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The relationship between energy demand and real GDP growth rate: The role of price asymmetries and spatial externalities within 34 countries across the globe☆

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ABSTRACT

The aim of this paper is to empirically explore the relationship between energy demand and real Gross Domestic Product (GDP) growth and to investigate the role of regional externalities on per capita Final Energy Consumption (FEC) in 34 countries during the period from 2005 to 2013. The paper utilizes a Dynamic Panel Generalized Method of Moments (DPGGM) approach and spatial econometric techniques in order to analyse the effect of real GDP growth rate on FEC through an Error Correction Model (ECM) and to examine clustered patterns of energy consumption. The results show that a) the demand is elastic both in the industrial and the household/services sectors, b) electricity and natural gas are demand substitutes, c) the relationship between real GDP growth rate and per capita energy consumption exhibits an inverted U-shape for all the sample countries under scrutiny (34 countries, Eurozone and EU28), but not for all the employed sectors of the economy, d) price (electricity and gas) and GDP growth asymmetries are supported from the employed parametric tests, and, e) distance does not affect per capita FEC, but economic neighbours have a strong positive effect.

1. Introduction

In 2013 energy consumption within European Union (EU) fell back to its 1990s level (1. 666 million tons of oil equivalent - MTOE) and down by 9.1% to its 2006 peak. The amount of energy that EU must import to satisfy its consumption needs was 53% the same year (European Union, 2015). At the same time European Commission estimates that Gross Domestic Product (GDP) growth rate will be on average 1.6% over the period 2015–2030, while lower growth rates are assumed (on average 1.4%) in the longer term (2013–2015).[1]

A recent analysis of per capita energy consumption (tons of oil equivalent per capita) versus GDP per capita (2011 USD PPP) by European Environmental Agency (2015) has shown mixed results regarding the relationship between energy consumption and GDP. Particularly, some countries such as Canada, United States and Australia depict positive relationship between energy consumption and GDP, while others such as Italy, Turkey, Brazil and India exhibit low levels of energy consumption to GDP per capita.

The motivation of this paper stems from the traditional Kuznets curve (Kuznets, 1955). According to it, as per capita income increases, at the beginning income inequality also increases but after some turning points it starts declining. In other words, at lower levels of per capita income its distribution is skewed to higher income levels, but skewness is reduced as per capita income increases. This relationship is represented by an inverted U-shaped pattern.

The environmental version of traditional Kuznets curve (Environmental Kuznets Curve, EKC)[2] follows a similar line of reasoning. EKC basically states that the relationship between energy intensity or consumption and income level exhibits an inverted U-shape

☆ The views expressed herein are strictly and purely those of the authors.

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[1] See European Commission (2013), p. 14.

[2] For more details see the papers by Shafik and Bandyopandhyay (1992), Grossman and Krueger (1995) and Holtz-Eakin and Selten (1995).

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pattern.[3] Medlock and Soligo (2001) and Galli (1998), *among others*, have found a non-monotonic relationship between energy intensity and real GDP. It is assumed that there is a point of real GDP growth rate at which beyond this point energy intensity begins to decline as growth rate continues to rise.

Based on the above findings, this paper adopts the EKC methodology to empirically explore the existence or not of a non-monotonic relationship (inverted U-shape) between per capita Final Energy Consumption (FEC) and real per capita GDP growth rate and to investigate the role of asymmetries (price and GDP growth asymmetries) and regional externalities on FEC for an updated panel data set of 34 countries (EU28 countries, 5 candidates - Montenegro, FYROM, Albania, Serbia, Turkey - and Norway). The time period spans from 2005 to 2013. For these purposes we employ yearly data and a Dynamic Panel Generalized Method of Moments (DPGMM) approach in an Error Correction Model (ECM) and we use spatial econometric techniques to examine clustered patterns of energy consumption. Also, we utilize parametric tests (Wald tests, F-tests and impulse response functions) in order to examine the asymmetric responses of prices and real per capita GDP growth rate on per capita FEC.

The paper contributes in four different angles: a) it examines the effect of spatial externalities on FEC per capita, b) it analyses the price (electricity and gas) and real GDP growth rate per capita asymmetric adjustment paths, c) it provides an investigation of the competitive pressures that natural gas may impose on electricity by presenting own and cross price elasticities in the industrial and household sectors of the countries under examination, and, d) it extents the literature regarding the relationship between energy consumption and GDP growth rate per capita. To the best of our knowledge the first contribution of this paper has not been analysed so far in the literature.

The remainder of this paper is organized in the following way. Section 2 reviews the literature and Section 3 presents the data and descriptive statistics of the employed variables. Sections 4 and 5 present the methodology and the empirical models that are utilized and Section 6 reports the empirical results and the parametric tests for price and growth asymmetric responses. Lastly, Section 7 concludes.

