International Comparison of Japanese and Korean Banking Efficiency

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This study investigates the pattern of changes in efficiency and productivity of the banking sectors at the firm level for the period of 1991-2005 using output distance function and applying the one-stage stochastic frontier approach. This study pools Japanese and Korean bank dataset to effectively compare the pattern of change between Japanese and Korean banking efficiency. Our results indicate that estimates of technical progress, technical efficiency, and total factor productivity (TFP) depend on the viewpoint about the true function of bank: intermediation approach, value-added approach, or operating approach. While intermediation approach results imply that the productivity has overall declined over the sample period for the both country banks, operating approach results are mixed for the two countries. Value-added approach indicates positive TFP growth for the both countries. In most cases, the levels of technical efficiency were further behind the technological frontier for the Korean banks than for the Japanese banks.

Keywords: Stochastic frontier analysis, Technical progress, Technical efficiency, Total factor productivity

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I. Introduction

Both Japanese and Korean banking industries faced regulatory reform and increased competition in the 1990s. At the same time, Japanese and Korean banks were left with large amounts of bad loans associated with the bursting of the "Bubble" in 1990-1991 and the financial crisis in 1997-1998, respectively. In responding both to these problems and to increasing competitive pressures, the governments of both countries permitted banks to set up financial holding companies[1] to make mergers and acquisitions easier and to help banks to realize scale economies.

In Japan, the financial liberalization process started gradually in the early 1980s, gathering pace in the 1990s. Prime Minister Ryutaro Hashimoto announced the so-called "Japanese Big Bang" plan in 1996, a plan that aimed to complete the deregulation of the financial system by 2001. Several important reforms were implemented, some of which were the lifting of remaining international capital controls, and revisions of the *Banking Act*, the *Securities and Exchange Act* and the *Insurance Business Act* in order to increase the options available to savers, fundraisers and financial institutions.[2]

Responding to these rapid changes in the financial environment in the late 1990s, seven mergers between city banks occurred between 2000 and 2005. During this period of consolidation, the number of city banks was reduced from 13 in 1989 to 6 in 2007, and they were reorganized into three mega-banking groups (Mizuho, Mitsui-Sumitomo, and Mitsubishi-UFJ). The government also promoted the consolidation of regional banks and six mergers between regional banks occurred in the period between 2000 to 2005.

The Korean banking sector deregulation process started in the early 1980s. During this process, the government undertook several reforms to liberalize the financial system by revising the *General Banking Act* in 1982. For example, the government re-privatized some of the national banks, removed interest rate ceilings and entry restrictions, reduced government-directed lending, expanded product deregulation, and reduced restrictions on foreign exchange

[1] Japanese and Korean governments allowed the banks to establish financial holding companies in 1998 and 2000, respectively.

[2] A more detailed explanation and analysis of the "Japanese Big Bang" can be found in Hoshi and Kashyap (2001).

transactions.

Further reforms were implemented *via* a series of revisions to the *General Banking Act* between 1991 and 1997 in which interest rates were further deregulated, greater autonomy was given to bank managements, bank security holdings and maturities on loans were liberalized, and foreign exchange transactions and foreign investment were further liberalized.

However, in spite of these efforts at liberalization, the Korean banking system collapsed after the Asian financial crisis. In responding to this situation, the Korean government implemented a two-stage financial restructuring process, as described by Park and Webber (2006):

> "In the first stage, two banks were nationalized for later sale to foreigners, five insolvent banks were closed and then merged with blue-chip banks, foreign capital injections were given to seven banks, and public funds were used to normalize the operations of the remaining surviving banks" (p. 2374)
>
> "The second stage of restructuring began in June 2000 and focused on restoring bank profitability. Financial holding companies were created to make merger and acquisitions easier and help banks realize scale economies." (p. 2374)

Our research question is how these changes and reforms in the financial market affected banking efficiency in both countries. Both Japanese and Korean banks are considered to be inefficient comparing to those in the U.S. and European countries. The governments in both countries have taken several measures aiming to increase international competitiveness of the banking sector. In this study, we would like to examine whether the Korean banks efficiency levels have caught up with those of Japanese banks after the several reform measures taken in the 1980's and 1990's. An international comparison of efficiency is often associated with difficulties in controlling for the differences in economic environments across nations, but Japan and Korea share some similar economic environments in the sense of prudential supervisory and regulatory conditions. To the best of our knowledge, this is the first study to undertake a comparison of efficiencies of the banking sector between the two countries.

The remainder of this paper is organized as follows. The next section briefly reviews previous studies on international comparisons of banking efficiency, and Japanese and Korean banking efficiency. Section III explains the methodology employed in this paper, and Section IV explains the data used. Section V discusses the estimation results and Section VI concludes.

II. Literature Review

A. Specification of Bank Inputs and Outputs

Since a typical bank assumes many roles in the financial system, studies found it difficult to identify and agree upon a bank's true function. Different studies in the banking industry literature have adopted different inputs and outputs to analyze the efficiencies of the banks depending on various approaches defining the true function of banks. The following are the descriptions of several common approach, as explained in Maggi and Rossi (2003) and Das and Ghosh (2006). The treatment of deposits can be quite sensitive, depending on the approach employed in the analysis:

1) The intermediation approach views banks as institutions that collect and allocate funds as loans and other assets. This approach includes both operating and interest expenses as inputs, whereas loans and other major assets count as outputs.
2) The asset approach is a variant of the intermediation approach whereby deposits, other liabilities, labor, and physical capital are considered to be inputs and loans and other assets are considered to be outputs.
3) The user cost approach assumes that it is the net contribution to bank revenue that defines inputs and outputs;[3] in this approach, deposits are counted as outputs.
4) The value-added approach identifies as outputs those balance sheet categories (assets or liabilities) that contribute to the value added to the bank. In this approach, deposits, loans and services are counted as outputs because they account for a significant proportion of value added. Labor and the value of

[3] If the financial returns on an asset exceed the opportunity cost of the funds, they are considered to be outputs; otherwise, they are considered to be inputs.

physical capital are categorized as inputs.

5) The production approach, which is more concerned with the technical efficiency[4] of financial institutions, defines banking activity as the production of services. Deposits are counted as outputs and interest paid on deposits is not included in a bank's total costs (Ferrier and Lovell 1990). According to this approach, inputs and outputs are measured as physical quantities (number of accounts, transactions processed, *etc.*).
6) Operating approach (or income-based approach) views banks as business units with the final objective of generating revenue from the total cost incurred for running the business. Accordingly, banks' output is defined as the total revenue (interest and non-interest) and inputs are defined as the total expenses (interest and operating expenses).

After we have specified the outputs and inputs, we have to control for their quality in assessing banking efficiency. In particular, controlling for problem loans can be very important in the context of Japanese and Korean banking. However, as Berger and Humphrey (1997) argue, control is a controversial issue. If problem loans are generally caused by "bad luck" events exogenous to the banks, such as regional downturns, then problem loans should be controlled for in the efficiency model. If, on the other hand, problem loans are mainly caused by "bad management," then they are essentially endogenous to the financial institution and should not be controlled for in the analysis of efficiency. In contrast to the discussion on the assessment of quality of outputs, few studies have attempted to control for the quality of inputs.

