The Impact of Information Technology on Productivity in Korean Banking Industry

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Abstract

This paper aims at analyzing the effect of Information Technology (IT) on the output growth and Total Factor Productivity (TFP) of Korean banks. Data on 23 and 14 banks, depending on

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the sub-periods, for the eleven years (1991-2001) are used for the analysis. It is identified that there are both direct and indirect impacts of IT investment of the Korean banking industry on output growth. The total effect on output growth is 2.48 percentage point per year, which divided into a direct effect of investment in IT on the output growth is 0.31 and an indirect effect on the TFP is 2.17 percentage points per year. Results show that IT investment contributes to increased banking industry productivity. Therefore, the commercial banks have benefited from increased expenditures on Automation Teller Machine and other computerized equipments in increasing productivity, implying the so-called productivity paradox did not exist during the period.

Key Words: Information Technology, Output Growth, Total Factor Productivity, Bank Industry, Productivity Paradox

I. Introduction

Coupled with innovative business minds, information technology (IT) is rapidly changing the way financial services are designed and delivered. Banking is an information intensive business and IT plays an increasingly significant role in it.[1] Many banks have established a presence on the Internet and many others are in the process of doing so.

Using electronic media such as Automation Teller Machines (ATM), telephones, personal computers and the Internet, a bank can reach out to customers and provide them not only with general information about its services, but also with the opportunity of performing interactive retail banking transactions. Previous studies have shown

1. Shaoyi Liao, Yuan Pu Dhao, Huaiqing Wang, and Ada Chen, "The Adoption of Virtual Banking: An Empirical Study," *International Journal of Information Management*, Vol. 19 (1999), pp. 63-74.

the use of IT has helped banking organizations. A recent study on the U.S. retail banking sector shows that the transaction cost of telephone banking is only 40% of the cost of physical branches.[2]

At the same time, there have been doubts about the role of IT in improving the productivity of banks. Despite rapid computerization, productivity growth has not exceeded the trend and cannot be linked to an increase in computer investment in the last few years. This phenomenon has been called a productivity paradox.

This study attempts to analyze the effect of IT on the output growth and total factor productivity (TFP) of Korean banks. A growth accounting framework developed by Solow to compute the contributions of production factors related to IT is examined, followed by the decomposition of the TFP into several factors to find the effect of IT on the TFP. From this study we fully understand both the direct and indirect effects of IT investment of Korean banking industry.

One major characteristic of our study lies in the method of accounting for information capital and information labor. We differentiate information workers from other types of workers in the banking industry. Further we differentiate capital stock between production capital stock and information capital stock. Using information on the annual Information System (IS) budget, the number of desktop machines (PCs and terminals), the cost of computer laborers, the number of computer laborers, Cash Dispenser (CD) & ATMs and the amount of central computer equipment used (mini- and supercomputers), information capital stock is measured.

Data and measurements are examined in Section II. Section III presents a growth accounting framework developed by Solow to compute the contributions of production factors related to IT. In Section IV, the TFP is decomposed into several factors to find the effect of IT on the TFP. Section V concludes the paper.

2. S. Talmor, "New Life for Dinosaurs, The Banker," Vol. 145 (September 1995), pp. 75-78.

II. Data

It is assumed that a commercial bank is considered as a firm, which employs labor and capital to produce deposit and loans. It is also assumed that an the output of a commercial bank includes its loans, securities and deposit using several inputs, such as production labor, information labor, production capital, information capital and financial input.

Financial inputs consist of production labor, information labor, production capital and information capital. Production labor and capital are defined as the number of workers excluding computer workers and the capital stock that is the fixed investment subtracts information capital, respectively. Further, information capital implies the information capital stock and borrowings are used for financial input.

The basic IT spending data was collected from a survey of the Bank of Korea from a sample of firms. These surveys, conducted annually from 1991 to 2001, collect information on the annual IS budget, the number of desktop machines (PCs and terminals), the cost and number of computer laborers, CD & ATM and the number of the central computer equipments, such as mini- and supercomputers.

