

Energy Market Liberalization and Renewable Energy Policies in OECD Countries

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Aim of the Work

- Study empirically the evolution of Renewable energy policy, their trend and their determinants.
- Build an aggregate indicator of renewable energy policy

Scope of the Work

- A few papers have empirically investigated the determinants of REPs, by focusing on the adoption of a specific REP (Lyon and Yin 2010 for RE certificates, Jenner et al. 2012 for feed-in tariffs and RE certificates)
- Less attention paid to the overall policy commitment.
- Recent research has shown that an appropriate policy mix combines policies to reduce pollution with policies for learning and innovation

Determinants – lobbies

- The mainstream literature 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).
- The incumbents in the energy sector prefer less stringent policies and do the best they can to reduce policy stringency, while environmentalists support the approval of ambitious policies. **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 the policy.**

Determinants – lobbies

- The relative value assigned by politicians to the brown lobby bribe has been typically interpreted as dependent on the **level of corruption**, and the negative impact of corruption on environmental policy has been confirmed by substantial empirical research (Fredriksson and Svensson (2003) and Fredriksson (1997)).
- case study evidence shows that the existing incumbents tend to oppose approval of ambitious renewable energy policies (e.g. Neuhoff 2005, Jacobsson and Bergek 2004, Nilsson et al. 2004)

Determinants – lobbies

- Since REP mainly 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.**
- In fact, whereas the production of energy from renewable sources is decentralized in small-medium sized units, the competences of the existing incumbents are tied to large scale plants using coal, nuclear or gas as primary energy inputs.

Determinants – lobbies

- Following on this argument, **the recent liberalization of energy markets should have reduced the incumbents' opposition, favoring the adoption of ambitious renewable energy policies.**
- We use product market regulation, as proxy for incumbents' lobbying power in the energy sector
- We control also for the level of corruption, which is considered here as a proxy of institutional quality

Main Mechanisms

- **Lowering entry barriers** should reduce the capacity of utilities to influence energy policies and should favour the emergence of new green actors.
- **state-owned monopoly** that characterises the energy sector before liberalisation should be willing to internalise the pollution externalities stemming from traditional energy sources. As a result, it should be easier to support REPs in a market with widespread public ownership than in a market dominated by private utilities.

Determinants – Income & Inequality

- Renewable energy policies are also affected by social welfare considerations and depend on the aggregation of citizens' preferences. **Since environmental quality is a normal good, the wealthier households demand more stringent environmental policies to satisfy it – a prediction that is consistent with the empirical evidence at both the micro and the macro level** (Arrow et al. 1995, Diekmann and Franzen 1999, Dasgupta et al. 2001, Esty and Porter 2005, Oecd 2008)
- Citizens' preferences for a clean environment are influenced also by income distribution, consistently with models where the median voter decides on environmental policy (Magnani 2000, Kempf and Rossignol 2007).

Empirical Protocol

$$\text{REP}_{it} = \beta \text{PMRelec}_{it-1} + \gamma X_{it-1} + \mu_t + \mu_i + \varepsilon_{it}$$

PMR is the index of Market Regulation

Xs are our time-varying covariates lagged one year to capture delayed effects:

- ✓ Index of brown lobbies (Corruption)
- ✓ GDP per capita & Income inequality
- ✓ share of energy produced from nuclear power
- ✓ energy dependency

μ_i and μ_t are country and year fixed effect

Augmented specification

- ✓ two proxies for the green lobby,
 1. the share of green deputies in the parliament
 2. dummy equal to one since the year in which a solar association began (Jenner et al., 2012)
- ✓ a measure of energy intensity
- ✓ Polity 2 index capturing the level of democracy (Environmental policies tend to be more stringent in democratic societies)

Identification Issues

- **Omitted Variable bias:** Unobserved heterogeneity (i.e. ideology) can influence both REPs and PMR
- **Measurement Error:** Our index of regulation is an imperfect proxy for the effective incumbents' market power, on which the capacity to capture policies depends
- **Reverse Causality:** 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

IV Strategy

we use regulation in other sectors to instrument regulation in electricity. The idea is that widespread liberalisations are implemented to pursue general goals and reflect policy learning and the diffusion of a liberal political ideology. The sequence of reforms across sectors validates our instrument choice, as early liberalisations in telecommunications and air transport have paved the way for energy liberalisations (Høj et al., 2006)

IV Strategy

We argue that liberalisations are more likely to be successful and hence effective in reducing the market power of existing incumbents if an ambitious liberalisation plan is pursued.

