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The Impact of Informatization Level on Productivity

Sehyung Cho

Yong-Kyun Chung

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Se-Hyung Cho, Department of Business Administration, Konyang University, South Korea.
Tel: (8241) 730-5180; Fax: (8241)733-2070; E-mail: shcho@kytis.konyang.ac.kr
Yong-Kyun Chung Center for International Area Studies, Hankuk University of Foreign Studies, Korea.
Tel: Tel: (8231) 330-4809; Fax: (8231) 330-4810; E-mail: ykchung@hufs.ac.kr

ABSTRACT

In recent times, most of governments make tremendous efforts to build up the information technology (IT) industry. This study investigates whether the huge amount of injection of money to IT industry is really effective to upgrade the national competitiveness through the examination of the relationship between the productivity and informatization. In particular, we test the hypothesis that the informatization level has a positive effect on the productivity at the national level utilizing the aggregate data on index of informatization and productivity. The proxies for productivity are total factor productivity (TFP) and labor productivity. Our main findings are twofold. First is that the informatization level has a positive relationship with total factor productivity in broad sense. Second, the positive relationship between total labor productivity and informatization gets stronger in the countries with relatively higher informatization level, such as USA or Finland.

INTRODUCTION

Over the past twenty to thirty years Information Technology (IT) has spread rapidly throughout modern industrial economies. Despite of enormous investments in IT and significant enhancements in the underlying technology there is controversy as to whether these investments have made businesses and economies, in aggregate, more productive (Brynjolfsson and Hitt 1993 & 1996; Strassmann 1990; Berndt and Morrison 1992; Triplett 1998; Krueger 1993). Although the information systems literature is replete with anecdotal evidence documenting spectacular successes obtained through IT investments (e.g., American Airlines or Federal Express), there is a critical shortage of research documenting statistical evidence linking IT investments to increased firm performance. There are, however, a significant number of empirical studies that show little or no evidence relating IT to macroeconomic productivity, moreover showing the so-called "productivity paradox" phenomenon.

IT can produce different impacts at different levels of aggregation in the environment: for the individual, group, organization, industry, and economy or society. Obviously, there are different types of impacts which also vary depending on the process or phenomena (Chismar & Kriebel 1985). In this paper we execute empirical study of IT's impact on macroeconomic productivity. We investigate six countries in OECD to analyze the relationship between the national informatization level and the macroeconomic productivity. Total Factor Productivity (TFP) and real output per worker hour are used to measure the macroeconomic productivity. Based on ITU(International Telecommunication Union) data, national informatization index is measured to compare informatization level among the six countries. The main objective of the present study is descriptive. We set out to explore the relations between IT and productivity, and whether these relations are statistically significant according to our expectations. We also examine whether the IT productivity paradox exists and, if then, how we can explain the phenomenon.

PAST RESEARCH ON THE IMPACT OF IT

Impact of IT on firm performance

Review of the literature on IT and business performance reveals that three different models of the IT-performance linkage have been proposed and tested: the direct effects model; the conversion effectiveness model; and the intermediate effects model (Bharadwa, Bharadwa & Konsynski 1995).

The direct effects model (Figure 1) hypothesizes a direct link between IT and some measure of business performance. This model implicitly assumes that investigating in IT will suffice to produce superior results along some dimensions of organizational performance (Lucas 1993). Taken as a whole, studies employing this model reveals only weak or negative effects of IT's impact on firm level performance (Wilson 1993).

The conversion effectiveness model (Figure 2) is a revised version of the direct effects model. Weill(1992) argued that investments in IT do not per se translate into superior performance, unless the investing firms can efficiently use their IT resources. A firm's conversion effectiveness mediates its ability to translate IT investments into productive output. However, the assumption that there is a direct and measurable link between the use of IT and firm performance still persists.

The intermediate effects model (Figure 3) posits that IT will impact organizational performance indirectly through intermediate outcome variables. In their study employing this model, Barua, Kriebel, and Mukhopadhyay (1995) concluded that IT favorably impacts certain intermediate outcome variables (e.g., capacity utilization, inventory turnover), which in turn are found to be significant drivers of market share and ROA.

