The Political Economy of Energy Innovation

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Overview

This paper empirically investigates the effects of environmental policy stringency, institutions, political orientation, and lobbying on energy innovation and finds that they significantly affect the incentives to innovate and create cleaner energy efficient technologies. We conclude that political economy factors may act as barriers even in the presence of stringent environmental policy, implying that, to move towards a greener economy, countries should combine environmental policy with a general strengthening of institutional quality, consider the influence of government's political orientation on environmental policies, and the implications of the size of energy intensive sectors in the economy.

Methods

We use fixed effects regressions approach to investigate the role of four key political economy factors in the context of energy innovation. The paper uses two measures of energy innovation; 1) industrial energy R&D and 2) energy patents. The following general reduced form equation is estimated:

$$y_{it} = \alpha_i + \gamma_t + \boldsymbol{\pi_{it}}\beta_1 + \beta_2\varphi_{it} + \beta_3\rho_{it} + \beta_4\theta_{it} + \boldsymbol{Z}_{it}\omega + \varepsilon_{it} \qquad (3)$$

where the subscripts *i* and *t* indicate respectively the country and the year and:

- y_{it} is a variable measuring the energy innovation intensity of the economy. Specifically, we define y_{it} as the share of one of our innovation proxies (industrial energy R&D, power R&D, power patents, or environmental patents) over total value added. We scale all innovation proxies relative to the total value added to account for the heterogeneity in the countries included in our sample.
- $\boldsymbol{\pi}_{\mathbf{it}}$ is a vector of policy stringency measures, discussed in detail in the next subsection and includes both Market-Based (MB) and Non-Market-Based (NMB) instruments directly targeting the environmental externality, such as taxes or standards, as well as government R&D investments in energy innovation targeting the knowledge externality.
- φ_{it} is a proxy for institutional quality, measured either by government effectiveness or by an aggregate indicator of governance quality discussed in the next section.
- ρ_{it} is a proxy of the political orientation of the government.
- θ_{it} is a proxy of the distribution of resources to the energy sector relative to the rest of the economy, which in our framework inform on two different aspects, market-size effect and the power of the energy lobby within each country.
- $\mathbf{Z}_{\mathbf{it}}$ is a vector of other relevant control variables influencing innovation investments, including an index for industrial energy prices and trade openness. Higher energy prices are expected to increase innovation incentives, net of any political economy consideration (Popp 2002), whereas trade openness can have an ambiguous effect.
- α_i and γ_t are country and year fixed effects, while ε_{it} is a random error term. Country fixed effects control for time-invariant factors, including persistent institutional factors, such as the democratic/autocratic characteristics and system of government of countries. While these factors may influence incentives to invest in energy-related innovation, they do not vary significantly over time. The time fixed effects control for inter-temporal trends that are uniform across countries, such as the economic cycle.

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The expectations about the roles of the variables of interest, $\boldsymbol{\pi}_{\mathbf{it}}$, φ_{it}, ρ_{it}, θ_{it}, is detailed in the research hypotheses presented in sub-Section 3.2. The regressions are estimated using fixed effect linear models as both R&D and patent data[1] are continuous variables. Due to the different nature of R&D investments and patents, we use a different lag structure in the specifications. Specifically, we assume that R&D investments react faster to environmental policies than patents. This is due to the fact that patents measure the output of the innovation process. Applying for patent requires first to put the R&D investment to work and then develop and test new ideas. For this reason, the R&D specifications consider a one-year time lag, while the patent equation considers a two-year time lag.

We use this methodology to test the following hypotheses:

1. Environmental policy stringency results in dynamic efficiency gains and stringent regulations provide long-term incentives for energy-saving and pollution-reducing technologies.
2. Institutional quality, measured in terms of good governance, increases the incentives to invest in energy-related innovation.
3. Political orientation of government influences investments in energy innovation but it's impact can be ambiguous.
4. Higher share of energy intensive sectors induces market-size effect and increases lobbying power but also increases coordination costs. Impact of resource distribution on innovation is not clear a priori.