In order to construct the initial variable for information capital, the number of desktop machines, CD & ATMs and the amount of the central computer equipment used is converted into the total value. The average value of desktop machines was approximately 3,070,000 won (Korean currency) in 1991. In the same year, the average values of CDs & ATMs were approximately 6,240,000 won and 31,000,000 won, respectively.

The values of the remaining years (1992-2001) are calculated by the following equation.

$$K_{C,t} = I_t + K_{C,t-1}\,(1-\delta_C) \quad \text{----------} \quad (1)$$

where $K_{C,t}$, I_t, δ_C denotes information capital of t year, Investment of

t year, depreciation rate $\delta_C = 31.2\%$ are used.

In the same way, the value of production capital is determined by the following equation (2),

$$K_{P,t} = I_t + K_{P,t-1}\,(1-\delta_P) \quad \text{----------} \quad (2)$$

where $\delta_P = 9.4\%$.

The data set used in the estimation was compiled from annual issues of "The statistics of Banking Operation" from 1991 to 2001, published by Financial Supervision Authority, and the Annual Reports of Banks under investigation for the same period. In the analysis (1991-1997) 23 commercial banks were investigated, including 13 city banks (Choheung, Shinhan, First, Hanil, Seoul, Korea Bank of Commerce, Hanmi, Foreign Exchange, Dongwha, Dongnam, Daedong, Hana, and Boram banks) and 10 local banks (Kang-won, Kwangju, Kyunggi, Kyungnam, Daegu, Pusan, Jeju, Chunbuk, Choongchung, and Chungbuk banks). Since April of 1998, Korean Financial Services has carefully examined business performance and the plans of future restructuring provided by Korean commercial banks.

In 1988, the Evaluation Committee for the Banking Management of the Ministry of Finance released its decision on the structural reform of the banking industry according to the BIS standard for own capital ratio (8%). The banks that passed the critical line were called superior banks, which included Shinhan, Hana, Hanmi, Boram, Daegu, Pusan, Kwangju, and Kyungnam banks. Ultimately, five commercial banks were forced to close and transfer their assets and liabilities into other banks. Such insolvent banks as Dongwha, Daedong, Dongnam, Kyunggi and Choongchung banks were individually absorbed into the superior banks. Some commercial banks were merged with other banks.

Therefore, 14 commercial banks were investigated in the period of 1998-2001, consisting of eight city banks (Choheung, First, Han-

vitt, Seoul, Shinhan, Hanmi, Foreign Exchange, and Hana banks) and six local banks (Kwangju, Kyungnam, Daegu, Pusan, Chuanbuk, and Jeju banks).

A panel data set divided into two sub-periods (1991-1997 and 1998-2001) was used. Also, each period uses annual data for 23 and 14 commercial banks, respectively. The consumer price index, production price index, and ICT price index are used to convert the nominal value of the various inputs and the output into the real value to allow inter-year comparison on the same basis. The summary of statistics for data is provided in Table 1.

Table 1. General Statistics of Major Variables

Name of Variables		Samples	Mean	STD	Minimum	Maximum
Loan	Quantity	209	84,457.1	84,271.5	1,702.7	461,484.5
	Share	209	0.31	0.05	0.19	0.44
Security	Quantity	209	57,908.9	61,210.5	471.5	313,867.9
	Share	209	0.21	0.04	0.09	0.33
Deposits	Quantity	209	124,316.0	125,624.1	3,211.7	691,811.3
	Share	209	0.47	0.02	0.42	0.60
Production Labor Input	Quantity	209	3,564.9	2,927.2	307.0	11,283.0
	Share	209	0.19	0.14	0.01	0.74
Information Labor Input	Quantity	209	143.7	78.0	34.0	424.0
	Share	209	0.02	0.01	0.0004	0.06
Production Capital Input	Quantity	209	3,428.1	3,780.6	194.3	31,812.7
	Share	209	0.58	0.17	0.09	0.90
Information Capital Input	Quantity	209	285.4	296.3	8.6	1,390.4
	Share	209	0.01	0.01	0.003	0.05
Financial Input	Quantity	209	25,492.0	30,395.2	213.6	154,267.7
	Share	209	0.20	0.10	0.004	0.52

III. The Contributions of Information Technology to Output Growth

A. Methodology

In the neoclassical growth accounting framework, such as Solow (1957), the contribution of information Technology to the output growth depends on the income share and the growth rate of input.

