR_{entry} and $PMR_{publ\ own}$ in Models 2, 4 and 6. All regressions include year and country effects. Standard errors clustered by country. Significant levels: * 10%, ** 5%, *** 1%.

Table 5: Effect of different components of PMR on different REP indicators.

Dependent Variable	**REP_fact**	**REP_poly**	**REP_div**	**REP_price**	**REP_price solar**	**REP_inno**
$PMR_{entry\ -1}$	-0.1195*	-0.1341**	-0.1081*	-0.2656*	-0.3557**	0.1036***
	(0.0626)	(0.0655)	(0.0621)	(0.1497)	(0.1461)	(0.0372)
$PMR_{publ\ own\ -1}$	-0.0280	0.0623	-0.0415	0.4624***	0.5262***	-0.0581
	(0.0665)	(0.0648)	(0.0620)	(0.1587)	(0.1551)	(0.0389)
$GREEN_{-1}$	0.0429***	0.0598***	0.0415***	0.0518**	0.0506**	0.0087
	(0.0102)	(0.0114)	(0.0113)	(0.0255)	(0.0242)	(0.0061)
GDP_pc_{-1}	-0.1263***	-0.0524*	-0.0528*	0.1644**	0.1602**	-0.0100
	(0.0350)	(0.0307)	(0.0301)	(0.0768)	(0.0741)	(0.0199)
Squared GDP_pc_{-1}	0.0027***	0.0011**	0.0013***	-0.0038***	-0.0037***	0.0005
	(0.0006)	(0.0005)	(0.0005)	(0.0013)	(0.0012)	(0.0003)
$INEQ_{-1}$	-0.0325***	-0.0209**	-0.0327***	0.0145	0.0328	-0.0126***
	(0.0105)	(0.0098)	(0.0091)	(0.0211)	(0.0201)	(0.0047)
$CORR_{-1}$	0.0751***	0.0480**	-0.0172	0.0270	0.0841	0.0368***
	(0.0204)	(0.0237)	(0.0220)	(0.0621)	(0.0586)	(0.0132)
EN_DEP	0.0005***	0.0003***	0.0004***	0.0001	0.0000	0.0001**
	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0000)
NUKE	0.0522	0.1923***	0.1201**	0.1793	0.1959	-0.1008***
	(0.0684)	(0.0560)	(0.0516)	(0.1224)	(0.1192)	(0.0374)
ELEC_CONS	-0.0066***	-0.0031**	-0.0003	-0.0082**	-0.0074*	-0.0006
	(0.0018)	(0.0015)	(0.0016)	(0.0038)	(0.0038)	(0.0012)
N	677	677	677	677	677	677
Number of countries	25	25	25	25	25	25
F First step	17.31	17.31	17.31	17.31	17.31	17.31

Notes: We use PMR in telecommunication (entry and public ownership) as instrument for PMR_{entry} and $PMR_{publ\ own}$. All regressions include year and country effects. Standard errors clustered by country. Significant levels: * 10%, ** 5%, *** 1%.

Table 6: Effect of PMR on REP_fact, dynamic specifications

specification/ dep. var.	**(1)/ REP_fact**	**(2)/ *ΔREP_fact***
REP_fact $_{-1}$	0.9074***	
	(0.0270)	
PMR_{ener-1} *(Δ PMR_{ener})*	-0.0679**	-0.2759***
	(0.0274)	(0.0652)
GREEN *(Δ GREEN)*	0.0084	-0.0141
	(0.0052)	(0.0137)
GDP_pc *(Δ GDP_pc)*	0.0401***	-0.1346***
	(0.0123)	(0.0429)
Squared GDP_pc *(Δ GDP_pc)*	-0.0007**	0.0030***
	(0.0003)	(0.0009)
INEQ *(Δ INEQ)*	-0.0087**	-0.0193
	(0.0043)	(0.0127)
CORR *(Δ CORR)*	0.0255***	0.0172*
	(0.0089)	(0.0089)
EN_DEP *(Δ EN_DEP)*	-0.0000	0.0025***
	(0.0000)	(0.0005)
NUKE *(Δ NUKE)*	-0.0222	-0.0064
	(0.0350)	(0.0041)
ELEC_CON *(Δ ELEC_CONS)*	-0.0001	0.0522
	(0.0006)	(0.0779)
N	677	144
Number of countries	25	25
Hansen J	2.70	0.00
Hansen crit- prob.	0.74	

