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Trade-facilitated technology spillovers in energy productivity convergence processes across EU countries

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ABSTRACT

This empirical paper tests for trade-facilitated spillovers in the convergence of energy productivity across 16 European Union (EU) countries from 1995 to 2005. One might anticipate that by inducing specialization, trade limits the potential for convergence in energy productivity. Conversely, by inducing competition and knowledge diffusion, trade may spur sectors to greater energy productivity. Unlike most previous work on convergence, we explain productivity dynamics from cross-country interactions at a detailed sector level and apply a spatial panel data approach to explicitly account for trade-flow related spatial effects in the convergence analysis. Our study confirms the existence of convergence in manufacturing energy productivity, caused by efficiency improvements in lagging countries, while undermined by increasing international differences in sector structure. Further, we find that trade flows explain 30 to 40% of the unobserved variation in energy productivity. Trade continues to explain the unobserved variation in energy productivity even after accounting for geographic proximity. Last, we find that those countries and sectors with higher dependence on trade both have higher energy productivity growth and a higher rate of convergence, further implying that trade can enhance energy productivity. Thus, unlike concerns that trade may spur a 'race to the bottom', we find that promoting trade may help stimulate energy efficiency improvements across countries.

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1. Introduction

High energy prices, domestic energy security and disruptive global warming are making energy efficiency a priority for many governments (GEA, 2012; IEA, 2012). Despite this common goal, energy use varies widely across countries, with Finland having a per capita energy use more than one quarter higher than that of Sweden, more than twice that of the UK and three times higher than Portugal (World Bank, 2014). Cross-country differences in energy efficiency or energy productivity, defined as the ratio of economic output to energy input, are largely determined by differences in relative factor prices, patterns of specialization, and the level and direction of technological development (e.g. Berndt and Wood, 1975; Fisher-Vanden et al., 2004; Jorgenson, 1984; Mulder, 2005; Popp et al., 2010, 2011; Smulders and De Nooij, 2003; Sue Wing, 2008). Energy-saving technological change results not only from domestic innovation but also from foreign technology diffusion (Bosetti et al., 2008; Hall and Helmers, 2013; Popp, 2006; 2011; Verdolini and Galeotti, 2011). In this paper we study what factors contribute to improvements in industrial energy productivity and in particular, we ask whether growth in energy productivity is affected by trade.

Trade can influence the use of energy in production through various channels. Depending on which mechanism prevails, trade may contribute to either increasing or decreasing variation in energy productivity levels across countries. On the one hand, trade linkages may help reduce productivity gaps among countries by accelerating knowledge diffusion, equalizing factor prices and encouraging adoption of common environmental regulation (e.g. Alcalá and Ciccone, 2004; Coe and Helpman, 1995; Coe et al., 1997; Comin and Hobijn, 2004; Hayami and Ruttan, 1985; Holmes and Schmitz, 2001; Leimbach and Baumstark, 2010; Lovely and Popp, 2011; Parrado and De Cian, 2014; Waugh, 2010). On the other hand, trade may stimulate international specialization and spatial separation, which could lead to the divergence of factor productivity (Copeland and Taylor, 1999; Grossman and Helpman, 1991; Young, 1991).

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The extent to which these mechanisms facilitate or hinder less productive countries from catching up with more advanced economies depends on a variety of local characteristics, including sector composition, human capital and energy resource endowments, environmental stringency and distance to the trading partner. From a micro-perspective, to maintain a competitive advantage in the face of trade, firms have strong incentives to develop and commercialize new energy technologies. From a macro-perspective, firms that trade tend to be more productive than their domestic peers (Melitz, 2003) and one dimension of productivity is energy use. By increasing the reach of these high productivity firms, domestic firms will arguably also have to increase their energy productivity to remain competitive.

Conversely, in the case of a highly regulated input like energy, trade might also induce countries to 'race to the bottom', where a country weakens regulations and/or decreases energy prices to exploit its comparative advantage (Copeland and Taylor, 2004; Levinson, 2003). Cheap energy reduces the domestic demand for energy efficiency, and so the home market will not serve as a springboard for the international commercialization of energy-saving technology (Urpelainen, 2011). Further, local abundance of energy resource endowments may facilitate specialization in energy-intensive industries by suppressing domestic energy prices, thus contributing to structural divergence of production structures across countries (Gerlagh and Mathys, 2011; Mulder and De Groot, 2012). Trade-induced international knowledge spillovers may benefit different sectors in different ways (Giannetti, 2002), decline with geographical or cultural distance (Keller, 2002; Lankhuizen et al., 2011; Verdolini and Galeotti, 2011) and require certain 'social capabilities' to successfully turn them into productivity gains (e.g. Abramovitz, 1986 and Cohen and Levinthal, 1990). Thus, it is not clear whether trade flows or other spillover mechanisms will induce convergence or divergence in country energy productivity.

