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Analysing the drivers of the intensity of electricity consumption of non-residential sectors in Europe

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HIGHLIGHTS

- Determinants of electricity intensity of non-residential productive sectors.
- A static panel data model which is estimated with three different methods.
- Technological progress and the price of electricity reduce such intensity.
- The accumulated stock of physical capital and investment increase such intensity.
- Major influence of the accumulated capital stock. Limited influence of electricity prices.

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ABSTRACT

The electricity consumption of non-residential productive sectors represents a significant share of the overall energy consumption in the Member States of the European Union. Therefore, determining the main factors affecting the intensity of such consumption (defined as the ratio of the electricity consumed by the productive system of a given country to gross value added) is a research effort worth undertaking. The aim of this paper is to identify the main factors which affect such intensity with the help of a static panel data model, which is estimated with three different methods. Our results show that a higher degree of technological progress in the production systems and higher retail prices of electricity for non-residential consumers reduce such intensity. Other variables, which are statistically significant, lead to an increase of electricity intensity, including the accumulated stock of physical capital and the lagged gross fixed capital formation. The accumulated capital stock per unit of GDP is the variable with the highest influence on electricity intensity. Whereas the influence of price changes is limited, these results indicate that there is some rigidity to change energy intensity through demand-side policy measures, suggesting that they will need to be complemented with supply-side measures aimed at increasing low-carbon electricity generation capacity.

1. Introduction

Electricity plays a key role in the global energy system. Almost 40% of global primary energy is currently used to generate electricity, which covers 17% of global final energy needs (up from 9% in 1974). Among all final energy carriers, per capita growth of electricity has been the strongest, more than doubling from 1263 kilowatt hours per capita (kWh/cap) in 1974 to 2933 kWh/cap in 2011 [1]. The International Energy Agency (IEA) predicts that this trend will continue in the future. Electricity will represent around 25% of global final energy needs by 2050, since electricity demand is expected to grow by 80–130% by 2050 depending on the scenario, outpacing all other final energy carriers.

This trend towards electrification is not homogenous around the world. In fact, the meaning of electrification differs depending on whether a region's electricity system can be characterized as stable or dynamic. In dynamic systems, electrification is much more focused on providing access to electricity to society and industries in general, i.e., it is an enabler of economic growth. High growth rates for electricity are seen in all sectors, with a similar fundamental shift from oil to electricity as the primary fuel for transport [1]. Indeed, growth rates of demand since the 1970s are vastly different across the world. OECD countries remain almost flat with an average 16% demand growth. In non-OECD regions, electricity growth rates are as high as 300%.

In stable systems, such as those of EU countries, electrification refers

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to increasing shares of electricity in the energy system and a growth in electricity demand in given sectors such as transport or buildings. Overall growth in electricity demand is modest. In this context, electrification demonstrates a shift towards a greater use of electricity to displace other energy carriers, offering an opportunity to shift a country's primary fuel demand and exploit end-use efficiency benefits typically provided by using electricity, since electricity is deemed more energy efficient than other energy carriers [2,3]. The shift from other energy carriers to electricity does not mean that electricity efficiency should not be encouraged, i.e., that efforts should not be made to reduce electricity consumption for specific uses. Indeed, improving the electricity efficiency of a country is an important step towards decreasing greenhouse gas emissions due to fossil fuel-based electricity generation and consumption [4].

Electricity consumption by the non-residential sectors represents a significant share of the overall energy consumption in the EU Member States (21.5%). Those sectors have accounted for more than 70% of final electricity consumption in the last couple of decades in the EU, with the residential sector accounting for the rest. In 2013, industry represented the greatest share of this final electricity consumption by the productive sectors (51%), followed by services (43%), with transport (3%) and agriculture (1%) representing a very small share (data from Eurostat). The reason is that the services sectors are less electricity-intensive than the manufacturing sectors [5].

