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Time series analysis in the assessment of ICT impact at the aggregate level – lessons and implications for the new economy

Sang-Yong Tom Lee[a,*], Roghieh Gholami[b], Tan Yit Tong[b]

[a]*College of Information and Communications, Hanyang University, 17 Haengdang-dong, Seongdong-gu, Seoul 133-791, Republic of Korea*
[b]*Department of Information Systems, National University of Singapore, 3 Science Dr. 2, Singapore 117543, Singapore*

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Abstract

The major role of information and communication technology (ICT) in the new economy is well documented: countries worldwide are pouring resources into their ICT infrastructure despite the widely acknowledged ''productivity paradox''. Evaluating the contribution of ICT investments has become an elusive but important goal of IS researchers and economists. But this area of research is fraught with complexity and we have used Solow's Residual together with time-series analysis tools to overcome some methodological inadequacies of previous studies. Using this approach, we conduct a study of 20 countries to determine if there was empirical evidence to support claims that ICT investments are worthwhile. The results show that ICT contributes to economic growth in many developed countries and newly industrialized economies (NIEs), but not in developing countries. We finally suggest ICT-complementary factors, in an attempt to rectify possible flaws in ICT policies as a contribution towards improvement in global productivity.

Keywords: Information and communication technology (ICT); Economic growth; Productivity paradox; Time series; Solow's Residual

1. Introduction

The Nobel laureate economist Robert Solow once cited the infamous ''productivity paradox'' of the US economy, where productivity stagnated despite increasing computing power. His quip that ''the computer age is everywhere but in the productivity statistics'' [53] might apply to other advanced economies as well. Much of the early research of the 1970s and 1980s also indicated the negative effects of computers on productivity [2,51,55,49,46,50].

A number of authors attempted to provide justifications for the post-1970s ''clash of expectations and statistics''. Their review of the paradox [6,12] produced a gamut of explanations, including mismeasurement of outputs and inputs and lags due to learning and adjustment. The most widely recognized explanation for the post-1973 productivity slowdown was flaws in methodological frameworks and measurement errors. Another explanation was that the

* Corresponding author. Tel.: +82 2 2290 1814; fax: +82 2 2290 1886.
E-mail address: tomlee@hanyang.ac.kr (S.-Y.T. Lee).

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main benefits from using computers – improved quality, timeliness, and customization [7] – were not properly measured in official productivity statistics.

In the 1990s, a number of researchers sought to find a positive contribution of information and communication technology (ICT) to economic growth. Brynjolfsson and Yang [9] cited contemporary studies that had associated ICT with productivity growth. While refuting the productivity paradox, authors of recent studies have attributed this change to improved data quality and a new econometric framework that produced more satisfying empirical results.

At the firm and industry level, several authors have noted positive evidence of returns from ICT investments [36,19,23]. Their results have been confirmed by a number of recent studies and initiated a large stream of research. However, there are limitations to the implications of the results. In particular, as the ICT productivity paradox was originally defined at the economy level, one natural concern was that most of these recent IS studies have addressed the productivity question at the micro level [10,45].

In contrast to investigations at the firm and industry levels, studies at the aggregate level have *not* been conclusive. They have also suffered from limitations in their analysis. For instance, in their country-level research in the Asia Pacific area, Kraemer and Dedrick [30] found that a positive correlation existed between ICT and economic growth. However, they acknowledged that they could not provide conclusive evidence of a causal relationship, given the relatively small portion of the economy allocated to ICT in the overall capital and the broad array of factors affecting economic growth.

Similarly, Jorgenson and Stiroh [27] discovered that computer capital contributed to growth more than ordinary capital, suggesting a positive payoff from ICT. However, the extrapolation of total factor productivity (TFP) growth for long-term projections is questionable. Even the researchers themselves admitted: ''Only as the statistical agencies continue their slow progress towards improved data and implementation of state-of-the-art methodology will this murky picture become more transparent.''

Pohjola [48] indicated that disappointment in ICT is still chronicled in many macroeconomic studies, because the impact on productivity and economic growth has been much harder to detect. Therefore, better measurement methods and definitions are required for more precise appraisal, especially in the Internet and e-commerce era.

In response, we proposed the use of Solow's Residual together with time-series analysis tools to overcome the methodology inadequacies of previous studies. Our goal was to establish empirical evidences to assess previous productivity strategies. Our hope was that our findings would help guide future ICT investment decisions in both developing and developed countries.

The use of Solow's Residual offers the ability of better measuring the productivity attributable to technology. The majority of earlier research used tangible outputs, such as gross domestic product (GDP), national wealth, and revenue; these output measures might not capture the full contribution of ICT to an economy's productivity, because the impact of ICT usage is generally considered to be wide-ranging but intangible. Solow's Residual, which provides more information about changes in technology than other productivity measures, should therefore better appraise the effectiveness of the use of ICT.

For each of the countries sampled here, we first investigated the causal relationship between ICT and GDP by looking directly at the production function. Then we derived Solow's Residual for the country in order to analyze the impact of ICT on its economic growth. In both analyses, we incorporated time series statistical tools because all the variables – GDP, capital, labor and ICT – were generally generated for a particular instance in time. Econometricians, in their investigations, have often imposed theories on data even when its temporal structure does not conform to their theories; this inadequacy is common in studies on the relationship between ICT and productivity. In our study, we implemented time series analysis tools to eliminate this spurious regression problem.

Because time series tools allow the researcher to test data stationarity before making any further analyses, corrective measures can be incorporated in the statistical tests; the researcher would thus be spared the potential problems of ordinary regression. Thus, more consistent empirical findings can be expected from our methodology.

Traditional regression methods are susceptible to the limitation of reliable forecasting; similarly, the predicted values of the variable would also have to be