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Communication

Electricity consumption and economic growth: A cross-country analysis

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ABSTRACT

Electricity has been the foundation of economic growth, and constitutes one of the vital infra-structural inputs in socio-economic development. The world faces a surge in demand for electricity that is driven by such powerful forces as population growth, extensive urbanization, industrialization, and the rise in the standard of living. This paper attempts to ascertain whether there is a systematic relationship between electricity consumption and economic growth. To this end, we use a large set of data that spans 88 countries during the period, 1975–2004. A statistically significant inverted-U-shaped relationship between per-capita consumption of electricity and per-capita income is detected. Nevertheless, by using a purchasing power parity that is much higher than the per-capita income of all the countries in the world, the level of per-capita income is estimated at the peak point of per-capita electricity consumption to be $61,379 in 2000 constant international dollars. Moreover, we segment the sample into Organization for Economic Cooperation and Development (OECD) countries and non-OECD countries, and separately analyze the developed and developing countries. The separate estimation shows that even though the peak income is higher than the average per-capita income, a statistically significant inverted-U-shaped relationship is found in OECD and developed countries but not in non-OECD and developing countries.

1. Introduction

Electricity has been the foundation of economic growth, and constitutes one of the vital infra-structural inputs in socio-economic development. The world faces a surge in demand for electricity that is driven by such powerful forces as population growth, extensive urbanization, industrialization, and the rise in the standard of living. In the past three decades, numerous studies have been conducted to examine the relationship between electricity consumption and economic growth. The overall findings show that there is a strong relationship between electricity consumption and economic growth. For example, Ferguson et al. (2000) examined the issue in over one hundred countries, and found that as a whole there is a strong correlation between electricity consumption and economic growth.

However, the existence of a strong relationship between electricity consumption and economic growth does not necessarily imply a causal relationship. The relationship may very well run from electricity consumption to economic growth, and/or from economic growth to electricity consumption. These causality issues, therefore, have been widely investigated in the literature (for the example of ASEAN countries, see Yoo, 2006). A major question concerning this issue is which variable should take precedence over the other—is electricity consumption a stimulus for economic growth or does economic growth lead to electricity consumption? A number of empirical studies indicate that overall, electricity consumption causes economic growth although the causal relationship is not consistent across countries.

In particular, greater use of information and communication technologies (ICTs) marks a worldwide transition toward a digital society that may profoundly affect electricity consumption. A digital society implies a growing reliance on networked ICTs, with more and more people using the internet and other ICTs such as cell phones, digital video recorders, digital music players, personal computers, and so on. In addition, as commonly known, electricity has: become the preferred and dominant form of energy over an expanding portion of economic life in industrial economies; been a major source of betterment of the standard of living; and played a crucial role in technological and scientific advancement (Rosenberg, 1998).

A country's infrastructure for electricity supply has an important bearing on its ability to develop and thus, to achieve economic affluence in the contemporary economic context. The popular view is that economic growth will increase electricity consumption. Thus, efforts must be made to encourage government and industry to increase investment in electricity supply and to overcome the constraints on electricity consumption for proactively coping with the increased demand for electricity that accompanies economic growth.

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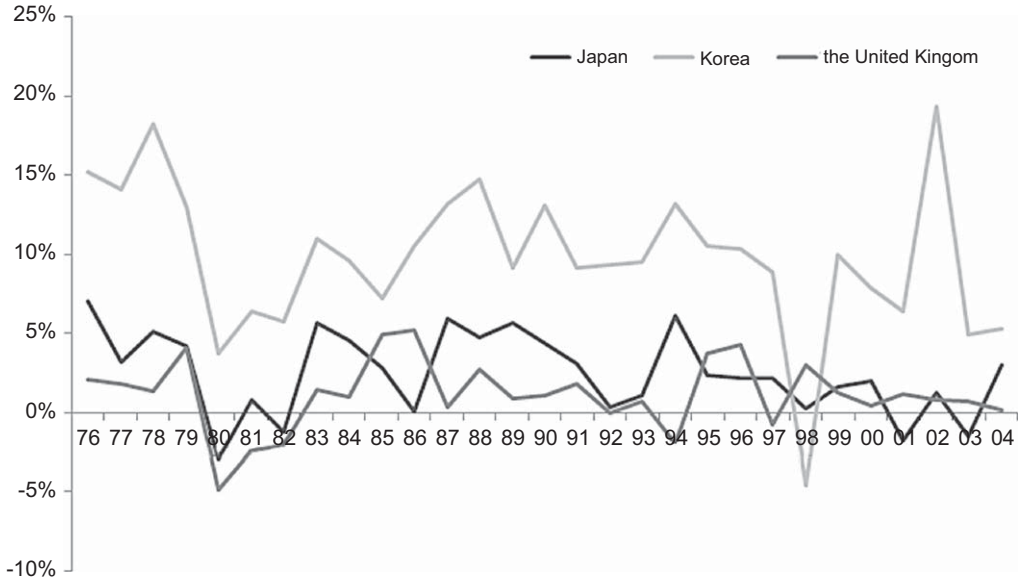

