



## Analysis

# Oil consumption and economic efficiency: A comparative analysis of advanced, developing and emerging economies

George E. Halkos\*, Nickolaos G. Tzeremes\*\*

Department of Economics, University of Thessaly, Korai 43, 38333, Volos, Greece

## ARTICLE INFO

## Article history:

Received 9 October 2010

Received in revised form 4 February 2011

Accepted 16 February 2011

Available online 24 March 2011

## Keywords:

Economic efficiency

Oil consumption

DEA window analysis

Dynamic panel data models

## ABSTRACT

This paper investigates the economic efficiency–oil consumption relationship in 42 countries during the period 1986–2006. In a first stage by using DEA window analysis countries' economic efficiencies are obtained. In a second stage an econometric analysis based on robust GMM estimators reveals an inverted 'U'-shape relationship between oil consumption and economic efficiency. In order to capture heterogeneities among countries' development stages the analysis has been separated into two groups (advanced economies and developing/emerging economies). The results show that advanced economies have much higher turning points compared to emerging and developing economies. It appears that oil consumption increases countries' economic efficiency. In addition the consumption patterns of oil products and its derivatives have changed through years and among countries. The different turning points from the econometric analysis indicate the dependence of oil consumption in advanced economies (higher turning points) is driven mainly by household purchasing activities and their standards of living (transport, housing and water, food, etc.). Finally, it appears that oil consumption is the main driver behind the progress of industrialization and urbanization regardless of the country's development stage.

© 2011 Elsevier B.V. All rights reserved.

## 1. Introduction

The impact of energy on a countries' economic growth has been the center of research agenda for several years. Kraft and Kraft (1978) were among the first who investigated the relationship between energy consumption and economic growth for the USA. Since then many studies have used Granger causality tests in order to establish the link between energy and income, and energy and economic growth (Abosedra and Baghestani, 1991; Akarca and Long, 1980; Yu and Choi, 1985; Soytaş et al., 2007; Soytaş and Sari, 2009; Zhang and Cheng, 2009). However, the results reported vary according to the country and the time period considered.

Furthermore, Huang et al. (2008) applied a dynamic panel approach examining the energy consumption–GDP relationship for 82 countries from 1972 to 2002. They divided the data into four categories according to countries' income levels and their results showed absence of evidence that energy consumption leads economic growth in any of the four income groups. Similarly, Ozturk et al. (2010) using a sample of 51 countries, divided into sub-samples according to income groups and for the period 1971 to 2005, found that there is no strong relationship between energy consumption and economic growth indicating the need for further research.

Jorgenson (1984) emphasized the fact that much research remains to be done until we are able to establish the relationship between energy utilization in productivity growth. According to Reynolds (1994, 1998) energy determines growth. The mechanism which explains how energy creates economic growth is presented and analyzed in Reynolds (2000). This mechanism is the energy utilization chain (EUC) that contains four links (namely energy source, conversion, consumption and service), which in combination can lead to growth. For instance, transportation and large independent mobile machinery (LIMM) operations are the most important energy services, which are strongly connected to countries economic growth.

In contrast to the majority of studies investigating the energy consumption–GDP relationship, our paper investigates for the first time (to our knowledge) the economic efficiency<sup>1</sup>–oil consumption relationship. In the literature and in most of the cases oil consumption is embedded in the 'total energy consumption' variable. But none of the studies have approached the economic growth–oil consumption relationship given the strong oil dependence in most of the countries.

According to Reynolds (2000) oil is the main energy source of LIMM operations and therefore the main driver behind countries' economic growth. In addition Reynolds (1994) explains the mechanism of how energy resources can contribute to economic growth and the reason why oil consumption is linked to countries' economic

\* Corresponding author. Tel.: +30 24210 74920; fax: +30 24210 74772.

E-mail addresses: [halkos@econ.uth.gr](mailto:halkos@econ.uth.gr) (G.E. Halkos), [bus9nt@econ.uth.gr](mailto:bus9nt@econ.uth.gr) (N.G. Tzeremes).