Let the production function be

$$Y = F(L_P,\ L_C,\ K_P,\ K_C,\ M,\ T) \quad \text{---------- (3)}$$

Where Y denotes the weighted sum loan, security and deposits, L_P, L_C, K_P, K_C, means production labor input, information labor input, production capital stock, information capital stock, M is intermediate input, and T represents disembodied technological change or, in other words, shifts in production function over time.

The growth accounting equation can be obtained by differentiating equation (3) with respect to time and dividing by Y.

$$\dot{Y} = s_{LP} \cdot \dot{L_P} + s_{LC} \cdot \dot{L_C} + s_{KP} \cdot \dot{K_P} + s_{KC} \cdot \dot{K_C} + s_M \cdot \dot{M} + \dot{A} \quad \text{---- (4)}$$

Where s_{LP}, s_{LC}, s_{KP}, s_M, depicts income share of each input, L_P, L_C, K_P, K_C, A stand for the TFP, and the growth rate $\dot{L_P}$, $\dot{L_C}$, $\dot{K_P}$, $\dot{K_C}$, $\dot{M}$ is defined as the natural logarithmic annual change in the use of each input.

B. Empirical Results

The results on the output growth in banking industry are provided in Table 2. The results show that information labor, production capital, information capital and financial input contribute to increasing the output growth. However, there is a negative association between pro-

Table 2. Contributions of Inputs to Output Growth and Total Factor Productivity

Period		Production Labor	Information Labor	Production Capital	Information Capital	Financial Input	Output Growth	TFP
1992		0.57	0.18	6.84	0.66	2.29	9.74	-0.80
1993		-0.03	0.19	3.90	0.28	-0.22	12.44	8.32
1994		-1.49	-0.09	8.14	0.48	1.56	18.37	9.76
1995		2.21	0.28	7.11	0.40	2.37	18.32	5.96
1996		0.17	-0.03	5.59	0.12	4.43	16.43	6.16
1997		-0.09	0.10	6.18	0.04	0.90	11.67	4.55
1998		-8.44	-0.14	14.54	-0.19	4.06	-7.15	-16.97
1999		-0.25	0.03	-19.13	-0.01	4.67	0.81	15.52
2000		-1.99	-0.06	-5.63	0.20	-0.97	-0.79	7.66
2001		1.38	-0.03	-8.79	0.23	-2.90	-4.89	5.22
Average	1992-2001	-0.46	0.06	3.38	0.25	1.78	9.99	4.96
	1992-1994	-0.38	0.08	6.40	0.48	1.23	13.79	5.98
	1995-1997	0.76	0.12	6.29	0.19	2.57	15.48	5.56
	1998-2001	-2.40	-0.05	-4.68	0.06	1.26	-2.91	2.91

duction labor and the output growth. The effects of each input on the output growth can be summarized as follows.

First, the effect of production capital on the output growth is the greatest among the inputs. That is, 3.38 percentage point of the output growth can be attributed to production capital, which is about 35 percent of the output growth. Specifically, an increase in production capital leads to increase in the output growth of 6.40 and 6.29 percentage points in the periods of 1992-94 and 1995-97, respectively. However, a negative impact of production capital on the output growth by 4.68 percentage point is also observed.

Secondly, the contribution of information labor to the output growth is 0.06 percentage point, accounting for 0.7 percent of the 9.99 percent in the output growth during the period of 1992-2001. The results of sub-periods are very similar in pattern to the input of production capital. That is, there exist positive impacts of information labor on the output growth in the periods of 1992-94 and 1995-97. The impacts are 0.08 and 0.12 percentage points, respectively. On the contrary, a negative relationship between information labor and the output growth can be found in the period 1998-2001. It is worthwhile to note that the effects of both production capital and information labor on the output growth increase until the period 1995-97 and then decrease. It does suggest that a comprehensive study of the dynamic effects of the inputs on the output growth by increasing time periods would be worthwhile.

