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The promotion of renewable energy innovation

When State intervention and competition go hand in hand[1]

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This policy brief addresses the issue of the complementarity of policies supporting renewable energy and market competition in fostering green innovation.

Innovation is commonly regarded as the best answer to sustaining current life standards while overcoming severe environmental concerns. This is especially relevant in the case of energy, where increasing resource scarcity calls for the rapid development of alternative energy sources, notably renewable energy.[2] Although as of today, renewable energy (RE henceforth) cannot compete with fossil fuel in terms of production costs, impressive technological progress has paved the way to new promising sources such as biomass, solar and wind, among others.[3] Countries too have developed areas of specialization in specific types of renewable energy sources: for example, Denmark has established a strong technological advantage in wind technologies, Sweden and Germany have specialized in bioenergy, Germany and Spain in solar, Norway and Austria in Hydropower. France, with its specialization in nuclear energy, seems to be lagging behind in RE innovation, as compared with other major players such as the USA or Germany.

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2. This development is also particularly relevant for the issue of the reduction in the energy dependency of resource-scarce European economies.

3. For example in the most favored geographical locations, wind proves to be almost as competitive as other forms of electricity generation (IEA. International Energy Agency), whereas solar energy still displays costs significantly higher than fossil fuel energy sources (see, e.g., IEA Experience curve for energy technology).

While several RE technologies are far from being fully mature, it is crucial to understand which policy design has contributed to spur the first wave of RE innovations, reducing the cost gap between renewable energies and traditional ones. This policy brief addresses this issue, focusing on the complementary effect of RE policies and market deregulation in fostering green innovation.

State of the art and open issues

The economic literature emphasizes the key role of public policies in fostering RE innovation. These policies have the double goals to spur investments in green capacity and technical change aimed at reducing the cost of RE generation. Although the adoption of the Kyoto agreement on climate change mitigation has created a consensus about certain environmental policies (*i.e.* emission trading schemes), there is still substantial diversity in the degree of RE policies adoption across countries. It is hence useful to test the effect of RE policies on innovation in a cross-country analysis. However, a correct evaluation of the effect of RE policies using cross-country data faces three main problems.

First, as it appears clear from Figure 1, each country adopts an array of policy measures in support of RE: obligations to produce energy from renewable sources; tax credits, subsidized tariffs and investment incentives for the new green capacity; subsidies to R&D; tradable permits targeted to energy intensive firms and sectors.[4] Between 1976 and 2007, the policies adopted have considerably increased to target different actors (specialized suppliers of electric equipment vs. large utilities) and tackle different type of market failures (pollution and technology).[5] However, such policy diversification has made it exceedingly difficult to evaluate the effect of a certain policy strategy to promote RE innovation.

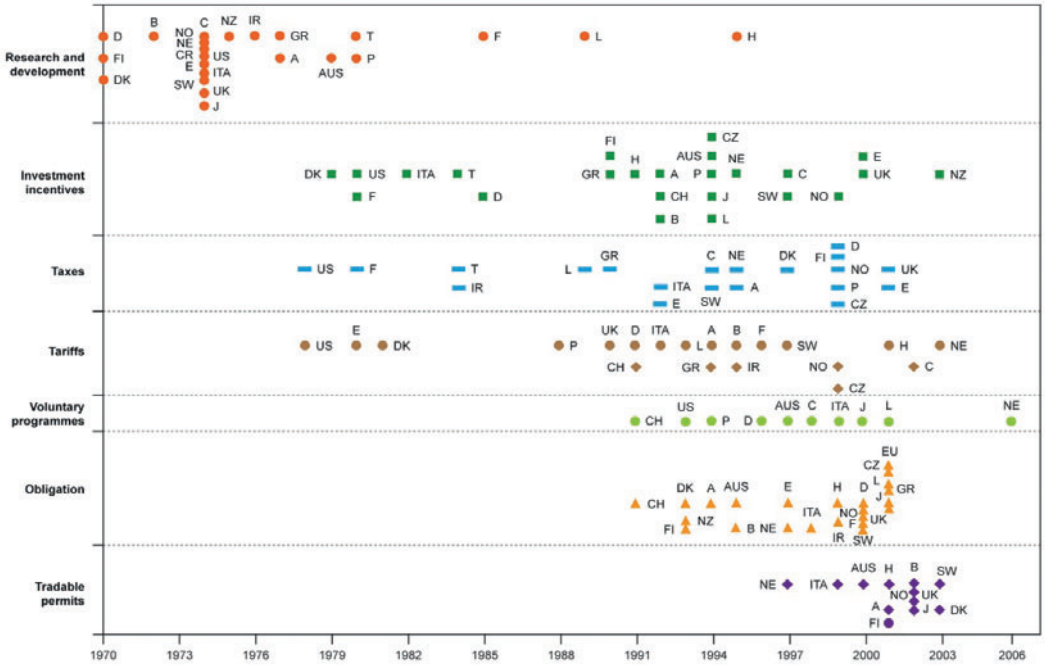
Second, causality can either go from policy to innovation or from innovation to policy. By way of example, successful innovation caused by past policies can reinforce the political support to RE policies by creating a new lobby of green energy producers (e.g. the solar energy industry association). This implies that changes in RE policies depend on changes in technology, hence it is difficult to interpret as causal the effect of policy on technology.