The underlined politico-economic logic is that liberalisations 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)

IV Strategy

A trickle-down effect of liberalisation between sectors is likely to occur for three reasons:

- ✓ The influence of international organisations (Høj et al., 2006),
- ✓ Strong complementarities (see, e.g., Li et al. 2002 on the case of finance and telecommunications),
- ✓ Policy learning (see, e.g., Levi-Faur 2003)

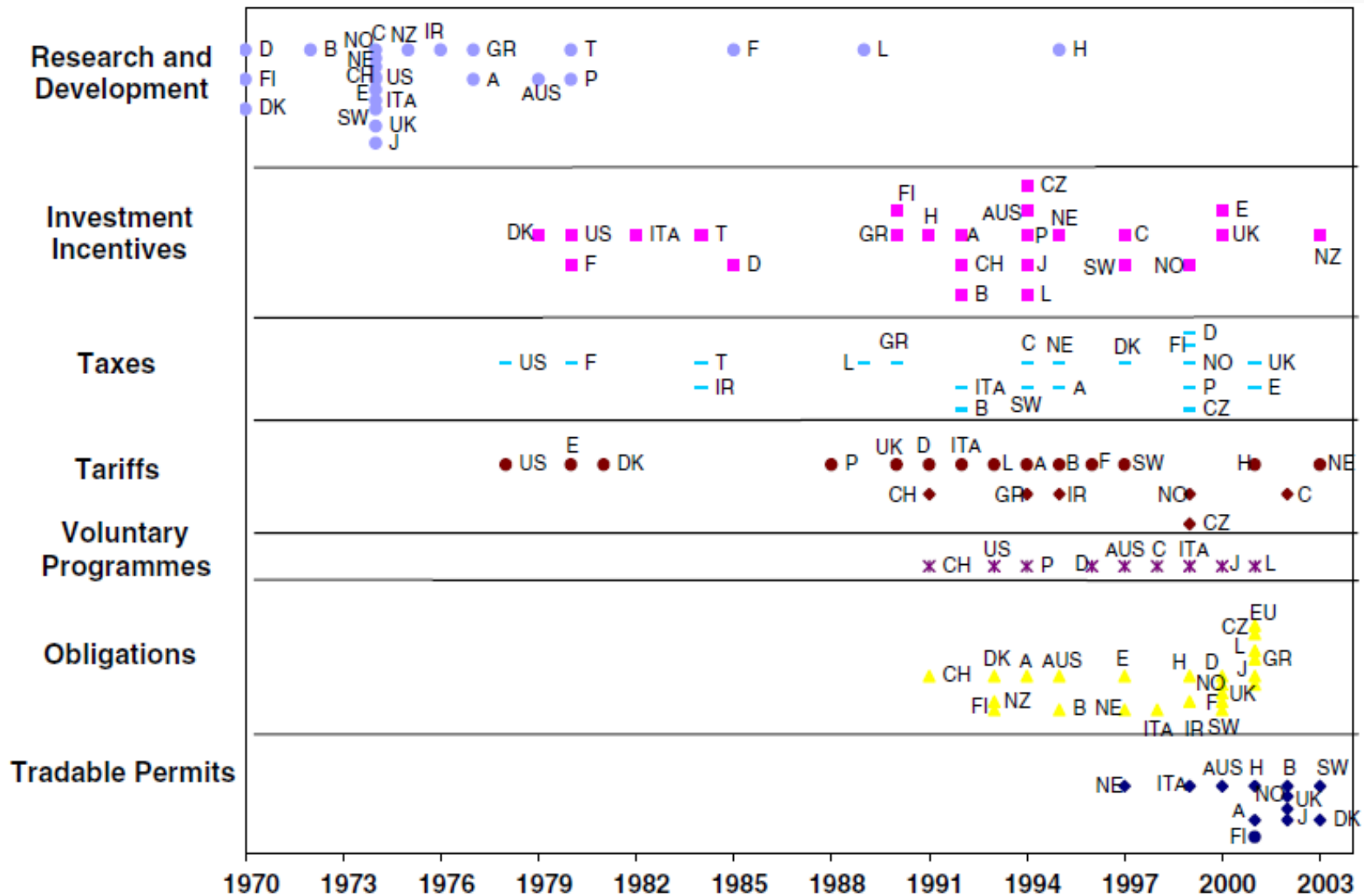
Høj et al. (2006) provides evidence on the existence of these spillovers between product market reforms