Thirdly, the impact of information capital on output growth is 0.25 percentage point, which is about 2.5 of output growth. If we examine by the sub-periods, the impacts of information capital on output growth decrease subsequently. That is, the impact is the highest in the period of 1992-94 (0.48 percentage point) and that in the periods of 1995-97 and 1998-2001 are 0.19 and 0.06 percentage points, respectively.

Finally, the contribution of information network to the output growth is 0.31 percentage point, which is the sum of 0.06 percent (the

contribution of information labor to the output growth) and 0.25 percent (the contribution of information capital to the output growth).

IV. Total Factor Productivities of the Banks and Information Technology

A. Methodology

1. The Fourier Flexible Cost Function

Gallant[3] shows that The Fourier Flexible form represents a semi-nonparametric approach to the problem of using data to infer relationships among variables when the true functional form of the relationships is unknown. The Fourier Flexible cost equation is written as follows

$$\ln C^{*} = c_0 + a'x + \frac{1}{2}x'Bx + \sum_{k=0}^{K_n} (v_k \cos(\eta_k' x) + \gamma_k \sin(\eta_k' x)) + \varepsilon \quad \text{---------- (5)}$$

Where ln $C_{,}^{*}$ is natural log of cost, c_0 is a constant to be estimated, x = [W', Y'] is n vector of scaled log-input prices, W, and scaled log-output quantities, Y. α is n+1 vector of coefficients to be estimated, $B = [\beta_{ij}]$ is $B = (n+1)\times(n+1)$ symmetric matrix of coefficients to be estimated, v_k and γ_k are coefficients to be estimated, η_k is n+1 vector with integer elements chosen by researcher, ε is error term and K_n is truncation parameters.[4]

3. A. R. Gallant, "On the Bias in Flexible Functional Forms and an Essentially Unbiased Form: The Fourier Flexible Form," *Journal of Econometrics*, Vol. 15 (1981), pp. 285-323; idem, "Unbiased Determination of Production Technologies," *Journal of Econometrics*, Vol. 16 (1982), pp. 285-323.
4. Gallant shows that increasing the number of Kn vectors relative to sample size reduces approximation error. See A. R. Gallant (1982), *op. cit.* Eastwood and Gallant identify rules for tying sample size to the total number of FF parameters estimated so

Cost share function is shown, as follows using (5).

$$\frac{\partial \ln C^*}{\partial \ln w_j} = S_j = \lambda_{w_j} + \beta_j' x + \sum_{k=1}^{K} \left(- \nu_k \eta_{kw_i} \cos\left(\eta_k' x\right) + \gamma_k \eta_{kw_i} \sin\left(\eta_k' x\right)\right) \quad \text{---------- (6)}$$

$i = 1,\ldots\ldots\ldots, n.$

All estimates reported were produced by estimating a cost function jointly with share equations using Iterated Seemingly Unrelated Regression (ISUR) technique when the variance-covariance matrix is unknown.

2. The Decomposition of Total Factor Productivity

To decompose the TFP of Korean commercial banks into the several effects, the two-step method suggested by Denny, Fuss, and Waverman[5] was adopted. In the first step, a cost function of a commercial bank was built and estimated, and in the next step, the estimated elasticity of the cost function was substituted into a decomposition equation, which represents the TFP growth rate as a sum of above effects. The decomposition of TFP is shown as follows

$$\dot{TFP} = [1 - e_y]\, \dot{Y} - e_{L_c} \dot{L_C} - e_{K_c} \dot{K_C} - e_{Br} \dot{Br} - T \quad \text{---------- (7)}$$

as to produce consistent and asymptotically normal parameter estimates. Following the studies by Eastwood and Gallant, and Mitchell and Onvural, this paper also applies Kn= 31, because output is one and input is 5. See K. Mitchell and N. M. Onvural, "Economics of Scale and Scope at Large Commercial Banks: Evidence from the Fourier Flexible Function Form," *Journal of Money, Credit, and Banking*, Vol. 28 (1996).