URL: <http://www.halkos.gr/> (G.E. Halkos).

<sup>1</sup> Economic efficiency according to Ayres (1998) is linked to "technological progress". That is the efficiency with which resources (capital and labor) are converted into GDP.

growth. Specifically, Reynolds (2000, p. 218) claims that energy resources have four grade types: (1) the weight grade (British thermal units, BTUs, per pound of energy resource); (2) the volume grade (BTUs per cubic foot of energy resource); (3) the area grade (BTUs per acre, where the energy resource is found in its original state); and (4) the state grade (the original physical state of the energy resource as a liquid, gas, solid, or energy). The higher the grade types of the energy resource, the higher its contribution to economic growth. Oil is a liquid state grade and it has high area grade, weight grade and volume grade characteristics that no other energy resources can match.

Therefore, it appears that oil has the highest characteristic grades from all energy resources making difficult its substitution from other resources (Reynolds, 1994, 1998). After 100 years the price of oil has been constant in real terms and any additional alternatives haven't been found in order to replace oil dependence of economic growth (Reynolds, 2000, p. 216).

Additionally Goldemberg (2007) claims that fossil fuels (oil, coal, and gas) represent 80.1% of the total world energy supply, nuclear energy 6.3%, and renewables 13.6%. From that total of 80%, oil represents 45% of consumption, coal 30% and gas 25%. As can be observed oil consumption is still the dominant source of energy. Furthermore, Pimentel et al. (2009) over the past century indicated that affordable supplies of fossil fuels have mainly powered growth, industrialization, and prosperity of the USA and other countries' economies.

In order to capture the effect of energy consumption on economic growth, the energy-economic growth studies have used GDP as a proxy of economic growth. Following the analysis by Ayres (1996a, 1996b) our paper, instead of GDP as a proxy of economic growth, uses countries' economic efficiency. The standard growth theory (Solow, 1956, 1957) assumes that the production function is a function of capital and labor, but the most important growth factor is an unexplained exogenous driver, the "technological progress" (Ayres and Warr, 2005; Ayres and van den Bergh, 2005). As explained by Ayres (1998) and Li and Ayres (2008) "technological progress" is the efficiency with which resources are converted into final services. Generally, efficiency, where inputs are converted to outputs can provide us with more useful information than an absolute measure.<sup>2</sup>

As such our paper measures countries' economic efficiency over the period 1986–2006 by applying a variation of Data Envelopment Analysis (hereafter DEA) in order to handle panel data and allow for dynamic effects. This methodology is called DEA window analysis and has been introduced by Charnes et al. (1985). It works on the principle of moving averages and helps to establish efficiency measures over time by treating each country in a different period as if it was a different unit (Asmild et al., 2004; Cooper et al., 2007; Halkos and Tzeremes, 2009a, 2009b). Thus country's economic efficiency in a particular period is contrasted with its own efficiency in other periods in addition to the economic efficiency of other countries. In this way robustness related problems associated with DEA measurement techniques can be avoided.

In a second stage our paper introduces a partial adjustment model formulation using Dynamic Panel Data Analysis with one- and two-step Arellano and Bond (1991) and Arellano and Bover (1995) GMM estimates. These GMM estimators are robust, as they do not require information of the exact distribution of the disturbances. The estimators rely on the assumption that the disturbances in the equation are uncorrelated with a set of instrumental variables. At the same time we also apply a random coefficients model formulation assuming that each parameter is a random variable. Countries are

<sup>2</sup> In addition, the efficiency of this conversion is very crucial in our study since oil is a major driver behind the transformation of capital and labor into GDP. Furthermore, consider two countries with the same measure of GDP. If one of these countries converts inputs more efficiently than the other, then this country is more economic efficient and it is likely to grow faster than the other country. If we consider GDP as a measure of economic growth then these countries have the same economic growth, which is possible to lead us in misleading conclusions (Ayres, 1996a, 1996b, 1998; Ayres and Warr, 2005; Ayres and van den Bergh, 2005; Li and Ayres, 2008).

heterogeneous with different stochastic regression coefficients, which arise from a  $k$ -variate normal distribution.