IV Strategy - Instruments

- ✓ **PMR in telecommunication**, an industry that was liberalised slightly earlier,
- ✓ **PMR in railways**, an industry that has been liberalised in only certain countries.

The former instrument captures regulatory spillovers, and the latter captures the broad country's commitment to liberalisation.

REP – Time of adoption



Instrument	Brief explanation	Construction
Investment incentives	Capital Grants and all other measures aimed at reducing the capital cost of adopting renewable energy technologies.	Dummy Variable
Tax Measure	Economic instruments used either to encourage production or discourage consumption. They may have the form of investment tax credit or property tax exemptions, in order to reduce tax payments for project owner.	Dummy Variable
Incentive tariff	Price systems that guarantee above market tariff rates. In such cases, the Environmental authority generally sets a premium price to be paid for power generated from renewables.	Dummy Variable
Feed-in Tariff	Guaranteed price that may vary by technology. (Wind, Solar, Ocean, Geothermal, Biomass, Waste, Hydro).	Level of price guaranteed
Voluntary program	These programs generally operate through agreement between government, public utilities and energy suppliers, that agree to buy energy generated from renewable sources.	Dummy Variable

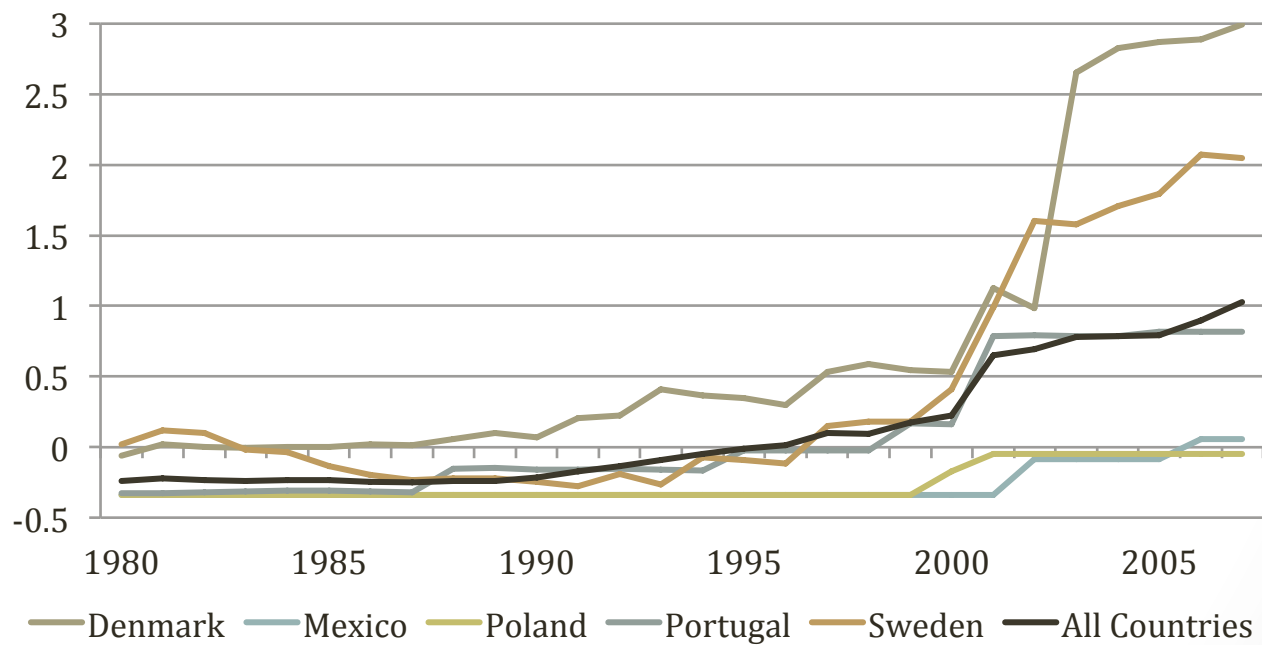
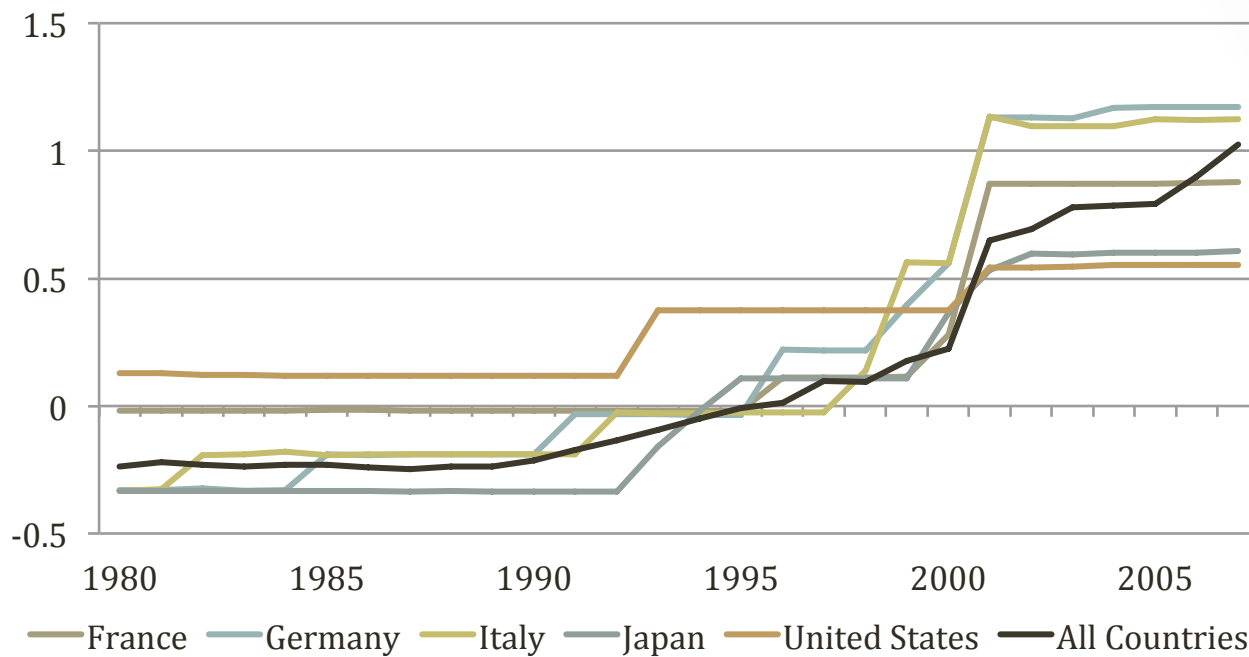
Obligations	Obligation and targets take generally the form of quota systems that place an obligation on producers to provide a share of their energy supply from renewable energy. These quota are not necessarily covered by a tradable certificate.	Dummy Variable
Tradable Certificate	Renewable energy Certificates (REC) are used to track or document compliance with quota system and can generally be traded in specific markets.	Share of electricity that must be generated by renewables or covered with a REC.
Public Research and Development	Public financed R&D program disaggregated by type of renewable energy	R&D (USD, 2006 prices and PPP).
EU directive 2001/77/EC	Established the first shared framework for the promotion of electricity from renewable sources at European level.	Dummy Variable

The policy indicator

REP_fact : Built using principal component analysis, it contains information on both adoption dummies and level of feed-in tariffs, RECs and public R&D. The analysis generally produces three relevant principal components that have been used to build a single indicator as their simple average.

REP_fact - Loadings

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



Other Indicators - Polychoric

REP_poly: Follow the method developed by Kolenikov and Angeles (2009) to generalise PCA when both discrete and continuous variables are present.

Derives the correlation matrix used to build the PCA by estimating the latent continuous variable that corresponds to each discrete or categorical variable.

We only used the first derived PC (58% of var), which by the way have no clear interpretation.

