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The Difference between Real Output Growth and TFPG in Korea for the Role of R&D Stocks and Information and Telecommunication (IT): 1985-1998

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〈CONTENTS〉

요 약

본 논문은 연구개발 및 정보통신스톡의 투입이 국내 산업의 생산성을 단순히 양적인 측면에서 증가를 유도하였는지 아니면 총요소생산성의의 증가를 통한 질적인 향상을 유도하였는지의 차이를 성장회계분석과 시계열분석을 통하여 차이를 규명하고 있다. 양적인 측면에서 투입요소들에 대한 영향정도는 유효하게 나타나고 있는 반면, 질적인 측면에서의 투입요소들의 유효성은 모호한 결과를 보이고 있다.

Key Words: R&D stocks, information and telecommunication stocks, growth accounting, time series, impulse response

핵심어: 연구개발, 정보통신스톡, 실질산출량, 총요소생산성증가율, 시계열분석

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I. Introduction

As the importance of IT technology[1] is steadily on the increase, a wide range of decision makers of company, industry and nation level must be driven to the bold investment decision marking, so that investment on IT is rapidly growing compared to most of traditional industries. This sort of trend emerging in a recent is not only limited to our country regardless of developed country and developing country and it is carried out to anyplace, in which is concerned about acquiring the competitiveness in the near future.

What investment on IT technology is economically influenced is too much focused, however, it is a difficult situation to expect if it has the spreading effect throughout a wide range of economy and see if IT technology capital and R&D stocks are simply extended to different kind of industry sectors in quantity without being variable analysis. The relevance between IT technology capital and productivity has been already reviewed in many developed countries, going on many researches in a recent.

This paper is based on the common themes of the literature that R&D and IT technology have been regarded as an important factors in the improvement of productivity levels or growth rate since the 1960s and 1980s, respectively. In detail, as for R&D relations, increase in R&D effort of industry leads to improvement of knowledge stocks, which end up higher productivity. On the other hand, as for IT technology, increase in the diffusion of IT technology leads to improvement of production infrastructure, which we believe increases economic activities. At this time, this motivation allows us to ask the following question: are those motivations suitable to explain in Korea's industrial sector?

At the country level, Singh and Trieu (1996) perform a growth accounting exercise for Japan, Korea and Taiwan, and suggest that TFPG (Total Factor Productivity Growth) has been higher in Korea and Taiwan that one might have expected for countries at their levels of development. Dewan and Kraemer (2000) Estimate an inter-country production function on a panel of 36 countries over the period of 15 years and find that a significant difference in returns to IT investment between developed and developing countries.

By looking throughout the related works, we realize that not many works have been done for the role of

1) We will be able to define IT technology as the ability that can generate productivity and value added; manage complaints, information, and transmission, revelation, related manufacture, aerial and trolley and service. This involves the traditional electronic communication, data communication and allied industry, computer and computer related industry, broadcasting and contents industry, electronic processing related business - to detect, measure and control physical phenomenon. Whether the contents business is involved or not, IT industry which OECD defines is different from information & telecommunication industry, which the ministry of information and communication defines. So far, the ministry of information and communication havent yet involved the contents industry into information & communication industry

R&D and IT technology in explaining productivity or growth rate of real output in the level of countries in terms of relative effectiveness among them. Based on the shortcomings of previous literature, the purpose of this paper is to analyze the role of R&D and IT technology on TFPG and real output growth rate in Korea by growth accounting and VAR methodology to answer for the "are the IT technology and R&D stocks in the Korea influencing TFPG or physical real output growth rate?"

This paper is organized as follows. In chapter 2, we analyze the spreading effects cased by IT technology capital and R&D stocks on the growth of domestic industrial sectors through growth accounting methods, Granger causality test, and impulse response function. Finally, chapter 3 shows implications and conclusions of the empirical analysis.

Ⅱ. The Empirical Analysis

2.1 Statistical data

<Table 1>

2.2 By the Growth Accounting Methodology

In this subsection, we show the general production function to analyze the difference between the real output growth and the total factor productivity growth. In common with most analyses of the contribution of R&D and IT technology to productivity growth or real output growth rate, we assume the following Cobb-Douglas form of production function:

$$Y = A\ e^{\lambda t}\ L^{\alpha 1}\ K^{\alpha 2}\ R\&D^{\beta}\ IT^{\gamma} \quad (1)$$

〈Table 1〉 Contents and source of statistic data.