B. International Comparison

Berger and Humphrey (1997) and Berger (2007) surveyed the literature on international comparisons of efficiency in the banking industry. According to Berger (2007), the literature can be classified into three types of research.

(1) Comparisons of the efficiency of banks in different nations, with all banks measured against a common frontier.

[4] Farrell (1957) defines the technical efficiency as the ability of a firm to obtain maximal output from a given set of inputs.

(2) Comparisons of the efficiency of banks in different nations, with banks from each nation measured against their own nation-specific frontiers.
(3) Comparisons of the efficiency of foreign-owned *versus* domestically owned banks within the same nation, with both types of bank measured against the same nation-specific frontier.

The first category of research is necessary in order to compare efficiency between nations, although relatively little research has been carried out in this category because of the difficulties in controlling for the very different economic environments of different nations. The vast majority of studies in the literature fall within the second category, which measures efficiency in terms of deviation from the nation-specific frontier and sometimes compares the efficiency distributions for different nations. These differences in efficiency dispersion can be used as an indicator of the degrees of competition in different nations, since if the country has competitive input and output markets, the dispersion in efficiency will be expected to be relatively small. The third category of research has recently begun to expand.

C. Japanese and Korean Banking Efficiency

Some of the recent Japanese banking efficiency estimation studies include Altunbas *et al.* (2000), Fukuyama and Weber (2002), Drake and Hall (2003) and Hori (2004).[5] Altunbas *et al.* (2000) estimated the scale and X-inefficiencies as well as the technical changes for a sample of Japanese commercial banks between 1993 and 1996.[6] They specified three outputs (total loans, total securities and off-balance sheet items) and three inputs (price of labor, total funds, and physical capital). Their study extends the established literature in that it evaluates the impact of risk and asset quality on cost efficiency in Japanese commercial banking and shows that scale economies will tend to be overstated if these factors are not taken into account.

Fukuyama and Weber (2002) used Data Envelope Analysis (DEA) to estimate input technical efficiency and output allocative efficiency

[5] Hori (1998) surveyed the early studies on Japanese banking efficiency.

[6] Their database consists of 139 banks for each year from 1993 to 1995 and 136 in 1996.

for a sample of Japanese banks operating in the period 1992-1996. They employed the asset approach and assumed that banks transform labor, physical capital and funds from customers to produce loans, security investments and other interest-bearing assets. They found that Japanese banks experienced a decline in productivity averaging 2% per year and that they could have used only 78-93% of actual inputs if they had chosen the revenue-maximizing output mix during their estimation period.

Drake and Hall (2003) employed DEA to analyze technical and scale efficiency in Japanese banking using data from 149 banks for the financial year ending March 1997. They followed the intermediation approach and estimated a DEA model consisting of three outputs (total loans and bills discounted, liquid assets and other investments in securities, and other income) and three inputs (general and administrative expenses, fixed assets (premises and equipment) and retail and wholesale deposits). They found that the larger city banks generally operate above the minimum efficiency scale and have limited opportunities to gain from eliminating X-inefficiencies. The opposite result was found for the smaller banks.

Hori (2004) investigated cost efficiency in 139 Japanese banks using data for the financial year ending March 1995. He applied the DEA model and included three outputs (adjusted loans, market value of investment securities, and current and ordinary deposits) and three inputs (labor, physical capital, and other deposits). He found that allocative inefficiency is the main source of overall cost inefficiency in city banks, while technical inefficiency is the main source of overall cost inefficiency in regional banks.

Recent studies on Korean banking efficiency include Hao *et al.* (2001) and Park and Weber (2006). Hao *et al.* (2001) examined the productive efficiency of a sample of 19 private Korean banks over the 1985 to 1995 time period. They employed the intermediation approach and estimated a stochastic frontier cost function. They specified total loans and securities, demand deposits, and fee income as outputs, and wage rate, interest for borrowed funds and price of physical capital as inputs. The cost function also included the variable of equity capital for each bank to adjust for increased cost of funds due to financial risk. They calculated the efficiency score by using the estimation results and used this method to identify the key determinants of efficiency gains between 1985 and 1995. Their results show that banks with higher rates of asset growth, fewer employees per million won of assets, larger amounts of core deposits, and lower expense ratios were more efficient. They also found that the financial deregulation measures of 1991 had little or no significant effect on the level of sample bank efficiency.

Park and Weber (2006) estimated Korean banking inefficiency and productivity changes for the period 1992-2002. They estimated a directional technology distance function for Korean Banks[7] during the period by applying DEA. The directional distance function gives the expansion in desirable outputs, contraction in undesirable outputs, and simultaneous contraction in inputs multiplied by the directional vector. They defined 9 different types of output, namely commercial loans, personal loans, securities, demand deposits, total loans less non-performing loans, deposits, interest income, non-interest income and fee income. As for inputs, they defined 5 types of input, namely labor, physical capital, deposits, interest expenses and non-interest expenses. They found that the Korean banking industry became more inefficient in the years prior to the Asian financial crisis, but that this decline in efficiency was offset in the 1992-2002 period thanks to productivity growth in the sector during this period.

III. Methodology

A. Stochastic Frontier Model

In the literature on efficiency and productivity growth estimation[8] in the banking sector, either the non-parametric approach or the parametric approach has been adopted. Within the non-parametric approach, DEA and Index Numbers Approach are the two methods most commonly adopted in the literature.

DEA does not require the specification of both a functional form for the cost and production function and a distributional form for the inefficiency term. However, it cannot account for noise, or conduct conventional tests of hypotheses. Thus, if there is measurement error in the estimation of inputs and outputs, this influences

[7] The number of banks varies substantially, depending on the year of estimation. For example, there were 24 banks in the period between 1992 and 1994, but only 14 banks in 2002.

[8] A more general discussion of the methods for estimating productivity can be found in Van Biesebroeck (2004).

the shape and position of the frontier, and DEA may overstate the true levels of relative inefficiency in the sector. As will be explained in more detail in Section IV, mainly because of a lack of some necessary data, we have had to estimate input and output data ourselves by applying several estimation methods. Hence, it is more likely that our data contains measurement errors.

Total Factor Productivity (TFP) is often estimated by using Tornqvist index numbers and we usually impose constant returns to scale in the estimation for the underlying production function. This assumption does not affect the results to any significant extent if the empirical evidence suggests near-constant returns to scale, but several previous studies such as Kasuya (1986), Tachibanaki *et al.* (1991), McKillop *et al.* (1996) and Hori (2004) find that Japanese banks generally operate at increasing returns to scale.[9] In addition, because of the multi-output nature of banking activity, associated price information for each output is essential for the TFP estimation by index number approach; however, there is no clear consensus on the measurement of these prices.

We have therefore employed the parametric approach, using the stochastic frontier model. But at the same time, we also fully acknowledge that the distributional assumptions of the stochastic frontier model are fairly arbitrary.

B. Output Distance Function

In this study, we adopt the distance function approach,[10] a function approach that has been increasingly applied to efficiency studies. This function can be used to estimate multi-output and multi-input production technologies where no price information is available and/or it is inappropriate to assume that firms minimize costs or maximize revenue when the industry is regulated. Output distance functions tend to be used when firms have more control over outputs than they have over inputs (Coelli, Rao, O'Donnell, and Battese 2005). The banking sector is a typical example of such an industry, because the sector has multiple outputs and multiple inputs and is more regulated than other sectors.