Third, in the last two decades liberalizations have substantially changed the working of energy markets in most OECD countries. Liberalization has increased market competition by combining three elements: entry barrier reductions, unbundling and privatization.[6] Economic theory predicts that an increase in

4. The European Emission Trading Scheme is an example of this type of policy.
5. From figure 1, it is evident that a first phase focusing on RD&D (Research, Demonstration and Development) subsidies and grants is followed by a second phase characterized by the greater use of market-based instruments such as taxes, incentives, feed-in tariffs, and more recently, tradable permits and RECs.
6. The process of liberalization has three pillars: ensuring access to the grid to independent power producers and free choice to consumers, privatization of electric utilities and the unbundling of production and grid management activities.

competition affects the incentive to innovate, although the direction of this effect is the subject of a heated academic debate.[7] For the particular field of RE innovation, we expect the effect of competition to be positive. Without the entry of new players, especially independent power producers, RE policies are less likely to favor radical innovation because large incumbents have little incentive to fully develop renewable technologies that would question past investments in large-scale energy production. In addition, the effect of RE policies can be crucially mediated by the degree of competition. Finally, these policies provide to new players the financial resources needed to support innovative projects and can significantly reduce the uncertainty associated with these projects.

Figure 1. Evolution of specific RE policies in OECD countries



Source: Nicolli et Vona (2014).

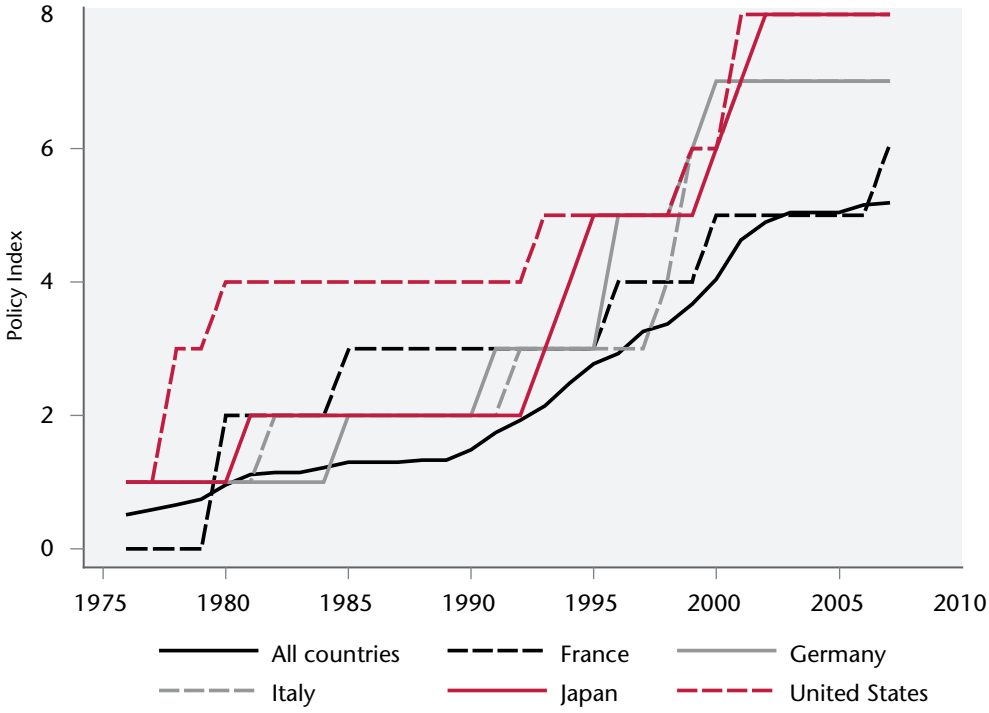
Analysis and results

Recently, we have addressed these issues in a paper published in the *Journal of Environmental Economics and Management*.[8]

