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The energy-efficient transformation of EU business enterprises: Adapting policies to contextual factors

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ABSTRACT

Business contexts differ in their ability to foster the energy-efficient transformation (EET) of enterprises. Accordingly, energy efficiency policies have to be adapted to different situations. The present paper analyzes the relationships between the EET of European Union (EU) business end-users and three contextual factors, i.e. high energy prices, stringency of regulations, and society's alertness toward environment conservation. Enterprises from 9 EU Member States have been grouped according to country, industry and size. The final sample includes 256 enterprise classes, and the model controls for the innovation propensity and energy intensity of each enterprise class. Our results show that regulatory stringency is the most impactful contextual factor, while the environmental alertness of society does not have a significant effect. Concerns over energy costs have not been found to drive EET per se, but more energy-intensive enterprise classes are more likely to react to high energy prices. We discuss the implications of our results for the EU governments that are currently monitoring and refining the transposition of the 2012 Energy Efficiency Directive.

1. Introduction

The European Union (EU) is committed to saving 20% of its primary energy consumption by 2020, compared to the business-as-usual projection, and has set an even more ambitious target for the longer term, i.e. a 27% saving by 2030 (European Council, 2014). Great emphasis is currently put on enhancing the energy efficiency of transport and buildings, in part because the EU business sector has already made substantial progress over the last 25 years (European Commission, 2014). However, the energy efficiency of EU business enterprises is not a solved issue. Industry, services and agriculture enterprises account for 42% of the EU's final energy consumption (Eurostat, 2016), but entire industries and countries lag behind the energy efficiency frontier (ODYSSEE-MURE, 2015a; International Energy Agency, 2016, pp. 24–29).

The Energy Efficiency Directive (EED, Directive 2012/27/EU) is the overarching act for EU business in this area (Section 2). EU policymakers are currently engaged in an adaptive process, as they have to set, monitor and refine their national energy efficiency plans. With the purpose of supporting their effort, this paper investigates the contextual factors that drive the energy-efficient transformation (EET) of EU business operations. Sections 2 and 3 will discuss and operationalize the definition of EET, but in general terms a business enterprise is engaged in EET when it undertakes innovations that reduce the energy consumed to produce the output.

This paper analyzes the role of the following three contextual conditions: high energy prices, stringency of regulations, environmental attentiveness and activism in society. A thorough analysis of the quantitative significance of the market, regulatory and social drivers that may have spurred business EET in Europe in recent years is missing, although we believe such an analysis could provide policy-makers with helpful insights on the policy mechanisms that better cope with specific business environments.

On the one hand, a large amount of literature is devoted to the firm-specific characteristics that determine energy efficiency advances, such as size, managerial capabilities and innovation propensity (DeCanio and Watkins, 1998; Rennings and Rammer, 2009; Bloom et al., 2010; Sorrell et al., 2011; Martin et al., 2012; Costa-Campi et al., 2015). However, despite their importance in managerial decision-making, firm-specific characteristics can be the target of policies only to a limited extent. Energy policies instead have the responsibility of making business environments more conducive to EET, by offering an appropriate support to the components of business environments that are found to foster EET and by remedying the failures of other components.

On the other hand, while many EET studies focus on firm-level determinants, relatively fewer works have analyzed contextual conditions, and these few have been addressing energy prices (Popp, 2001; Linn, 2008) and regulations (Horbach et al., 2012; Martin et al., 2012; Veugelers, 2012; Costa-Campi et al., 2015; Trianni et al., 2016). We

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include these factors in our model, but we also verify whether society's alertness toward environment conservation has any effect. Business enterprises could undertake EET not only to reduce their operational costs and to comply with regulatory pressures, but also to enhance their reputation with non-governmental organizations, the media and citizens at large, thanks to two positive EET externalities, namely emission abatement and enhanced security of supply. Unlike other environmental innovations (Berrone et al., 2013; Brunnermeier and Cohen, 2003; Khanna and Damon, 1999), business EET has not been examined as a means of coping with attentive and activist social stakeholders.

The model focuses on the relationship between EET and the three components of business context, i.e. energy price, regulations, and society's alertness, but it also controls for the influence of internal drivers, such as a firm's innovation propensity, energy intensity and size. The considered unit of analysis is the "enterprise class", i.e. the group of firms belonging to the same size class (SMEs with less than 250 employees v. larger enterprises), operating in the same industry (across 21 industries) and located in the same country (across 9 EU economies). The heterogeneity of this empirical test-bed increases the variation of contextual factors and augments the generalization potential of the analysis (Jeswani et al., 2008). The present paper measures EET, contextual conditions and control variables across very different countries, industries and size categories, in this way arguably ensuring a greater external validity to the findings. To this aim, 43,110 firms, surveyed in the sixth wave of the Community Innovation Survey that was conducted in 2009, have been classified. The reasons for using this CIS wave are explained in the subsequent sections. The final sample includes 256 different classes of business enterprises. Coherently with our definition of EET, class-level EET is measured as the percentage of all the class enterprises that have reduced their own energy use thanks to process, product, organizational and marketing innovations. We analyze the relationship between EET and its determinants through a Generalized Linear Model (GLM) for grouped data, and check the robustness of results by modeling the contextual conditions in different ways. Finally, we use the model coefficients to simulate the response of a business sector to contextual factors, other things being equal. These simulations allow us to pinpoint the strengths and weaknesses of different business contexts, and to make recommendations on policy support mechanisms tailored to each specific business environment.

