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Analysis

Unveiling the dynamic relation between R&D and emission abatement National and sectoral innovation perspectives from the EU

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ABSTRACT

This paper examines investment decisions regarding innovation and emissions abatement in a dynamic framework, where knowledge stock is an impure public good. We take a sector perspective based on neo Schumpeterian theory that emphasises the role of both sector and innovation systems. We interpret results taking into account sector and country based institutional, market and policy conditions. Econometric outcomes, based on an original sector dataset which exploits the NAMEA source for 15 European Union (EU) countries and 23 manufacturing sectors in the time frame 1995–2006, show that innovation efforts are positively correlated to various spillover effects. Those effects include the emissions abatement of the other sectors, thus pointing out the relevance of forces which opposite typical free riding behaviour in public or mixed public good frameworks. Different reactivity strengths for different global and local emissions also allow us to disclose the specific role of technological and economic complementarity. When considering CO_2 emissions, innovation is mainly triggered by national interactions, a fact which is coherent with a dominance of national innovation and policy systems in the EU. The result is also consistent with the fact that CO_2 abatement technologies heavily regard energy efficiency that provides joint private and public benefits. The fact that NMVOC abatement efforts by other sectors from abroad impact R&D investments positively means that, in some cases, a realm of sectoral systems of innovation is also relevant. The different evidence between local and global externalities is surely explained not only by the different technological and economic contents, but also by the fact that the EU has witnessed different policy implementation.

1. Introduction

Do environmental protection decisions in other firms, sectors or countries foster innovation in a given firm or sector? Namely, is the innovation effort influenced by how others innovatively behave towards the environment? The answer is notoriously negative if we stick to standard public economics reasoning: more provision of public goods (e.g. abatement efforts) by others determines shrinking incentives. To this sense, free riding behaviour can be one important reason behind the many weaknesses our societies show with respect to global concerns as climate change mitigation (Dietz and Maddison, 2009).

A more optimistic view on future sustainable growth is nevertheless possible if we introduce in the discussion about the mixed good (alternatively impure public good) feature, that often characterise environmental-friendly technologies and the geographical aspects of innovation, thus unveiling the existence of several forms of complementarity and spillovers. Firms and sectors could contribute to environmental damage reduction beyond the targeting mandate of policies. This eventually depends upon the intensity of innovation spillovers, as well as upon the specific features of different types of environmental externalities. In this context, technological development is a key factor by which our society may positively influence future emissions reductions (Horbach et al., 2012). According to this new strand of literature, the relationship between environmental performance and innovation patterns has received increasing attention in the current policy agenda of advanced economies especially in the energy sector, and in particular within the European Union (EU).

Although the crucial role of such linkages is now fully recognized, there are spare scientific contributions addressing the causal relationships between how technology and environmental protection activities evolve over time and how much of this dynamics is explained by decisions taken by other agents (Carrión-Flores and Innes, 2010).

Given the aforementioned background, this paper focuses on a specific causal link between environmental protection and innovation path.

More precisely, the novelties of the paper are the following: i) at the best of our knowledge there are no empirical contributions dealing with

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the interaction between environmental performance of other agents and the investment decisions in technological innovation of one agent; ii) the dynamic treatment of such linkage is still sparely adopted and the specific analysis of the role of knowledge or policy spillovers is directed towards the investigation of the influence on the innovation path in environmental innovation domains (Braun et al., 2010; Inoue et al., 2013; Lehmann, 2013; Nemet, 2012; Peters et al., 2012) rather than on a generally defined knowledge production function We address those issues through the construction of a wide dataset that covers several EU countries and 23 manufacturing sectors, with information on innovation efforts, environmental performances and production inputs. This could constitute a valuable tool also for other types of empirical analyses, as for instance regional applications (Ghisetti and Quatraro, 2013).

The analytical framework used for this analysis relies on theoretical studies that investigate the reasons behind agent's behaviours in a context of mixed good provision (Cornes and Sandler, 1984, 1986; Löschel and Rübbelke, 2009; Markandya and Rübbelke, 2012). We first assume that innovation (knowledge production) and the resulting technological stock is to be considered as an impure public good (Keller, 2004; Stiglitz, 1999). In order to study how private agents behave when dealing with investment decisions regarding innovation efforts that generate both a fully appropriable private characteristic and a public characteristic,[1] we pose the mixed good conceptual approach in a dynamic empirical setting. This helps analysing the extent to which innovation and environmental spillovers influence the investment behaviour of agents in technological development.

Our mixed good is thus represented by the total amount of cumulated investment in innovation, here empirically modelled as research and development (R&D) expenditures cumulated over time.[2] The causal link between environmental performance of other agents and the investment decisions in technological innovation of one agent is formally represented by the dynamic behaviour of the knowledge stock over time (with respect to decisions taken by other agents) which could be easily assumed to be represented by yearly innovation investment decisions. According to this methodological framework we formulate two research hypotheses (RH).

