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The effect of ICT development on economic growth and energy consumption in Japan

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ABSTRACT

A strongly held belief in Japan is that information and communication technologies (ICT) contribute to both a reduction in energy use and an increase in economic growth. As this assertion is presently unproven, the purpose of this analysis is to estimate the long-run relationship between ICT, energy consumption, and economic growth in Japan. Using an autoregressive distributed lag (ARDL) bounds testing approach, we estimate two different multivariate models corresponding to the production function and the energy demand function, both including ICT investment as an explanatory variable, over the period 1980–2010. The results reveal the presence of a long-run stable relationship, not only for the production function, but also for the energy demand function. However, in the production function, the long-run coefficient estimate for ICT investment is statistically insignificant, unlike the coefficients for labor, stock, and energy. In the case of the energy demand function, the coefficients for GDP, energy price, and ICT investment are statistically significant. The results also indicate that the long-run ICT investment elasticity of energy consumption is −0.155. On this basis, we conclude that while ICT investment could ceteris paribus contribute to a moderate reduction in energy consumption, but not to an increase in GDP.

1. Introduction

From the end of World War II until the early 1970s, the average annual growth rate of energy consumption in Japan was higher than the nation's remarkable economic growth rate. However, following the 1973 oil crisis, the Japanese economy was obliged to make some efforts to decrease its energy intensity (the ratio of energy consumption to GDP), and largely succeeded in slowing the growth rate of energy consumption without an accompanying decrease in GDP. Nonetheless, the fact remains that energy consumption has continued to grow in the long term, with Japanese energy use rising by nearly 50% from 1973 to 2010. In other words, the decrease in energy intensity has not revealed the concomitance of a reduction in energy use and economic growth.

However, there is some hope that information and communication technologies (ICT) have the potential to solve the dilemma of this "win–win" situation, that is, producing more output from less energy. For example, the Global Information Infrastructure Commission (GIIC, 2008) emphasizes the role of ICT in protecting the environment without any sacrifice in economic output. Similarly, the Japanese government also relies strongly on ICT, not only to provide the economy with

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market competitiveness through technical innovation and global entrepreneurship, but also to enable transport, buildings, and industry to reduce their energy consumption.

Currently, ICT investment represents about 25% of total investment in Japan, with software accounting for about 50% of total ICT investment and equipment the remainder. ICT has also been one of the fastest growing components of total investment, having almost doubled over the last 15 years. Nevertheless, the average annual growth rate of ICT investment in Japan is relatively low when compared with the US or many European Union countries. For this reason, the Japanese government has emphasized the importance of introducing policies and institutions to stimulate additional investment in ICT. However, on this point, there is insufficient evidence showing whether ICT investment can actually lead to a win–win lower energy use-economic growth situation, and so it is inappropriate to suggest that ICT investment is an absolute good for society. In the worst-case scenario, there is even the possibility of a deadweight loss stemming from excessively high ICT investment.

The aim of this paper is to explore the nexuses between ICT–GDP and ICT–energy using an autoregressive distributed lag (ARDL) bounds test approach. Considering the problems associated with the use of a bivariate model pointed out by Stern (1993), Stern (2000), we employ a multivariate approach in our analysis. For the ICT-growth nexus, we specify a neoclassical aggregate production function including energy consumption and ICT investment as explanatory variables. For the ICT–energy nexus, we develop a conventional energy demand function, also including ICT investment as an explanatory variable.

The remainder of the paper is organized as follows. Section 2 reviews the literature on related studies. Section 3 describes the methods and data used in this analysis. Section 4 reports the results of the respective econometric analyses. In Section 5, we discuss the empirical results and Section 6 concludes.

2. A brief literature review

2.1. ICT and economic growth

Studies on the relationship between ICT development and economic growth began in the 1960s, and have since been conducted mainly in the US. Although these results have generally found a positive correlation between ICT and economic growth (Jipp, 1963; Gilling, 1975; Hardy, 1980; Saunders et al., 1983), for the most part these studies have been based on static data. They therefore say nothing about the long-run equilibrium among the various variables included. In other words, these studies do not provide sufficient information about the actual contribution of ICT development to economic growth.

Since the seminal work by Engle and Granger (1987), cointegration analysis has become a widely used technique for investigating long-run association among the time-series variables. Studies on the ICT–growth nexus using time-series analysis first began in the 1990s. For example, Cronin et al. (1991); Cronin et al. (1993) investigated the causal relationship between ICT development and economic growth and find evidence of a bidirectional relationship in the US. Subsequently, there have been many similar studies in both developed and developing countries. While most of these have confirmed the existence of a causal relationship running from ICT to growth (Madden and Savage, 1998; Dutta, 2001; Chakraborty and Nandi, 2003; Chu et al., 2005), there are a few cases where there is no evidence of causality from ICT to GDP (Shiu and Lam, 2008).

It is natural that empirical results sometimes diverge because of the different methodologies employed, the use of different countries over dissimilar periods, and so on. One important problem is to select a variable to represent the level of ICT development, for which there are two main ways: nonmonetary and monetary. As a nonmonetary variable, teledensity (the number of fixed telephones per hundred inhabitants, if available, including mobile phone subscribers and internet broadband subscribers) is usually used to investigate the ICT–growth nexus. Alternatively, in the monetary approach, either ICT investment or ICT stock is typically used. Importantly, while data on teledensity are usually easy to obtain, one disadvantage of using such data is that they do not reflect the investment in software that has become so important in developed countries. Therefore, when investigating the effect of ICT development on economic growth in a developed country, such as Japan, it is preferable to employ monetary measures to represent ICT development. Until now, Shinjo and Zhang (2004) is the only study that has conducted time-series analysis to investigate the relationship between ICT development, as measured in monetary terms, and GDP in Japan, for which they found a unidirectional causality running from GDP to ICT investment, implying the rejection of the ICT-led growth hypothesis.

Other than the problem of measuring ICT development discussed earlier, previous studies leave much room for improvement in the methods used. First, most existing studies of the ICT–growth nexus employ bivariate analysis, that is, only two variables (ICT and GDP) are specified in the estimations. However, the bivariate approach is subject to some criticism as it effectively ignores any bias arising from omitted variables, which could be potentially substitutable for each other (Stern, 1993; Stern, 2000; Zachariadis, 2007; Gross, 2012). In the case of the ICT–growth nexus, the bivariate approach may also lead to erroneous conclusions given it ignores the substitution effects between ICT and other factors of production (e.g., capital, labor, energy).

Second, there is no precedent for studying the ICT–growth nexus using an ARDL model. Developed by Pesaran and Shin (1999), Pesaran et al. (2001), the ARDL bounds cointegration approach has been used extensively in recent years to examine the existence of long-run relationships among time series variables. One of the reasons for preferring this approach is that it is more robust and performs better with small sample sizes than many other techniques. Note especially that even a developed country such as Japan does not have a long series of data on ICT investment or stock when measured in monetary terms.