Other Indicators – REP_div

REP_div: rewards policy diversity and is the sum of policy dummies; it takes 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)

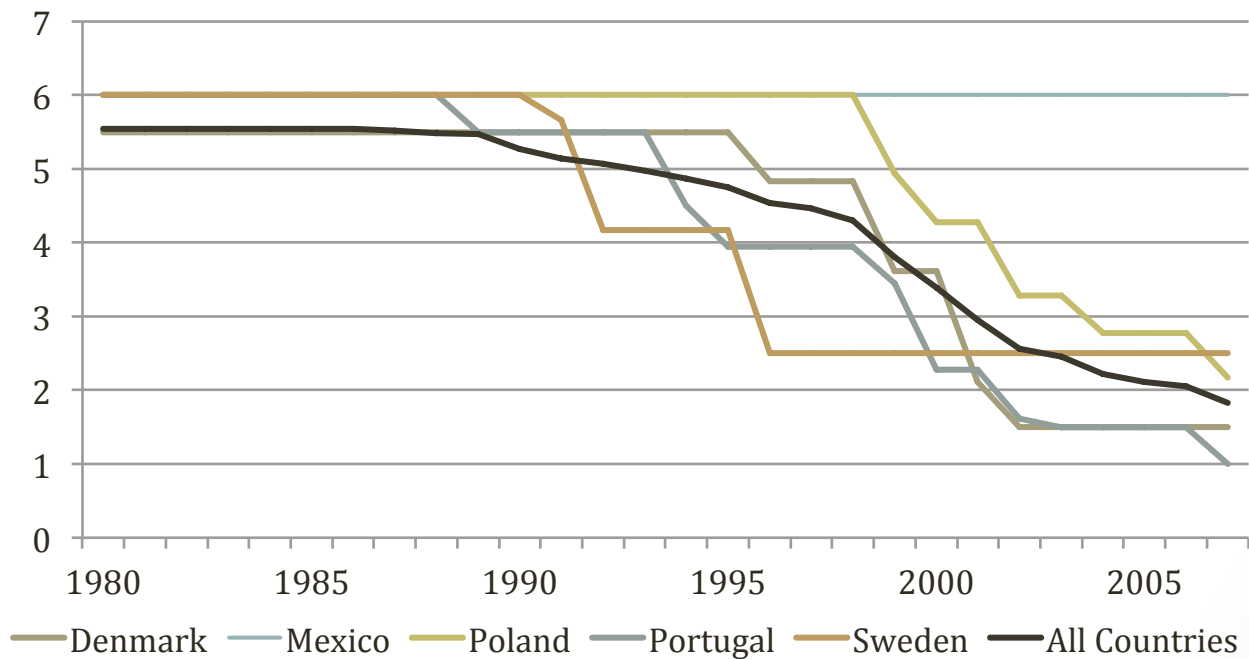
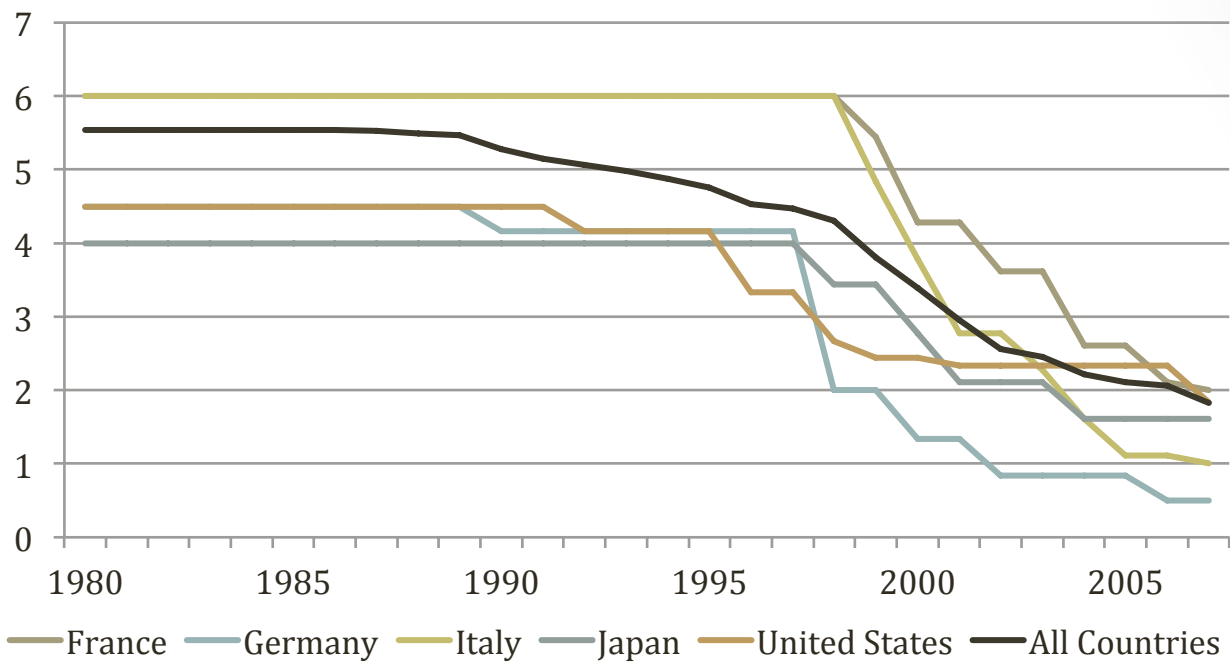
REP_div – example