Notes: Standard errors are clustered by country. Significant levels: * 10%, ** 5%, *** 1%. Notes Model 1: we use ΔREP_fact from t-2 to t-5 and the average REP_fact from t-5 until t-1979 (the initial year of our analysis) as instruments for REP_fact (t-1). We instrument PMR_{ener} using PMR in telecommunications lagged 0 and 1 year. All variables are detrended to eliminate year effects, while country effects are explicitly added. Notes Model 7: we take the 5-year average of all the variables and then take the long-difference; this explains the lower sample size. The instrument for ΔPMR*ener* is ΔPMR*tel*. All variables are detrended to eliminate year effects.

Appendix (for on-line publication only)

Table A1. Principal Component Analysis results.

	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)	3.72	0.35
Second	Obligation (Dummy) EU Directive 2001 (Dummy) REC target (Value)	1.15	0.18
Third	Public R&D (Value)	1.01	0.12

Note: The above results were obtained applying an orthogonal (VERIMAX) rotation, but an oblique rotation, not presented in the paper, yields very similar outcomes.

Table A2. Country ranking according to the different indicators (std. values). Average value 1980-07.

Rank	REP_fact		REP_poly		REP_div	
1	Denmark	0.98	Denmark	0.95	United States	1.30
2	Sweden	0.42	United States	0.78	Japan	0.75
3	Austria	0.39	Austria	0.50	Denmark	0.68
4	Switzerland	0.31	Germany	0.45	Germany	0.59
5	United States	0.29	Switzerland	0.44	Italy	0.53
6	Netherlands	0.29	France	0.43	France	0.44
7	Germany	0.20	Belgium	0.37	Finland	0.41
8	France	0.19	Spain	0.35	Switzerland	0.35
9	Belgium	0.18	Italy	0.33	Netherlands	0.32
10	Italy	0.18	Portugal	0.30	Austria	0.30
11	Finland	0.12	Netherlands	0.21	Belgium	0.30
12	Ireland	0.02	Sweden	0.15	Spain	0.13
13	Spain	0.02	Finland	-0.03	Canada	0.08
14	Portugal	-0.06	Japan	-0.04	Sweden	0.06
15	United Kingdom	-0.06	Ireland	-0.09	United Kingdom	0.05
16	Japan	-0.15	United Kingdom	-0.10	Ireland	-0.02
17	Norway	-0.20	Czech Republic	-0.10	Australia	-0.02
18	Australia	-0.26	Canada	-0.27	Norway	-0.09
19	Canada	-0.26	Australia	-0.31	Portugal	-0.09
20	Greece	-0.30	Norway	-0.33	New Zealand	-0.45
21	Czech Republic	-0.31	Greece	-0.42	Czech Republic	-0.52
22	New Zealand	-0.38	Hungary	-0.48	Greece	-0.55
23	Hungary	-0.54	New Zealand	-0.57	Hungary	-0.67
24	Poland	-0.59	Poland	-0.68	Poland	-1.02
25	Slovak Republic	-0.68	Slovak Republic	-0.86	Slovak Republic	-1.21

Table A3. Correlations among the policy indicators. Years 1970-2007.

	REP_fact	REP_poly	REP_div	ESI (Only year 05)
REP_fact	-			0.47*
REP_poly	0.93*	-		0.26
REP_div	0.85*	0.94*	-	0.37

*$p<0.05$

Table A4. First stage estimations of Model 2 Table 3 and Model 2, 4 and 6 Table 4 (results for exclusion restrictions only).