Fig. 1. The annual increasing rate of per-capita electricity consumption in Korea, Japan, and the United Kingdom.

However, in developed countries, the pace of per-capita electricity consumption increase has been slowed down with income rising. For example, as illustrated in Fig. 1, the increasing rate of per-capita electricity consumption in Korea is higher than those of Japan and the United Kingdom while the per-capita income of Korea is lower than those of Japan and the United Kingdom. Furthermore, the pace of per-capita electricity consumption increase has been slowed down in these countries. For considering this pattern of per-capita electricity consumption, this paper attempts to explore whether or not there is a systematic relationship between electricity consumption and economic growth, and in particular, an inverted-U-shaped relationship. The paper uses a cross-country analysis that is based on data from 88 countries for the period, 1975–2004.[2]

In particular, a notable empirical finding in the recent literature on environmental economics has been the existence of an inverted-U-shaped relationship between per-capita income and environmental indicators (Grossman and Krueger, 1995; Cole et al., 1997; Cole, 2004). Since this relationship bears a resemblance to the Kuznets relationship between income and income inequality, it has become known as the environmental Kuznets curve (EKC). To the best of our knowledge, EKCs have never been estimated for electricity consumption, despite the potentially severe repercussions of excessive electricity consumption and the seeming applicability to electricity consumption of mechanisms that are used to explain the shape of the EKC (scale, composition, and technique effects).

The message of the paper is all the more useful because few studies attempt to analyze a systematic relationship between electricity consumption and economic growth. On the other hand, several studies examine: the relationship between various environmental indicators, including air pollution, water use, deforestation, municipal waste, and economic growth; and the causal relationship between electricity consumption and economic growth. Therefore, the aim of this paper is to assess whether an EKC exists for electricity consumption by employing data from 88 countries. The remainder of the paper is organized as follows. Section 2 provides detailed information on the methodological issues. Section 3 explains the data employed and reports the results on estimation. Some concluding remarks are made in Section 4.

2. The methodology

The inverted-U-shaped relationship between electricity consumption and economic growth can be explained in terms of the interaction of scale, composition, and technique effects. The scale effect (S) states that as the scale of the economy increases, *ceteris paribus*, so too will electricity consumption. The composition effect (C) refers to the fact that as economies develop, there is generally a change in emphasis from heavy industry to light manufacturing and services. Since the latter are typically less electricity-intensive than the former, the composition effect of growth, *ceteris paribus*, will reduce electricity consumption. Finally, there is the technique effect (T). A greater investment in research and development, along with increasing income, leads to improved energy efficiency and thereby, lowers electricity consumption. Fig. 2 provides a hypothetical EKC and illustrates how the interaction between S, C, and T contribute towards its shape (Cole, 2004).

To assess whether or not such a relationship exists for electricity consumption, the following equation can be formulated and tested:

$$y_{it} = \alpha_i + \beta_1 \,\text{income}_{it} + \beta_2 \,\text{income}_{it}^2 + \varepsilon_{it}. \quad (1)$$

In Eq. (1), y refers to the per-capita electricity consumption, income_{it} and income_{it}^2 are the per-capita income and the square of the per-capita income, respectively, and the subscripts i and t refer to the country and year, respectively. An EKC is considered to exist if $\beta_1 > 0$ and $\beta_2 < 0$ and both coefficient are statistically significant. Furthermore, to be a meaningful EKC, the estimated peak point (Y^*) computed as $-\beta_1/2\beta_2$ should be within the income range of the sample.

[2] An anonymous reviewer pointed out that if electricity consumption and economic growth are inverted-U-shaped relationship, then per-capita electricity consumption should eventually go down to zero as countries get richer, since the quadratic function is symmetrical. However, in theory, since the quadratic function is symmetrical, per-capita electricity consumption should eventually go down to zero as countries get richer. However, to be realistic, since the peak point income is too high, it is impossible for per-capita electricity to go down to zero with increasing income.