5. M. Denny, M. Fuss, and L. Waverman, "The Measurement and Interpretation of Total Factor Productivity in Regulated Industries, with an Application to Canadian Telecommunications," in T. G. Cowing and R. E. Stevenson (eds.), *Productivity Measurement in Regulated Industry* (Reading, M.A.: Academic Press, 1981), pp. 179-218.

The first term ($[1 - e_y] \dot{Y}$) in equation (7) is an output effect and the second term ($-e_{L_C} \dot{L_C}$) in the same equation indicates information labor effects. The third term ($-e_{K_C} \dot{K_C}$) means information capital effect. The fourth term ($-e_{Br} \dot{Br}$) is the branch effect. The last term ($-T$) shows a general technology growth effect.

B. Decomposition Results

1. Cost Function Estimation Results

All estimates reported are produced by estimating a cost function jointly with share equations using Iterated Seemingly Unrelated Regression (ISUR) technique when the variance-covariance matrix is unknown.

The estimation results of the cost function are reported in Table 3 and Table 4. The goodness of fit (R^2) statistics of cost function is high, indicating 0.99 even panel data. R^2 of share equation is also high, 0.77-0.90, while one of the information capital share is somewhat low, 0.0548.

The estimated coefficient on information capital (K_C) is signifi-

Table 3. Estimation Results of The Fourier Flexible Cost Function

Equation	N	Coefficient	RMSE	R^2	χ^2	P-value
Cost Function	159	92	0.096	0.993	148,248.7	0.000
Production Labor Shares	159	29	0.044	0.903	1,748.6	0.000
Information Labor Shares	159	29	0.005	0.772	105.8	0.000
Production Capital Shares	159	29	0.068	0.841	1,214.9	0.000
Information Capital Share	159	29	0.004	0.548	54.9	0.004

Table 4. Estimated Coefficients

ln(y)	0.133(0.459)	ln(p1p4)	0.000(0.001)	ln(p4p5)	-0.003(0.002)
ln(p1)	0.714(0.040)***	ln(p1p5)	-0.003(0.005)	ln(p5p5)	0.034(0.010)***
ln(p2)	0.099(0.012)***	ln(p2p2)	0.007(0.003)**	ln(yp1)	-0.034(0.003)***
ln(p3)	0.643(0.060)***	ln(p2p3)	-0.005(0.002)***	ln(yp2)	-0.007(0.001)***
ln(p4)	0.046(0.013)***	ln(p2p4)	0.000(0.002)	ln(yp3)	-0.027(0.005)***
ln(p5)	-0.503(0.060)***	ln(p2p5)	-0.001(0.003)	ln(yp4)	-0.003(0.001)***
ln(yy)	0.010(0.020)	ln(p3p3)	0.135(0.008)***	ln(yp5)	0.070(0.005)***
ln(p1p2)	0.101(0.003)***	ln(p3p4)	-0.005(0.005)***	ln(B)	0.690(0.125)***
ln(p1p2)	-0.002(0.001)	ln(p3p5)	-0.028(0.008)***	ln(Lc)	0.385(0.080)***
ln(p1p3)	-0.097(0.004)***	ln(p4p4)	0.007(0.002)***	ln(Kc)	-0.148(0.041)***

1) A trans-log type of cost function is build up, as follows.

$$\ln C^{*} = c_{o} + a'x + \frac{1}{2}x'Bx + \sum_{k=0}^{K_{0}} \left(v_{k} \cos\left(\eta_{k}' x\right) + \gamma_{k} \sin\left(\eta_{k}' x\right)\right) + \varepsilon$$

2) ( ) are standard errors and *** and ** indicate the estimated coefficients are significant at the 1 percent and at the 5 percent level, respectively.

3) Coefficients of sine and cosine terms are not provided in Table.

cant at 1 percent and negative, indicating that as information capital stock increases, the total cost decrease. The coefficient on the number of branches (B) is estimated statistically significant and positive, showing that as the number of branches increases, the total cost increases.

2. Decomposition Results

The decomposition results of the TFP growth rate of Korean commercial banks are reported in Table 5. The results indicate that while the output and information capital increase the TFP growth rate, information labor and the number of branches decrease the TFP growth rate. The estimation results give following implications.