[9] By contrast, Alutunbas *et al.* (2000) and Fukuyama (1993) find evidence of diseconomies of scale in Japanese banking.

[10] A detailed explanation of distance functions can be found in Coelli and Perelman (1999).

When a firm uses P inputs denoted by $x=(x_1, x_2, \cdots, x_P)$ and produces M outputs denoted by $y=(y_1, y_2, \ldots, y_M)$, the production technology set can be defined as follows:

$$S=\{(x, y), x \text{ can produce } y\} \tag{1}$$

We assume this production technology set satisfies a standard set of axioms listed in Färe and Primont (1995). Färe and Primont (1995) show that this technology can also be described using an output distance function, as follows:

$$D_o(x, y)=\min\{\delta: \delta>0, (x, q/\delta)\in S\} \tag{2}$$

where δ is the scalar 'distance' by which the output vector can be deflated. The value of $D_o(x, y)$ will be less than or equal to 1 if the output vector y is an element of feasible technology set S.

C. The Translog Output Distance Function[11]

The translog output distance function is commonly employed in the estimation for the efficiency analysis Equation (3) for F firms producing M outputs and P inputs.

$$\begin{aligned}\ln D_{oi}=&\alpha_0+\sum_{m=1}^{M}\alpha_m \ln y_{mi}+0.5\sum_{m=1}^{M}\sum_{n=1}^{M}\alpha_{mn}\ln y_{mi}\ln y_{ni}+\sum_{p=1}^{P}\beta_p \ln x_{pi}\\ &+0.5\sum_{p=1}^{P}\sum_{j=1}^{P}\beta_{pj}\ln x_{pi}\ln x_{ji}+\sum_{p=1}^{P}\sum_{m=1}^{M}\gamma_{pm}\ln x_{pi}\ln y_{mi}\end{aligned} \tag{3}$$

$$i=1, 2, \cdots\cdots, N$$

In order to meet the constraints on homogeneity of degree one in outputs and restriction of symmetry, the following conditions should be satisfied.

$$\sum_{m=1}^{M}\alpha_m=1, \textit{ and } \sum_{m=1}^{M}\alpha_{mn}=0\,(m=1,2,\ldots,M), \textit{ and } \sum_{m=1}^{M}\gamma_{pm}=0\,(p=1, 2,\ldots,P)$$

[11] The explanation given in this section essentially follows Yao and Jiang (2007).

$\alpha_{mn}=\alpha_{nm}(m, n=1, 2, ..., M)$, *and* $\beta_{pj}=\beta_{jp}(p, j=1, 2, ..., P)$

The homogeneity condition can be imposed by normalizing the output distance function for one of the outputs. We choose the M^{th} output for normalization. Equation (3) can then be transformed as the following equation.

$$\ln D_{oi}/y_{Mi}=\alpha_0+\sum_{m=1}^{M-1}\alpha_m \ln y^*_{mi}+0.5\sum_{m=1}^{M-1}\sum_{n=1}^{M-1}\ln y^*_{mi}\ln y^*_{ni}+\sum_{p=1}^{P}\beta_p \ln x_{pi}$$
$$+0.5\sum_{p=1}^{P}\sum_{j=1}^{P}\beta_{pj}\ln x_{pi}\ln x_{ji}+\sum_{p=1}^{P}\sum_{m=1}^{M-1}\gamma_{pm}\ln x_{pi}\ln y^*_{mi} \tag{4}$$

where $y^*_{mi}=y_{mi}/y_{Mi},\ y_{ni}=y_{ni}/y_{Mi}$

Moving $\ln D_{oi}$ from the left hand side of Equation (4) to the right hand side and reinterpreting it as a traditional SFA disturbance term with a noise (v_i) and technical inefficiency (u_i), the equation then becomes the following:

$$-\ln y_{Mi}=\alpha_0+\sum_{m=1}^{M-1}\alpha_m \ln y^*_{mi}+0.5\sum_{m=1}^{M-1}\sum_{n=1}^{M-1}\alpha_{mn}\ln y^*_{mi}\ln y^*_{ni}+\sum_{p=1}^{P}\beta_p \ln x_{pi}$$
$$+0.5\sum_{p=1}^{P}\sum_{j=1}^{P}\beta_{pj}\ln x_{pi}\ln x_{ji}+\sum_{p=1}^{P}\sum_{m=1}^{M-1}\gamma_{pm}\ln x_{pi}\ln y^*_{mi}+v_i-u_i \tag{5}$$

This function is slightly modified by transforming the left hand side of the equation to become $\ln y_{Mi}$ rather than $-\ln y_{Mi}$. A multi-output distance function such as Equation (5) contains outputs as regressors and hence there is the possibility of simultaneous equation bias. Coelli and Perelman (1996) argued, however, that output ratios may be assumed to be exogenous, since the distance function is defined for radial (proportional) expansion of all outputs, given the input levels, and, by definition, the output ratios are therefore held constant for each firm.[12]

[12] Berger *et al.* (1987) develops the methodology for evaluating the effects of changing product mix on costs and competitive viability of firms. In order to implement this methodology, input costs information is necessary, but those data such as average annual salaries including fringe benefits paid to all employees and rental cost to office space are not available both in Japan and

We have estimated modified Equation (5) as defined in a later section using the Maximum Likelihood methods, based on the usual distributional assumption for the v_f and u_f terms, as in Battese and Coelli (1995).

The baseline empirical specification of our model is provided in Equation (6). The model is a direct application of the model in Battese and Coelli (1995) for unbalanced panel data which has firm effects which are assumed to be distributed as truncated normal random variables, which are permitted to vary systematically with time. Time variable is included as one of the inputs to account for technical progress (TP). TP is the improvement of the underlying production technology and the improvement of Total Factor Productivity (TFP) is defined as the sum of improvements of technical efficiency and technical progress.

$$-\ln y_{Mit} = \alpha_0 + \sum_{m=1}^{M-1} \alpha_m \ln y^*_{mit} + 0.5 \sum_{m=1}^{M-1}\sum_{n=1}^{M-1} \alpha_{mn} \ln y^*_{mit} \ln y^*_{nit} + \sum_{p=1}^{P} \beta_p \ln x_{pit}$$

$$+ 0.5 \sum_{p=1}^{P}\sum_{j=1}^{P} \beta_{pj} \ln x_{pit} \ln x_{jit} + \sum_{p=1}^{P} \beta_{ptime}\, time \cdot \ln x_{pit} + \beta_{time}\, time + v_{it} - u_{it}$$

$$i = 1, 2, \cdots\cdots, N \qquad (6)$$

where the v_{it}'s are random variables which are assumed to be iid. $N(0,\ \sigma_v^2)$ and independent of the u_{it}'s $= u_i exp(-\eta(\tau - T))$ where the u_i's are non-negative random variables which are assumed to account for technical efficiency in production and are assumed to be independently distributed as truncations at zero of the $N(\mu,\ \sigma_u^2)$ distribution.

