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What drives energy efficiency? New evidence from financial crises

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ABSTRACT

Using a sample of 100 countries from 1980 to 2015, this paper investigates the impact of Foreign Direct Investment (FDI), imports, gross capital formation, and industry value-added on energy efficiency before and after the 2008 global financial crisis. Our findings reveal that failing to control for economic downturns may lead to misleading results. Moreover, we find that the effects of these channels are different between low, middle and high-income countries. Our study also shows that the effect of FDI on energy savings is inverted U-shaped whereas the effect of imports on energy savings is U-shaped when we control for the income level of the countries.

1. Introduction

The industrial revolution has brought unprecedented economic prosperity and significant improvements in living standards. However, this economic growth had often led to large increases in energy use and pollution, significant climate change, and an overall environmental degradation.[1] While the literature has extensively examined the impact of economic growth on energy demand and the environmental quality (Kraft and Kraft, 1978; Stern, 2004; Ang, 2007; Soytas et al., 2007; Apergis and Payne, 2009; Ozturk, 2010; Wang et al., 2011; Arouri et al., 2012; Omri, 2014; Farhani et al., 2014; Kahia et al., 2017; among many others), a rapidly growing body of research has explored how other channels interact with energy use in different countries and geographical regions (Halicioglu, 2009; Hübler and Keller, 2010; Pao and Tsai, 2011; Sadorsky, 2011a, 2011b, 2012; Shahbaz et al., 2014; Çoban and Topcu, 2013; Omri and Kahouli, 2014; Dogan and Turkekul, 2016; Salim et al., 2017; among many others).

The first of these channels relates to the technology transfer effect and postulates that foreign investments, imports, and international aid are typically associated with the transmission of energy-efficient technologies resulting in lower energy intensity (the amount of energy used per unit of output). This transmission of knowledge and improvement in energy efficiency is usually achieved when countries employ new technologies, import less energy intensive goods, and foster better management practices. The transfer of knowledge may also occur when local firms hire energy-aware labor from multinational enterprises (MNEs) and promote energy friendly practices with suppliers and clients. Moreover, local firms have an incentive to be more productive and potentially more energy efficient to enhance their competitive advantage in local and international markets (Tybout, 2002; Hübler, 2011; Doytch and Narayan, 2016).

The second channel studies the effects of cumulative capital (vintage capital) on energy intensity. A larger stock of capital fosters 'learning by doing' and leads to more energy efficiency (Arrow, 1962). On the other hand, energy intensive industries are usually capital intensive. As a result, an increase in accumulated capital may generate a surge in energy intensity. Hence, the impact of accumulated capital on energy intensity is ambiguous depending on which effect prevails (Hübler and Keller, 2010).

Finally, the composition effect refers to whether the economy is oriented towards agriculture, industry, or services. Typically, industry oriented economies are more energy intensive than agriculture and services.

While the existing literature has investigated various dimensions that affect energy use, several important research questions remain unexplored. In particular, prior work failed to investigate the impact of the global financial crisis on energy use as well as the interaction of the crisis with the technology transfer, the vintage capital, and the sectoral composition factors. Additionally, the existing literature examined separate aspects of energy demand but did not construct a framework that incorporates all its determinants. For instance, Doytch and Narayan (2016) investigate the effects of FDI on energy consumption for different income panels, but they do not control for other technology transfer factors such as imports and they do not investigate the effects

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[1] For instance, the World Bank (2014) reports that for the period 2000–2005, energy consumption in China increased by 70%, coal use surged by 75%, air pollution emissions have either increased or remained stable, and surface water suffered noticeable degradation.

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of financial downturns. Hübler and Keller (2010) control for all three channels but do not study whether the effects on energy demand are different across country income levels.[2] Additionally, their sample period does not include the 2008 financial crisis and is only limited to developing countries.

The empirical literature investigating the effects of the 2008 crisis on energy intensity is thin despite the impact of the crisis on energy use, economic growth, international trade, and FDI (Reinhart and Rogoff, 2008, 2009; Desbordes and Wei, 2017; Altdorfer, 2017). In particular, global FDI declined by 20% in 2008 and an additional 39% in 2009 (Desbordes and Wei, 2017). Altdorfer (2017) documents that the financial crisis had a significant effect on energy efficiency in the European Union (EU) in the 2007–2014 period. His analysis reveals that, for the period 2007–2014, energy consumption fell by 11% while GDP recovered its 2007 level. It is interesting to note that a similar decoupling of energy use from GDP growth had occurred following the 1979 oil crisis and had sparked the literature on the impact of FDI on energy intensity. While Altdorfer's (2017) analysis is mainly descriptive and restricted to the EU region, it provides a starting point to carry further research on the effects of the crisis on energy intensity.