Variables	Statistic data	Source
Y	An amount of value added output (Total Industry) (1990 standard of 1 billion won) (1985-1998)	Annual economic statistic from Korea bank
IT	Estimated result by domestic industry and asset capital stock (1985-1998)	Pyu (1998) and ETRI[2] (2001)
R&D	R&D stocks by domestic industry (in 1900, standard of thousand won (1985-1998)	'Science technology research activity survey report' by the ministry of science and technology. ETRI (2001)

Note: The classified number in Korea's Inter Industry Table are as follows: 1985 (1~399), 1990 (1~402), 1995 (1~399).

2) ETRI(2001) extends of Pyu (1998) in terms of the periods of IT technology capital stocks from 1997 to 1998.

Where α_1, α_2, β, γ are cost share of labor, capital, R&D, and IT in output. γ is constant growth rate of output.

From equation (1), we can estimate the role of R&D stocks and IT technology by two ways: one is for regression to explain real output growth rate. The other one is for regression to explain TFPG. The first estimation equation for the role of R&D stocks and IT technology to explain real output growth rate is given by:

$$d\ln Y/dt = \lambda + \alpha_1 d\ln L/dt + \alpha_2\, d\ln K/dt + \beta\, d\ln R\&D/dt + \gamma\, d\ln IT/dt \qquad (2)$$

The result of estimation for the equation (2) is following

Where $\alpha_1 L$ refers to the coefficient of labor, $\alpha_2 K$ indicates the coefficient of capital, $_\beta R$ for the coefficient of R&D, $_\gamma IT$ for the coefficient of IT technology. The results of Table 2 indicate that the role of growth of R&D stocks and IT technology in quantitative perspective are relatively important to explain the growth rate of real output in Korea during 1985-1998.

Likewise, the second estimation equation for the role of R&D stocks and IT technology to explain total factor productivity growth is given by:

$$d\ln TFP/dt = d\ln Y/dt - [\alpha_1 d\ln L/dt + \alpha_2\, d\ln K/dt] = \gamma + \beta\, d\ln R\&D/dt + \gamma\, d\ln IT/dt \qquad (3)$$

Where λ indicates the time effects, β_R for the coefficient of R&D, and γ_{IT} for the coefficient of IT technology. The results of Table 3 indicate that the role of growth of R&D stocks in qualitative perspective is more important to explain the growth rate of real output in Korea during 1985-1998 than the role of growth of IT technology.

2.3 By the VAR (vector auto -regression) Methodology

Methodology that is used for analyzing the effectiveness of IT technology capital and R&D stocks in domestic industry development is VAR (vector auto-regression) model. A motive of using this model is easily able to grasp the relative importance of IT technology capital and R&D stocks respectively, in

〈Table 2〉 Results of Regression to Explain Real Output Growth Rate: Dependent variable ($\Delta\ln Y$) 1985-1998

Industrial Classification	Constant	$\alpha 1L$	$\alpha 2K$	βR	γIT	R2	DW
Total Industry	-0.02	1.22* (7.34)	0.04 (0.29)	0.17* (4.88)	0.09* (2.06)	0.97	2.25

Note: ( ) t-statistics

explaining the industrial growth via impulse response function and variances decomposition, and performs the intended analysis minimizing a priori restriction as much as it can. We begin with the VAR representation of the structural form:

$$A(B)X_t = \xi_t \tag{4}$$

Where X is a (3×1) vector of the endogenous variables, the real output growth rate, IT technology capital growth rate, and R&D stock growth rate: $X = [\Delta \ln Y, \Delta \ln IT, \Delta \ln R\&D]^T$; ξ_t is a (3×1) vector of independent structural shocks: $\xi = [\xi^Y \ \xi^{IT} \ \xi^{R\&D}]^T$; B is the lag operator and A(B) is a nonsingular lag matrix polynomial.

Define dependant variables as below: Y = value added quantity in industrial sector, IT = industrial IT technology capital stock, R&D = industrial R&D stock.

In the structural form (4), the three structural shocks considered are an output shock (ξ^Y), a IT technology shock (ξ^{IT}), and a R&D stock shock ($\xi^{R\&D}$). Assume that A(1) is lower triangular and that ξ is orthogonal. Following Blanchard and Quah (1989), we can estimate the reduced form and retrieve the moving average representation of the structural form:

$$X_t = C(B)\xi_t \tag{5}$$

Where $C(B) = A^{-1}(B)$. The estimated C(1), which is also lower triangular, contains the estimated long-run multipliers of the structural shocks on the endogenous variables. Thus, the identifying restrictions on A(1) involve conditions on the long-run comparative static multipliers.