IV. Data

The study is based on a dataset of the 107 Japanese banks for the period of 1991-2004, and 14 Korean banks for the period of 1991-2005. The data source for the Japanese bank financial statements is Nikkei Financial Quest. Our data set includes commercial banks and excludes "specialized" banks such as trust banks. Commercial banks are categorized into three types: (1) city banks; (2) regional banks;

Korea.

and (3) second-tier regional banks. We have used data from 5 city banks, 61 regional banks, and 41 second-tier regional banks for the estimation. Korean bank financial statements are extracted from KIS Value DB and the missing values are additionally collected from the series of Bank Management Statistics (BOK) and DART website (Korean Financial Supervisory Board). Since the Korean banks underwent a series of M&As in the late 1990s and the early 2000s in the aftermath of the 1997 financial crisis, the number of banks in Korea reduced dramatically from 25 banks to 8 nation-wide commercial banks and 6 regional banks by 2005. Since individual bank data exists for the pre-M&A periods, we have derived the data for the 14 Korean banks by assuming as if the merged banks existed from the beginning of the sample period by summing the separate relevant individual bank statistics for the pre-M&A periods. Japanese bank data exist in the analogous form in the original database.

Among different viewpoints regarding the function of banks provided in Section II, we have selected the following three approaches and respective specifications for inputs and outputs. The sources of the relevant variables are explained below.

(1) Intermediation Approach: this approach specifies three inputs — physical capital ($x1$), labor ($x2$), and total deposits ($x3$) — and two outputs — total loans ($y1$) and securities and investment assets ($y2$).
(2) Value-added Approach: this approach specifies three inputs — physical capital ($x1$), labor ($x2$), and total interest expense ($x4$) — and three outputs — total loans ($y1$), securities and investment assets ($y2$), and deposits ($y3$).
(3) Operating Approach: this approach specifies three inputs — physical capital ($x1$), labor ($x2$), and total interest expense ($x4$)— and two outputs — net interest income ($y4$) and non-interest income ($y5$).

Total deposits, total loans and investment assets, interest expense, and output variables are converted to real terms by using GDP deflator (base year is 1995) in each country and a same currency unit (US \$) by applying financial sector output PPP,[13] respectively.

[13] EU KLEMs project provide the 1997 output PPP estimates for European countries and some selected countries such as USA, Japan and Korea. Based

Labor is the number of employees in each bank multiplied by the average working hours for the banking industry in each country. We have estimated the physical value of capital by applying the perpetual inventory method. For the Japanese banks, we take the 1980 as the benchmark year value of capital stock and each bank's book value for premises and equipment (excluding the book value of land owned) is converted into a real term using an investment deflator. The same approach was taken for the Korean banks, where the benchmark years for individual banks were the year 1980 or the earliest available year. Using the equation below, we then estimate real physical capital stock series.

$$K_t = \sum_{i=1}^{2} (1-\delta_{it}) K_{it-1} + \sum_{i=1}^{2} \frac{NOM_{it}}{PK_{it}}, \tag{7}$$

$$(1=\text{buildings},\ 2=\text{equipment})$$

where K_t is real physical capital, δ_{it} is the depreciation rate for i-type capital goods, NOM_{it} is nominal investment in i-type capital goods, and PK_{it} is the deflator for i-type capital goods at time t. The depreciation rate for each type of capital good in the banking sector is obtained from the JIP 2006 database and has been applied to the capital stocks of banks in both countries. The deflator for each type of capital good is obtained from the JIP 2006 database in Japan and from Bank of Korea Database in Korea, respectively. In addition, we have capitalized the rental payments for land, buildings, and machinery (RF_t) and calculated imputed capital stock (IK_t) based on the equation below.[14]

$$IK_t = \frac{RF_t}{(r_t + \delta_t - \dot{P}_{Kt}/P_{Kt})P_{Kt}} \tag{8}$$

where r_t is long-term interest rate, δ_t is the average depreciation rate for the banking sector, and P_{Kt} is the average deflator for capital goods at time t. Since the Korean bank data provides limited

on this 1997 PPP estimates, we have estimated 1995 PPP by adjusting for the change in GDP deflator differential between Japan and Korea.

[14] We have not taken into account the tax effect on capital service price in this study.

samples of rental fee figures, the missing values for the rental fees were estimated using regression estimates of rental fees on the number of total branches. Finally, our physical capital stock used in the estimation is then obtained as follows: $x3_t = K_t + IK_t$.

V. Estimation Results

We have selected following three approaches — intermediation approach, value-added approach, and operating approach — for this study to investigate the performance of banks viewing from different perspectives. Since different inputs and outputs are specified for each approach, we predict that the empirical results may or may not result in similar findings amongst different approaches.

Tables 1 through 3 provide the maximum likelihood method estimates under the intermediation approach, value-added approach, and operating approach, respectively. Each table contains two sample results: full sample and restricted sample estimates. Since Korea has experienced an exceptionally turbulent period immediately after the 1997 financial crisis, the restricted sample drops the period of 1997-1999 from the Korean sample. The estimates are strongly significant in all regressions and the estimates for both the unrestricted and the restricted samples do not differ significantly in most cases. The estimated coefficients for the output variables under all approaches show the correct signs implied by the model. The marginal impact of each input variable can be calculated by differentiating with respect to each input and we find that the estimated marginal impacts are all correctly signed. To avoid the anomalies during the 1997 financial crisis period for Korea affecting our results, we have taken the restricted sample results to calculate the main efficiency and productivity measures in what follows.

The changes in TP are calculated from differentiating the Equation (6) with respect to time and attaching a negative sign (since the right-hand side of Equation (6) is the output distance function). The changes in TP and TFP are calculated as follows.

$$\Delta TP/TP = -\sum_{p=1}^{P} \hat{\beta}_{ptime} \ln x_{pit} - \hat{\beta}_{time} \tag{9}$$

$$\Delta TFP/TFP = \Delta TP/TP + \Delta TE/TE \tag{10}$$

TABLE 1

STOCHASTIC FRONTIER ESTIMATION: INTERMEDIATION APPROACH

	Full Sample		Restricted Sample	
	Estimate	*t*-ratio	Estimate	*t*-ratio
const	-84.771	(-84.642)	-73.767	(-72.035)
*y*2s	0.153	(24.605)	0.156	(26.666)
*x*1	-4.646	(-4.118)	8.146	(5.243)
*x*2	0.411	(0.678)	5.220	(7.075)
*x*3	9.870	(8.826)	-6.791	(-3.951)
*x*1**x*2	-0.032	(-3.453)	-0.045	(-4.562)
*x*1**x*3	0.022	(4.098)	0.037	(6.998)
*x*2**x*3	0.016	(1.743)	0.035	(3.837)
time	0.043	(65.514)	0.039	(58.468)
*x*1**time*	0.002	(4.217)	-0.004	(-4.995)
*x*2**time*	0.000	(-0.716)	-0.003	(-6.928)
*x*3**time*	-0.006	(-10.088)	0.003	(3.005)
sigma-sq	0.012	(14.374)	0.021	(27.978)
gamma	0.748	(34.324)	0.876	(124.602)
mu	0.188	(15.179)	0.272	(15.255)
eta	-0.020	(-3.821)	-0.015	(-6.604)
Log likelihood function		2257.557		2380.707
LR test		915.623		896.483
(with number of restrictions)		(3)		(3)
Number of cross-sections		120		120
Number of years		15		15
Total number of observations		1688		1688

Note: Intermediation Approach specifies three inputs — physical capital (*x*1), labor (*x*2), and total deposits (*x*3) — and two outputs — total loans (*y*1) and securities and investment assets (*y*2).

