Efficiency, Productivity Growth and Profitability of Korean Banks

Kang H. Park and William L. Weber *

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* Southeast Missouri State University, USA

All correspondence to Kang H. Park, Professor of Economics, Southeast Missouri State University, Cape Girardeau, MO 63701, Tel: 573-651-2942, Fax: 573-651-2947, e-mail: khpark@semo.edu

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In this paper we present estimates of efficiency, productivity change and profitability in Korean banking for the period of 1992-2002 when the Korean banking system experienced financial liberalization, financial crisis and restructuring. The estimates for efficiency and productivity change of individual banks and the banking industry as a whole are derived from the directional technology distance function. Our method allows the aggregation of individual bank efficiency and productivity growth to the industry level. This method also controls for loan losses (non-performing loans) that are an undesirable by-product arising from the production of loans. These two features of our paper, aggregation of efficiency and productivity measures from the firm to the industry level and the modeling of desirable and undesirable bank outputs, are our unique contribution to the study of the Korean banking system.

Our findings indicate that in the years before the Asian financial crisis, inefficiency in the Korean banking system increased dramatically. Although the banking system as a whole became less efficient throughout the period, technical change which can be thought of as shifting the production technology in a welfare enhancing direction was more than enough to offset efficiency declines so that the banking system experienced overall productivity growth. Weakening financial intermediation of Korean banks might be the result of their efforts to increase productivity growth in the face of efficiency declines. This paper also identifies the major determinants of profitability in the Korean banking sector. The results indicate that bank efficiency has a significant effect on bank profitability and support the efficient structure hypothesis. We also find that the major determinants of bank profitability in Korea changed between pre- and post-Asian financial crisis periods.

JEL classification: G21
Key words: bank efficiency, bank productivity, bank profitability, Korean banking

Ⅰ. Introduction

The Korean banking system underwent financial liberalization, financial crisis and restructuring during 1992-2002. At the same time, there was a considerable change in the composition of bank assets, and the Korean banking system experienced weakening its financial intermediation function after the financial crisis of 1997-1998. As a percent of total bank assets, commercial loans averaged 33.5% in the years 1992-96 before the Asian financial crisis, but averaged only 27% of total assets in the years 1999-2002 following the crisis. Personal loans and securities grew from an average of 5% and 16% of total assets, respectively, in the years before the crisis to 14% and 26%, respectively, in the years following the financial crisis. In this paper we examine how financial liberalization, financial crisis and restructuring affected efficiency, productivity growth and profitability of the Korean banking system for the period of 1992-2002.

In measuring bank efficiency and productivity growth we address certain empirical problems that have been encountered in bank efficiency studies. First, measures of technical efficiency that are estimated using Shephard (1974) output or input distance functions are not additive from the bank to the industry level. Thus, estimates of mean bank efficiency and its change over time provide minimal insight into industry performance. To address this problem, we use the directional technology distance function, which Färe and Grosskopf (2004) have shown can be aggregated to an industry measure of performance. Second, the fact that some bank loans become non-performing and are eventually written off requires an efficiency measure that can account for both desirable outputs, such as bank loans and security investments, and undesirable by-products, such as non-performing loans. Again, the directional technology distance function is capable of modeling efficiency for firms that simultaneously produce desirable outputs and undesirable outputs.

We have panel data consisting of between fourteen and twenty-six banks for the period 1992-2002, so we also measure productivity growth and its decomposition into growth due to greater efficiency and growth due to technical change. Our measures of productivity growth can also be aggregated to the industry level. Many studies of firm productivity growth yield estimates of technical regress from period to period. The measured technical regress is usually thought to be an artifact of the method that defines the frontier. For example, when data envelopment analysis (DEA) is used to construct the production frontier, firms that exhibit the best-practice output-input combination define the frontier in a given period and are technically efficient. If those same firms produce less output or use more input in a subsequent period but still define the frontier, the inward shift of the frontier is denoted as technical regress, when it more logically could be deemed lower efficiency. In their examination of labor productivity growth across countries, Kumar and Russell (2002) measure technical regress for some countries that have low capital-labor ratios and state that the "best-practice" frontier constructed by the DEA technique is well below the "true" but unobservable frontier at very low capital-labor ratios and therefore that the apparent technological degradation at these low levels of capitalization are in fact efficiency declines.

