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Carbon abatement, sector heterogeneity and policy responses: Evidence on induced eco innovations in the EU

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ABSTRACT

The paper offers sector-based qualitative evidence concerning the climate and energy policy effects on eco innovations in the EU. Through interviews with industry associations of Emission Trading Scheme (ETS) sectors, it analyses the extent to which past innovation adoption dynamics were influenced by policy and regulatory levers, by looking at the single and interaction effects of policies. As could be expected from the neo-Schumpeterian theory on innovation, differences emerge across sectors. Policies appear to be relevant in some sectors, namely energy, coke and refinery, and paper, but energy costs considerations dominate over the potential effects of CO_2 targeted policies. Overall, technological and organisational levels are both relevant: organisational innovations emerged as important in most sectors, often operating as a leading force in technological development. We expect this 'complementarity' to play a crucial role in the future path towards 2030 and 2050 aims, whose achievement is possible only by integrating technological, organisational and behavioural innovations.

1. Introduction

It is well known that innovation plays a key role in sustainable economic development. Technological change is an important exogenous driver of long-run growth in per capita income in neo-classical models (Solow, 1956). Moreover, neo-Schumpeterian theory, suggests that techno-organizational progress is central in the evolution of economic systems (Dosi et al., 1988; Fagerberg et al., 2005).[2]

Narrowing down the focus on Environmental Innovations (hereafter EI, Rennings, 1998, 2000; EEA, 2013; Gilli et al., 2013, Chappin et al, 2009) they are indeed crucial as part of the investment flows in technology and organisational/labour improvements that are needed to achieve sustainable economic growth in the long run. The Stern review itself acknowledges the role of technological change for climate change mitigation as one of the three pillars towards a low carbon economy (together with policy and behavioural change).

One of the most diffused definitions of eco-innovation[3] identifies it as the production, application or use of a product, service, production process or management system new to the firm adopting or developing it, and which implies a reduction in environmental impact and resource use (including energy) throughout its life-cycle (Kemp, 2010).

We here link the analysis of EI adoption to policy and sectoral frameworks, thus emphasising the idiosyncratic factors that characterise 'sector agents' (Chappin et al., 2009). More specifically,

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[2] In this paper we adopt a broad perspective towards the analysis of innovation activities, which comprises both technological and non-technological innovations. Following the OECD Frascati Manual (2002), it is possible to distinguish within the former group between product innovation (i.e. the market introduction of a new or significantly improved good or service) and process innovation (i.e. the implementation of a new or significantly improved production process, distribution method, or supporting activity). Within the second group we will refer in particular to organisational innovation, which consists of a new organisational method in the company's business practices, workplace organisation or external relations, not previously used by the enterprise. We will also distinguish between radical innovations and incremental innovations classified according to their different degrees of novelty with respect to available technological knowledge and existing products, organisation and production processes.
[3] In what follows, we will use eco-innovation as synonym for environmental innovation, as is commonly done in the literature on this issue (Carrillo-Hermosilla et al., 2010).

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we focus on the impact of policies and regulations, by adopting a (to our knowledge) original sector level perspective. In this respect we link to different strands of literature.

Firstly, we are connected to contributions from the literature on the incentives by firms to invest in EI to reduce compliance costs and/or emissions, starting with Milliman and Prince (1989) and Downing and White (1986); [4] contributions on this line suggest that the chosen environmental policy instruments and their design can be crucial in determining adoption and, more generally, innovation incentives.

Secondly, we base our analysis on the literature connecting environmental regulation and competitiveness. Many theoretical studies carried out until twenty years ago supported the idea that environmental policy would necessarily increase compliant firms' costs, and that a country's comparative advantage could be adversely affected by stringent environmental regulations. For instance, the works of Pethig (1976), Siebert (1977) and McGuire (1982), stress that environmental policies increasing firms' internal costs affect countries' competitiveness. Nevertheless, in the last two decades, many scholars have challenged this idea. In particular, Porter (1991) and Porter and Van der Linde (1995) have strongly criticised this approach, underlining that it was not addressing properly the environmental regulation/competitiveness relationship. In the view of Porter and Van der Linde, correctly designed policies may, for instance, signal resource inefficiencies and/or potential technological or organizational improvements, or may place pressure on firms, pushing them to develop innovations and promoting technological change. Within this view, the policy-driven innovation may offset the loss of competitiveness due to the additional costs induced by regulation. Jaffe and Palmer (1997) and Kozluk and Zipperer (2014), among others, propose a taxonomy which is helpful in distinguishing the different lines of research that have further developed. A "Weak" Porter Hypothesis is identified, stating that, by placing constraints to regulated firms, environmental regulation may stimulate innovation, which comes, however, at a (opportunity) cost for the regulated sectors. There is then a "Strong" version of the Porter Hypothesis, which holds that regulation is not only able to spur innovation, but also that this gain in efficiency is able to completely offset any loss in competitiveness due to compliance costs. In other words, this last approach suggests that more stringent and well-designed regulation promotes competitiveness. Finally, there is a "Narrow" version of the Porter Hypothesis, which shows that *certain types* of environmental regulations (e.g. outcome rather than process based policies) are able to stimulate innovation.