Model **Instrumented Var**	**Mod 2 tab 3** $PMR_{ener\ -1}$	**Mod 2 Tab 4** $PMR_{ener\ entry\ -1}$	**Mod 4 Tab 4** $PMR_{ener\ public\ own\ -1}$	**Mod 6 Tab 4** $PMR_{ener\ entry\ -1}$ $PMR_{ener\ vertical\ int\ -1}$
$PMR_{tel\ -1}$	0.3516*** [0.0328]			
$PMR_{entry\ tel\ -1}$		0.185*** [0.0278]		0.1713*** [0.0315]
$PMR_{public\ own\ tel\ -1}$			0.2653*** [0.0353]	0.0581 [0.0428]
N	677	677	677	677
Number of countries	25	25	25	25
first-stage F	114.68	44.48	56.21	17.62

Notes: Standard errors are clustered by country. Significant levels: * 10%, ** 5%, *** 1%.

Table A5. Effect of Product Market Regulation on Renewable Energy Policies, dependent variable: REP_fact. Additional Estimates.

Model	Model 1	Model 2	Model 2 - bis	Model 3	Model 3-bis
$PMR_{ener\ -1}$	-0.1853*	-0.2325***	-0.0918		
	(0.0904)	(0.0531)	(0.0612)		
$PMR_{elec\ -1}$				-0.1834***	-0.0817
				(0.0443)	(0.0503)
$GREEN_{-1}$	0.0446*	0.0477***	-0.0034	0.0439***	-0.0028
	(0.0241)	(0.0090)	(0.0093)	(0.0092)	(0.0093)
GDP_pc_{-1}	-0.1619*	-0.1704***	-0.0960***	-0.1690***	-0.0999***
	(0.0838)	(0.0333)	(0.0214)	(0.0332)	(0.0220)
Squared GDP_pc_{-1}	0.0035**	0.0036***	0.0021***	0.0035***	0.0021***
	(0.0014)	(0.0006)	(0.0005)	(0.0006)	(0.0005)
$INEQ_{-1}$	-0.0299**	-0.0319***	0.0025	-0.0333***	0.0016
	(0.0143)	(0.0092)	(0.0093)	(0.0096)	(0.0094)
$CORR_{-1}$	0.0800**	0.0709***	0.0189	0.0736***	0.0209
	(0.0373)	(0.0176)	(0.0164)	(0.0174)	(0.0163)
EN_DEP	0.0004**	0.0005***	-0.0002	0.0005***	-0.0005
	(0.0002)	(0.0001)	(0.0075)	(0.0001)	(0.0075)
NUKE	0.0546	0.0621	0.3061	0.0931	0.5037
	(0.1563)	(0.0596)	(3.6615)	(0.0601)	(3.6529)
ELEC_CONS	-0.0061*	-0.0058***	-0.0171**	-0.0061***	-0.0183**
	(0.0031)	(0.0012)	(0.0082)	(0.0012)	(0.0078)
N	677	677	677	677	677
Number of countries	25	25	25	25	25
F First step		60.3715	51.5086	62.7916	38.9531
Hansen J		0.6979	2.3712	1.2461	1.7682
Hansen J prob		0.4035	0.1236	0.2643	0.1836
Country-trend	No	No	Yes	No	Yes

Notes: In Models 2, 3 and 4, we use PMR in telecommunication as instrument for PMR in energy and electricity. All regressions include year and country effects. Standard errors are clustered by country. Significant levels: * 10%, ** 5%, *** 1%.

Table A6: Inclusion of SOCIAL (Share of votes of the party classified as social-democratic) as independent variable.

