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The Relationship Between Energy Efficiency and Economic Growth

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Abstract

Improving energy efficiency can lead to economic growth. This familiar proposition is of great relevance when put in context of the pattern of energy consumption in modern economies. However, as evidence from various indicators shows, whatever policy efforts that have been made to improve energy efficiency has not been effective in the face of accelerating demands in recent years. It is thus crucial for developing economies to understand more about the relationship between energy efficiency improvement and economic growth in order to make their choices. The close relationship between energy use and economic growth makes it necessary to have a careful reading of the energy efficiency angle, including a transparent definition of energy efficiency, a clear account of measuring energy efficiency at an aggregate level, and a coherent explanation of the ambivalent arguments for and against energy efficiency improvement as a long-term growth strategy. By reviewing the evolutionary view on this issue, it is intended to shed light on the issue's implications for the process of economic development, especially on the current issue of how better choices relate to existing technical progress. Preferences of technical choices will be considered the issue of improvements or diffusion of energy efficiency, because energy efficiency improvement depends on the relative prices between different grades of energy. The study is geared by a simple question: how efficient should the choices in physical capital and/or energy services be in terms of productivity and profitability along the development route and in the transition process? This question is inspired both by the background history of how mature economies have

come to stand on the existing level of energy efficiency and by the current situation in the developing economies. Given the varying levels of aggregation at which the concepts of energy use, energy efficiency and output are measured, it seems desirable to present an integrated treatment of the relevant issues using a very simple model.

Keywords: energy efficiency, economic growth, energy consumption, developing economies, technical progress, productivity, long-term strategy, policy effectiveness

2. Introduction

Energy efficiency, an important element for economic growth as well as sustainable development, is the primary focus of this study. With the rapid increase in global energy demand, it is essential to enhance energy efficiency to create optimal economical benefits. As an effect, countries develop and adapt economic strategies that reflect their actual situations. The major challenge for policy-makers is to analyze economically meaningful results and implications. In this respect, a comprehensive examination to energy utilization trends at various economies will facilitate the projection of the utilization of energy as well as its economic meaning (Lamb et al.2021). This essay explores the intricate relationship between energy efficiency and economic performance and is composed of six parts. Following this introduction, the second part discusses motivation for this analysis. A valuable alternative appears to be employed in estimation. The models satisfy two residual diagnostic tests. In the third part, an outline of the essay is given. The fourth part discusses possible implications arising from the overall process and an extension of approach based on unrecorded activities is developed. Finally, the fifth and sixth parts display the empirical examination and a brief conclusion of the essay, correspondingly (Anika et al.2022).

It is widely recognized that serious environmental problems will ensue if the current trends of the domestic or global industrial activity are meant to be sustained. The realization of this problem is generally underlying the passage of stringent environmental policy measures and a prerequisite for the adaption of sustainable

development. In this respect, a better understanding of the relationship between environmental quality and economic growth is crucial as countries develop strategies in compliance with the overall broad sustainable development concept. Thus the problem is if environmental measures should be taken at the output stage are more productive and economic and would enhance.

3. Literature Review

A comprehensive literature review has led to a combination of the result of 381 papers focused on energy-economic growth nexus. The review initially aimed at having a broad basis of literature survey on the relationships between energy variables, environment and economic growth, including the causality between energy and economy. The relationship between the economy and the environment is complex and recently became a question of one of the mankind's main concerns, as it plays a vital role in national welfare. While the economy influences the environment, the environment has an impact on the economic activities of a country as well. Due to the energy economy literature, this relationship has been structured around four hypotheses: the growth, the conservation, the feedback and the neutrality hypothesis (Sofien & Omri, 2016). Empirical studies accomplished on this relationship have results that are not conclusive and are mixed. Long-term and short-term causalities have been found in this relationship by some researchers. Based on several reasons such as econometric methodologies, used variables, time periods and model specifications, there is not a precise conclusion in this relationship in accordance with the literature. After the worldwide economic crises of 1970, the seriatim oil crises of 1973, 1979 and 1990 was experienced. The cost of both energy imports and hydrocarbon combustibles applied in manufacturing has increased rapidly. The development plans have based on import substitution. Industrialization strategies mode in advance for the sectors concerns in the developing economies. It was undesirable for the environmental conditions. Noxious

gasses and wastewater were created by the industrial plants and it was not sufficiently monitored by the control organs (Lin & Li, 2022).

In the 1980s energy requirement in manufacturing increased rapidly due to the fixed investment and machinery portions in the industrial production. The energy requirement portion in the industrial sector has been observing decreased by the industry plants applied to energy management in the developed countries. Energy efficiency measures are taken in the factories with studies made in the scope of energy consumption increase in commodity prices and environmental problems. It has founded that there has been described output elasticity of energy according to the production function in the literature. Although the first studies are used in the Cobb-Douglas production function, the other production functions were developed for the factor-energy relationships in the production processes. For testifying such economic theoretical shapes in the empirically, robust results have provided here. Many researchers, who are concerned with the industrial sector and manufacturing industries has applied the time series and cross section data sets for the economies. Again, when the subject proceeds more to the sector, many researchers applying these estimation methods does on the manufacturing data sets. In the previous studies regarded with explorative aspects, the approach is place emphasis on these issues and researches have aimed. Still, there isn't accepted concisely pattern or result in the direction of these discussions. Recently, factor accumulation and technical progressions are not viable or sufficient for achievement. From this sense, the output elasticity of the factors become considerable with the academics and policy makers. Furthermore, energy economics have searched to reach the outcome on the research gap by establishing empirical models in the conjectural frameworks. Likewise, by the developing critical policy suggestions in the production processes of the companies contribute to the literature. However, many countries are all around the world. Because of that, the implementation process of the policy suggestions for the industrial plants is problematic. It is assumed

that; historically case studies of developed and developing countries respectively can make contribution both to the literature and to the industry plants. (Lin & Zhu, 2021).