An alternate conceptualization of IT, that of the moderator (contingency) model of IT's effects on business performance, was proposed by Bharadwa and et al. (1995). In

contrast to the mediational role of IT, they argued that the benefit which a business derives from its IT capabilities is contingent on the joint effects of IT with industry structure variables, competitive strategies, and firm-specific intangibles.

Impact on macroeconomic productivity

Measures of IT productivity at the macro level of the economy do not yield a fair comparison because there are many other factors that have influenced the productivity of the entire national economy (Due 1994). Although the total investment in capital stock of the economy represented by IT have been increasing rapidly, productivity gains resulting from this investment have not become apparent and some researches have shown even decrease in productivity.

This embarrassing and controversial phenomenon is the so-called productivity paradox. Brynjolfsson(1992) pointed out that four explanations for the phenomenon can be given:

- Measurement error. The input and output of information-consuming industries are not being properly measured by conventional approaches.
- Lags. Time lags in the payoffs from IT make analysis of current costs versus current benefits misleading.
- Redistribution. IT may be used to benefit parts of the enterprise in way that may not benefit the enterprise as a whole.
- Mismanagement. The lack of explicit measures of the value of information makes it vulnerable to misallocation and over-consumption.

However, recent studies using the United States data on and after 1990 have shown the positive relationship between IT investment and productivity. While many empirical researches have been done on the productivity paradox problem in the United States, there has been little comparable research among other countries (Wong, 1994). Therefore, it is needed to study whether this phenomenon is different among several countries and , if then, how we can explain it.

Informatization level and productivity

For the comparable research among several countries, objective measure is required to indicate IT investment level of one country as an independent variable. We use national informatization index, as a sort of surrogate variable, to show IT investment (or informatization) level. It can be conveniently used to identify various phenomena of IT utilization quantitatively. National informatization index is composed of seven items (table 2-1) that are extracted from four areas for the easy and objective comparison. This index is based on ITU (International Telecommunication Union) data.

In this paper, Total Factor Productivity (TFP) and real output per worker hour are used to measure the macroeconomic productivity. TFP concept was appeared to measure the actual contribution of technology advancement to economic growth. Growth accounting methodology (Solow 1957) has been used to analyze TFP in a number of researches. This paper also uses real output per work hour in manufacturing industry to compare productivity of labor among six countries.

HYPOTHESES AND METHODOLOGY

Hypothesis

This paper is to investigate the relationship between informatization level and productivity using the sample from OECD countries. The first hypothesis is that informatization level has the positive relationship with total labor productivity for each country. In recent times, the spread of Information Technology influences the performance of business activity through the channel of technological innovation. The technological innovation can be represented by the total factor productivity(TFP). Second hypothesis is that informatization level has the positive relationship with labor productivity for each country. The labor productivity is defined as the ratio of GDP to working hours. As the informatization level deepens, the infrastructure of information technology in each society arrives at the mature stage. The high level of capital output ratio strengthen the labor productivity. Third hypothesis is that the positive effect of informatization level to total factor productivity and labor productivity is stronger in the society with higher level of information technology than the case of the society with lower level of information technology. The third hypothesis is to explain the productivity paradox in terms of lag effect of informatization level to productivity.

Empirical model

For the test of three hypothesis, this study utilizes the regression techniques as well as correlation methods. In case of regression models, we test the hypothesis using four empirical models. The equation (1) is to test the first and second hypothesis that informatization level has the positive relationship with total factor productivity or labor productivity

$$PROD(t) = \alpha INT + \beta INFO(t) \qquad (1)$$

Where PROD(t) is the proxy variable to represent the current state of productivity. In this paper, we employ total factor productivity and labor productivity. INT is the intercept of regression equation. INFO(t) represent the current state of informatization level for each country. The α and β are regression coefficients.. The equation (2) is to test the third hypothesis that it t akes a time for the informatization level to influence the productivity. In other words, there is a lag effect.

$$PROD(t) = \alpha INT + \beta INFO(t) + \chi INFO(t-1) \qquad (2)$$

Where PROD(t) is the proxy variable to represent the current state of productivity. The INT is the intercept of regression equation and INFO(t) represent the current state of informatization level for each country. The novelty of equation (2) is that the equation (2) includes the term INFO(t-1), last year's informatizatio level, to examine the

significance of lag effect of informatization to productivity. The α, β and χ are regression coefficients. This study employs the equation (3) and equation (4) to obtain more detailed dynamic pattern of the information and technological investment to productivity.