Tables 4-6 and Figures 1-3 provide average annual rates of changes in technical progress (TP), in technical efficiencies (TE), and in TFP of each respective country's banks by three sub-periods based on the estimates from the restricted samples in Tables 1-3.

The intermediation approach in Table 4 shows us that the TP and TE growths have been mildly negative for Japan, resulting in negative TFP growth (-0.52% in the final sub-period) for Japan throughout the sample period. As for Korean banks, TP growth has been positive for the pre-crisis period, but has turned to become

TABLE 2

STOCHASTIC FRONTIER ESTIMATION: VALUE-ADDED APPROACH

	Full Sample		Restricted Sample	
	Estimate	*t*-ratio	Estimate	*t*-ratio
const	-781.792	(-783.183)	-905.122	(-906.432)
*y*2s	0.104	(5.005)	0.089	(4.303)
*y*3s	0.580	(6.574)	0.556	(6.168)
*y*2s**y*3s	0.109	(1.669)	0.093	(1.379)
*x*1	-9.753	(-10.224)	-19.362	(-20.308)
*x*2	73.181	(131.565)	83.069	(136.579)
*x*4	-13.405	(-8.578)	-17.544	(-10.735)
*x*1**x*2	0.064	(7.190)	0.069	(7.792)
*x*1**x*4	0.053	(6.880)	0.038	(5.115)
*x*2**x*4	-0.090	(-9.698)	-0.074	(-8.101)
time	0.393	(573.587)	0.454	(668.368)
x1**time*	0.004	(8.675)	0.009	(18.348)
x2**time*	-0.037	(-129.081)	-0.042	(-132.737)
x4**time*	0.007	(9.611)	0.009	(11.762)
sigma-sq	0.073	(21.656)	0.047	(10.219)
gamma	0.888	(98.437)	0.812	(39.788)
mu	0.509	(12.709)	0.391	(11.014)
eta	0.028	(14.536)	0.027	(10.950)
Log likelihood function		1262.530		1309.830
LR test		1502.842		1341.106
(with number of restrictions)		(3)		(3)
Number of cross-sections		120		120
Number of years		15		15
Total number of observations		1688		1646

Note: Value-added Approach specifies three inputs — physical capital (*x*1), labor (*x*2), and total interest expense (*x*4) — and three outputs — total loans (*y*1), securities and investment assets (*y*2), and deposits (*y*3).

negative after the crisis, resulting in negative TFP growth for the final sub-period (-0.68% TFP growth for the final sub-period). One surprising finding is that the most of the negative TFP growth has been driven by the changes in TE growth for this final sub-period. The findings suggest that the deregulations in Japan have not had any significant influence in improving the productivity of the

TABLE 3

STOCHASTIC FRONTIER ESTIMATION: OPERATING APPROACH

	Full sample		Restricted Sample	
	Estimate	*t*-ratio	Estimate	*t*-ratio
const	-708.277	(-708.179)	-751.351	(-748.562)
*y*5s	0.161	(14.215)	0.169	(14.864)
*x*1	19.816	(17.204)	21.624	(12.847)
*x*2	58.053	(62.126)	59.461	(50.364)
*x*4	-46.416	(-37.638)	-45.468	(-36.572)
*x*1**x*2	0.095	(14.356)	0.098	(14.160)
*x*1**x*4	-0.034	(-6.678)	-0.032	(-6.042)
*x*2**x*4	-0.049	(-7.560)	-0.057	(-8.330)
time	0.358	(623.967)	0.380	(654.975)
*x*1**time*	-0.011	(-17.712)	-0.012	(-13.272)
*x*2**time*	-0.029	(-62.280)	-0.030	(-50.576)
*x*4**time*	0.023	(40.040)	0.023	(39.237)
sigma-sq	0.052	(20.554)	0.060	(15.766)
gamma	0.877	(90.673)	0.899	(101.889)
mu	0.409	(13.693)	0.427	(13.211)
eta	-0.143	(-26.145)	-0.135	(-21.051)
Log likelihood function		1650.107		1641.195
LR test		1101.814		1108.996
(with number of restrictions)		(3)		(3)
Number of cross-sections		120		120
Number of years		15		15
Total number of observations		1688		1646

Note: Operating Approach specifies three inputs — physical capital (*x*1), labor (*x*2), and total interest expense (*x*4) — and two outputs — net interest income (*y*4) and non- interest income (*y*5).

Japanese banks in intermediating funds in the financial system. The negative TFP growths in the final sub-period for the Korean banks may have been due to the transitional process after the numerous M&A's during the early 2000s. The real effect of M&A is yet to been been mildly positive for Japan for all periods. Korean case illustrates a very much similar pattern. The most of the TFP growth dynamics are driven by the changes in TP growth for the both country banks. Contrary to the intermediation approach, the findings imply that the deregulations in Japan and capital market liberalization in Korea may have continuously been contributing to the positive productivity

TABLE 4
AVERAGE ANNUAL CHANGES IN TECHNICAL PROGRESS, TECHNICAL EFFICIENCY, AND TFP BY SUB-PERIODS (BASED ON INTERMEDIATION APPROACH ESTIMATES UNDER RESTRICTED SAMPLE)

(percent)

	1992-1996	1997-2000	2001-2004
*d*log*TP* (Japan)	-0.172	-0.130	-0.154
*d*log*TE* (Japan)	-0.325	-0.348	-0.366
*d*log*TFP* (Japan)	-0.497	-0.477	-0.520
	1992-1996	1997-2000	2001-2005
*d*log*TP* (Korea)	0.204		-0.031
*d*log*TE* (Korea)	-0.567		-0.646
*d*log*TFP* (Korea)	-0.363		-0.677

TABLE 5
AVERAGE ANNUAL CHANGES IN TECHNICAL PROGRESS, TECHNICAL EFFICIENCY, AND TFP BY SUB-PERIODS (BASED ON VALUE-ADDED APPROACH ESTIMATES UNDER RESTRICTED SAMPLE)

(percent)

	1992-1996	1997-2000	2001-2004
*d*log*TP* (Japan)	7.460	7.971	8.383
*d*log*TE* (Japan)	1.830	1.618	1.443
*d*log*TFP* (Japan)	9.289	9.590	9.826
	1992-1996	1997-2000	2001-2005
*d*log*TP* (Korea)	11.110		8.893
*d*log*TE* (Korea)	0.484		0.373
*d*log*TFP* (Korea)	11.593		9.266

enhancements when we expand the bank's output to include deposits as well as loans and services. seen in this dimension.