Results

Role of environmental policy stringency

Our results generally confirm previous findings on the inducement effect of environmental policies with respect to energy-related innovation activities. We find that the effect is weaker in the case of energy-related R&D and stronger in the case of energy-related patents. Regressions suggest that one unit increase in the market based score (corresponding approximately to an interquartile (IQR) change) increases power patents intensity by between 1.3 and 1.4 per cent and environmental patent intensity by between 3 and 3.2 per cent. In the case of non-market-based policies, a similar change increases power patents intensity by between 1.2 and 1.5 per cent, and environmental patents intensity by 2.3 per cent. It should be noted that the median improvement in policy stringency between 1995 and 2010 across the 20 countries has been approximately 1 unit for EPS market-based score and 2 units on a scale of 0 to 6 for EPS non-market-based score.

Overall, with respect to Hypothesis 1, our regression results suggest that more stringent environmental policies provide dynamic efficiency gains and incentives for innovation in energy-saving and pollution-reducing technologies.

Role of good governance

Good governance appears to be an important driver of innovation. Depending on the governance proxy used, a one-unit increase in government effectiveness is associated with between 62 per cent and 96.4 per cent increase in power R&D intensity and between 6.5 per cent and 31.3 per cent increase in patent intensity. The marginal effect of governance might appear substantial given the coefficient interpretation provided above. However, a one-unit increase in the governance proxy is a rather significant change. It is comparable to moving from the governance quality of a country such as Portugal (1.02) or Slovenia (1.03) to that of countries such as Sweden or Finland (2.01 and 2.25) in 2010.

[1] The patents from the OECD database are computed using fractional counting and hence are continuous in nature.

Overall, with respect to Hypothesis 2, our regression results suggest that improvements in governance and government effectiveness provide incentives for energy-related innovation.

Role of political orientation

Political orientation seems to be a more important factor for the input rather than the output of innovation, as the variable has a statistically significant effect only in the case of power and energy R&D intensity. A change in the political orientation of the government from right towards a left-leaning position, which corresponds to an IQR change in our sample, is associated with an increase in industrial R&D of 11 per cent (power) and 22 per cent (energy), respectively.

Overall, with respect to Hypothesis 3, left-leaning governments are more likely to implement regulations that attract energy R&D investments, but this does not translate into higher patent intensity.

Role of resource distribution, market-size effect, and lobbying

The size of the energy sector, measured as the value added share of energy intensive industries, has a positive impact on R&D intensity, suggesting that either due to the larger size of the potential market for energy innovations, industries will allocate more resources towards R&D, or a larger energy sector will be able to lobby for more resources to be allocated to energy R&D. A 1 per cent increase in the value added share of energy intensive industries, approximately corresponding to an IQR change, increases power R&D intensity by between 0.54 and 0.83 per cent.

Overall, with respect to Hypothesis 4, the larger the size of the potential markets for energy innovation, the larger the inducement effect for industries to invest in energy R&D. At the same time, larger energy sector has power to lobby for more resources to be allocated to energy R&D. These effects seem to prevail over coordination costs, however, market-size effects or lobbying from the energy sector do not result in a larger number of cleaner patents.

Conclusion

The insights emerging from our empirical analysis show that all the factors affect the incentives to devote resources to energy R&D and to create new clean and energy efficient technologies. Specifically, market-based incentives, and to some extent also non-market based incentives, results in dynamic efficiency gains. Higher levels of energy-related R&D characterize countries with better governance, while left-wing governments are more likely to devote R&D resources to the energy sector but this does not translate into higher power-related patent intensity. A larger distribution of resources toward energy intensive sectors can induce market-size effects and have more power to lobby for more resources to be allocated to energy R&D but this does not translate into higher patent intensity.

Overall, our results show that political economy factors can act as barriers even in the presence of stringent environmental policy. This implies that in order to favor changes towards a greener economy, countries should combine environmental policy with a general strengthening of institutional quality, consider the influence of government's political orientation on environmental policy, as well as the size of energy intensive sectors in the economy, which affect both the lobbying structure and the demand for energy innovations. Hence, our contribution calls for increased attention to the determinants of energy-related innovation, to go beyond the focus on environmental policy instruments that have dominated the environmental economics literature in recent years.