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Do eco-innovations harm productivity growth through crowding out? Results of an extended CDM model for Italy

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ABSTRACT

This paper discusses the results for Italy of a CDM model (Crepon et al., 1998) further extended with the objective of evaluating drivers and productivity effects of environmental innovations. The particular nature of environmental innovations, especially as regards the need of government intervention to create market opportunities, is likely to affect the way through which they are pursued (innovation equation within the CDM model) and their effect on productivity (productivity equation).

The contribution of the paper is manifold. First, the drivers of environmental innovations (measured with environmental patents) are investigated by using mainly administrative data instead of survey data. Second, I investigate the extent to which firms with big polluting plants tend to bias their innovation strategies towards environmental technologies. Third, the return of environmental innovations is compared to the one of other innovations to indirectly assess the presence of a crowding out effect of environmental innovations at the expenses of other (possibly more profitable) innovations.

Results, based on administrative data (AIDA by Bureau van Dijk and patent data from PATSTAT) of Italian manufacturing firms, show that innovation efforts of polluting firms is significantly biased towards environmental innovations and that environmental innovations tend to crowd out other more profitable (at least in the short run) innovations.

1. Introduction and literature review

Technological progress, together with structural change and shifts in consumption patterns, has been acknowledged to be a crucial factor in achieving environmental sustainability (Jaffe et al., 2002; Popp et al., 2009; Popp, 2010). Technological progress might improve environmental performance both through increased resource efficiency and lower emission intensity in production activities and through the supply new more 'sustainable' products as substitutes to other less efficient products (e.g. energy intensive durable goods). Firms are key actors in the creation, adoption and diffusion of environmental innovations as well as the most important responsible for environmental pressures.

The economic literature on eco-innovation patterns at the micro level has focused to a great extent on the identification of the drivers of eco-innovation by firms with little attention given to the effect of eco-innovation on productivity or financial performance of firms. Rennings and Ziegler (2004) use data from the German Community Innovation Survey (CIS) finding significant positive effect of environmental organizational measures (EMAS and ISO14001), market opportunities and R&D intensity on process and product environmental innovations. Wagner (2007) uses both data on environmental patent applications and self-reported measures of eco-innovation to investigate the effect of environmental management on environmental innovations. Results for German firms show a positive effect of EMS adoption on self-reported process environmental innovations and a negative effect on firms' general patenting activity. The paper by Horbach (2008) uses a discrete choice model for German manufacturing firms finding strong positive effects of technology push (knowledge capital), demand pull (social awareness of customers) and environmental policy (either mandatory or voluntary through environmental management tools) factors on environmental innovations. Horbach et al. (2012) is the first relevant study investigating the determinants of different of environmental innovations in different technological fields. Their analysis, based on the German CIS for 2009, shows that the introduction of innovations aimed at reducing by-products of production activities such as the release of air, water and noise emissions are strongly related to government regulations (current and expected). On the other hand, innovations aimed at reducing material and energy use are driven by cost-savings and resource and energy taxes due to the easier appropriability of the returns from innovation through reductions in production costs. Rave et al. (2011) base their analysis on German firms and on their patenting

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behaviour. They highlight the importance of a clear and strict environmental regulatory framework, of possible cost savings due to environmental innovations and of the possibility of creating new markets.

Going beyond the German case, it is worth considering studies looking at other countries. Cainelli et al. (2011) show that different types of environmental innovations introduced and adopted by manufacturing firms in Emilia Romagna (Italy) are very strongly correlated to international characteristics (foreign ownership and export propensity) and networking with other firms and institutions. Demirel and Kesidou (2011), focusing on the UK, highlight the importance of environmental regulation and the adoption of the ISO14001 standard for end-of-pipe technologies and environmental R&D while equipment upgrade motives positively correlate with the adoption of both end-of-pipe technologies and cleaner production technologies. The same authors further investigate the UK case (Kesidou and Demirel, 2012) focusing both the probability of performing green R&D and on its intensity, finding strong links between demand factors and the probability of performing green R&D (extensive margin) while no such a relationship is found with R&D intensity (intensive margin). The paper by Belin et al. (2011) is one of the few examples of cross-country comparison of the drivers of eco-innovation. In their comparative study between Germany and France based on the harmonized Community Innovation Survey, they find many similarity between the two countries, with a crucial role played by environmental regulatory stringency and cost-saving motives while some difference is found about the extent to which firms rely on internal or external sources of knowledge in order to successfully adopt eco-innovations.