Country	Year	Pol 1	Pol 2	Pol 3	Pol 4	Index
AU	1980	0	0	0	0	0
AU	1981	1	1	0	0	2
AU	1982	1	1	1	0	3
AU	1983	1	1	1	0	3
BE	1980	1	0	0	0	1
BE	1981	1	0	0	0	1
BE	1982	1	0	0	0	1
BE	1983	1	1	1	0	3

Product Market Regulation

The product Market Regulation (PMR) index is built using common factor analysis by combining objective sector-specific policies and regulation from different data sources. The PMR index for electricity and gas aggregates three sub-indexes ranging from 0 to 6 (maximum anti-competitive regulation):

1. **ownership:** private (=0), mostly private, mixed, mostly public and public (=6).
2. **entry barriers:** that use information on third party access to the grid, regulated(=0), no access(=6) and minimum consumer size to choose supplier freely (from 'no threshold=0' to 'no choice=6').
3. **vertical integration** ranging from unbundling (=0) to full integration (=6).



Acronim	Description
GDP_pc	GDP per capita, thousands US 1990 Dollars, ppp.
INEQ	Gini Coefficient
CORR	Corruption index that ranges from 0 (highly corrupt) to 10 (highly clean).
Green	share of green deputies in the parliament
EN_DEP	Energy imports, net (% of energy use)
NUKE	Electricity production from nuclear sources (% of total)
ELEC_CONS	Average value of industrial and residential consumption per capita
GREEN	Share of green deputies in parliament
POLITY 2	Political regime characteristics (from -10 (hereditary monarchy) to +10 (consolidated democracy)
SOLAR_ASS	Existence of a state chapter of the international Solar Energy association (ISES)

Model	FE	IV	IV	IV
PMR _{elec} ₋₁	-0.0939*	-0.2427***	-0.2353***	-0.2646***
GDP_pc ₋₁	0.1186***	0.1150***	0.1308***	0.1084***
INEQ ₋₁	-0.0337	-0.0480***	-0.0512***	-0.0565***
CORR ₋₁	0.0910**	0.0675***	0.0906***	0.0779*
EN_DEP ₋₁			0.0031***	0.0024***
NUKE ₋₁			-0.0009	-0.001
ELEC_CONS ₋₁				-0.1128***
GREEN ₋₁				0.0515***
POLITY 2 ₋₁				0.0562
SOLAR_ASS				0.0206
N	760	760	760	611

Main Results – Model 1, FE

- **large utilities contrast the approval of ambitious REPs** to retain their *raison d'être*, which is intimately related to centralised energy production .
- Regarding the other variables of interest, **INEQ, GDP_pc and CORR have all the expected effects on REP** Recall that a higher Corruption Perception Index implies a less corrupted country.

Main Results – Model 2, IV

- When comparing the results of Model 1 and 2, **the effect of liberalising the electricity market appears considerably larger in the IV specification.**
- The chosen instruments have the expected signs, high explanatory power (the F-test for the first stage is 56.7, which is well above the usual cut-off level of 10), and appear exogenous, as is evident from the p-value of the Hansen tests. This hold for all IV estimations.