2.4 Preliminary Data Analysis by Unit Root Test.

For time series analysis, the stability of time series data must be guaranteed, and unit root test[3] can confirm this. There are some sorts of unit root tests to time series analysis; in general, DF test presented by Dickey-Fuller (1979), informs that ADF test extends to DF test, and PP test revealed by Phillips-Person(1988). PP test, which is introduced by Phillips-Perron (1988), modifies and supplements DF test by introducing a case of hetero-phenomenon, even autocorrelation of error terms as well - that is a comprehensive situation which is not adequate to the assumption error terms should come to i.i.d$(0,\Sigma)$. Accordingly, PP test have an advantage that is able to test a wide rage of variables compared to DF test or ADF test.

The following two models are used for ADF test. First of all, general AR model (1) is

$$\Delta Y_t = \mu + \rho Y_{t-1} + \varepsilon_t \tag{6}$$

3) In case that regression analysis is preformed among the unstable time series, which involves a unit root, it is possible that spurious regression (being not clear for statistical significance) is likely to be generated

〈Table 4〉 Unit root test result of domestic industry sectors

Variable/Classification	Domestic industry classification
Value added output (Y)	-1.59 (level data) -5.04*** (1st difference data)
IT Technology Capital (IT)	-2.79*(level data) -3.65**(1st difference data)
R&D stock (R&D)	-3.97**(level data) -5.32***(1st difference data)

Note: 1) apply lag number to '1' for model (2)

2)***(**, *) Stands for a significant level, 1%(5%, 10%)

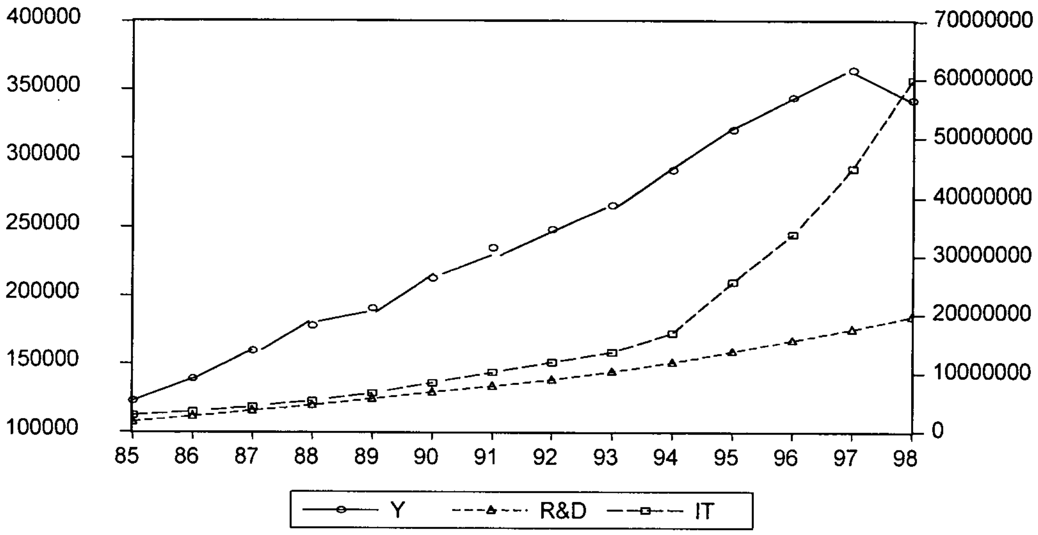
3) Critical point at the level of significant 1%, 5%, 10%, is each -4.32, -3.219, -2.75 in model (2)

In equation(1), AR (1) has a stable time series in terms of 1<ρ<1, but result in a unstable time series if any p=1.

Therefore, we can generally verify from Table 4 that a unit root exists in each industrial variable, so that by taking into account the fact which statistic data for this research is extremely limited we use 1st difference of each industrial variable for this research.

Figure 3 shows that R&D has continuously been increased without fluctuation, and IT technology capital has been slowly increased and rapidly increased after 1994. The level of real output has been increased until 1997 and decreased due to IMF crisis in Korea.