We address this problem in our model by specifying a current period technology that depends on current observations of inputs and outputs and the input-output combinations from all preceding periods. Specifying the production technology in this manner means that our method will rule out technical regress as a source of productivity decline. Instead, should productivity declines occur, our method will assign those declines as arising from less efficiency. However, our method still does not measure efficiency relative to the true, but unobservable technology, but instead constructs the technology given the best-practice techniques of observed banks.

In the next section we provide a brief review of the Korean banking system, 1992-2002 including financial liberalization, the event that occurred prior to the Asian financial crisis, and subsequent post-crisis reforms. Studies of Korean bank efficiency and profitability are reviewed in section 3. In section 4 we present the method used to estimate efficiency and productivity growth. In section 5 we describe the data and estimates of Korean banking system efficiency (or inefficiency) and productivity growth. In section 6 two competing hypotheses explaining bank profitability are briefly discussed. Section 7 describes the data and estimates of Korean bank profitability and tests the two competing hypotheses. Estimates of bank inefficiency obtained in section 5 are used as X-inefficiency in explaining bank profitability in section 7. In the final section we offer a summary of our work and draw conclusions.

Ⅱ. Liberalization, Crisis, and Restructuring in the Korean Banking System

In response to pressure from the OECD and the US to open its financial markets, Korea began a series of revisions to the General Banking Act during 1991 to 1997. Interest rates were deregulated, policy loans and other credit controls were eliminated, reductions in non-performing loans were targeted, foreign exchange market transactions were deregulated, and bank ownership was restructured to allow individual shareholders up to a 12% equity stake.

The 1991 to 1997 reforms allowed Korean banks easier access to foreign capital without government approval and supervision, a fact that some observers attribute as a major cause of the Korean currency crisis of 1997-1998. Furthermore, a long period of recession and low domestic interest rates in Japan led to an influx of foreign capital to Asian countries. Contributing to the over-lending to Korean banks and firms was a moral hazard effect, as foreign lenders perceived explicit or implicit loan guarantees. A lack of appropriate supervision and regulation also allowed serious asset-liability mismatches to develop as long-term domestic loans were financed through short-term foreign borrowing, with short-term foreign debt accounting for up to 65% of total foreign debt. Similar mismatches in the duration of loans and deposits caused the Savings and Loan Association Crisis of the 1980s in the US (Saunders, 2000).

The excessive borrowing by Korean banks financed investment in tradable goods by Chaebols, causing overcapacity in sectors such as automobiles and micro-chips, resulting in low profits and subsequent bad loans. According to Corsetti, Pesenti and Roubini (1999), evidence of risky overinvestment was seen in the high rate of non-performing loans and high leverage ratios of the corporate sector in the Asian countries that experienced the currency crisis. As non-performing loans increased, foreign creditors became less willing to refinance, igniting speculative attacks. In Korea, non-performing loans as a share of total loans reached 16% in June 1997 and then 22.5% in the first quarter of 1998 (Park, 2003).

The financial crisis of 1997-1998 brought about a significant transformation in the banking sector in Korea as the government carried out a two-stage financial restructuring. 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, inducements for foreign capital injections were given to seven banks, and public funds were used to normalize operations at the remaining surviving banks. Korean banks responded with cost reductions and the fastest disposal rate of non-performing loans among the Asian countries suffering the currency crisis.

The second stage of restructuring began in June 2000 and focused on restoring bank profitability. Financial holding companies were created to make merger and acquisition easier and help banks realize scale economies. Although bank concentration increased as nationwide banks gained market share in deposits and loans at the expense of regional banks, a study by the IMF (2001) found that Korean bank concentration was still not high relative to other OECD countries. The reforms also promoted market accounting methods and loan loss provisioning rules, and required equity capital injections into those banks affected by the recognition of loan losses. As a consequence of the equity capital injections government ownership increased from less than 18% of total bank capital to over 56% of total bank capital. Foreign ownership of banks also increased to about 30% of Korean bank assets as foreign equity capital limits were eliminated.

Although Korean banks are more focused on profitability the government still is engaged in credit allocation. Loan portfolios have shifted away from corporate loans toward household loans in response to government stimulants to domestic consumption to compensate for the reduction in exports. Increased bank competition for household loans accompanied by easy financing resulted in high default rates of consumer and credit-card debts in 2003. Today, Korean bank profitability remains poor, due to a high share of nonperforming loans and inefficient pricing of credit risk. However, after four years of negative rates of return on assets and equity stemming from the crisis, both measures of profitability turned positive in 2001 and remained positive thereafter.