7. The degree of market competition is known to have two contrasting effects on innovation. On the one hand, it should reduce innovation insofar as the extra-profits from innovation are pin down by competition. On the other hand, it increases innovation to retain a technological advantage vis-à-vis new entrants or to exploit new technological trajectories, such as the one of RE technologies. See, Aghion, P., Bloom, N., Blundell, R., Griffith, R., Howitt, P., 2005, "Competition and innovation: an inverted-u relationship," *Quarterly Journal of Economics,* 120; Aghion, P., Harris, C., Howitt, P., Vickers, J., 2001, "Competition , Imitation Growth with and Step-by-Step Innovation," *Review of Economic Studies*, 68.
8. Nesta, L., Vona, F., Nicolli, F., 2014, "Environmental Policies, Competition and Innovation in Renewable Energy," *Journal of Environmental Economics and Management,* vol. 67(3), 396-411.

The first contribution of the paper is to build a policy indicator (REP henceforth), the main idea of which is to grasp policy diversity. The indicator simply counts the number of policies adopted by each country at a given year.[9] Figure 2 tracks the evolution of the REP indicator for selected countries. It clearly shows a generalized upward trend.

Figure 2. Evolution of the Policy Index (REP) for 5 countries and for all countries (1976-2007)



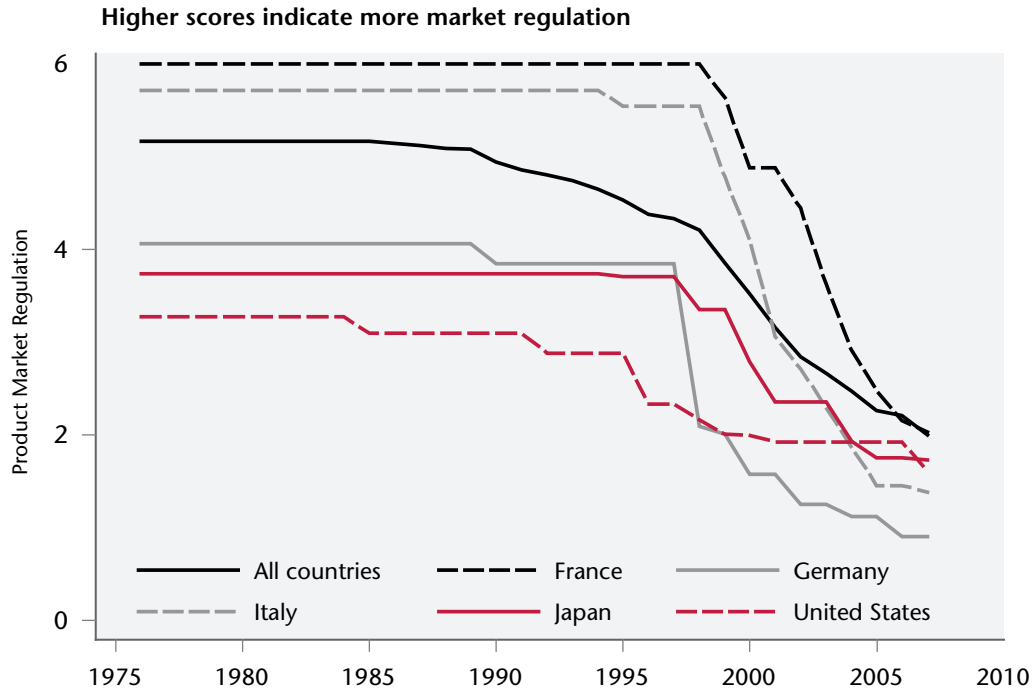
Source: Nesta *et al.* (2014).