The value-added approach in Table 5 shows that the TP and TFP growth have been persistent and strong while the TE growths have The calculations based on the operating approach in Table 6 show a very distinguishing picture for the both country banks. The TP and

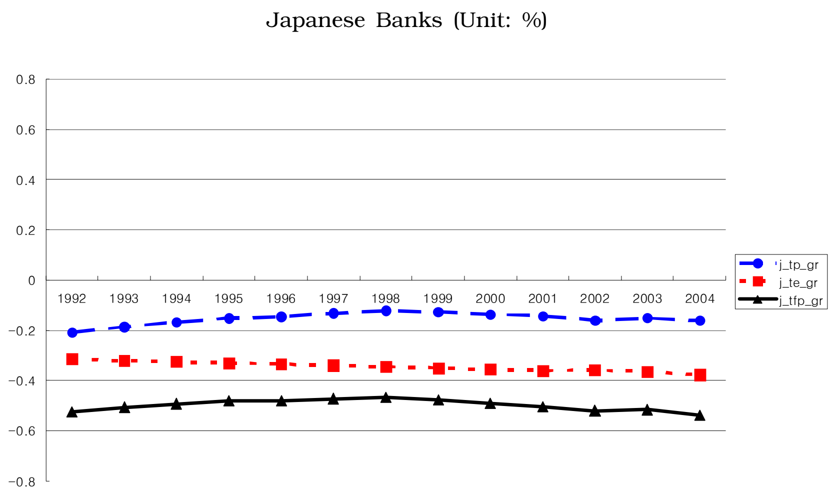
TABLE 6

AVERAGE ANNUAL CHANGES IN TECHNICAL PROGRESS, TECHNICAL EFFICIENCY, AND TFP BY SUB-PERIODS (BASED ON OPERATING APPROACH ESTIMATES UNDER RESTRICTED SAMPLE)

(percent)

	1992-1996	1997-2000	2001-2004
*d*log*TP* (Japan)	1.037	3.551	5.974
*d*log*TE* (Japan)	-1.050	-1.914	-3.277
*d*log*TFP* (Japan)	-0.012	1.637	2.697
	1992-1996	1997-2000	2001-2005
*d*log*TP* (Korea)	1.712		0.003
*d*log*TE* (Korea)	-2.419		-7.927
*d*log*TFP* (Korea)	-0.706		-7.925

TFP growths for Japanese banks have risen strongly (5.974% for TP and 2.697% for TFP growth in the final period) while TE growth has declined throughout the sample period. As for the Korean banks, strong negative TE growth (-7.927%) account for the strong negative TFP growth in final sub-period (-7.925%). This implies that when we consider banks as a business unit generating revenues based on incurred costs, Japanese banks have been improving their productivity throughout 1990s and 2000s. Although technical efficiency has been declining throughout the period, the strong increase in technical progress dominated the productivity growth. As for the Korean banks, the results are very much similar to those of the intermediation approach. There has been a slowdown in technical progress and technical efficiency change has been negative following the series of bank mergers of the late 1990s and early 2000s. This is striking since the mergers have been targeted to increase the profitability of the banks from economies of scale. We may understand this lack of productivity effect by considering a slow transition of banks to adjust to the new environment created by the mergers.



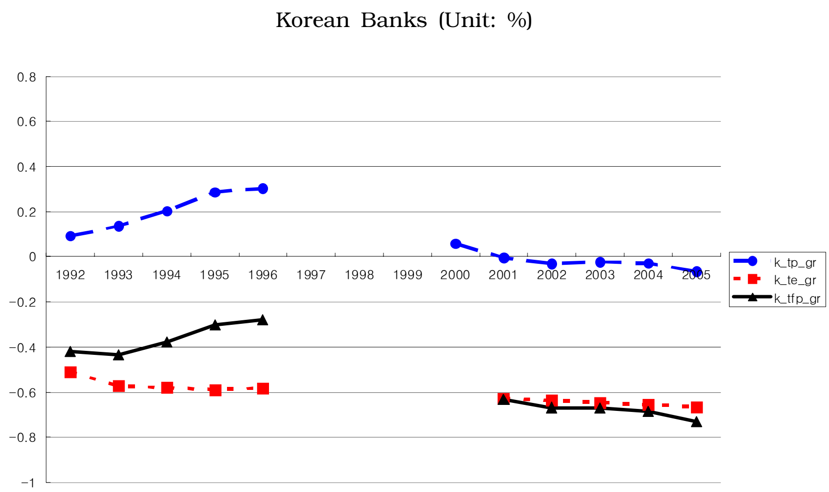
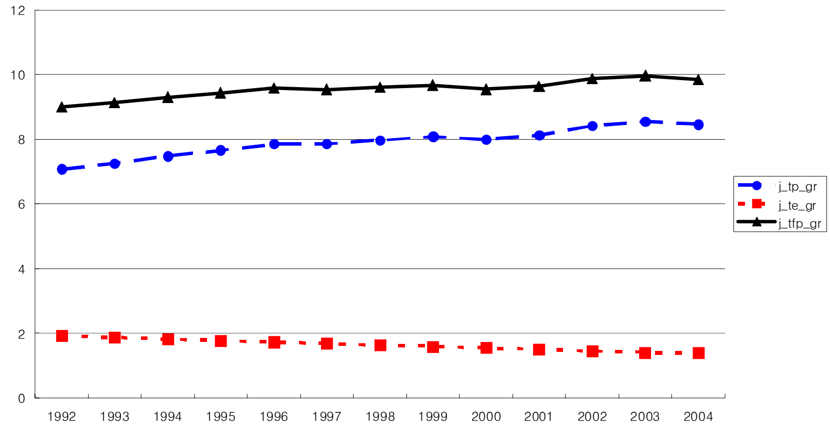


FIGURE 1

ANNUAL GROWTH RATES OF TP, TE, TFP FOR JAPANESE AND KOREAN BANKS (INTERMEDIATION APPROACH UNDER RESTRICTED SAMPLE)

Japanese Banks (Unit: %)



Korean Banks (Unit: %)

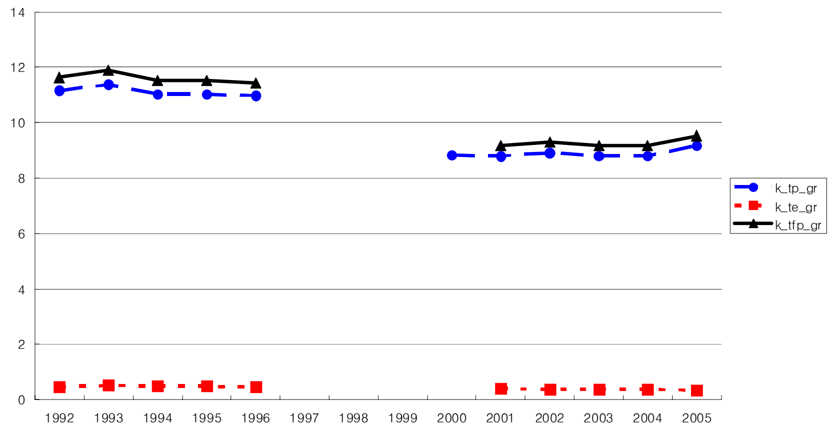


FIGURE 2

ANNUAL GROWTH RATES OF TP, TE, TFP FOR JAPANESE AND KOREAN BANKS (VALUE-ADDED APPROACH UNDER RESTRICTED SAMPLE)