The rest of the paper is organized as follows. The recent literature on EET is presented, and EU energy efficiency policies for business end-users are reviewed (Section 2). The empirical methodology is then illustrated (Section 3), and this is followed by the presentation of the estimates, simulations, robustness analyses and a discussion of the empirical findings (Section 4). Finally, some implications for energy efficiency policies are discussed (Section 5).

2. Literature survey and policy overview

The present section reviews the pre-existing research on external and internal EET determinants, and introduces society's alertness as an additional factor. It then summarizes the EU policy framework for the energy efficiency of business end-users.

In the following, we assume that a firm undertakes an EET of its operations whenever it decreases its energy intensity, that is, given its output, it reduces the energy consumed, or given the energy consumed, it increases its output (International Energy Agency, 2014). EET may be triggered by innovations of various nature, but it is an instance of process innovation.[1]

[1] Other studies addressed the invention and supply of energy-saving products and technologies (Newell et al., 1999; Popp, 2002; Verdolini and Galeotti, 2011; Rexhäuser and Löschel, 2015).

2.1. Contextual factors and internal drivers

Among the contextual factors that spur enterprises toward energy efficiency, energy prices and regulations have been studied extensively. According to the "induced-innovation" view (Newell et al., 1999; Rose and Joskow, 1990; Jaffe and Stavins, 1995), EET is the response of profit-maximizing firms to current and expected changes in energy price and regulations.

Popp (2001) finds a significant and negative response of the United States (US) industries' consumption to energy price changes. Linn (2008) concludes that energy price increases lead to a small but significant reduction in the energy intensity of US manufacturing plants, but only for new entrants. Business enterprises that expect to reap cost savings or to face rising energy prices are more likely to conduct EET activities (Horbach et al., 2012; Trianni et al., 2016).

As far as energy and climate regulations are concerned, business surveys conducted in different countries return a mixed picture. Veugelers (2012) finds that voluntary agreements, public financial support and future regulations are powerful drivers of innovations that reduced energy consumption in Flemish firms, particularly if maintained over time and combined with taxes that increase energy prices. Horbach et al. (2012) do not find any correlation between the present and future regulations and energy-efficient process innovations of German firms. Martin et al. (2012) demonstrate that management practices play a more significant role than policies in energy efficiency of UK manufacturing plants. Costa-Campi et al. (2015) show that the energy-efficient innovations of Spanish firms are associated with public financing and unrelated to the importance attributed to regulatory requirements. Trianni et al. (2016) show that the ease of financing and regulatory restrictions are important factors for Italian manufacturing SMEs.

A third type of contextual factor, namely the degree to which business enterprises respond to the pressure of social stakeholders, is absent from the literature on business EET. Enterprises could in fact undertake EET efforts to enhance their reputation with social groups such as the media, NGOs, and citizens at large, and to behave as "good corporate citizens" who reduce emissions from the use of fuels and enhance their country's energy security.

Environmental management literature has long argued that enterprises enhance their own environmental performances in response to society's pressures and for discouraging adverse information campaigns (Buysse and Verbeke, 2003; Kassinis and Vafeas, 2006; Lyon and Maxwell, 2008). For instance, some firms introduce pollution control mainly to gain public recognition and legitimacy (Khanna and Damon, 1999), while they attach less importance to the pressures of regulatory agencies (Brunnermeier and Cohen, 2003; Kassinis and Vafeas, 2006). Horbach et al. (2012) and Veugelers (2012) find that EET innovations are associated with the customers' demand for environmental innovation, but the reasons for associating the "green-demand" pull with the EET of enterprises are not as clear.

To what degree external stakeholders are aware of the energy efficiency of internal business operations, and business enterprises undertake their own EET as a response to stakeholders is a research question that we will investigate in the remaining part of the paper.

Finally, several studies have examined the following EET internal drivers in detail (see the reviews by Gillingham et al., 2009, and Sorrell et al., 2011): the firm's size and economic performances (DeCanio and Watkins, 1998; Rennings and Rammer, 2009; Trianni and Cagno, 2012; Costa-Campi et al., 2015), its organizational and managerial capabilities (Bloom et al., 2010; Horbach et al., 2012; Martin et al., 2012; Cagno et al., 2015; Costa-Campi et al., 2015; Gerstlberger et al., 2016; Trianni et al., 2016), its commitment to environmental targets and innovation activities (Rennings and Rammer, 2009; Horbach et al., 2012; Costa-Campi et al., 2015; Cagno et al., 2015; Gerstlberger et al., 2016).