Specification	(1)	(2)	(3)	(4)	(5)
$PMR_{ener\ -1}$	-0.2015*	-0.2152***	-0.1107		
	(0.0969)	(0.0607)	(0.0695)		
$PMR_{elec\ -1}$				-0.1779***	-0.0892
				(0.0527)	(0.0569)
$GREEN_{-1}$	0.0374	0.0379***	-0.0016	0.0347***	-0.0012
	(0.0248)	(0.0098)	(0.0098)	(0.0101)	(0.0099)
N	584	584	584	584	584
Number of countries	21	21	21	21	21
F First step		89.35	80.86	83.53	60.84
Country-trend	No	No	Yes	No	Yes

Notes: In Models 2 to 5 we use PMR in telecommunication as instrument for respectively PMR_{ener} and PMR_{elect}. The number of country is smaller due to missing data in SOCIAL (for Czech Republic, Hungary, Poland, Slovak Republic). All regressions include year and country effects. Standard errors are clustered by country. Significant levels: * 10%, ** 5%, *** 1%.

Table A7: Inclusion of GOV LEFT (Social-democratic and other left parties in percentage of total cabinet posts, weighted by days) as independent variable.

Specification	(1)	(2)	(3)	(4)	(5)
$PMR_{ener\ -1}$	-0.1930*	-0.2308***	-0.0982		
	(0.1023)	(0.0627)	(0.0743)		
$PMR_{elec\ -1}$				-0.1927***	-0.0794
				(0.0555)	(0.0607)
$GREEN_{-1}$	0.0379	0.0391***	-0.0022	0.0357***	-0.0019
	(0.0256)	(0.0099)	(0.0100)	(0.0102)	(0.0101)
N	584	584	584	584	584
Number of countries	21	21	21	21	21
F First step		86.87	75.53	78.41	56.76
Country-trend	No	No	Yes	No	Yes

Notes: In Models 2 to 5 we use PMR in telecommunication as instrument for respectively PMR_{ener} and PMR_{elect}. The number of country is smaller due to missing data in GOV LEFT (for Czech Republic, Hungary, Poland, Slovak Republic). All regressions include year and country effects. Standard errors are clustered by country. Significant levels: * 10%, ** 5%, *** 1%.

Table A8: Inclusion of GOV LEFT (Social-democratic and other left parties in percentage of total cabinet posts, weighted by days) and GOV CEN*T* (Centre parties in percentage of total cabinet posts, weighted by days) as independent variable

Specification	(1)	(2)	(3)	(4)	(5)
$PMR_{ener\ -1}$	-0.1949*	-0.2421***	-0.1215		
	(0.1021)	(0.0664)	(0.0786)		
$PMR_{elec\ -1}$				-0.2053***	-0.0990
				(0.0599)	(0.0651)
$GREEN_{-1}$	0.0377	0.0391***	-0.0040	0.0355***	-0.0036
	(0.0255)	(0.0099)	(0.0102)	(0.0102)	(0.0103)
N	584	584	584	584	584
Number of countries	21	21	21	21	21
F First step		79.03	70.47	72.24	52.44
Country-trend	No	No	Yes	No	Yes

Notes: In Models 2 to 5 we use PMR in telecommunication as instrument for respectively PMR_{ener} and PMR_{elect}. The number of country is smaller due to missing data in GOV LEFT and GOV CENT (for Czech Republic, Hungary, Poland, Slovak Republic). All regressions include year and country effects. Standard errors are clustered by country. Significant levels: * 10%, ** 5%, *** 1%.

Table A9: Sub-sample including only the countries with the correct sequence of liberalization.

