Ecological Economics 70 (2011) 513–523

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

The innovation impact of the EU Emission Trading System — Findings of company case studies in the German power sector

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ARTICLE INFO

Article history:
Received 8 February 2010
Received in revised form 23 July 2010
Accepted 21 September 2010
Available online 16 November 2010

Keywords:
EU ETS
Emission trading
Innovation
Technological change
Organizational change
Power sector

ABSTRACT

This paper provides a detailed analysis of how the European Emission Trading System (EU ETS) as the core climate policy instrument of the European Union has impacted innovation. Towards this end, we investigate the impact of the EU ETS on research, development and demonstration (RD&D), adoption, and organizational change. In doing so, we pay particular attention to the relative influences of context factors (policy mix, market factors and public acceptance) and firm characteristics (value chain position, technology portfolio, size and vision). Empirically, our qualitative analysis is based on multiple case studies with 19 power generators, technology providers and project developers in the German power sector which were conducted in 2008/09. We find that the innovation impact of the EU ETS has remained limited so far because of the scheme's initial lack of stringency and predictability and the relatively greater importance of context factors. Additionally, the impact varies significantly across technologies, firms, and innovation dimensions and is most pronounced for RD&D on carbon capture technologies and organizational changes. Our analysis suggests that the EU ETS on its own may not provide sufficient incentives for fundamental changes in corporate innovation activities at a level which ensures political long-term targets can be achieved.

1. Introduction

Despite the setback in Copenhagen (UNFCCC, 2009), the global negotiations concerning a successor for the Kyoto Protocol (UNFCCC, 1997) as well as the implementation of a variety of climate policies around the world (IEA, 2009a) document a growing political will to limit climate change (UNFCCC, 1992). The cornerstone of the European Union's climate policy mix is the EU Emission Trading System — the EU ETS (EU, 2003). This market-based climate policy instrument is primarily aimed at achieving cost-minimal compliance with a given greenhouse gas (GHG) emission target, but it is also expected to provide innovation incentives (EU, 2005). In the long term, these dynamic incentives may be the most important means to achieve the deep GHG emission cuts required (IPCC, 2007b; Kneese and Schulze, 1975). However, the actual implementation of the EU ETS has raised doubts about its capacity to trigger innovation (Gagelmann and Frondel, 2005; Schleich and Betz, 2005). Yet, there are only a few empirical studies that have analysed the innovation impact of the EU ETS (Cames, 2010; Hoffmann, 2007; Pontogolio, 2008; Rogge and Hoffmann, 2010). In addition, these early studies do not cover all the aspects relevant for such an analysis (del Río González, 2009) and do not consider the more stringent second trading phase (2008–12) and the ambitious revision of the EU ETS post-2012 (Schleich et al., 2009). As a consequence, policy makers in countries with newly emerging trading schemes[1] may face difficulties in transferring the lessons learned regarding the innovation impact of the EU ETS.

Against this background, this paper aims to provide a detailed analysis of how the EU ETS has impacted innovation and whether it does so at a level adequate to reach the long-term political targets required for a decarbonization of the economy. In doing so, we address several of the research recommendations made for studying the determinants of environmental technological change (del Río González, 2009). We build our research framework on environmental economics (Popp et al., 2009) and innovation studies (Fagerberg and Verspagen, 2009) and extend the existing studies in four respects: First, we distinguish innovation into the three dimensions of research, development and demonstration (RD&D), adoption, and organizational change, and address interlinkages between them. Second, we include not only regulated entities in our analysis, but also corporate actors from other value chain positions relevant for innovation outcomes (Pavitt, 1984). Third, we specifically address firm heterogeneity to understand how the innovation impact of the EU ETS differs according to firm characteristics such as a firm's technology portfolio.

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[1] The innovation incentives generated by these new schemes may have repercussions for those generated by the EU ETS and vice versa, as it is envisaged that different trading schemes will be linked directly or indirectly via mechanisms such as the CDM.

0921-8009/$ – see front matter
doi:10.1016/j.ecolecon.2010.09.032

Fourth, we also explicitly address the role of context factors in the business environment to account for the multitude of determinants of corporate innovation activities (see e.g. del Río González, 2005; Horbach, 2008; OECD, 2007).

We limit our study to the power sector because it has by far the largest share of CO_2 emissions covered by the scheme (71.3% in 2008) (EU, 2010).[2] The power sector is also the largest contributor to CO_2 emissions in the rest of the world and thus plays a key role in future emission reductions and innovation (IEA, 2009b). Furthermore, we confine our analysis to Germany as this country exhibits a fairly diversified mix of power generation technologies and is characterised by significant capacity renewal needs (IEA, 2007; Platts, 2008).[3]

We chose a qualitative methodological approach based on multiple company case studies because we aim at generating insights into the complex nature of corporate innovation decision making and how this is affected by the EU ETS, thereby contributing to the identification of causal links (Yin, 2002). In-depth interviews with company representatives constitute the prime data source which was supplemented by archival data.

The paper is organized as follows. Section 2 presents a brief overview of the literature on the EU ETS and innovation. Sections 3 and 4 introduce our research framework and the case study methodology, respectively. Section 5 presents our findings on the so far rather limited impact of the EU ETS on RD&D, adoption and organizational change. Finally, Section 6 discusses these findings before Section 7 concludes with research and policy recommendations.