RH1. If investment in innovation is an impure public good, there is a positive reaction function of one agent's investment in the mixed good with respect to the other agents' investment in the public component.[3]

RH2. If RH1 is confirmed, we expect that the reaction is stronger when the private and the public components of the benefit function are *complements*, than when the two components are substitutes. In the case of a *strong* complementarity, an increase in the other sectors' investment in the public component increases the single sector's marginal benefit of accumulating the complementary private component, and consequently, the overall mixed capital good. This is primarily due to a deeper appropriability degree of the positive externalities. When considering RH2, what we are specifically interested in is investigating upon the driving forces which shape the complementarity degree.

When investigating on RH1 and RH2, given the focus on knowledge production, in line with already existing literature, various relevant spillovers are analysed, of both inter-sector and inter-country types, in order to detect all possible relationships.

We do believe that the dynamic setting is the only one which is consistent with the analysis of agents' investments, with regard to how agents make their decision not only about R&D today, but also rather about their R&D and their investment today, which will determine their R&D capital tomorrow. This is particularly relevant in our analysis, where we consider the case in which each agent's R&D capital (the mixed good) tomorrow is determined by the other agents' investment in the public component today, defining the slope of the reaction function (Klette and Griliches, 2000). Moreover, when studying interrelationships between agents' decisions in innovation investments, the dynamic setting is particularly useful for addressing how such relationships evolve over time (Del Monte and Papagni, 2003; Hagedoorn, 2002).

In order to test our research hypothesis we have built an original dataset that considers 23 manufacturing sectors for 15 European Union (EU) countries over the period 1995–2006 accounted in the National Accounts Matrix including Environmental Accounts (NAMEA) data source. This sector-based dataset choice is primarily coherent with consolidated theories in innovation working at sector level (Breschi et al., 2000; Malerba and Orsenigo, 1997) and also allows a long enough time series for a panel of countries from the empirical point of view, thus shaping also the dynamic dimension of the present analysis. We do believe that the sector-based level is strongly consistent with our purposes from both an applied and a conceptual perspective, since it allows a good coverage at geographical level, and it assures a good degree of heterogeneity.[4]

In order to test RH2, we study the positivity of the sector reaction function – the response of one agent's to the other effort/contribution – for two different environmental externalities given by carbon dioxide (CO_2) and non-methane volatile organic compounds (NMVOC) emissions. The diffusion patterns of these pollutants are different enough to define CO_2 as a global externality, and NMVOC as a more localised environmental damage. In addition, the economic sectors involved in polluting activities for these two emission types are substantially different both in technological capabilities and in geographical distribution. These differences allow us to provide some interesting insights also into relationships between the degree of complementarity between innovation and abatement in the related technology and the nature of the environmental externality.

If RH1 and RH2 are empirically confirmed, our results could have influence on a new reasoning about the optimal policy mix where a combination of public support for innovation and environmental performance might mutually benefit from spillover effects. This could bring to useful policy advice especially for budget allocation decisions, since the mutual positive forces influencing innovation and environmental performance could partially reduce budget constraint concerns. Spending further efforts in policy coordination both at domestic and international levels is another consequential step for policy making.

The rest of the paper is structured as follows. Section 2 presents the relevant literature. Section 3 presents the empirical strategy whereas Section 4 provides the main empirical results. Section 5 concludes the paper.

2. Relevant Literature

The early adoption of an impure public good approach was presented in Cornes and Sandler (1984), and was further developed by Andreoni (1989, 1990). Cornes and Sandler (1994) then analysed how different degrees of substitutability or complementarity of the private and public characteristics of the impure public good lead to divergent comparative static results in the provision of impure public goods.

[1] Very briefly, by defining knowledge capital as a mixed good, the private characteristic of innovation could be generally represented by higher economic productivity, whereas the public characteristic could be represented by lower negative environmental externalities (a reduction in polluting emissions, for instance).

[2] At this purpose a first attempt is provided by the analysis by Ek and Soderholm (2010), where they treat R&D as a stock of knowledge in the ecological economics field with an application to economic sectors within the EU context.

[3] Apergis et al. (2013) analyse for three EU countries the relationship between R&D and CO_2 abatement taking R&D as driver in a microeconomic setting. The study highlights that firm based analyses are worthwhile even though due to data availability the coverage is often shrunk.

[4] For sector-based studies using economic–environmental accounting data such as NAMEA and WIOD sources see Costantini et al. (2013); Gilli et al. (2013); Marin and Mazzanti (2013).