Main Results – Model 3 & 4, IV

- energy dependency has the expected significant effect on REPs.
- the influence of nuclear share is far from being statistically significant but retains the expected sign
- All variables in the augmented specifications have the expected signs and are significant at the 99% level with the exception of Polity 2 and the dummy for the existence of a solar association

Quantification - PMR

- The inter-quartile increase in REP_fact explained by an inter-quartile decrease in PMR is greater than 3/4.
- To provide a concrete example of this effect, France and Italy would have ranked just below Denmark in REP_fact with an electricity market, on average, regulated to the same extent as the German one.
- The explained inter-quartile deviation is 1.6 for GDP_pc, 0.38 for INEQ, 0.32 for CORR and 0.18 for EN_DEP.

Dependent	REP_fact	REP_poly	REP_div	REP_price	REP_quan	REP_inno
PMR _{elec} _1	-0.2353***	-0.2433***	-0.0746	-0.7907***	-0.6626***	0.1990***
GDP_pc _1	0.1308***	0.0559***	0.0387***	0.0206**	0.0048	-0.0035
INEQ _1	-0.0512***	-0.0455***	-0.0088	-0.0870***	-0.0959***	0.0265**
CORR _1	0.0906***	0.0371*	0.024	-0.0836*	0.0676**	0.0665**
EN_DEP _1	0.0031***	0.0018***	0.0006	0.0024***	0.0007	0.0008***
NUKE _1	-0.0009	-0.0011	-0.0016	0.0018	-0.0033	0.0009
N	760	760	760	760	760	760

Robustness - different Policy indicators (Column 1-3)

- The results are qualitatively unchanged for all of the variables.
- The size of the estimated effects is unchanged for PMR and slightly reduced for INEQ.
- In turn, the effects of GDP_pc and CORR decrease by more than half compared to the baseline specification.
- The largest differences are observed for REP_div. All of the effects are substantially reduced to the point of becoming insignificant.

Robustness - different Policy indicators (Column 4-6)

- that the effect of PMR is stronger on price-based policies than on other REPs. Because price-based policies have a strong effect on renewable energy innovations (Johnstone et al. 2010, Fisher and Newell 2008), this result lends support to the idea that the incumbents' opposition to REPs is linked to technological competition.
- negative effect of liberalisation on public R&D expenditures (e.g., Jamasb and Pollitt, 2008)

Dependent	REP_fact	REP_poly	REP_div	REP_price	REP_quan	REP_inno
PMR _{elec entry} -1	-0.3245***	-0.2480**	-0.4012***	-0.8993***	-0.3460**	-0.6253***
PRM _{elec public own} -1	0.4958***	0.6956***	0.6116***	0.4051*	0.7297***	0.4220**
PMR _{elec vertical int} -1	-0.1624	-0.3172**	-0.0274	0.4867**	-0.5359***	0.3901**
GDP_pc ₋₁	0.1196***	0.0706***	0.0410***	0.0249**	0.0197	-0.012
INEQ ₋₁	-0.0411***	-0.0281*	-0.0024	-0.0262	-0.0674***	0.0083
CORR ₋₁	0.1309***	0.0913***	0.0634**	0.0342	0.1205***	0.0735*
EN_DEP ₋₁	0.0058***	0.0052***	0.0044***	0.0064***	0.0045***	0.0053***
NUKE ₋₁	0.0036	0.0048	0.0045	0.0078	0.0034	0.0068
N	760	760	760	760	760	760

Various Features of the Liberalisation Process

- The positive and significant effect of lowering entry barriers is offset by a negative and significant effect of privatisation
- the effect of unbundling tends to be negative and significant
- PMR_ent has a considerably stronger effect on REP_price and REP_inno
- if Canada had the same level of entry regulation as Sweden, it would have climbed 12 positions in the REP_fact's ranking, reaching a level similar to that of Germany

Conclusions

- Our main result is that energy market liberalisation has a positive and perhaps unintended impact on REPs
- our IV strategy highlights a substantial downward bias in the OLS estimate of this effect
- the effect of PMR is the second largest after that of GDP_pc
- 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