Energy Strategy Reviews 20 (2018) 90–98

Contents lists available at ScienceDirect

Energy Strategy Reviews

journal homepage: www.ees.elsevier.com/esr

The relationship of energy intensity with economic growth:Evidence for European economies

Tahir Mahmood [a, b, *], Eatzaz Ahmad [c, d]

[a] PhD Economics, University of Eastern Finland, Joensuu, Finland
[b] Assistant Professor, School of Economics, QAU, Islamabad, Pakistan
[c] PhD Economics, McMaster University, Hamilton, Canada
[d] Professor, Peshawar University, Pakistan

ARTICLE INFO

Article history:
Received 2 November 2017
Received in revised form
12 January 2018
Accepted 10 February 2018

JEL classifications:
O4
Q00
Q4

Keywords:
Energy intensity
De-trending
Economic growth
Panel data

ABSTRACT

This study analyzes the impact of economic growth on energy intensity in European countries. Since energy intensity may decrease with economic growth due to technical changes accompanying growth, the study removes the effects of technical changes in the use of energy as captured by trend while analyzing the energy-growth relationship. It is argued that the negative relationship does not have to be interpreted as the result of declining trend in energy intensity. The empirical analysis shows that energy intensity is significantly reduced in response to economic growth even when the former is de-trended. The inverse relationship between energy intensity and economic growth, as already found in the literature, persists even if the trend and inertia in the energy-intensity series are controlled and the effects of rising taxes on energy, environment and transport and rising energy prices are taken into account. It is further observed the European countries have been able to economize on the use of energy not only through their economic growth but also due to stable and in some cases declining populations.

1. Introduction

Energy is considered to be a crucial input in the process of economic growth. Sustainable economic growth necessitates sufficient and continuous availability of energy input, which can be made possible if energy intensity declines with growth. The term energy efficiency refers to the extent to which the available energy resources are used economically in the production of goods and services. When a given amount of energy can produce a larger amount of goods and services or, taking it the other way, when a given level of output can be produced by using less amount of energy, this is known as gain in energy efficiency. Energy intensity is commonly used to measure energy efficiency of a country [33]. Improvement in energy efficiency - through adoption of environment-friendly production techniques and/or through changes in the composition of national output towards less energy intensive products - can be set as an intermediate goal to reduce relative consumption of energy with the ultimate aim of improve environmental quality.

The data on energy intensity can be used to compare the state of energy efficiency across different countries, which may differ in energy intensity depending on the extent of industrialization, product mix and the attention paid to energy efficiency. Curtis paribus, if energy intensity is relatively higher in a country, it would mean that the country has to bear additional costs in terms of damage to environment. Huang *et al.* [16] observed that relative to poor countries, European countries tend to require less energy input to achieve any particular growth rate of GDP. According to the European Environment Agency [10], GDP in the region grew at an annual compound rate of 2.2% during 1990–2002, while energy consumption grew at an annual compound rate of just 0.5%. This resulted in a decrease in energy intensity in Europe by an annual compound rate about 1.7%, which is a significant saving in energy use.

This pattern appears to support the phenomenon of the so-called Environmental Kuznets Curve (EKC), which hypothesizes

* Corresponding author. School of Economics, QAU, Pakistan.
E-mail addresses: tahirraja2000@yahoo.com (T. Mahmood), eatzaz@qau.edu.pk (E. Ahmad).

https://doi.org/10.1016/j.esr.2018.02.002
2211-467X/

an inverted U-shaped relationship between economic development and environmental pollution. At the initial stages of economic growth environment tends to get more polluted whereas when the industrial potential expands, the environment takes an important and urgent position in decision making. Hence, as the level of per capita income increases beyond a certain critical level, more efforts are putin to ensure that the technology and product mix are environment friendly. A major component of this effort appears in the form of low energy intensity products and technologies [8,9,14,16].

According to EEA [10] report, Southern European region is slightly less energy efficient than Nordic and Central European regions. In any case, if Europe is able to capitalize on the maximum potential of energy efficiency in the next few decades, the continent may not only reap substantial economic gains in terms of cost savings but also ensure cleaner environment for its inhabitants. According to the report, significant positive returns on this account are available even with the already existing technologies.

There is a general agreement in the literature that developed countries have already realized the importance of energy efficient technologies and product mix [15,16,31]. By-and-large it is an accepted observation that energy intensity and economic growth are inversely correlated. However, there is no clear indication as to whether this observation is based on an underlying relationship between energy efficiency and economic growth or it is caused by a general declining trend in energy intensity. According to Stern [34], there exists a legitimate relationship between economic growth and energy efficiency if economic growth is accompanied by growing share of service economy, which is relatively less energy intensive.