The financial crisis of 1997-1998 and subsequent restructuring the Korean government brought a change in the composition of bank assets. The number of banks was reduced and the average asset size of banks increased leading to greater market concentration. The Korean banking industry has experienced polarization in bank size. While a few super size banks have been created through mergers and acquisitions and establishment of a financial holding company like Woori bank, there are still six small regional banks. Larger banks' loan activities are standardized based on publicly available financial information while small banks tend to base their lending decision on soft information obtained from personal contact or relationship. Decrease in the number of regional banks would negatively affect loans to small and medium enterprises (SMEs). The data shows that the percentage of loans to SMEs in total bank loans was 55% in 1996, a year before the crisis, but it declined to 40% in 2003. It is also found that the larger bank assets are, the smaller share of loans to SMEs is. Furthermore, with high default rates in consumer loans, banks increased the share of securities in their total assets in recent years.

Ⅲ. Review of Previous Studies on Korean Banking

Gilbert and Wilson (1998) investigate the effects of privatization and deregulation on the productivity of fourteen nationwide and ten regional Korean banks for the period 1980-1994. They find that Korean banks dramatically changed their mix of inputs and outputs as privatization and deregulation occurred during the 1980s and early 1990s. Using Malmquist indexes, they decompose productivity change into technical efficiency change and technological change and find that privatization and deregulation enhanced potential output as well as productivity among Korean banks.

Hao, Hunter, and Yang (2001) extend the analysis of Gilbert and Wilson (1998) to identify the key determinants of the efficiency gains. Using a stochastic cost frontier approach, they compute efficiency scores for a sample of nine nationwide banks and ten regional banks for the period 1985-1995. In a regression, they find that banks with higher rates of assets growth, fewer employees per million won of assets, larger amounts of core deposits, lower expense ratios, and classification as a nationwide bank are more efficient. However, Hao, Hunter, and Yang find that the financial deregulation of 1991 had little or no significant effect on the level of sample bank efficiency.

Extending the time frame of Gilbert and Wilson, Lee and Kwon (1999) find that financial liberalization in the 1990s helped enhance input technical efficiency of nationwide banks leading to a 2.7% annual productivity growth, while regional banks experienced declines in efficiency resulting in a 1% decline in productivity. Cho and Shin (2004) find that the five biggest Korean banks experienced a decline in rates of return during 1992-1997 relative to other Korean banks, although these big banks maintained greater cost and technical efficiency.

Park and Kim (2002) estimate efficiency and productivity change for the period 1995-2000 and find that regional banks are less efficient and are experience fewer gains in efficiency than nationwide banks. Park and Yi (2002) use the data for the period 1995-1999 to estimate efficiency and simulate the effects of various hypothetical merger scenarios. They find evidence of decreasing returns to scale for mergers among two technically efficient banks, but if those same two banks produce different mixes of outputs, strong scope economies might arise via the merger.

Chun and Kim (2004) estimate the degree of competition in the Korean banking industry for the period 1994-2001 and examine whether the monopoly power of banks increased along with the increased market concentration after the 1997-1998 Asian financial crisis. Using the Wald test for H statistics proposed by Panzar and Rosse (1987), they conclude that the banks operated under monopolistic competition both before and after the crisis, although the monopoly power of banks increased after the crisis. Jeon and Miller (2004) analyze the effect of the Asian financial crisis on the performance of Korean national banks for the period of 1991-1999, by regressing returns on assets and equity on the balance sheet and income statement information and macroeconomic variables. They find the equity ratio correlated positively with bank performance, even when the government recapitalized a number of banks that performed poorly.

While the previous studies on efficiency and productivity of Korean banks were done on individual banks, Park and Weber (2006a) show that the estimates of individual bank inefficiency and productivity change can be aggregated for the banking industry as a whole, with the 1992-2002 Korean banking data. Instead of a typical Malmquist method which is based on redial expansion of the frontier, they use the Luenberger (1992) benefit function which allows non-redial expansion. Park and Weber (2006b) test the market structure hypothesis against the efficient structure hypothesis with the Korean banking data and find that bank efficiency has a significant effect on bank profitability while the effect of market structure on profitability is marginal.