Specification	(1)	(2)	(3)	(4)	(5)
$PMR_{ener\ -1}$	-0.1625*	-0.3088***	-0.1698***		
	(0.0846)	(0.0526)	(0.0502)		
$PMR_{elec\ -1}$				-0.2398***	-0.1341***
				(0.0433)	(0.0406)
$GREEN_{-1}$	0.0312	0.0305***	-0.0131*	0.0255**	-0.0132*
	(0.0251)	(0.0094)	(0.0071)	(0.0101)	(0.0073)
N	539	539	539	539	539
Number of countries	20	20	20	20	20
F First step		34.82	10.84	34.82	10.84
Country-trend	No	No	Yes	No	Yes

Notes: In Models 2 to 5 we use PMR in telecommunication as instrument for respectively PMR_{ener} and PMR_{elect}. Excluded countries: Ireland, Norway, Portugal, Spain and Switzerland. All regressions include year and country effects. Standard errors are clustered by country. Significant levels: * 10%, ** 5%, *** 1%.

Appendix (for on-line publication only)

A1. Data Sources

Renewable energy policies data. The dataset made available by the IEA contains detailed country fact sheets that allow to construct dummy variables reflecting the adoption time of selected REPs for most OECD countries. Where possible, we integrated this data with information on the stringency of the single policies. 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), plus the REN21 website. Our measure of the stringency of renewable energy certificates (RECs) is the variable constructed by Johnstone et al. (2010) that reflects the share of electricity that must be generated by renewables.

Market Liberalization. To account for the degree of liberalization in the energy market we choose the index of Product Market Regulation (PMR) in the electricity and gas sector provided by the OECD. This index is 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 indexes for electricity and gas aggregates three sub-indexes, which takes on values from 0 to 6:

- Ownership, ranging from public (6) to private (0)
- Entry barriers, which synthesizes information on: third party access to the grid (regulated (0), negotiated (3), no access (6)) and minimum consumer size to freely choose suppliers (no threshold (0) - no choice (6));
- Vertical integration, ranging from unbundling (0) to full integration (6).

The other indexes of Product Market Regulation used in the analysis (Telecommunications and Roads) are constructed following the same procedure, but are composed of a different mix of sub-indexes. In particular, PMR in Telecommunications is composed by the following components: entry, public ownership and market structure, while PMR in Road is composed by the entry and price sub-indexes. For other variables detailed data sources are reported in Table 1.

A2. Policy Indicators

REP_FACT. 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 (obtained finding the eigenvalues and eigenvectors of the covariance matrix of the initial set). With 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. The components obtained in the analysis are generally rotated to produce more readily interpretable results. 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.

Table A1 provides an in-depth summary of the main variables that 'load' each relevant component entering the indicator REP_fact. 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 (35%) is primarily a combination of price-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). Starting from PCA analysis we constructed our favourite indicator REP_fact taking the simple average of the three components.

[TABLE A1 HERE]

REP_POLY: Further details on the methodology used to build this indicator can be found in Kolenikov and Angeles (2009). For sake of space, we provide here just the main intuition. In presence of discrete data, the normality assumption that underlines the PCA method is violated as the skewness and kurtosis in the distribution of, i.e., dummy variable is much larger. This is likely to bias downward the pairwise correlations used to build principal components. A maximum likelihood estimator can overcome this issue and allows to obtain the unobserved, normally distributed, continuous variable from their observed discrete counterpart, i.e. the so-called polychroric correlations. Practically, the likelihood function is maximized with respect to both the thresholds of a multivariate Probit model and the matrix correlations among the underlined, but unobservable, variables. This allows to obtain such correlation matrix as if each variable was draw from a normal distribution. More important for us, this method can be easily extended to obtain correlations between continuous and discrete variables, i.e. so-called polyserial correlations. Finally, the derived correlation matrix is used to carry out a PCA in the usual way.

As documented by the large simulation study analysis of Kolenikov and Angeles (2009), the main advantage of using this polyserial correlation method is that the proportion of variance explained by each component is larger than with PCA. Our comparison of indicators confirms this finding. The first component alone explain 58% when using polyserial correlation, while only 40% is explain by the first PC when not correcting for such discrete variable bias. The downside is that the first principal component has a less clear interpretation in this case as several policies load on it. For this reason and to be consistent with previous works on environmental policy indicators, we choose to use the PCA indicator as our favorite one.