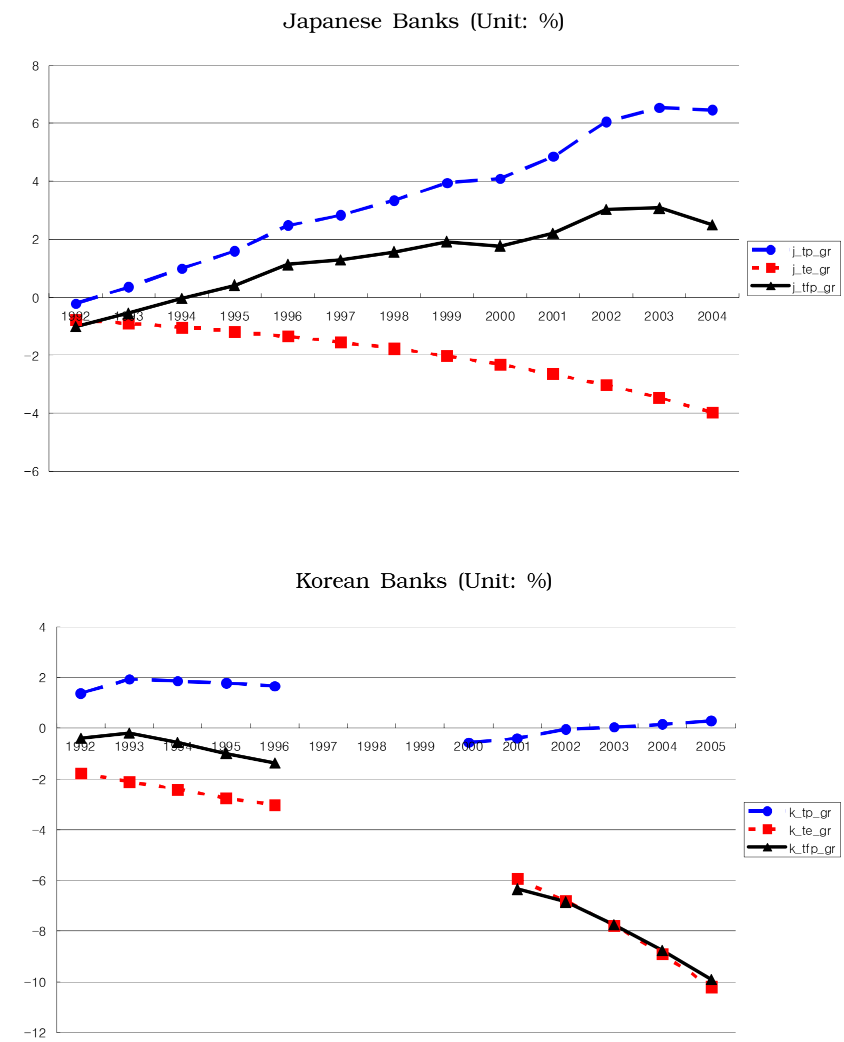


FIGURE 3

ANNUAL GROWTH RATES OF TP, TE, TFP FOR JAPANESE AND KOREAN BANKS
(OPERATING APPROACH UNDER RESTRICTED SAMPLE)

Our findings depart from the findings of Fukuyama and Weber (2002) for the case of Japanese banks where the productivity declined about 2% annually. Our findings are also distinguished from that of Park and Weber (2006) for the Korean bank case where the efficiency decline was said to be offset by the increase in technical progress.

Figures 4-6 compare the TE between Japanese and Korean banks based on restricted sample estimates under the three different approaches. The graphs show how much each country's banks have lagged behind the technological frontier dictated by the estimated stochastic frontier. The parameters of the stochastic frontier are common to all the banks, but each individual bank's actual frontier is also influenced by the levels of input variables as shown in Equation (6). Therefore, we need to interpret the derived TE estimates as the TE with respect to each individual bank's own technological frontier. We notice that under intermediation and operating approaches, Korean banks' technical efficiency levels have lagged further behind than those of the Japanese banks. Furthermore, the TE has been declining over the whole period, substantially more in the Korean case. However, the value-added approach estimates indicate the reverse. Both countries' TEs have been rising for the whole period and Korean banks closer than Japanese banks to the respective production frontier.

VI. Conclusion

The goal of this study was to investigate the productivity of the banking sector at the firm level using the stochastic frontier approach. Since banks are known to produce multiple outputs, we have taken output distance function method and appropriately modified it to apply stochastic frontier approach. As we have taken pooled dataset of Japanese and Korean banks, the comparison between Japanese and Korean banking efficiency was also possible.

Our results indicate that growth rates of technical progress, technical efficiency, and TFP calculated from the estimates of various empirical models depend very much on what we think the true function of bank is: intermediation approach, value-added approach, or operating approach in our study. Intermediation approach results are very much consistent with the traditional view that the

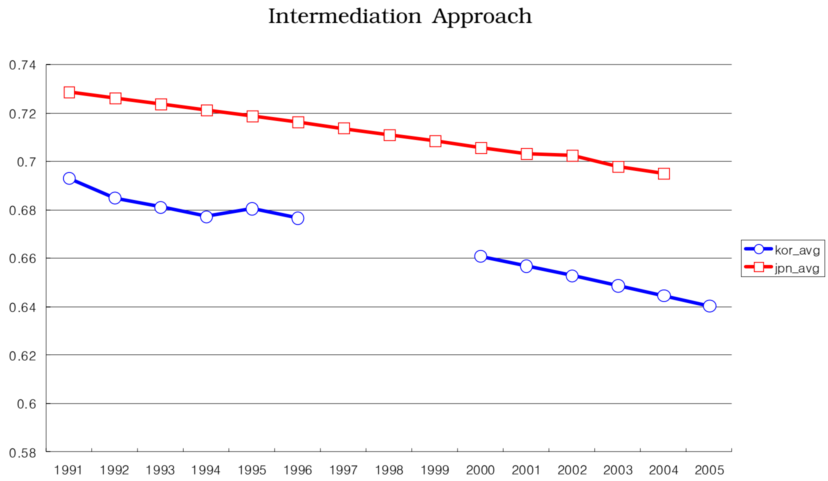


FIGURE 4

COMPARISON OF TECHNICAL EFFICIENCY BETWEEN JAPANESE AND KOREAN BANKS (INTERMEDIATION APPROACH UNDER RESTRICTED SAMPLE)

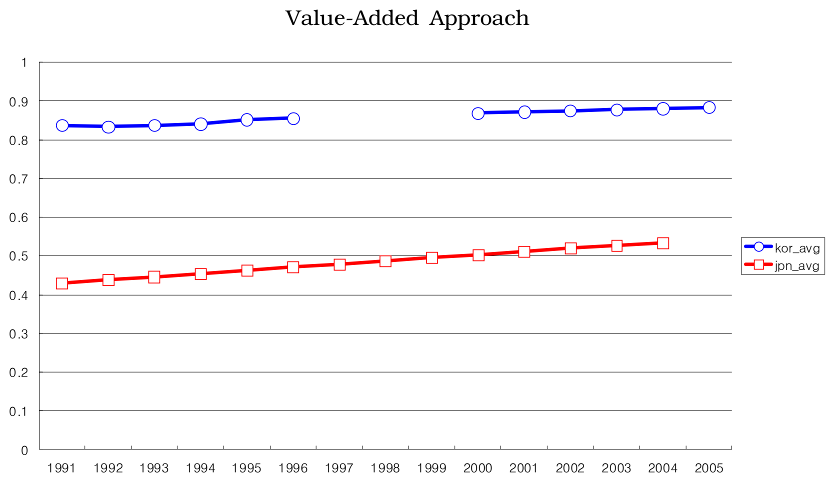


FIGURE 5

COMPARISON OF TECHNICAL EFFICIENCY BETWEEN JAPANESE AND KOREAN BANKS (VALUE-ADDED APPROACH UNDER RESTRICTED SAMPLE)