Our framework extends the existent literature by including the technology transfer, the vintage capital, and the sectoral composition channels in the same model; analyzing their effects across all country income levels; and including financial crisis as another potential channel explaining energy intensity. In doing so, we explore several externalities that financial crises may have on energy use by examining the following questions: did the 2008 crisis lead to a reduction in energy intensity? Alternatively, did the crisis represent opportunities for pollutant foreign investments to find new hosts in developing countries? How did the impact of the crisis on energy efficiency differ across countries according to their level of income? Did the crisis affect the magnitude with which the technology transfer, vintage capital, and composition factors affect energy intensity? Are there any effective tools that policymakers can employ to control the environment degradation without compromising growth?

Our results reveal some interesting and novel patterns. First, we find that pooling the data for the prior and after crisis periods may hide important disparities and lead to false inference. For instance, we find that the crisis interactive terms are significant for several channels (FDI, vintage capital, imports). This indicates that failing to control for economic recessions may yield insignificant parameters resulting from a significant impact prior to the crisis which is offset by a significant interactive term of opposite sign after the crisis. Hence, in these cases, pooling the pre and post-crisis periods will lead to incorrect conclusions. Second, our results show that pooling all countries together without controlling for the income level may also be misleading due to aggregation bias. Specifically, the impact of FDI is negative and significant for the overall sample, but this effect varies considerably between the three income panels. Middle-income countries achieved higher energy savings compared to low and high-income countries leading to an inverted-U shaped relationship between FDI and energy savings (or U-shaped between FDI and energy intensity). Accordingly, governments, especially in middle-income countries, should promote cross-border investments through fiscal reforms or other means that attract foreign capital. Moreover, we find that imports lead to a decrease in energy intensity for the full sample. When we control for the income level of countries, substantial differences emerge. More imports lead to larger energy intensity in middle-income countries but to negative or insignificant effect for low and high-income countries supporting a U-shaped relationship between imports and energy savings (or inverted-U shaped relationship between imports and energy intensity). Therefore, policy authorities in middle-income countries may modify the structure of their imported goods through tax reforms to allow for more energy efficient imports and hence lessen potential harmful effects on the environment.

The rest of the paper is organized as follows. Section 2 presents a brief literature review. Section 3 lays out the hypothesis development. Section 4 describes the data and the estimation methodology. Section 5 discusses the results. Section 6 reports the robustness checks. Finally, Section 7 concludes and provides several policy implications.

2. Literature review

This paper investigates the relationship between energy intensity, imports, FDI, vintage capital, and the sectoral structure of the economy. Our analysis extends the framework of Hübler and Keller (2010) and Antweiler et al. (2001) by including the effects of the 2008 global financial crisis and controlling for the income level of countries. We provide below a brief review of the literature on the different bivariate relationships between energy use and its determinants.[3]

2.1. FDI and energy use

Mielnik and Goldemberg (2002) pioneered the work on the relationship between FDI and energy intensity. The authors showed that FDI fosters the transfer of energy saving technology and leads to lower energy intensity for a panel of 20 developing countries. Using the model of Antweiler et al. (2001) who analyzed the impact of trade on the environment, Hübler and Keller (2010) extended the framework of Mielnik and Goldemberg (2002) by decomposing the effects of economic activity on energy intensity into a scale, technique, and composition effect. This decomposition allows the authors to disentangle the FDI technology transfer effect from potential scale and structural changes in the economy that FDI may cause. Within this framework, they show that FDI does not impact energy intensity in a sample of 60 developing counties. Similarly, Sadorsky (2010) finds that FDI does not impact energy demand in a panel of 22 emerging economies and argues that this may be due to the institutional environment in these countries.

Focusing on Central and Eastern European and EU 27, respectively, Sadorsky (2011a) and Çoban and Topcu (2013) find a positive and significant relationship between FDI and energy demand.

More recently, Doytch and Narayan (2016) investigate the effect of FDI on renewable and non-renewable energy. Using a large panel of 74 countries from 1985 to 2012, they show that FDI reduces the demand for non-renewable energy and that this finding depends on sectors and income groups. Specifically, the authors show that FDI in Financial Services raises the demand for renewable energy, but FDI in Manufacturing leads to an opposite effect. Paramati et al. (2016) also find that FDI has a positive impact on the demand for clean energy in a sample of 20 emerging economies for the 1991–2012 period. In the context of China, Salim et al. (2017) show that FDI reduced energy consumption in China over the 1982–2012 period. The above discussion reveals that the evidence on the effects of FDI on energy use is far from conclusive.

2.2. Imports and energy use

The seminal work of Grossman and Krueger (1991) has generated a large literature investigating the relationship between trade and the environmental quality. However, few papers have analyzed the effects of trade on energy use (Cole, 2006; Ma et al., 2009; Narayan and Smyth,

[2] Following Doytch and Narayan (2016), we divide our sample in three panels of countries. Low-income countries include category 1 and 2 in the World Bank 2016 classification. Middle-income countries include category 3 in the World Bank 2016 classification. High-income countries include category 4 in the World Bank 2016 classification.

[3] We refer the reader to Salim et al. (2017) for a comprehensive review of the literature.