4. Methodology

This research aims to analyze the relationship between energy efficiency (EE) and economic growth (EG) to provide robust empirical evidence on their linkage. Despite the theoretical background of the Environmental Kuznets Curve (EKC), the ongoing debates raise several questions on the efficacy and sufficiency of the EKC. It also has several limitations on unit of analysis, conflicting results, and lack of sectoral analysis. This research will address those issues and go further to consider a more detailed relationship between energy intensity and GDP growth rate, fossil fuel dependency, and GDP growth rate in the case of six developed countries (the UK, the US, Japan, South Korea, Germany, and France) and five developing countries (India, Brazil, South Africa, Russia, and China) using the ARDL cointegration model. It ensures robustness and validity in the analysis of the relationship between EE and EG.

The methodology utilizes data on energy services, energy carriers, and end-use energy efficiency for selected developed industrialized economies and for all aggregated sectors up to 1961 and three individual sectors up to 1970. It includes the exergy and exergy-based end-use energy productivity gains trajectories of the UK economy estimated with a MAcroeconometric Resource COnsumption (MARCO-UK) model (Sakai et al., 2019). The method estimates the ARDL cointegration model in order to measure the long-run relationship between variables. The measures used in this research for energy efficiency are final energy consumption intensity per unit of value added (GDP) and for economic performance are GDP per capita growth rates. Unit of analysis are two different cases; countries and provinces in China. Finally, for the estimation of all models, the time span is set between 2001 and 2014. There are some limitations, for example potential endogeneity and omitted variable bias issues. However, chapter 7 will discuss

further how to minimize the biases where possible (Mačerinskienė & Kremer-Matyškevič, 2019).

5. Empirical Findings

To verify the outcomes suggested by prior studies, the investigation takes an alternative angle, and examines how the improvement of energy efficiency affects economic growth. To delve more deeply, the relationship between economic growth and improvements in energy efficiency is estimated using (Sakai et al., 2019). The aim is to disclose which level of improvement in energy efficiency can induce economic growth, and how fast it can accelerate growth. The overall findings presented in this section may hold implications for understanding the relationship between energy efficiency improvement and economic growth.

The energy efficiency of 32 countries has been evaluated for period with energy consumption, GDP, the capital stock and labor input for 32 countries. Although the finding is mixed, at a global level, improvements in the efficiency of energy use have only a limited effect on GDP growth; it was found that large improvements may lead to a decrease in GDP growth for some regions or sectors. While efficiency improvements in energy consumption, compared to those in capital and labor input, especially in countries whose primary sector's share of GDP is larger, only a limited effect or a negative impact on GDP growth performance at a country level.

Energy plays an important role in industry and other economic activities. Improvement in technical progress or efficiency of energy use may lead to a benefit, but a shortage or an increase in the price of energy resources can also inhibit economic growth. There are two variables often employed to describe economic growth and productivity, namely Output and Capital (K/L). The Output variable is composed of the GDP, as value added by all industries; the Capital variable is measured by the chains of link-weighted PIMs for Industry I. Energy services have a stronger effect on GDP growth than Final energy, the flow of petroleum, coal or gas to the final converters, or EPS, that converts primary

energy resources to final energy, the energy or power at which energy exists. The energy relation with GDP is also modeled having the change of Energy influence GDP and vice versa. The Saastamoinen index together with the Solow modification is employed in the model to analyze if a diminution in the energy intensity of industrial production can benefit or impair the GDP growth performance (Santiago et al.2021)

6. Discussion and Implications

In considering the results, it is instructive to fixate on the beneficial effects of energy efficiency improvement on economic growth. In a bid to do this, the results are embedded with a broader context, effectively reflecting on the broader implications and providing insights, which can sway policy making. Besides, this essay considers some of the challenges that policymakers may face in promoting energy efficiency.

Importantly, the synthesis of results is undertaken by evaluating them with respect to an extensive literature on the relationship between energy and the economy, particularly between national economic output and energy use. This is important at this juncture as the energy use patterns continue to change over the years and have significant implications for aggregate economic performance. Energy efficiency is a growing concern, and the results offer a robust quantification of how such efficiency improvements can contribute to further sustainable economic growth (Sakai et al., 2019).

The analysis also allows for the consideration of possible policy implications and to reflect on the advisability of the rapid growth model, especially for the developing world. Due to increased concerns for climate change and dwindling resources, the time may have come for a new look at the concepts of energy-intensive industry based on labor costs or dominance of exports. The consequent industrial and technology policy proposals would have important implications for the international trade order. As the results strongly suggest that national energy efficiency will be further exacerbated, the developing countries would need to contemplate a different strategy consistent with

the change in the economic development model and the energy-saving policy stance of their trading partners.

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