In this way we calculate the effect of oil consumption in the obtained countries' economic efficiencies and test the existence of an inverted U-shape relationship between economic efficiency and oil consumption. Li and Ayres (2008) suggest that oil consumption is a good energy proxy when the relationship between energy and economic growth needs to be tested. In addition to other studies our paper uses oil consumption since oil is an exhaustible nonrenewable resource and the consumption behavior of the current generation affects the economic development and welfare of future generations (Abdel and Sabry, 2005).

The paper is organized as follows. Section 2 presents the data used in the analysis whereas, Section 3 discusses the proposed methodology and the econometric methods adopted. Section 4 presents the empirical results derived while the last section concludes the paper.

## 2. Data

Following, Halkos and Tzeremes (2009a, 2009b) we measure countries economic efficiency (EFF) based on production of two inputs and one output. We use data for 1986–2006 for 42 countries.<sup>3</sup> The inputs used are total labor force (in absolute values in thousands) and gross capital formation (in million US\$ at current prices).

In addition the output used is GDP (market prices) in volumes.<sup>4</sup> Several authors suggest that GDP variable has some advantages over the disposable income variable and in many cases it can be an appropriate measure in the absence of a wealth measure (Bilson, 1981; Zuehlke and Payne, 1989; Craigwell and Rock, 1992).

The inputs/output used have been obtained from UNCTAD (2008) database. The external variable used is oil consumption (in million tonnes).<sup>5</sup> The oil consumption (OC) quantities have been obtained from the BP Statistical Review of World Energy (2007).

## 3. Techniques Adopted

### 3.1. DEA Window Analysis

Charnes and Cooper (1985) introduced this variation of DEA technique with the ability to measure the efficiency and handle cross-sectional and time-varying data. According to Asmild et al. (2004) the main advantage of this technique is its ability to detect efficiency trends over time by comparing every DMU against itself and against other DMUs overtime. Tulkens and Vanden Eeckaut (1995) suggest that the number of time periods (years in our case) included in the analysis form a 'window'. In our study we use 42 countries ( $n = 42$ ) for the time period of 1986–2006 ( $T = 21$ ). Asmild et al. (2004) highlight the fact that there are no technical changes within each of the windows because all DMUs in each window are measured (compared) against each other and suggest that in order for the results to be credible a narrow window width must be used.

As such in our analysis a 3-year window has been chosen ( $w = 3$ ). Then each DMU is placed in the window treated as different DMU for each of the three years (the width of the window). Thus in our case the

<sup>3</sup> The countries used in our analysis are separated according to IMF (2009) distinction as: Advanced Economies (28): Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong SAR, Hungary, Ireland, Italy, Japan, Lithuania, Netherlands, New Zealand, Norway, Portugal, Republic of Korea, Singapore, Slovakia, Spain, Sweden, Switzerland, UK, USA. Emerging and Developing Economies (14): Argentina, Brazil, Bulgaria, Chile, China, Colombia, Ecuador, India, Indonesia, Malaysia, Philippines, Poland, Romania, Thailand.

<sup>4</sup> As can be realized the inputs/output used are in aggregate economy level. This is because the oil consumption patterns during 1986–2006 have changed among countries and their development stages (Leung, 2010). Thus it will be impossible to capture oil consumption's effect on countries' economic efficiency.

<sup>5</sup> The oil consumption is measured in million tonnes instead of tonnes of oil per capita (which can make comparisons more understandable) because for the calculation of economic efficiency real values are needed and not per capita.

متن کامل مقاله

دریافت فوری ←

**ISI**Articles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات