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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Abstract

This paper examines the effects of IT technology capital and R&D stock's variation on the growth of Korea's industries with the empirical approaches. We analyze the Granger causality and Impulse response function analysis among the Korea's industrial real output, IT technology capital, and R&D stocks. When it comes to this research conclusion, we know that IT technology capital and R&D stock's shocks affect the growth of Korea's industrial sector in terms of increasing in the real output growth rate.

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I. Introduction

As the importance of IT technology is staidly on the increase, a wide range of decision markers 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 [1]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[2] has been already reviewed in many developed countries, going on many researches in a recent.

The motivation of this paper based on the common beliefs among people 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 firm level, Wilder and Stansell (1974) develop a model of the determinants of R&D outlays of privately owned electric utilities and tests the model empirically with data for the years 1968 through 1970. The findings are that R&D outlays have an elasticity greater than one with respect to firm size, and are positively associated but relatively inelastic with respect to profitability. Klette (1996) presents an alternative specification of knowledge production and derive a structural econometric model with some desirable properties providing a simple and less data-intensive framework for empirical studies of the relationship between firm performance and R&D. The main empirical findings are as follows: (i) R&D has a positive effect on performance, (ii) the appropriable part of

[1] IT industry has been playing an important role in Korea's economic development as it is rapidly growing in the middle of 1990.

[2] Investment on IT technology capital goods generates network externality or spreading effects by performing production, application and distribution of knowledge

knowledge capital depreciates at a rate of .2, (iii) there are significant spillover effects of R&D across lines of business within a firm, and (iv) there are significant spillovers in R&D across firms that belong to the same interlocking group of firms. In domestic literature, Sin and Song(1999), Lee(1999) emphasis on the concept of reshaping or conversion efficiency, and analyze the growth of value -added and IT technology investment. They found that IT technology investment itself doesn't guarantee the improvement of growth of value-added.

At the industry level, Brynjolfeeson and Hitt(1998) stress that a positive effect is not certainly happened at the level of industry because industry that co-exist positive and negative effects in the tantalization process is supposed to be generating inter-offset effects. Goto and Suzuki (1989) state that the rate of return on R&D investment in Japan manufacturing industries tends to be around 40%. However, for the US manufacturing sector, Link (1983) asserts that the R&D coefficient in the 1970s failed to achieve statistical significance. On the contrary to the result of Link, many studies (for example, Terleckyi (1974)) showed that by adapting an R&D intensity model, the rate of return on R&D lies between 20-50% in US manufacturing industries.

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 R&D and IT technology in explaining productivity or growth rate of real output in industries in terms of relative effectiveness among them. Based on the shortcomings of previous literature, the purpose of this paper is two fold: one is to anlyze theoretical relationship between production inputs, for instance, R&D and IT technology, and economic growth. Second 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 3, we analyze the spreading effects cased by IT technology capital and R&D stocks on the growth of domestic industrial sectors through Granger causality test, impulse response function, and Johansen co-integration test. Finally, chapter 4 shows implications and conclusions of he empirical analysis.

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 haven't yet involved the contents industry into information & communication industry.

II. The Empirical Analysis

2.1 Statistical data

< Table 1> Contents and Source of statistic data.

Variables	[illegible]	[illegible]
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 (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).

2.2 By the Growth Accounting Methodology

In common with most analyses of the contribution of R&D and IT technology to produticity growth or real output growth rate, we assume the following Cobb-Douglas form of production function:

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

Where $\alpha 1$, $\alpha 2$, β, γ are cost share of labor, capital, R&D, and IT in output. λ 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

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

Industrial Classification	Constant	$\alpha_1 L$	$\alpha_2 K$	βR	γIT	R^2	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.

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, γIT 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:

$$d\ln TFP/dt = d \ln Y/dt - [\alpha 1 d \ln L/dt + \alpha 2\, d\ln K/dt] = \lambda + \beta\, d\ln R\&D/dt + \gamma\, d\ln IT/dt \qquad (3)$$

Table 3:Results of Regression to Explain TFPG: Dependent variable TFPG (1985-1998)

Industrial Code	Constant	λ	β_R	γ_{IT}	R^2	DW
Total Industry	-2.90	-0.058 (-1.52)	0.33* (3.84)	0.11 (0.86)	0.89	1.48

Note:: ( ) t-statistics.

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 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:

$$A(B)X_t \;=\; \xi_t \qquad (4)$$

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:

$$X_t \;=\; C(B)\xi_t \qquad (5)$$

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

[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

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,Σ). 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

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

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 ρ=1.

Table 4 indicates the result of unit root test.