Thus, given the relevance of final electricity consumption by the productive sectors, determining the main factors affecting such intensity is a research effort worth undertaking. Similarly to other contributions on the topic ([6–8], among others), the intensity of electricity consumption in this paper is defined as the ratio of electricity consumed by the productive sectors of a country divided by the gross value added. This ratio can be interpreted as an indicator of the degree of "electrification" of the production system. Obviously, a higher ratio implies a greater electricity consumption per unit of output.

This paper focuses on the evolution of the intensity of final electricity consumption in the non-residential sectors of 18 EU countries in the period 1995–2011. Its aim is to identify the main factors which affect the evolution of such intensity with the help of a panel data econometric model. Relevant explanatory variables include the productive efficiency of the economic system, the accumulated stock of physical capital, the annual investment effort and the price of electricity.

With respect to the literature (see Section 2), our paper contributes on several fronts. On the theoretical side, we test the relevance of several variables which have hardly been considered in the past (the accumulated stock of physical capital, the productive efficiency of the system and the lagged investment effort), while considering variables which are deemed relevant for the analysis but whose influence have been underresearched in non-econometric studies, such as prices. In particular, previous contributions have not analysed the relationship between two main input factors into the production process (capital and electricity) and have not analysed the link between productive efficiency and electricity intensity, or have done so in a very superficial way (i.e., with a time variable, see below).

Our approach provides a comprehensive coverage in that we take into account all relevant drivers of electricity intensity. All the drivers to electricity intensity which have shown to be relevant in the theoretical literature and in past research (see Sections 2 and 3) are included. There is not any contribution which includes all the variables which are relevant to explain electricity intensity (see Table 1). The most complete in the inclusion of drivers are Kwon et al. [6], Zha et al. [9] and Horowitz [10]. However, Kwon et al. [6] do not include technological change, Zha et al. [9] do not consider electricity prices and Horowitz [10] does not include capital. We show in the empirical analysis that all these variables are relevant drivers of electricity intensity (see Section 5). Furthermore, our analysis allows the identification of the relative importance of each driver. Previous contributions have only identified

Table 1
Main features of contributions to the analysis of the drivers of electricity intensity with econometric models.
Source: Own elaboration.

	Sectoral scope	Geographical scope	Method	Variables	Time period
Zha et al. [9]	Power industry	China	Production function model, panel data estimation techniques.	Technological change, factor demand, inter-factor substitutability, electricity price	1985–2007 (yearly data)
Verbruggen [5]	All sectors	14 high-income OECD countries	Hyperbolic function, OLS	Electricity price	1997
Herrerías [14]	All sectors	China	Unobserved-components model.	Seasonal component, electricity price, temperature	2003–2009 (monthly data)
Bagayev and Najman [13]	All sectors	29 transition economies	Ordinary Least Squares (OLS)	Total sales, capital, labour, firm characteristics, population density	2008
Kiss and Kocsis [37]	All sectors	Hungary	OLS	Price of electricity, income per capita (GDP).	1995–2010
Xia and Hu [15]	All sectors	China	Finite mixture model	Urban morphology, industrial structure, regulation context, urbanization degree, price, natural conditions, and resource endowments	2009
Kwon et al. [6]	Manufacturing	South Korea (16 regions)	Simultaneous equations system.Panel data (fixed effects)	Labour demand, capital demand, gross manufacturing output, electricity price, wage rate, capital rental rate, climate and weather conditions, external factors	2004–2012 (monthly data)
Horowitz [16]	Commercial sector	USA (42 states)	Fixed panel effects model	Electricity prices, heating and cooling degree days, gross state product, lagged dependent variable, time trend, demand-side management (DSM) savings	1989–2001 (yearly data)
Horowitz [10]	All sectors	USA (42 states)	Differences in differences estimators and a fixed panel data model	Retail prices of electricity and natural gas, state economic status (per capita gross state product or per capita income), a time trend, heating and cooling degree days	1970–2003 (yearly data)