Our second contribution is to propose a method that allows us to interpret the causality running from REP to innovation. In particular, we find another variable, a so-called instrument, that affects the variable of interest (i.e. the REP indicator), but not the dependent variable (i.e. RE innovation). We choose to use the number of years during which a country has been under a democratic regime as an instrument for REP.[10] This choice is corroborated by an active strand of literature supporting the idea that democratic societies are more willing to adopt ambitious RE policies.[11]

9. To build a single policy index that varies over years and across countries, we created a series of dummy variables reflecting the adoption of the following eight policies: investment incentive schemes; tax measures; incentive tariffs; feed-in tariffs; voluntary programs; obligations; tradable certificates, and public investment in research and development in renewable energy.
10. We then take the predicted value of REP as explanatory variable for RE innovation.
11. For further details and references, see: Nesta, L., Vona, F., Nicolli, F., 2014, "Environmental Policies, Competition and Innovation in Renewable Energy," *Journal of Environmental Economics and Management,* vol. 67(3), 396-411.

The third and main contribution of the paper is to include the effect of energy market liberalization, captured by the index of product market regulation (PMR henceforth) provided by the OECD,[12] and to allow it to vary depending on the policy support to RE. Figure 3 shows that the degree of product market regulation tends to decrease uniformly over time, although the process started earlier in the USA and Germany compared to Italy and France.

Figure 3. Evolution of the PMR index for 5 countries and for all countries (1976-2007)

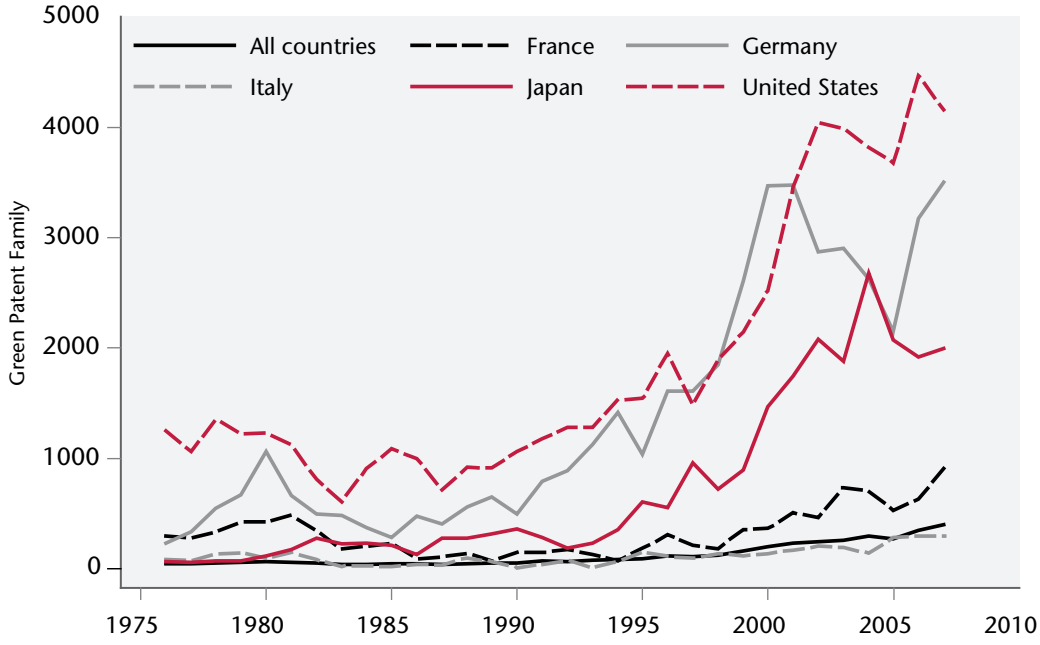


Source: Nesta *et al.* (2014).

Have differences in the timing of reforms been important for RE innovation? Figure 4 displays the trend of patent applications in RE, our measure of RE innovation. The increase in RE innovation seems more pronounced in countries that have liberalized earlier (Germany and the USA) and that have a more diversified policy portfolio (Japan, Germany and the USA). However, differences across countries in REP and PMR indices alone seem too small to account for the large difference in countries' performance in terms of RE innovation.[13]

12. See, e.g., Conway, P., Janod, V., Nicoletti, G., 2005, "Product Market Regulation in OECD Countries: 1998 to 2003, OECD Economics Department," *OECD Working Papers*, 419.
13. Two additional factors may have played a role to explain this divergent pattern in RE innovation. On the one hand, it can be the case that other factors matter, such as country size, persistency in the propensity to innovate and energy prices. On the other hand, it can be that reductions in entry barriers and RE policies have a complementary effect on RE innovation. To test these two hypotheses in our econometric model, we include additional variables and we allow for a complementarity effect between PMR and REP.