< Table 4> Unit root test result of domestic industry sectors

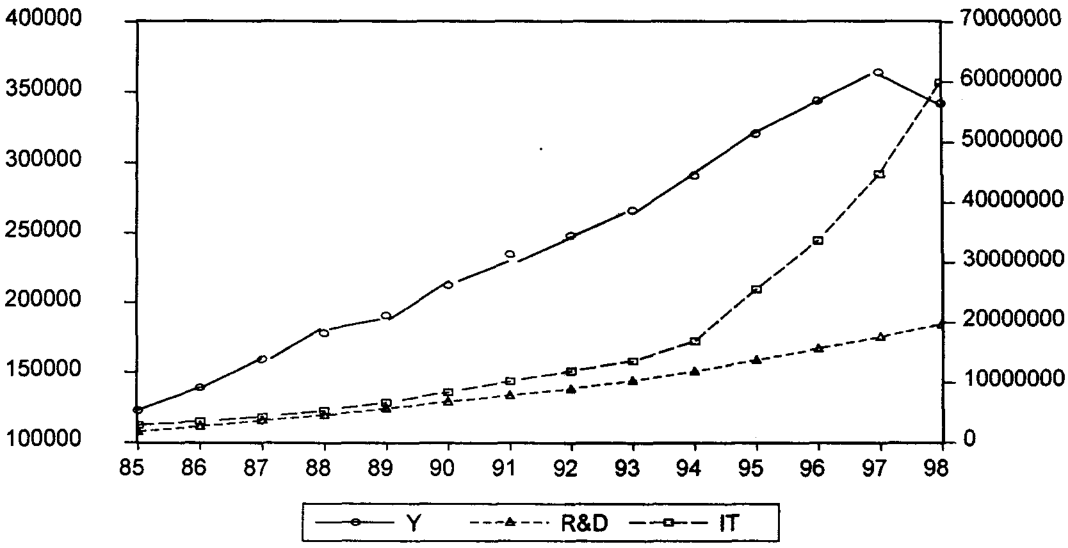
Variable/ Classification	Domestic industry classification
Value added output (Y)	-1.59 (level data) -5.04*** (1st difference data)
IT Technology Capital (IT)	-2.79*(level data) -3.65**(1st difference data)
R&D stock (R&D)	-3.97**(level data) -5.32***(1st difference data)

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)

Therefore, we can generally verify from Table 4 that a unit root exist 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> some information about TO, R&D, and IT at the level data

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.

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_i =0, we judge existence of causality by practicing F test[4] about each null hypothesis.

[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

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 opposites side, it is estimated that Granger cause from Y to X exist.

(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)

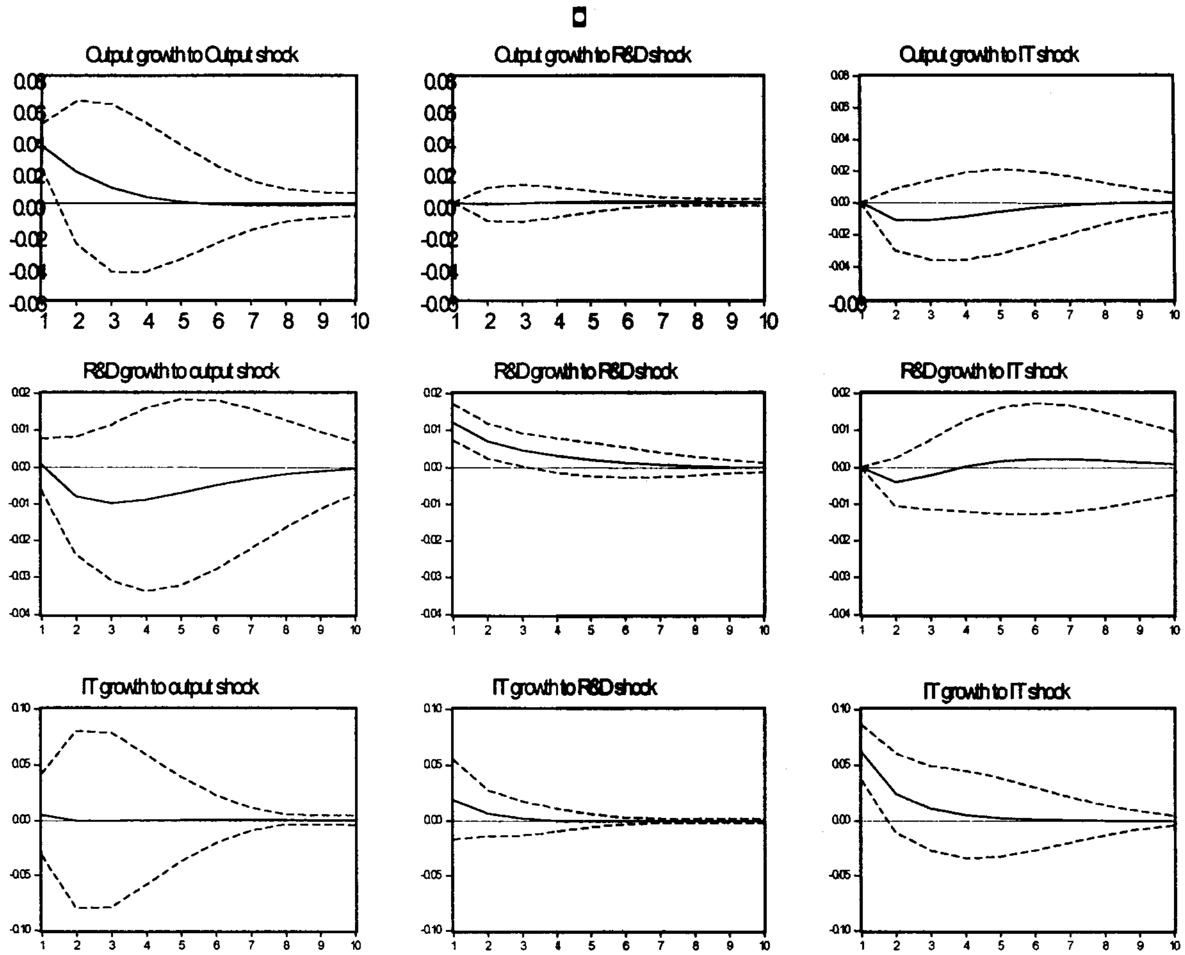
Note:() value of p to F Test.