〈Figure 3〉 some information about TO, R&D, and IT at the level data



2.5 Analysis of Granger Causality Test

The Granger approach to the question whether X causes Y is to see how much of the current Y can be explained by past values of Y and then to see whether adding lagged values of X can improve the explanation. Y is said to be Granger-caused by X if X helps in the prediction of Y, or equivalently if the coefficients on the lagged Xs are statistically significant. Note that two-way causation is frequently the case; X Granger causes Y and Y Granger causes X. It is important to note that the statement "X Granger causes Y" does not imply that Y is the effect or the result of X. Granger causality test measures precedence and information content but does not by itself indicate causality in the more common use of term.

We, namely, can think of two-equation system that expresses it clearly such as the following or vector auto-regression by column vector of (X.Y) After presuming above formulas and thinking two null hypotheses, which is H_o^1:a_i=0 and H_o^2:d_j = 0, we judge existence of causality by practicing F test[4] about each null hypothesis. If rejecting H_o^1: a_i=0 and H_o^2:d_j=0, causality exists, and if selecting those. In terms of rejecting H_o^1: a_i=0 and not rejecting H_o^2:d_j=0, Grander cause from X to Y exist. On the opposite side, it is estimated that Granger cause from Y to X exist.

As shown in table 5, the increase of R&D stock has Granger cause on the growth of real output growth, but no vice versa cause and effect exist. The rising of stock of IT technology cause on the growth of real output, but no vice versa cause and effect exist. Also, it is shown that there is no cause and effect relationship between R&D and IT technology in Korea.

2.6 Impulse－Response Function

The impulse response function analysis allows us to see how three endogenous variables respond, over a fourteen-year horizon, to each shock of one standard deviation, and to keep track of current and future reactions by monitoring the standard deviation shock of an endogenous variable. Impulse response function analysis operates, however, on the hypothesis that co-relations among variables do not exist in terms of pure noise, and that we are able to accurately gauge an

〈Table 5〉 Cause and Effect relation in domestic industry

Industrial mark	R&D⇒Y	Y⇒R&D	IT⇒Y	Y⇒IT	R&⇒IT	IT⇒R&D
Total industry	7.48* (0.01)	0.24 (0.63)	5.39* (0.03)	0.80 (0.48)	1.83 (0.22)	0.63 (0.55)

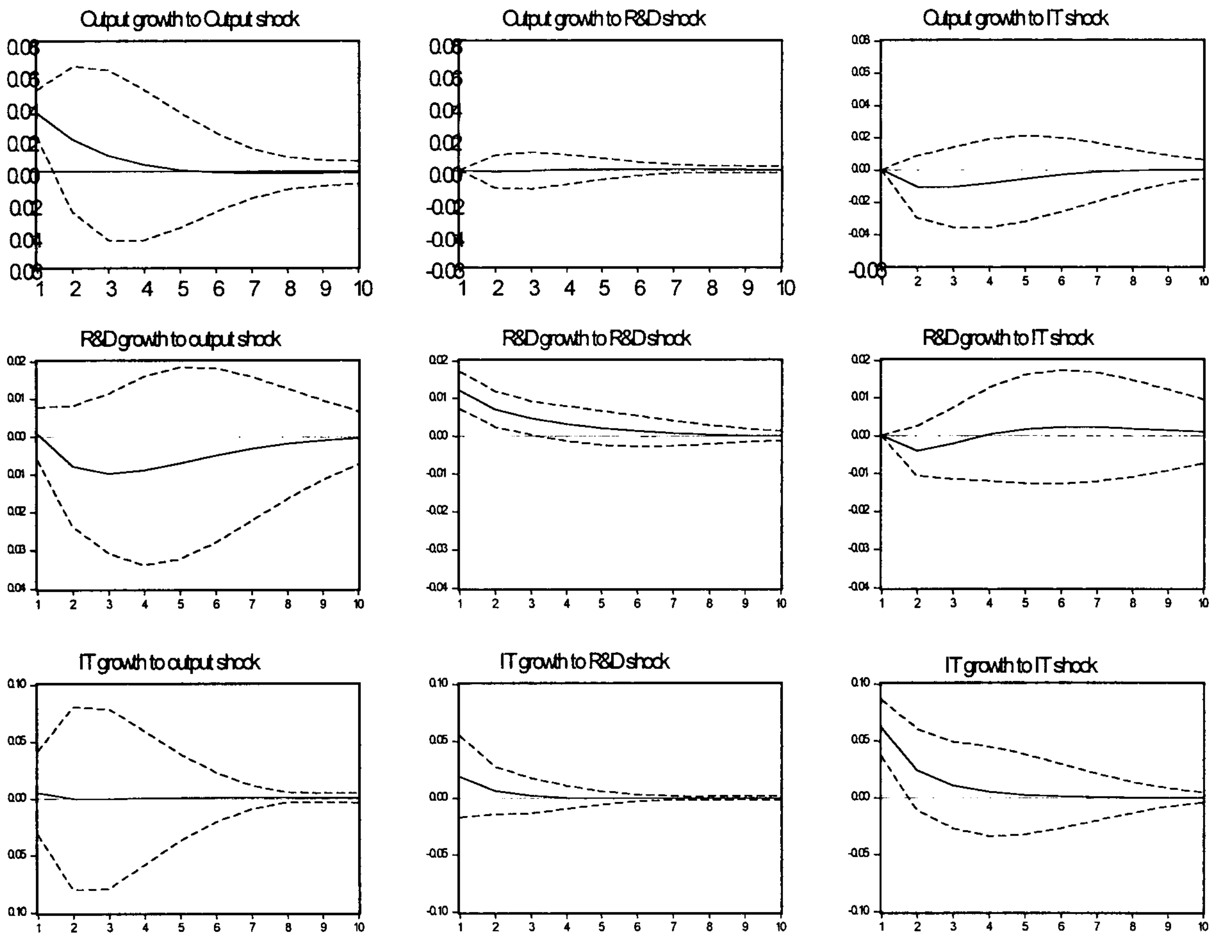
Note: ( ) value of p to F Test.