Historic data show that energy intensity in Europe continued to decline even in those years when the growth rate of GDP also declined.[1] There are various reasons to believe that energy intensity has declined independent of economic growth. First, with increasing awareness about the importance of clean environment, new vintages of capital are designed to be less energy intensive, resulting in declining energy intensity with the passage of time. A few examples are the switch from large European and American cars to fuel efficient Japanese cars and from window ACs to split ACs. Second, with the surge of economic growth in Asia, especially China, a significant portion of manufacturing activity in Europe has been either directly transferred to Asia or replaced by imports with the result that the share of services sector, which is relatively less energy intensive, in GDP has increased. According to EEA [10] report, energy efficiency in EU-28 is gained from less energy-intensive services sector and a shift from high energy intensive-industries to low energy intensive industries.

The above observation indicates that the decline in energy intensity can at least partly be attributed to changes in technology and comparative advantage of Europe vis-à-vis Asia independent of GDP growth. These are sufficient reasons to suspect that the declining trend in energy intensity in Europe could have been independent of the GDP growth. Therefore, the proposition that energy intensity in Europe declined primarily due to economic growth needs to be re-examined. In particular, whether or not the effect of growth on energy efficiency remains favorable once the declining trend in energy intensity due to other factors is controlled is an empirical question that still needs to be answered.

Recent literature (e.g., [18] and [12] has shown that along with per capita GDP, energy prices and energy taxes are important determinants of energy intensity and efficiency. This literature suggests that the level and structure of these variables should be considered and used as a valuable energy policy tools for improving energy efficiency. These suggestions are also supported by the fact that Denmark, Germany and Italy have the highest share of energy taxes in the structure of the final electricity price, and at the same time the lowest energy intensity [12].

The existing economic literature has mostly focused on the comparison of energy intensities between developed and developing countries [1], while others have conducted convergence analysis of energy intensity [11,23,26]. In contrast to these studies, the objective of the present paper is to estimate the impact of economic growth on energy intensities after filtering out trend from the latter and controlling for changes in energy and related taxes and energy prices. By doing this an attempt is made to control for the changes in energy intensity brought about by such changes in technology and product mix that are not necessarily correlated with the growth rate of GDP. Therefore, at the first stage, the energy intensity series of each country is de-trended. At the second stage, the impact of the growth rate of GDP on the de-trended energy intensity is analyzed, while controlling for other factors like taxes and energy prices. This procedure opens new research options. For example, one can study the energy productivity of different sectors, and compare the growth and trend effects. In transport sector, for example, energy saving has been noticeable besides the growth effects.

An important issue in the context of energy intensity and growth nexus in Europe is whether the energy-intensity relates to the growth rate of GDP or the growth rate of per capita GDP. Growth in per capita output requires productivity growth and can be brought about by continued adoption of more efficient techniques and alignment of domestic product mix to the changing patterns of comparative advantage. On this basis the present study postulates a negative relationship between energy-intensity and the growth rate of per capital GDP.

The paper is organized as follows. Section 2 presents a very simple theoretical model to relate energy intensity with GDP growth rate and the state of technology. Based on this theoretical underpinning, section 3 proposes various empirical models to be estimated, while section 4 describes the data and estimation procedure followed. Section 5 presents the results and discussion and section 6 concludes the study.

2. Economic growth and energy intensity in neoclassical growth framework

There are various ways to model the relationship between energy intensity and economic growth. The most straightforward approach is to start with the famous steady-state growth condition in neoclassical growth model:

$$\dot{k}(t) = sf(k(t)) - (g + \delta)k(t) = 0 \tag{1}$$

where k(t), s, g and δ denote capital stock per effective unit of labor, saving rate, growth rate of labor and depreciation rate respectively. It follows that the capital-output ratio forms the following inverse relationship with the steady state growth rate of output:

$$k/f(k) = s/(g + \delta) \tag{2}$$

The reason for the inverse relationship, as illustrated further in Fig. 1, is that higher steady state growth rates are sustainable only at lower capital-output rate.

To bring energy into the picture it is assumed that energy is used

[1] According to the data used in the present study on 19 European countries, about 60.8% of the observations show year to year decrease in energy intensity, out of which about half (30.6%) of the times the decrease in energy intensity accompanied a decrease in GDP growth rate. See Fig. 3.