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Environmental policies, competition and innovation in renewable energy

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ABSTRACT

We investigate the effect of environmental policies on innovation under different levels of competition. Using information regarding renewable energy policies, competition and green patents for OECD countries since the late 1970s, we develop a pre-sample mean count-data econometric specification that accounts for the endogeneity of policies. We find that renewable energy policies are more effective in fostering green innovation in countries with liberalized energy markets. We also find that environmental policies are crucial only in the generation of high-quality green patents, whereas competition enhances the generation of low-quality green patents.

Introduction

This paper investigates the effectiveness of policies in support of renewable energy under different levels of competition. Our contribution is motivated by the fact that although both competition and environmental policies are key drivers of innovation (Newell, 2011), their interplay has never been explored. The literature stresses the importance of either policy interventions (Fischer and Newell, 2008; Acemoglu et al., 2012; Popp et al., 2009; Popp, 2002; Johnstone et al., 2010) or market liberalization (Jamasb and Pollitt, 2008; Sanyal and Ghosh, 2014) as determinants of innovation in the energy sector. Instead, we argue that it is the interplay between environmental policies and competition that matters.

Our contention is that environmental policies, essentially in the form of subsidies for renewable energy, are more efficient when conducted in competitive markets. The intuition is the following: because the production of energy is generally more costly when using green technologies, only public subsidies can spur demand for renewable energy and make market entry – a competition enhancer – attractive to new players. Without the entry of new players, environmental policies are less likely to favor radical innovation because large incumbents have little incentive to fully develop renewable technologies that would jeopardize their investments in large-scale energy production.

To our knowledge, this paper is the first to carry out a cross-country analysis that empirically assesses the complementarity between environmental policies and competition in energy production. To do so, we assemble a dataset that contains cross-country information on renewable energy policies (henceforth RE policies or REP), product market regulation (PMR) and various measures of renewable energy patents, which allows us to differentiate their effects depending on the quality of inventions. Based on Blundell et al. (2002), the econometric specification controls for unobserved country heterogeneity by means of the pre-sample mean using a Poisson model. In addition, we use a dynamic

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empirical setup that accounts explicitly for the fact that innovation activities are highly persistent. Finally, we choose the GMM estimator to account for the endogeneity of both renewable energy policies and product market regulation.

Our main findings are the following: first and foremost, we find that renewable energy policies are more effective in fostering green innovation in countries with liberalized energy markets. Second, the effect of renewable energy policies is sizeable for high quality innovation, where such policies are almost three times as effective in highly deregulated energy markets than in more regulated ones. Conversely, energy market liberalization has a positive and large effect on low-quality innovations rather than on radical ones. Third, the independent effect of REP disappears when accounting for policy endogeneity. Fourth, frontier innovation exhibits far less path dependency than generic innovation, implying that to remain at the technological frontier is a matter of sustained research efforts.

The remainder of the paper is organized as follows. The section "Factors affecting renewable energy innovations" discusses the theoretical underpinnings upon which our empirical strategy is based. The first part of the section "Empirical protocol" presents the methodology used to build our dataset and our main policy indicators, and the second part describes the econometric specification and discusses the endogeneity of the policy variables. The section "Empirical results" presents the baseline results, estimates the impact of the variables of interest on various measures of patent quality and quantifies the marginal effect of the policy variables. The final section concludes.

Factors affecting renewable energy innovations

In the past two decades, the realm of energy production and distribution has undergone profound structural changes in two directions. First, the liberalization of the energy markets in many countries has aimed to challenge the monopolistic power of large utilities. The main contention is that increasing market competition will induce reductions in energy prices, in turn leading to higher social welfare.[1] Second, global warming and increased environmental awareness have favored demand for alternative forms of energy, such as wind, geothermal and solar, in response to negative environmental externalities stemming from traditional energy sources. Because cleaner forms of energy production cannot compete with traditional ones in terms of cost, they receive public support by means, *inter alia*, of fiscal or investment incentives.

An important question then arises. In fostering market competition and addressing environmental externality, what is the effect of these broad policy reforms on a country's capacity to actually improve the efficiency of alternative solutions? And does the combination of the two reforms matter for innovation?

Below, we discuss the expected effect on innovation of these two variables and of their interaction.

Competition and innovation: The question of whether competition stimulates innovative activities is certainly not new. From a theoretical standpoint, the innovation regime theory (Winter, 1984) and the industry life cycle theory (Klepper, 1996) insist on the importance of small firms.[2] In these models, radical or product innovation is generated by new, generally smaller players, which contest the dominant position of incumbents. The latter generally focuses on process – not product – innovation, both to increase their cost competitiveness and to avoid product cannibalization. Renewable energy innovations fit well with this explanation because they are competence-destroying for the centralized paradigm of energy production (David and Wright, 2006; Lehtonen and Nye, 2009). In particular, while production of energy from renewable sources, such as wind, biomass, geothermal and solar, is mainly decentralized in small- and medium-sized units, the skills of incumbents are tied to large-scale plants using coal, nuclear materials or gas as primary energy inputs.

From the empirical standpoint, past contributions have previously assessed the effect of liberalization on innovation in the energy sector. Country-level studies, mostly limited to the US and the UK, found that R&D expenditures and patent activities declined after liberalization.[3]

In the case of renewable energy innovation more specifically, competition seems to support innovative activities, at least in the short run. Jamasb and Pollitt (2011) analyze UK patents in the energy sector, and observe that renewable patents have significantly increased in the post-liberalization period. Liberalization favors the entry of nonutility generators, such as farmers, small communities, municipalities and environmentally conscious households, who diversify their offer toward green energy (Delmas et al., 2007; Bird et al., 2006) and specialize in decentralized energy production (e.g., combined generation, local heating systems and renewable sources).[4] For the US, Sanyal and Ghosh (2014) show that the entry of non-utility generators increased the incentives of specialized suppliers of electric equipment to innovate. Additionally, there is a rich case-study evidence for Nordic and Central European countries showing the sustained entry of new firms producing

[1] However, empirical evidence shows that liberalization has not brought down consumer prices see, e.g., Fiorio and Florio (2013).

[2] Recent Schumpeterian models by Aghion et al. (2001, 2005) incorporate both the classical Schumpeterian effect, in which competition reduces innovative rents and therefore R&D investments, and an escaping competition effect. The latter effect holds that the threat of entry of new firms induces incumbents to increase R&D investments to preserve or enhance their market shares. The interplay of these two mechanisms generates an inverted-U shaped relationship between competition and innovation.

[3] See, e.g., for the US: Dooley (1998), Sanyal (2007), Nemet and Kammen (2007), Sanyal and Cohen (2009) and Sanyal and Ghosh (2014) and for the UK: Jamasb and Pollitt (2008). Similar negative effects of deregulation on energy R&D were found for electric utilities worldwide by Sterlacchini (2012) and Salies (2010).

[4] In Denmark, for instance, most wind turbines are owned by households, municipalities and small communities, whereas utility-owned wind capacity accounted for only 15% of the total installed wind capacity in 1990 (Hadjilambrinos, 2000). Similarly, in the US, the approval of the Public Utility Regulatory Policies Act mandates that public utilities purchase energy from small-scale power producers, essentially non-utility generators producing from renewable sources (Loiter and Norberg-Bohm, 1999).