A3. Comparison of the Policy Indicators

As show by the correlation matrix presented in Table A3, the differences between the three indicators are small. In fact, the cross-correlations are statistically significant and range between 0.87 and 0.94. This similarity is also confirmed by the country ranking presented in Table A2, which 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 REP 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. In particular, the absence of feed-in tariff schemes in certain countries altered the ranking between REP_div and the other two indicators. For instance, Japan ranks second in REP_div and only 17th in REP_fact. Similarly, Sweden have much better rankings in indicators employing information from continuous variables because of their higher than average levels of feed-in, REC targets and public R&D expenditures.

[TABLE A2 HERE]

As an external validation, in last column of Table A3 we compute the correlation of our three indicators with a widely used indicator of environmental policy, i.e. the Environmental Sustainability Index (ESI).[1] We restrict the analysis to the 2005 as it is the only year for which we have the ESI. Among the three indicators considered in our analysis, our preferred indicator REP_fact is the only one that displays a statistically significant correlation of 0.47 with the ESI. This further validates our choice of using it as main policy indicator.

[TABLE A3 HERE]

A4. First Stage Results

Table A4 below presents results for the first stage of Model 2 in Table 3 for the PMR_{ener} and Model 2, 4 and 6 in Table 4, for the three different specifications (instrumenting only PMR_ent, only PMR_pub or both). The excluded instruments are statistically significant and all have the expected sign, being a higher PMR in telecommunication industries positively associated with a higher PMR in the energy sector. The only exception is given by the non-significance of PMR public ownership in telecommunication in the last specification. Observe that the F-statistic for the excluded instruments is always well-above the threshold of 10. Finally, Table A5 replicates Table 3 adding PMR in road as additional exclusion restriction. Results are consistent with the main evidence and the Hansen test confirms our theoretical claim on the exogeneity of our instruments.

[1] The ESI is an indicator developed by developed by the Yale Center for Environmental Law and Policy and the Center for International Earth Science Information Network - Columbia University (WEF, 2001).

A.5 Additional Robustness

The share of green deputies in parliament is an imperfect proxy of green lobbies for several reasons. First, green parties are heterogeneous across nations; second, some of the requests and values traditionally carried forward by the greens could have been absorbed by other left or social-democratic groups. Considering the story and the evolution of the greens in OECD countries, we believe that this second argument need to be taken into account. The upsurge of green movements dates back in the 1980s, but after the initial breakthrough, they struggled to consolidate their electoral successes. During the 1990s, green parties faced a strong opposition, which was accompanied by internal disputes, electoral disappointments and the incorporation of green issues by other existing political forces (Burchell, 2002). As a result, the greens have often been accepted into coalition government as member of left or centre parties.

In order to control for this possible source of bias, in Table A6 we included among covariates the share of votes for democratic parties in parliament (*SOCIAL*). Results are qualitatively unchanged; both PMR and ***green*** are statistically significant and have a coefficient of a similar magnitude with respect to our favourite specification in Table 3.

A second source of concern is that that also other parties may have had an influence in the liberalisation process, and their exclusion from the empirical framework can have led us to overestimate the effect of ***green***. For this reason, in Table A7 we controlled for the percentage of social-democratic and other left parties in the cabinet (*GOV LEFT*), and in Table A8 for the share of left, social-democratic and centre parties (*GOV CENT*). Also in this case, the two robustness exercises confirmed the main evidence presented in Table 3.

As a final robustness, we re-estimate Table 3 using the sample of countries which respected the precise sequencing of liberalisation assumed in the IV strategy (energy market follows telecommunications). The results presented in Table A9, are aligned with our benchmark specification, and the effect of PMR turns out to be robust to the inclusion of a time trend (Columns 3 and 5).

[Table A6-A9 ABOUT HERE]