4) F Test is little different from the existing method like this. That is F=[(SSRR-SSRU)/q]/ [(SSRU)/(n-k)]. n,k,q is relatively total data number, the number of estimated parameter, and the number of constraints

impulse, but, due to the low level of statistical research in this regard, results may prove to be ambiguous. This figure 4 plots the response of output growth, R&D growth, and IT technology growth to the output, R&D, and IT technology shocks. The solid lines give the point estimates while the dotted lines show the one standard error bands (standard errors were generated by computer simulation based on 1000 replication.

As shown in the first row of figure 4, output growth responds to output shocks in the first year, then levels out after approximately five years. However, in response to R&D shocks and IT technology shocks, output growth does respond little. Likewise, R&D growth responds to output shocks negatively in the short-run, then levels up after three years. For the R&D growth to R&D shocks, first increase in the short-run, then levels out after six years. As for the R&D growth to IT shock, it responds little. Lastly, IT growth responds to R&D shocks, increases in the short-run, then levels out after three years. As for the IT growth to IT shocks, it increases in the short-run, then levels out after four years.

〈Figure 4〉 An Analysis of Impulse response function in Korea's industry



Ⅲ. Conclusions

We could gain the following suggestion in analysis for understanding potential effects of IT technology and R&D stock. The theoretical analysis shows that the optimal amount of IT technology and R&D stocks are dependent upon the production factor of R&D stocks and IT technology, respectively. That is, in this information-based economy, the output in the industrial sector of IT technology can affect significantly to the optimal amount of R&D stocks, vice versa.

In terms of the empirical approaches, growth accounting methods show that even the amount of output has been increased except after 1997, the amount of R&D and IT stocks has been varying from between industries - some fluctuations exist, no statistical significance appears in the relationship among Y, R&D, IT within industries. R&D has more effective than IT in overall contribution or productivity. It is also shown that the role of growth of R&D stocks and IT technology in quantitative perspective are relatively important to explain the growth rate of real output in Korea during 1985-1998.

By directional analysis in VAR methodology, the role of R&D and IT technology are restricted to increasing the growth of outputs, implying other non-economic factors might affect the growth of output in most of industrial sectors. Or exist some ambiguous effects of R&D and IT in Korea's Industrial sector.

In Granger Causality test for analyzing cause and effect relation among three variables like Table 4, it shows that in all portion of domestic industry, R&D stock and IT technology drives the increase of real output growth. With connection to cause and effect relation itself, we must consider that acquiring a decisive result would be limited to a temporary interpretation via more strict time series.

The results of Impulse response function show that IT technology and R&D shocks affect the growth rate of real output in Korea's Industry, even though the impact on each variable tends to be short run effect.

However, I am very cautious of the economic implications from the test results by the following reasons: (1) the time period of test variables is too short in the analysis of the impulse response function to show the relative effectiveness of shocks or fluctuations among variables, (2) the selection of stock data (IT technology and R&D stocks) may lead some ambiguous effects in explaining the pure role of flow data of IT and R&D investment .

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