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 impulse, but, due to the low level of statistical research in this regard, results may prove to be ambiguous.

number of constraints



<Figure 4> An Analysis of Impulse response function in Korea's industry

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 low 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.

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 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 affects 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.

Reference

Brynolfsson, E. and L.M. Hitt (1998), "Beyond the productivity paradox: Computer are the catalyst for bigger changes", *Communications of the ACM* 41(8), 49-55

Barro, R., N.G. Mankiew, and X Sala-I-Martin.(1995). "Capital Mobility in Neoclassical Growth Models", *American Economics Review*, pp.103-115.

______________1995. Economic Growth, *MaGraw-Hill*, Inc,.

Dewan, S and Kraemer, K.L (2000), "Information Technology and Productivity: Evidence from Country-level Date", *Management Science*, 46(4)

Dickey, D.A&W.A. Fuller (1979), "Distribution of the Estimates for Autoregressive Time series with a Unit Root," *Journal of American Statistical Association*, 74, pp.427-31.

ETRI (2001), " The Spreading Effect of IT Technology in Korea", *ETRI Projects*.

Goto,A. and K. Suzuki (1989), " R&D Capital Rate of Return on R&D Investment and Spillover of R&D in Japaness Manufacturing Industries", *The Review of Economics and Statistics*, 56(4), 555-564.

Klette, T.J. (1996). "R&D, Scope Economies and Plant Performance." *RAND Journal of Economics* 27, no. 3 (Autumn), pp. 502-522.

Korea Bank (2000), Quarterly National Accounts.

Korea bank (1987), Inter Industry analysis explanation.

Link, Albert N., (1987), "Technological Change and Productivity Growth", Chur, Switzerland: Harwood Academic Publishers.

National Computerization Agency (1999), Information Technology statistical data.

Pyou, Hark Kil (1998), "Estimated result of capital stock in industry and asset," *Korea Institute of Public Finance*.

Phillips.P.C.& P. Perron (1988), "Testing for a Unit Root in Time Series Regression," *Biometrika*, 75(2),pp.335-346.

Singh, Nirvikar, and Hung Tries (1996), "Total Factor Productivity Growth in Japan, South Korea, and Taiwan", *Working Paper No. 301*, University of California, Santa Cruz.

Sin, ill soun and Song, jae gyung (1999), " Identification on several hypotheses that the growth of information technology affects productivity", *Korea Information Society Development Institute*.

Sims, Christoper A (1980), "Macroeconomics and Reality," *Econometrica*, 48, pp.1-48.

Terleckyj, N.E., (1974), "Effects of R&D on the Productivity Growth of Industries: an Exploratory Study", *Report No.* 140.

The Bureau of Statistic (1998), Information & Communication Statistical Report.

Wilder, Ronald P. & Stansell, Stanley R., (1974). "Determinants of Research and Development Activity by Electric Utilities" *RAND journal of Economics*, Volume 5, No. 2, pp. 646-650.