2. Theoretical Background on the EU ETS and Innovation

Launched in 2005, the EU ETS is the world's largest and first multi-country greenhouse gas (GHG) emission trading scheme (Skjaerseth and Wettestad, 2008). It applies to large stationary GHG emitters in the energy and industry sectors of EU Member States and operates in trading phases, the first of which was a three-year pilot phase (2005–07), while the second coincides with the Kyoto commitment period (2008–12). Due to its decentralised policy implementation, EU Member States were granted significant leeway in specifying EU ETS design details in their National Allocation Plans, such as the allocation rules governing the distribution of EU allowances (EUA) (Betz et al., 2004; Harrison and Radov, 2002; Kruger et al., 2007).

As a cap-and-trade scheme the EU ETS sets a cap on the permitted amount of emissions and distributes a corresponding number of allowances. Companies failing to submit the correct number of allowances in line with their emissions face severe sanctions. Since allowances can be traded at the market price and companies are granted flexibility in their compliance strategy, in equilibrium, the market price reflects the marginal abatement costs which are equalised across companies. Hence, overall abatement costs are minimised ensuring static efficiency (Dales, 1968; Tietenberg, 1985, 2006).[4] Compliance costs are further reduced by allowing for the inflow of a certain number of certificates generated under two flexible mechanisms of the Kyoto Protocol (EU, 2004): the Clean Development Mechanism (CDM) and Joint Implementation (JI). In the CDM, the larger scheme, companies buy certificates from carbon-saving projects in developing countries which can often be generated at lower abatement costs than in the EU ETS sectors and thus reduce the price of EU allowances (Schneider et al., 2009).

In addition to the cost minimisation rationale, the establishment of a price for carbon by such a trading scheme is expected to generate dynamic incentives for the development and diffusion of low carbon technologies (for an overview, see Fischer, 2005). In contrast to other instrument types, particularly command-and-control measures, theory-based economic reasoning refers to the continuous innovation incentives provided by economic instruments and thus their superiority in spurring innovation (Jaffe et al., 2002; Popp et al., 2009; Requate, 2005; Vollebergh, 2007).[5]

The existing literature on the innovation impact of the EU ETS can be differentiated into studies trying to anticipate the scheme's impact and those conducting ex-post evaluations. Regarding the former, based on the theoretical and empirical evidence from US trading schemes for SO_2, NO_x and lead (for an overview, see Hansjürgens, 2006), Gagelmann and Frondel (2005) conclude that the innovation impact of the EU ETS is likely to be limited in its pilot phase from 2005 to 2007. They identify the generous initial allocation of EU ETS allowances, linking the scheme to the project-based Kyoto Mechanisms JI and CDM without upper limits and the distribution of free allowances as the main reasons for its limited impact. Schleich and Betz (2005) arrive at a similar conclusion after discussing the potential innovation relevance of EU ETS design choices. These innovation-specific studies are complemented by broader analyses on the economic implications of the design of the EU ETS (e.g. Egenhofer et al., 2006; Ellerman and Joskow, 2008). For example, two innovation-relevant aspects of the EU ETS which have been analyzed are the distortionary incentives arising from the treatment of new entrants and closures and the short trading phases (Ahman et al., 2007; Ellermann, 2008; Neuhoff et al., 2006).

In sum, the rare ex-post evidence indicates a rather limited innovation impact of the EU ETS, particularly on research and development and long-term portfolio decisions (Cames, 2010; Hoffmann, 2007; Rogge and Hoffmann, 2010).

3. Research Framework

We build our conceptualisation of innovation on the Oslo Manual and focus on innovations new to the firm (OECD, 2005). In line with neoclassical (Requate, 2005) and evolutionary studies (Oltra and Saint Jean, 2005), we differentiate innovation into research and adoption and add organizational change as the third innovation dimension (Armbruster et al., 2008; Christensen and Rosenbloom, 1995; Edquist, 1997). Regarding *research, development, and demonstration* (RD&D), 'research' stands for basic laboratory research; 'development' consists of testing the new technology on a small scale in pilot projects, and 'demonstration' refers to the first larger scale implementation of the technology. We conceptualise *adoption* as companies' investments in state-of-the-art technologies. This encompasses both investments in new installations and retrofits of existing ones, thereby determining the diffusion of commercially available technologies. Finally, *organizational change* is made up of changes in procedures, structures and visions. We are particularly interested in activities contributing to a reduction of GHG emissions and refer to them as *corporate climate innovation activities*.

Since the recent literature has increasingly pointed out that a policy's design features may be more influential for innovation than the instrument type (Kemp and Pontoglio, 2008; Vollebergh, 2007), we do not merely consider the EU ETS' carbon price and thus its nature

[2] The figure is based on the verified emissions of "main activity 1" (combustion installations).

[3] In 2008, the German power generation mix consisted of 23% lignite, 23% nuclear, 19% hard coal, 14% gas, 8% hydro, biomass and other, 7% wind and 6% fuel oil, pumped storage and other. The total power generation capacity in that year amounted to 147.1 GW and the net electricity generation was 599 TWh. The largest energy user is industry (47%) followed by private households (26%) and commercial activities (22%). Four large power generators dominate the sector (E.ON, RWE, Vattenfall and EnBW), although in total around 450 electricity generating companies exist, among them 26 larger local utilities (BDEW, 2009). Within the EU ETS the energy sector constituted 78.1% of total verified emissions in Germany (DEHSt, 2009).

[4] However, this line of theoretical reasoning does not take into consideration transaction costs which can be particularly burdensome for smaller emitters (Betz et al., 2010).

[5] Empirical studies are less conclusive here (e.g. Mickwitz et al., 2008; Taylor et al., 2005).