2. Literature review

In this paper we mainly focus on the relationship between FEC and income level. A strand of this literature is occupied with the casual relationship between energy consumption and income level. Narayan (2016) uses a panel data of 135 countries and concludes that empirical findings strongly support the neutrality hypothesis between energy consumption and economic growth. However, the empirical results for a panel of 35 middle-income countries show that energy consumption predicts real GDP per capita. Polemis and Dagoumas (2013) have found that the causal relationship between electricity consumption and economic growth in Greece is bi-directional. They also state that in the long-run electricity demand appears to be price inelastic and income elastic, while in the short-run the relevant elasticities are both below unity. Maggazino (2015) states that in the short-run the flow of causality in Italy runs from energy use to GDP, and there is a long-run bidirectional causal relationship between the two variables. Therefore, he concludes that energy is a limiting factor to GDP growth.

Jakob et al. (2012) use a difference-in-difference estimator on panel data for 51 countries from 1972 to 2005. They examine the relationship between income growth, measured by market exchange rates, and primary energy consumption. They find that the elasticity of total primary energy use with respect to income is 0.631 for developing countries. However, the corresponding value for developed countries is 0.181 but statistically non-significant. On the contrary, Soytas and Sari (2003) use cross-section and panel data in the top 10 emerging markets and G-7 countries and conclude that elasticity of energy consumption with respect to GDP is significantly above one (namely 1.35).[4] The authors have also discovered bi-directional causality in Argentina, causality running from GDP to energy consumption in Italy and Korea, and from energy consumption to GDP in Turkey, France, Germany and Japan.[5,6]

Another strand of the literature examines the validity of EKC. Particularly, Brookes (1972) uses cross section data for 22 countries from 1950 to 1965 and estimates that the income elasticity for the less developed income countries were considerably higher than for the developed countries. Even though Brookes (1972) utilizes a log-log linear model his findings eventually support the idea of a non-monotonic relationship between per capita energy consumption and per capita GDP. Zilberfarb and Adams (1981) use panel data to examine the relationship between energy consumption and GDP in 47 developing countries over the period 1970 to 1976. The empirical results show that the elasticity of energy consumption with respect to GDP remains stable and significantly above unity over the scrutinized period and particularly in developing countries it is around 1.35. Ang (1987) found that for 100 countries in 1975 energy elasticity is about unity for the low-income developing countries, between 1.6 and 1.8 for the high-income developing countries, and decreases slightly thereafter for the industrial countries. These findings support the idea of a bell shape relationship between energy consumption and GDP.[7]

Galli (1998) estimates the long term trends of energy intensity in 10 emerging Asian countries from 1973 to 1990 by using a quadratic (non-monotonic) function of log income. The author finds a change in trend of energy intensity as GDP increases indicating an inverted U-shaped pattern. Judson et al. (1999) examine a panel data of 123 OECD countries from 1970 to 1991. Their findings suggest that energy consumption tends to fall (increase) as national income falls (increases) in the household (transportation) sector, while in the industry sector the share of energy consumption with respect to income tends to follow a bell shape (an inverted U-shape). The study by Medlock and Soligo (2001) for a panel of data of 28 countries (9 countries from the Asian/Pacific geographic region, 15 European countries[8] and 4 countries from North/South America) during the period 1978–1995 verifies the empirical findings by Judson et al. (1999) regarding the transportation and industry sectors, while the share of energy consumption with respect to national income in the household sector rises at the beginning and then levels out.

[3] Recent work on the validity of EKC can be found in Alvarez et al. (2005), Richmond and Kaufmann (2006), Coondoo and Dinda (2008), Soytas and Sari (2009), Acaravci and Ozturk (2010), Marrero (2010), Jaunky (2011), Arouri et al. (2012a, 2012b), Esteve and Tamarit (2012), Fosten et al. (2012), Donfouet et al. (2013), Sephton and Mann (2013), Shahbaz et al. (2013), Danaeifar (2014), Ozturk and Al-Mulali (2015), Ajmi et al. (2015), Rodriguez et al. (2016), Polemis and Stengos (mineo), Apergis (2016) and Sephton and Mann (2016). For a survey of the EKCs on an empirical and theoretical perspective prior to 2000 see the relevant studies of López-Menéndez et al. (2014), Dinda (2004), Stern (2014). Panayotou (1995, 2000) has also given a critical overview of the research done from 1992 to 2000.

[4] Desai (1986) has found that the GDP elasticity of energy consumption for LDCs is found to be less than one.

[5] See also, inter alia, Asafu-Adjaye (2000), Lee (2005), Wolde-Rufael (2006), Mahadevan and Asafu-Adjaye (2007), Mechrara (2007), Hannesson (2009), Payne (2010), Pirlogea and Cicea (2012), Fuinhas and Margues (2012); Apergis and Tang (2013), Ouedraogo (2013), Hamdi et al. (2014).

[6] Other researchers utilize econometric and non-econometric tools in order to decompose the main determinants of energy intensity. Schäfer (2005) finds similar results with those of Judson et al. (1999) regarding household and industrial sectors and shows that in the service sector energy consumption decreases monotonically with national income. See also Boyd et al. (1987), Metcalf (2008), Wing (2008) and Nillesen et al. (2013), ch. 3, pp. 93.

[7] For a time-series analysis of individual non-oil developing country see Pourgerami and Von Hirschhausen (1991).

[8] Turkey, Greece, Portugal, Spain, Ireland, Austria, Italy, Belgium, Netherlands, UK, France, Finland, Sweden, Denmark, Norway.