First, the effect of the output on the TFP growth rate is considerable. It is estimated that 6.95 percentage point of the TFP growth rate

Table 5. Decomposition of TFP Growth Rate

Period		TFP	Output	Information Labor	Information Capital	Branches	Error Term
1993		1.43	6.25	-2.69	4.09	-6.22	-7.94
1994		10.38	11.18	2.15	5.93	-8.89	-3.32
1995		6.64	11.41	-3.57	5.50	-6.71	0.31
1996		3.75	10.78	0.25	1.63	-8.92	1.44
1997		1.44	8.32	-2.16	1.29	-6.01	2.42
1998		5.46	-4.07	3.23	-2.05	8.69	-23.47
1999		0.66	8.66	-3.13	0.65	-5.52	14.96
2000		5.98	-0.38	1.61	2.80	1.94	1.69
2001		0.98	-2.96	1.19	2.47	0.28	4.15
Average	1993-2001	4.29	6.95	-0.58	2.75	-4.60	1.19
	1993-1994	6.31	8.94	-0.05	5.09	-7.67	1.85
	1995-1997	3.90	10.15	-1.80	2.77	-7.22	1.41
	1998-2001	3.28	0.58	0.73	0.98	1.39	0.36

can be attributed to the output per year. This result implies that there exist increasing returns to scale in banking industry in the periods 1993-2001. If we examine by the sub-periods, the impacts of the output on the TFP growth rate is the highest in the period of 1995-97 (10.15 percentage point) and that in the periods of 1992-1994 and 1998-2001 are 8.94 and 0.58 percentage points, respectively.

Secondly, the negative impact of information labor on the TFP growth rate in the period 1993-2001 is 0.58 percentage point per year. This implies that information labor combined with an increase in costs adversely affects the TFP growth rate. In general, an expansion of information technology requires more labor inputs that should be employed at computer facilities, which serve as a component to increase costs.

Thirdly, an increase in information capital stock leads to increase in the TFP growth rate of 2.75 percentage point per year. Combining

information capital stock with information labor, the financial network has a positive impact on the TFP growth rate. The magnitude is 2.17percentage point, accounting for a positive effect of information capital stock (2.75 percentage point) and a negative effect of information labor (0.58 percentage point).

Fourthly, the impacts of information labor on the TFP growth rate may be explained by sub-periods. Specifically, the estimated coefficients are -0.05, -1.80 and 0.73 percentage points in the periods of 1993-94, 1995-97 and 1998-2001, respectively. This result implies that the employment of computer laborers increased the TFP growth after 1998.

Finally, if we examine by the sub-periods, the impacts of information capital stock on the TFP growth rate decrease subsequently. That is, the impact is the highest in the period of 1993-94 (5.09 percentage point) and that in the periods of 1995-97 and 1998-2001 are 2.77 and 0.98 percentage points, respectively. This implies that the marginal impact of information capital stock on the TFP growth decreases as the stock increases.

3. Total Effect of Information Technology

The direct and indirect effects of IT investment of Korean banking industry are reported in Table 6. We can summarize the results as follows.

First, the effect of the financial network on the output growth rate is 2.48 percentage point, which is about 24.8 percent of the output growth. We can observe that the financial network has both a direct and an indirect impact through the TFP growth rate on the output growth. The direct effect is 0.31 percentage point (3.1 percent) and the indirect effect is 2.17 percentage point (21.7 percent), implying that indirect effect is much greater than direct one in improving the output growth rate. This implies that the financial network has an influential role in technical advance rather than input.

Table 6. Summary of Estimation Results

Unit (%)	1992-2001	1992-1994	1995-1997	1998-2001
Output Growth	9.99	13.79	15.48	-2.91
Direct Effect	0.31 (3.1)	0.56 (4.1)	0.31 (2.0)	0.01 (-)
Information Labor	0.06	0.08	0.12	-0.05
Information Capital	0.25	0.48	0.19	0.06
Indirect Effect	2.17 (21.72)	5.04 (36.6)	0.97 (6.3)	1.71 (-)
Information Labor	-0.58	-0.05	-1.80	0.73
Information Capital	2.75	5.09	2.77	0.98
Total Effect	2.48 (24.82)	5.60 (40.6)	1.28 (8.3)	1.72 (-)

Secondly, the total contribution of the financial network to the output growth rate is 5.60 percentage point, accounting for 40.6 percentage of the output growth during the period of 1992-1994. In addition, an increase in the financial network leads to an increase in the output growth rate of 1.28 and 1.72 percentage points in the periods of 1995-97 and 1998-2001, respectively.