Figure 4. Evolution of quality weighted number of patents for 5 countries and for all countries (1976-2007)



Source: Nesta *et al.* (2014).

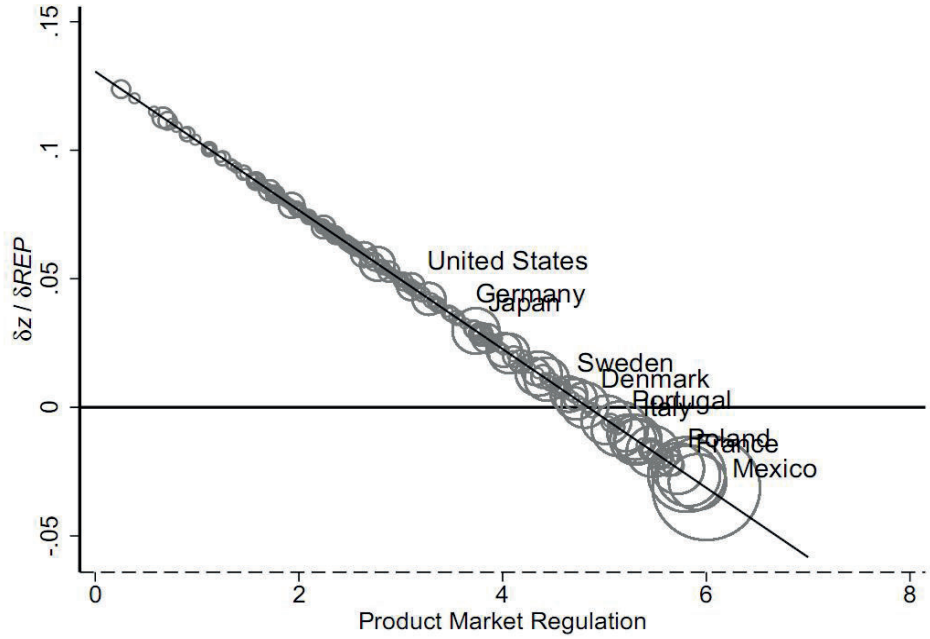
We try to explain this puzzle by allowing REPs to have a differential effect on innovation depending on the degree of market regulation. We find that renewable energy policies are more effective in fostering green innovation in liberalized energy markets. REPs are three times as effective in highly deregulated energy markets than in more regulated ones. In general, this complementary effect is one of the largest drivers of innovation, especially for high quality patents. Interestingly too, the independent effect of the REP indicator disappears when we instrument REP with the years of democracy, suggesting that our methodology is useful to account for the problem brought about by the mutual dependency of policy and technology. This implies that RE policy alone cannot explain RE innovation, but its effect depends on the degree of liberalization of the energy market. This result is summarized in Figure 5 where we depict the estimated effect of REP on innovation as a function of the degree of market deregulation. The effect of REPs is positive only for countries with a level of regulation below average, as is the case in Germany and the United States.

Did the complementary effect of liberalization and targeted energy policies have also redirected innovative efforts toward green rather than brown energy technologies? In an on-going research paper[14], we show that the complementary adoption of RE policies and market deregulation has effectively redirected the innovative effort of firms towards green rather than brown energy. Another

14. Nesta, L., Verdolini, E., Vona, F., "Liberalization and Directed Technical Change in the Energy Sector," *OFCE mimeo*.

key question regards which element of the liberalization process is more conductive to innovation and for which specific RE technology. Another paper of one of us shows that reductions in entry barrier played the major role in fostering renewable energy innovation, especially for wind energy and, to a lesser extent, solar energy[15].

Figure 5. Estimated marginal effect of RE policies on RE innovation



Source: Nesta *et al.* (2014).

Conclusions and further research

In this policy brief we show that the effect of RE policies on innovation is crucially mediated by the degree of competition in the energy market. The combination of ambitious RE policies and market liberalization seems to represent the best policy design to spur green innovation. In the energy sector then, in contrast with the common belief that competition demands no or low state intervention, innovation policy and competition complement each other.

15. See: Nicolli, F., Vona, F., 2014, "Heterogeneous Policies, Heterogeneous Technologies: the case of Renewable Energy," *OFCE working papers*. http://www.ofce.sciences-po.fr/pdf/dtravail/WP2014-15.pdf.