$$PROD(t) = \alpha INT + \beta INFO(t) + \chi INFO(t-1) + \delta INFO(t-2) \quad (3)$$

$$PROD(t) = \alpha INT + \beta INFO(t) + \chi INFO(t-1) + \delta INFO(t-2) + \varepsilon INFO(t-3) \quad (4)$$

In equation (3) and equation (4), the term INFO(t-2) and INFO(t-3) represent the informatization levels two years ago and three years ago.

Data

This paper employs the national informatization index to represent the informatization level for OECD countries such as Unites States, United Kingdom, France, Norway, Australia and South Korea. The national informatization index is calculated from the computer, communication, broadcasting and internet sectors. This paper employs the data of national informatization index obtained from the White Paper of National Informatization published from South Korea. This paper employs total factor productivity(TFP) and labor productivity as a proxy for the productivity.

EMPIRICAL RESULTS

The Relationship Between Informatization and Total Factor Productivity

The paper classifies six OECD countries into three categories: High informatization group, Middle informatization group and Low informatization group. The high informatization group includes United States and Norway. The middle informatization group includes Australia and United Kingdom, and the low informatization group, South Korea and France. The correlation analysis shows that the correlation relationship is stronger in case of high informatization group than those in case of middle and low informatization group.

Production Paradox and Lag Effect

The Regression results shows that the current value of informatization level, INFO(t) does not influence the current value of total factor productivity, PROD(t) in four specifications of the regression equation. It seems to signify that there is a phenomenon of production paradox. In case of lag effect, the coefficient of the lagged value of total factor productivity, PROD(t-2) is positive sign and t-value of that coefficient is relatively large although it is not significant. It might suggest that it takes a time to have a significant effect of investment in Information Communication Technology.

REFERENCES

[1] Brynjolfsson, E., 1993, "The Productivity Paradox of Information Technology: Review and Assessment," Communications of the ACM, Vol.35, no.12, pp.67-77.

[2] Brynjolfsson, E., Gurbaxani, V., McKeen, J.D. and Roach, S. S., 1994, "Information Technology Productivity Paradox: The Problem Facing IT Managers and Researchers," Proceedings of ICIS, pp.478-480.

[3] Chismar, W.G. and Kriebel, C. H., 1985, "A Method for Assessing the Economic Impact of Information Systems Technology on Organizations," Proceedings of ICIS, pp.45-56.

[4] Due, R. T., 1994, "The Productivity Paradox Revisited," Information Systems Management, pp.74-76.

[5] Greenan, N., Mairesse, J. and Topiol-Bensaid, A., 2001, "Information Technology and Research and Development Impacts on Productivity and Skills: Looking for Correlations on French Firm Level Data," Working Paper 8075, National Bureau of Economic Research.

[6] Hitt, L. M. and Brynjolfsson, E., 1996, "Productivity Business Profitability, and Consumer Surplus: Three Different Measures of Information Technology Value," MIS Quarterly, pp.121-142.

[7] Kauffman, R. J. and Weil, P., 1989, "An Evaluative Framework for Research on the Performance Effect of Information Technology Investment," Proceedings of ICIS, pp.377-388.

[8] King, W., 1994, "Forecasting Productivity," Information Systems Management, pp.68-70.

[9] Madden, G. and Savage, S. J., 2000, "R&D Spillovers, Information Technology and Telecommunications, and Productivity in Asia and the OECD," Information Economic and Policy, Vol.12, pp.367-392.

[10] Shin, N., 1997, "The Impact of Information Technology on Coordination Costs: Implications for Firm Productivity," Proceedings of ICIS, pp.133-146.

[11] Wong, P., 1994, "Productivity Impact of IT Investment in Singapore," Proceedings of ICIS, p.462.

[12] Yang, S., 2000, "Productivity Measurement in the Information Economy: A Revised Estimate of Total Factor Productivity of the US Economy," MIS/OA International Conference, pp.132-138.

FIGURES AND TABLES

Figures and tables are available upon request.