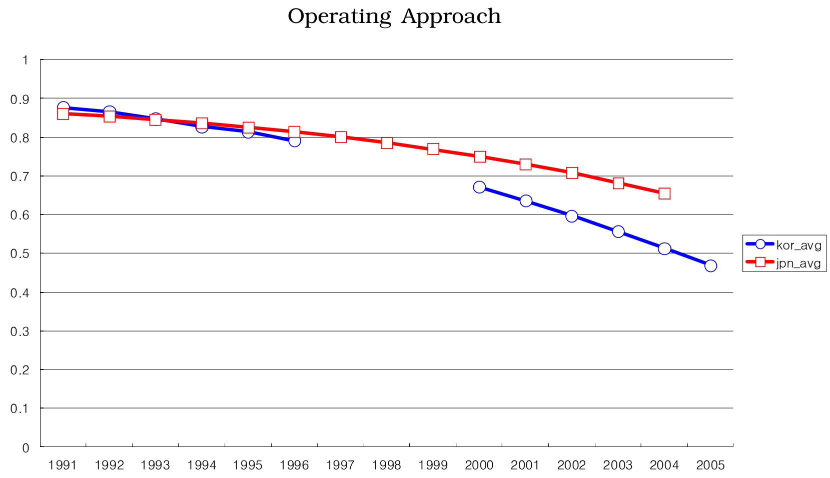


FIGURE 6

COMPARISON OF TECHNICAL EFFICIENCY BETWEEN JAPANESE AND KOREAN BANKS (OPERATING APPROACH UNDER RESTRICTED SAMPLE)

productivity has overall declined over the sample period we are considering. On the other hand, operating approach results indicate that the productivity and TFP gains in Japanese banks have increased significantly over time, while the negative and declining technical efficiency has driven down the TFP growth for the Korean case. Value-added approach results imply that there has been strong TFP growth for both country banks due to technical progress. Technical efficiency levels are further behind the technological frontier for the Korean banks than for the Japanese banks when we take intermediation or operating approaches.

In all approaches, this study finds that the efficiency and productivity growths have been generally greater for the Japanese banks than the Korean banks between the period of 1991 and 2005. Identifying the factors causing these differences in patterns will be an interesting issue for the future research.

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Comments and Discussion

*Comments by Dong Jin Shin**

This study compares the pattern of change between Japanese and Korean Banking efficiency for the period of 1991-2004. The study is meaningful, because it is the first research to undertake a comparison of efficiencies between the two countries. Especially, methodology of the paper is advanced.

Considerations:

1. The purpose of the study should be more specific.
2. For better understanding of the paper it is appropriate to define the technical efficiency.
3. It is important how the bad loans to be characterized and controlled. Non-performing loan of Korean banking industry was accelerated by the economic crisis as "bad luck" (p. 4). This can affect the research results significantly. Non-performing loan must be controlled for the quality in assessing banking efficiency.
4. The noise (Vi, p. 9, Equation 5) as crisis or hard bank restructuring (exit and M&A) can affect the technical inefficiency in two ways. (See, p. 30, Figure 2-B, and p. 32, Figure 3-B, Korean Banks from 1997 to 1999).

   (a) If the noise (Vi) is not independent of technical inefficiency (Ui), then the noise can affect the technical inefficiency.
   (b) Although the noise is independent of Ui, when Vi is greater than Ui, the observed output can be greater than the stochastic frontier.

Therefore it must be taken into consideration.

5. Technical efficiency (Constant Return to Scale: CRS) consists of

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pure technical efficiency (Variable Return to Scale: VRS) and scale efficiencies. Size differences between Japanese and Korean banks can affect the differences of technical efficiency. This must be taken into consideration.

Dataset and Research results:

6. It must be clarified, why the annual growth rates of technical efficiency of Korean banks reached the maximum and minimum at the same year, 1998, although the approach is different.
7. Because the periods of bank restructuring in Japan and Korea are not coincident, it is proper to extend target period from 1989 to 2006.
8. It must be clarified, why estimation results in the sub-sample of the Korean Case fall out of a reasonable range, because the same dataset can affect the results of the full-sample regression.
9. The results of sub-sample regression (p. 26) and figure 2-B and 3-B indicate that it is necessary to include country-specific dummy variable for Korea.
10. The comparison of sub-sample regression between Japanese and Korean banks can not be used to support the results of the full-sample regression because of the own nation-specific frontiers in sub-sample regression.

*Comments by Jung Bum Wee**

A. Overall Evaluation

This paper analyzes technical progress and efficiency of both Japanese and Korean banks during recent 14 years. It helps assess the effect of financial reforms in these countries. An international comparison is also feasible because these countries experienced similar financial reforms process during the period.

In addition, for Japanese banks, it is interesting to focus on the changes after the burst of bubble. Regarding Korean banks, this kind of work has been awaited for a long time. It is now possible to carry a reliable empirical test, using the data accumulated for about 10 years after the financial crisis.

However, the paper still needs much works. Since the main implication is somewhat striking, please make efforts to convince the readers by checking the robustness of the result in various ways. In addition, pay more attention to details.

B. Detailed Comments

a) Different Approach

This paper suggests that there have been technical progresses to some extent in the banking industries in both countries. However, total factor productivities decreased because of negative changes in technical efficiencies.

The implied inefficient use of inputs is disappointing since the reform measures were aimed at the contrary. Before making any definite evaluation about the reforms, I would like suggest the authors to strengthen reliability of the results. For instance, other approaches which consider deposits as outputs are worth while to pursue. Empirical results often depend on how deposits are counted.

b) Control for the Crisis Phenomena

The estimated technical efficiency of Korean banks moves sharply up and down during 1997-2000, in model B of each. (Figure 2-B, Figure 3-B)

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However, this might not reveal the “authentic” changes in technicality. It could reflect the jobs and expense related with bad debts and restructuring as well as the drastic changes in the loans and assets or the market interest rates. These were heavily influenced by the exogenous factors such as government actions. (Page 4)

c) Radial Expansion as a Limit of the Paper:

This paper assumes radial (proportional) expansion of all outputs, and, therefore, the outputs ratios are held constant. (Page 9)

I wonder if there is a way to consider the actual expansion path. Berger *et al.* suggests a measure to consider the expansion path in a model which includes the price vectors of the inputs and outputs. (Berger, Allen N, Hanweck, G. A., and Humphrey, David B. “Competitive Viability in Banking: Scale, Scope, and Product Mix Economies.” *Journal of Monetary Economics* 20 (1987): 501-20)

d) Editorial

1) Please, be friendly to readers. For instance, add the definitions or descriptions of technical progress, technical efficiency, and total factor productivity.
2) Line 17, page 7: “increasing” -> “increasingly”
3) Line 8, page 11: “from from” -> “from”
4) Page 13: An equation is missing? The changes in technical efficiency (TE) = $\Delta TE/TE$.
5) Line 18, page 14: “from for” -> “for”
6) All the tables: Please, put asterisks to the estimates, that denotes the level of significance.