Research Policy xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Research Policy

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

Characterizing the policy mix and its impact on eco-innovation: A patent analysis of energy-efficient technologies

Valeria Costantini[a,b,*], Francesco Crespi[a,c], Alessandro Palma[d,e]

[a] Roma Tre University, Rome, Italy
[b] SEEDS, Italy
[c] BRICK, Collegio Carlo Alberto, Turin, Italy
[d] CEIS – University of Tor Vergata, Rome, Italy
[e] IEFE – Bocconi University, Milan, Italy

ARTICLE INFO

Article history:
Received 17 July 2015
Received in revised form 6 February 2017
Accepted 16 February 2017
Available online xxx

JEL Classification:
O31
O38
Q48
Q55
Q58

Keywords:
Eco-innovation
Policy mix
Balance
Comprehensiveness
Policy spillovers
Energy efficiency
Residential sector

ABSTRACT

This paper provides an empirical investigation of the role played by selected characteristics of the policy mix in inducing innovation in energy efficiency technologies. An original dataset covering 23 OECD countries over the period 1990–2010 combines the full set of policies in the energy efficiency domain for the residential sector with data on patents applied over the same period in this specific technological sector. The econometric results suggest that when the policy mix is characterised by a more balanced use in demand-pull and technology-push instruments, its positive effects on eco-innovation tend to be greater. Moreover, a more comprehensive policy mix is shown to be able to enhance innovation activities for the generation of new energy efficient technologies. However, the simple addition of an indiscriminate number of simultaneous policy instruments may reduce policy mix effectiveness. Finally, the empirical findings confirm previous evidence on the importance of policy spillover effects, and suggest that policy similarity between countries may represent an important aspect to be accounted for in policy mix design.

1. Introduction

The analysis of eco-innovation in recent years is attracting growing attention both at academic and policy level. A definition of what eco-innovation is has been widely discussed in recent years and the most complete one is provided by Kemp and Pearson (2007, p.7): "[e]co-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (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".[1] Given this broad definition, the current debate has adopted distinguished analytical perspectives in order to better understand the dynamics, characteristics and determinants of eco-innovation (Arundel and Kemp, 2009; Beise and Rennings, 2005; Berkhout, 2011; Cainelli and Mazzanti, 2013; Kemp and Oltra, 2011; Marin, 2014; Markard et al., 2012; OECD, 2011; Van den Bergh et al., 2007; Wagner, 2007). These studies suggest that a variety of factors drive eco-innovation, but also highlight the primary role played by public policies (environmental regulation, energy and technology policies) that are increasingly used to foster the rate of introduction

* Corresponding author at: Department of Economics, Roma Tre University, Rome, Italy.
E-mail addresses: valeria.costantini@uniroma3.it, valeria.costantini3@gmail.com (V. Costantini).

[1] Given the wide range of different forms of innovations included in the definition by Kemp and Pearson (2007), in this paper the terms eco-innovation, green technologies, environmental innovation are used interchangeably where not explicitly defined in the text.

http://dx.doi.org/10.1016/j.respol.2017.02.004
0048-7333/

and diffusion of new environmental technologies to meet sustainable development goals (Del Río González 2009a; Horbach et al., 2012; Johnstone et al., 2010; Mowery et al., 2010; Newell, 2010).

The bulk of previous literature has focused its attention on the impact of single (though different) policy instruments mainly belonging to the two broad categories of demand-pull and technology-push instruments (Bergek and Berggren, 2014; Horbach et al., 2012; Kemp and Pontoglio, 2011; Peters et al., 2012; Rennings, 2000). Recent empirical contributions demonstrate that these instruments have differentiated impacts on the diverse types of eco-innovation activities such as those related to the introduction of incremental or radical innovations (Nemet, 2009) or those associated with technological exploitation or exploration activities (Costantini et al., 2015; Hoppmann et al., 2013). However, there is growing interest in understanding the role played by the different combinations of the available policy instruments in stimulating and directing technical change. In particular, the literature has recently focused on the role of policy mix, a concept that at its basics considers the combination of policies into a composite set, but that also includes the processes through which different instruments emerge and interact (Flanagan et al., 2011; Rogge and Reichardt, 2016).

Empirical studies that focus on the effects of policy mixes on innovation (Guerzoni and Raiteri, 2015) and in particular on eco-innovation performances (Cantner et al., 2016; Reichardt and Rogge, 2016; Uyarra et al., 2016) represent a limited though rapidly expanding area of research. Following these contributions, here we propose a quantitative analysis based on a large sample of OECD countries that aims to measure some significant characteristics of the policy mix and quantify their impact on eco-innovation activities through panel data econometrics. In particular, we first focus our attention on the balance in the policy mix between demand-pull and technology-push instruments and, then, we try to evaluate the role played by policy mix comprehensiveness. Finally, considering that policy decisions adopted by other countries are likely to influence domestic innovation performance (Dechezleprêtre and Glachant, 2014; Peters et al., 2012), we aim to address if and to what extent the similarity between domestic and foreign policy mixes fosters countries' eco-innovation performances.