We focus our analysis on the use of energy in the manufacturing sector across a sample of 16 European countries from 1995 to 2005. Apart from data availability (see below) this choice is motivated by the fact that the European Union (EU) is one of the regions in the world where the increase in bilateral trade has been especially strong due to its unique process of market integration. The value of internal trade among the EU-25 member states has approximately doubled in the period 1995–2005.[1] In addition, manufacturing goods comprise the vast majority of trade volume, while the manufacturing sector is still responsible for about one-third of total energy consumption in the EU. Specifically, we test to what extent trade has contributed to either convergence or divergence of energy productivity levels across countries.

Cross-country differences in aggregate energy productivity result from differences in energy technology at the sector and firm levels, as well as from differences in the structure of the countries' economies. This structural effect is caused by the fact that some production processes inherently require more energy inputs than others, relative to capital and labor inputs. In the field of energy studies, a popular line of research has been to separate the efficiency effect from the structural effect on energy productivity by means of index number decomposition analysis (for surveys see Ang and Zhang, 2000 and Liu and Ang, 2007). Recent evidence from this literature shows that the role of the structure effect in explaining aggregate energy productivity patterns is not only sizeable but also increasing in importance over time (e.g. Fisher-Vanden et al., 2004; Huntington, 2010; IEA, 2004; Ma and Stern, 2008; Mulder and De Groot, 2012; Unander, 2007; and Weber, 2009). Moreover, cross-country differences in energy productivity levels appear to be mainly driven by differences in the structure of economies. For example, Taylor et al. (2010) find that in 2005 structural effects are responsible for almost half of the variation in manufacturing energy intensities across developed countries. Duro et al. (2010) and Mulder and De Groot (2012) find that aggregate convergence patterns are predominantly caused by trends in energy efficiency, while structural changes tend to attenuate cross-country energy convergence. Mulder (2015) finds that increasing international differences in sector structure undermine convergence of manufacturing energy intensity levels.

Clearly, the increasing role of economic structure in aggregate energy productivity dynamics is related to the increase in international trade, given the fact that trade flows influence the structure of economies through its impact on (changing) production patterns. Existing literature does not yet provide us with a clear understanding of the role of trade as determinant of cross-country variation in energy productivity over time. Mulder (2015) finds a striking similarity in the timing of a trend-break towards increasing cross-country variation of specialization patterns and the trend-break towards decreasing cross-country variation of manufacturing energy intensity levels after 1995. Hence, his work indicates that since the second half of the 1990s, increasing trade and market integration appears to have helped in reducing energy productivity gaps across countries but that this relation deserves to be carefully tested in future work. This paper aims to empirically test for trade-facilitated spillovers in manufacturing energy productivity convergence. In doing so, we address two shortcomings in the literature to date. First, in our estimates of convergence, we explicitly control for spatial dependence, using spatial econometric tools to account for trade-flow related spatial effects in the convergence analysis. Second, we exploit a relatively high level of sector detail, allowing for the identification of productivity patterns across a range of manufacturing subsectors, including both energy-intensive and energy-extensive industries.[2]

Following the seminal work by Baumol (1986), Abramovitz (1986), and Barro and Sala-i-Martin (1992), numerous empirical convergence studies have been published in the macroeconomic literature, typically presenting evidence of convergence of per capita income, labor productivity or total factor productivity (for good surveys see Abreu et al., 2005, a special issue of the Economic Journal, 1996 and Islam, 2003). Various authors have presented evidence of misspecification in convergence estimations due to unaccounted for spatial dependence (Florax and Nijkamp, 2005; Rey and Janikas, 2005; Rey and Montouri, 1999). This concern has been addressed in recent studies that use spatial econometric techniques to address the role of 'spatial phenomena' like technology diffusion, trade and factor mobility in driving convergence patterns (e.g. Armstrong, 1995; Fingleton, 1999; Fingleton and McCombie, 1998; Lopez-Bazo et al., 1999; and Rey and Montouri, 1999).

Convergence analyses emerged more recently in the field of energy and environmental economics, (see, for example, Aldy, 2006; Duro et al., 2010; Duro and Padilla, 2011; Jakob et al, 2012; Liddle, 2009, 2010; Markandya et al., 2006; Miketa and Mulder, 2005; Mulder and De Groot, 2007, 2012; Mulder et al., 2011; Romero-Avila, 2008; and Sun, 2002). However, these convergence studies do not explicitly control for spatial dependence in their search for factors that may explain the evolution of cross-country differences in energy productivity. A notable exception is Mulder et al. (2011) who find that a country's energy productivity development is influenced by the spatially weighted average of the energy productivity growth rates of its neighboring countries. Moreover, they show that in terms of energy productivity performance, Western European countries over time have become more homogenous while various Eastern European countries have been able to catch up to this group. Their analysis, however, contains insufficient sector detail and explanatory variables to explain these cross-country spatial interactions.

To the best of our knowledge this paper is the first to explain energy productivity dynamics from specified cross-country spatial interactions

[1] Source: Eurostat Statistical Yearbook.

[2] One shortcoming of our approach is that we do not observe the potential of increased transportation energy use driven by trade. Inasmuch as trade induces a greater flow of goods and thus an increase in transportation, our analysis will miss this potentially large increase in energy demand (Gabel and Röller, 1992; Hecht, 1997 and Hummels, 2007, 2008).

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