Finally, contributions regarding Japan and US mostly refer to industry-level investigations on the links among environmental regulatory stringency, eco-innovation and economic performance[1] while little investigation at the firm-level is found for countries outside Europe.

While environmental innovations are expected to have, by definition, a beneficial effect on the environment,[2] their effect on productivity is less straightforward. The conventional wisdom predicts that starting from a situation of optimizing firms, any policy aiming at limiting environmental by-products of firms will result in a reduction in measured productivity. These productivity losses could be reduced by introducing environmental innovations. However, productivity losses cannot be fully removed and resources devoted to generate or adopt environmental innovations should be diverted from 'optimal' research projects with higher expected returns (crowding out). In this respect, Popp and Newell (2012) find no evidence of crowding out of energy R&D expenditures on general R&D across US industries. However, when they consider energy patents at the firm level, they actually observe that the amount of alternative energy patents is negatively related to the amount of other types of patents, even though this result seems to be driven by profit-maximizing strategies of firms.

An alternative view, promoted by Porter and van der Linde (1995), allows for the possibility of win-win outcomes. In this case, environmental regulations help to fill information gaps about available technologies and technological opportunities and they help solving the additional appropriability problem of environmental innovations (EI) due to the fact that EI reduce external, generally not priced, social costs ('weak' version of the Porter hypothesis). Moreover, early introduction of environmental technologies is expected to generate early mover advantages for regulated firms, with long run positive effects on competitiveness and, eventually, on measured productivity ('strong' version of the Porter hypothesis).[3]

In this respect, Rexhauser and Rammer (2013) use the German CIS 2009 to investigate the effect of different types of environmental innovations on the profitability of German firms. They find that cost-reducing innovations aimed at reducing energy and material input have a positive effect on firms' profitability while regulation-induced environmental innovations, mainly aimed at reducing environmental pressures, have a negative but weak effect on profitability.

Lanoie et al. (2011) attempt to investigate the complete chain of causality from environmental regulatory stringency to environmental and financial performance passing through environmental innovation by means of a survey on 4,200 facilities in seven OECD countries. Their findings support the weak version of the Porter hypothesis, with environmental regulatory stringency positively affecting green R&D investment. The strong version of the Porter hypothesis, however, is not confirmed, with the negative effect of environmental regulatory stringency on profitability being just partially offset by the positive effect of green R&D investment.

The aim of this paper is to assess the drivers of environmental innovations and their effect on firm-level productivity. I employ a panel of Italian manufacturing firms for the period 2000–2007 containing information on balance sheet and income statement, EPO patent applications and polluter status in order to jointly identify the drivers of eco-innovations and their contribution to firm-level productivity. The empirical framework is that of a modified CDM model (Crepon et al., 1998) to account for eco-innovation patterns. The rest of the paper is organized as follows. Section 2 briefly defines eco-innovation and the extent to which patent data are a useful source of information on eco-innovation. Section 3 focuses on the description of the empirical model and of the data. Section 4 discusses the results. Section 5 concludes.

2. Definition of environmental innovations and the role of patent data

A definition of environmental innovation is needed in order to investigate its impact on productivity and potential crowding out effects. There has been a rich debate in the economic literature about the distinctive features of environmental innovations as opposed to general innovations (Rennings, 2000). Environmental innovation (or eco-innovation) has been defined by Kemp and Pearson (2007) within the project 'Measuring Eco Innovation' as

> the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives.

This is a broad definition, making it difficult to measure environmental innovation in a comprehensive way. On the one hand, surveys are able to describe qualitatively the whole spectrum of eco-innovation strategies of innovative firms. On the other hand, however, the broad definition of eco-innovation is likely to result in ambiguous questions in the questionnaires which are prone to misleading interpretations by surveyed people. Moreover, surveys

[1] Among other, refer to Lanjouw and Mody (1996), Jaffe and Palmer (1997) and Brunnermeier and Cohen (2003) for the US, Hamamoto (2006) for Japan and Yang et al. (2012) for Taiwan.

[2] Economists and policy makers are increasingly worried about the possibility that cost and price reductions brought by environmental innovations through improvement in material and energy efficiency would result in an increased consumption of these new efficient goods, with an overall negative effect on the environment due to possible rebound effects (Binswanger, 2001).

[3] For a more detailed discussion about the difference between the 'strong' and 'weak' version of the Porter hypothesis refer to Jaffe and Palmer (1997).