The empirical analysis focuses on the case of energy efficiency (EE) technologies, which appears to be appropriate with respect to our research purposes, since a large number of different policies in several countries aims to enhance energy efficiency in the residential sector, especially by fostering the generation and diffusion of new technologies (IEA, 2015; Sovacool, 2009). In particular, in the examined case the full range of demand-pull, technology-push, soft and systemic instruments are usually adopted, allowing us to investigate how and to what extent, beside the role played by distinct instruments, the characteristics of the policy mix have an influence on eco-innovation performance.[2]

The remainder of the paper is organized as follows. Section 2 provides a literature review on the role of public policies in fostering eco-innovation and on the analysis of policy mix. Section 3 introduces the research case and the hypotheses to be tested, whereas Section 4 defines the dataset, the operationalization of policy variables and the econometric strategy. Section 5 presents the econometric results and, finally, Section 6 summarizes the main insights emerging from the study, highlights the policy implications and outlines possible further research lines.

2. Background literature

A large number of economic studies have been devoted to identifying the determinants of eco-innovations (see, for instance, Del Río González, 2009a; Foxon, 2003; Horbach, 2008; OECD, 2011). The analysis of eco-innovation drivers has constituted an empirical issue that has given rise to a flourishing strand of literature in which the role of public policies has been found to be of prominent importance (Bergek and Berggren, 2014; Haščič et al., 2009; Johnstone et al., 2010; Schmidt et al., 2012). In more detail, the literature has identified different types of policy instruments that have been classified in several categories which mainly refer to technology-push, demand-pull and systemic instruments (e.g., Crespi and Quatraro, 2013, 2015; Del Río et al., 2010; Kemp, 1997; Rennings, 2000; Wieczorek and Hekkert, 2012).

2.1. The role of distinct policies

The empirical literature investigating the role of different types of instruments in shaping eco-innovation activities is extensive. Earlier studies, mainly due to limited data availability, use a measure of the environmental regulatory stringency proxied by the expenditures certified by firms for implementing pollution control activities rather than specific information on the policy instrument adopted.[3] For instance, the pioneering contribution by Lanjouw and Mody (1996) examines the relationship between patenting activity in broadly defined environmental technologies and environmental regulation stringency measured by pollution abatement and control expenditures (PACE) paid by firms in three industrialized countries, Germany, Japan and the United States, and selected developing countries. Different reactions for patenting activity are highlighted, suggesting that eco-innovation performance positively responds to PACE in advanced economies, whereas the largest part of innovation activities in developing countries is explained by the need to adapt imported technologies to local conditions.

In the same vein, Brunnermeier and Cohen (2003) also investigate the relationship between PACE as a proxy of environmental policy stringency and environmental patents by analysing a dataset of 146 US manufacturing industries from 1983 to 1992. In line with the results by Lanjouw and Mody (1996), they find significant (though not extensive) evidence that pollution abatement expenditures are also positively correlated with successful environmental patent applications in the case of a single country and sector-based analysis.

Subsequent empirical analyses adopt more focused perspectives by selecting specific environmental technology sectors on the one hand, and by using variables specifically linked to different policy instruments on the other. One pioneering empirical exercise in this perspective is provided by Popp (2002). The author observes, over the period 1970–1994 in the US, that higher energy prices determined by higher energy taxation encouraged patenting activities in energy-efficient technologies by firms. In the same vein, Crabb and Johnson (2010) analyse if and to what extent fuel taxes applied in the US in the period 1980–1999 have influenced the pattern of patent applications in automotive energy-efficient technologies sector, confirming the positive effect found by Popp (2002).

Starting from the seminal work by Kemp (1997), more recent contributions analyse the different impacts on eco-innovation per-

[2] A previous work by Costantini et al. (2014a) applied to the EE domain is limited to an analysis of the direct policy-inducement effects on the dynamics of EE technologies without addressing the specific role played by the different policy mix characteristics which is the actual focus and contribution of this paper.

[3] The definition and measurement of environmental regulatory stringency are arguments for an extended debate. As clearly described by Brunel and Levinson (2013), the definition of stringency level is strictly correlated with data availability and can be broadly defined as the ambition level of the adopted policy in terms of environmental targets.

Please cite this article in press as: Costantini, V., et al., Characterizing the policy mix and its impact on eco-innovation: A patent analysis of energy-efficient technologies. Res. Policy (2017), http://dx.doi.org/10.1016/j.respol.2017.02.004