Thirdly, there exists a positive association between information capital and the output growth rate and further, the magnitude decreases as the stock of information capital increases. The direct impact is a bit different from the indirect one. That is, the direct effect of information labor on the output growth rate peaks at 1997 and decline subsequently. However, the indirect effect on the output growth rate increases to 1997 but eventually decreases.

That is, the total effect on the output growth is 2.48 percentage point per year, which divided into a direct effect of investment in IT on the output growth is 0.31 percentage point and an indirect effect on the TFP is 2.17 percentage point per year. As a result, it was confirmed that investment in IT contributes to increasing the productivity on banking industry. Therefore, the commercial banks have benefited from increased expenditures on ATM and other computerized equip-

ment by increasing productivity, implying that the so-called productivity paradox did not exist during the period.

V. Concluding Remarks

This study attempts to analyze the effect of Information Technology (IT) on the output growth and the Total Factor Productivity (TFP) of Korean banks. A growth accounting framework developed by Solow[6] to compute the contributions of production factors with related to IT was used. Further, the TFP was decomposed into several factors to find the effect of IT on the TFP. From this study we fully understand both the direct and indirect effects of IT investment on the Korean banking industry.

One of major characteristics of this study lies in the methods of accounting for the information capital and information labor. Information workers are differentiated from other types of workers in the banking industry. Further, capital stock is differentiated from production capital stock and information capital stock. Using information on the annual IS budget, the number of desktop machines (PCs and terminals), the cost of computer laborers, the number of computer laborers, CD & ATM and the amount of central computer equipments (mini- and supercomputers), information capital stock is measured.

Hence, it is estimated the effects of IT on the output growth and the TFP of Korean banks. Data on 23 and 14 banks, depending on the sub-periods, for the eleven years (1991-2001) are used for the analysis. It is identified that there are both direct and indirect impacts of IT investment of Korean banking industry on the output growth. That is, the total effect on the output growth is 2.48 percentage point per year, which divided into a direct effect of investment in IT on the output

6. R. M. Solow, "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics*, Vol. 39 (1957), pp. 312-320.

growth is 0.31 percentage point and an indirect effect on the TFP is 2.17 percentage point per year, respectively. As a result, it was confirmed that investment on IT contributes to increasing the productivity on banking industry. Therefore, the commercial banks have benefited from increased expenditures on ATM and other computerized equipment in increasing productivity, implying the so-called productivity paradox did not exist during the period.

The decomposition results of the TFP growth rate of Korean commercial banks have following implications. First, the negative impacts of information labor on the TFP growth rate in the periods 1993-2001 is 0.58 percentage point per year. This implies that information labor combined with an increase in costs adversely affects the TFP growth rate. In general, an expansion of information technology requires more labor input which should be employed at computer facilities, serving as a component to increase the costs.

Secondly, an increase in information capital stock leads to an increase in the TFP growth rate of 2.75 percentage point per year. Combining information capital stock with information labor, the financial network has a positive impact of the TFP growth rate. The magnitude is 2.17 percentage point, accounting for a positive effect of information capital stock (2.75 percentage point) and a negative effect of information labor (0.58 percentage point).

One limitation of this study is not looking into structural changes in the financial industry of Korea that arose during 1977-1988 period. From late 1997 to the present, Korea has experienced a so-called banking crisis and the Korean government has taken a strong step to restructure its banking sector. Many Korean commercial banks were technically insolvent and for the first time in Korean history, commercial banks have been forced to close or merge with other banks. As a result, there has been a very significant redistribution of the equipment and labor related to the information network among financial intermediaries. Had the banking industry taken into consideration the ramifications of the past banking practices, somewhat different

conclusions may have been reached.

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