Independently of the mechanics behind the policy-EI link, the impact of policies and the centrality of their design in determining adoption and R&D efforts is confirmed empirically in several environmental realms (see, among others, Kneller and Manderson, 2012; Cainelli et al., 2015; Horbach et al., 2012).

Specifically concentrating on sectoral issues, they have gained considerable momentum since the Pavitt (1984) taxonomy was introduced into the economics of innovation. From a conceptual point of view, we mainly refer to the integrated concepts of sectoral and national systems of innovation, which have been consolidated into innovation-oriented evolutionary theory (Malerba, 2004) and have been exploited in environmental economics literature examining EI and policy (Crespi, 2013; for a recent discussion and analysis see Mazzanti et al., 2014).

To foster a deeper understanding of this issue, we will critically examine the findings on the innovation effects of environmental policies that emerge from several interviews with *sector representatives*[5] across different European countries. Although the views of the industry representatives are obviously subjective and may reflect the industry's bias, qualitative research can provide some interesting insights that can be seen as complementary to the quantitative analyses on this issue. This seems particularly important in the present context in which data constraints have hindered so far detailed quantitative analyses of EI adoption at sector level.[6] Even when data on EI are available, they generally cover a very limited time period, as in the case of the last wave of the European Community Innovation Survey, that covers the period 2006–2008. To overcome the shortage of the data at disposal, some scholars have performed interview-based case-study analyses on the EI effect of specific environmental policies in single sectors and/or countries (e.g. Hoffmann, 2007 and Rogge and Hoffmann, 2010, on the impact of the European Emission Trading Scheme – hereafter EU ETS – in the German electricity sector; Rogge et al., 2011a on the German energy sector; Pontoglio, 2010 on the Italian paper and cardboard sector; Tomas et al., 2010 on the Portuguese chemical sector). Differently from these contributions, the present paper aims to extend the analysis of the EI effects of environmental regulation (including but not limited to the EU ETS) by considering several sectors, several countries and a larger set of years.

The paper is organised as follows. Section 2 highlights our research questions, while Section 3 describes the survey and data. Section 4 presents our main results for each of the four analysed sectors. Section 5 concludes.

2. Research questions

This paper investigates whether and to what extent energy and environmental policy instruments have been relevant forces behind the adoption of environmental innovations in the EU. We focus on technological and organisational innovations of product and process nature; incremental and radical features are also scrutinised.

Our focus is thus on the *ex post* assessments of EI drivers, looking at *single and interaction effects of policies*.

We take a sectoral perspective, that is theoretically based on neo-Schumpeterian evolutionary theory and focuses on EI aimed at enhancing energy efficiency and at abating CO_2. For this purpose, we performed interviews with industry representatives of key EU sectors: energy, paper, ceramics and cement, coke and refinery. In terms of policy, though the EU Emission Trading Scheme is an obvious keystone, the analysis hinges on 'drivers and obstacles' of innovation with some focus on the complementarities and trade-offs among policy tools as they emerge from interviews.

The setting of research questions is as follows.

RQ1) We investigate whether *energy and climate policy* played a significant role in driving innovation decisions, and if differentiated effects depending on the type of instruments under scrutiny and the related stringency have taken place. In so doing we will be able to assess the coherence of our results with the standard partial equilibrium analyses of technology adoption (Requate, 2005). Heterogeneity in responses to policies is also

[4] See Requate (2005), among others, for a survey.

[5] We thus interview and cover Industry associations, not firms. This approach extends the representativeness of our investigation with respect to the EU framework. Industries should reflect the 'average view', and then highlight possible specific features within the industry itself.

[6] See, for instance, Borghesi et al. (2015) for an in-depth description of the quantitative literature on environmental regulation and eco-innovation. See also Cainelli et al. (2015), Horbach et al. (2012), Mazzanti et al. (2014) for quantitative micro and meso analyses of innovation drivers. Sector data are often rich of missing values. Econometric analyses (see Marin and Mazzanti, 2013) that produce sector evidence require large and long panel datasets.