Ⅳ. Methodology

We use the directional technology distance function to model the production process of Korean banks. This directional distance function allows efficiency to be measured for firms that face a technology where both desirable outputs and undesirable outputs are produced. This function has been used in measuring the efficiency of firms or industries that generate polluting by-products in addition to desirable outputs. (Chung, Färe, and Grosskopf 1997, Färe et al. 2005, Yu 2004) For our purpose it is a useful tool for measuring the efficiency of banks that produce non-performing loans as a by-product of their loan portfolio. Similar models were also considered by Charnes et al. (1985) in a DEA setting. However, while the Charnes et al. additive DEA model yields an efficiency measure obtained by minimizing the slack in the output and input constraints, the directional distance function evaluates the inefficiency of a bank for a pre-specified direction to the frontier of the technology. Furthermore, the directional distance function can be estimated using nonparametric DEA methods as we do here, or using stochastic parametric methods.

Let $y \in R_+^M$ denote a vector of desirable outputs, $b \in R_+^J$ denote a vector of undesirable outputs, and $x \in R_+^N$ denote a vector of inputs. Production takes place in t=1,…,T periods by k=1,…,K banks. Therefore, an observation on bank k in period t is represented by (y_k^t, b_k^t, x_k^t).

The technology, *T*, is the set of desirable outputs, undesirable outputs, and inputs such that the inputs can produce the outputs and is represented by

$$T = \{(x, y, b) : x \text{ can produce } (y, b)\} \tag{1}$$

We assume the technology is convex and compact, and satisfies the condition of no free lunch. We also assume the technology satisfies strong disposability (SD) of desirable outputs and inputs, weak disposability (WD) of desirable and undesirable outputs and inputs, and null-jointness (NJ). These properties are represented as:

$$\begin{array}{ll} SD & \text{If } (x, y, b) \in T \text{ and } (-x', y', b) \le (x, y, b) \text{ then } (x', y', b) \in T \\ WD & \text{If } (x, y, b) \in T \text{ then } (\theta x, \theta y, \theta b) \in T \text{ for } 0 \le \theta \le 1 \\ NJ & \text{If } (x, y, b) \in T \text{ and } b = 0 \text{ then } y = 0. \end{array} \tag{2}$$

Strong disposability implies that banks can use more input to produce the same amount of desirable and undesirable outputs, or, it can produce fewer desirable outputs and the same amount of undesirable outputs from a given level of inputs. However, SD is not a maintained assumption for the undesirable output, since there is an opportunity cost of disposing of undesirable outputs. Instead, we assume that desirable and undesirable outputs are weakly disposable. The assumption of weak disposability models the idea that there is a cost to reducing undesirable outputs. If banks want to reduce their non-performing loans, they must make fewer total loans. The property of no free lunch implies that if no input is available, no output can be produced.

We use data envelopment analysis (DEA) to represent the technology. The piece-wise linear constant returns to scale DEA technology for period j is usually written as

$$T^j = \{(x,y,b): \sum_{k=1}^{K} z_k^j x_k^j \le x, \sum_{k=1}^{K} z_k^j y_k^j \ge y, \sum_{k=1}^{K} z_k^j b_k^j = b, z_k^j \ge 0, k = 1,...,K\} .$$

To address the concern of Kumar and Russell (2002) we modify the technology so that combinations of inputs that could produce the desirable and undesirable outputs in previous periods are feasible in the current period. The modified technology takes the form:

$$\begin{aligned} T^j = \{(x,y,b): &\sum_{t=1}^{j}\sum_{k=1}^{K} z_k^t x_k^t \le x, \sum_{t=1}^{j}\sum_{k=1}^{K} z_k^t y_k^t \ge y, \sum_{t=1}^{j}\sum_{k=1}^{K} z_k^t b_k^t = b, \\ &z_k^t \ge 0, k = 1,...,K, t = 1,..., j\} \end{aligned} \tag{3}$$

The best-practice technology is constructed from observations on all K banks in the current period, j, and each of the preceding periods, t<j, and is such that no less input can be used to produce no more desirable output and an equal amount of the undesirable output than a linear combination of observed inputs, desirable outputs, and undesirable outputs. The intensity variables, z_k^t, serve to form linear combinations of observations from the current and past periods. Constant returns to scale are imposed by constraining the intensity variables to be non-negative.

So that we might illustrate the technology in two-dimensional diagrams, we introduce three other sets that are equivalent representations of the technology. Dropping the time superscript and holding undesirable outputs constant, the set $V(b)$ gives the set of inputs that can produce desirable outputs and is represented as

$$V(b) = \{(x, y): (x, y,b) \in T\} . \tag{4}$$

An output possibility set *P*(*x*), gives the set of desirable and undesirable outputs that can be produced from a given level of inputs:

$$P(x) = \{(y,b) : (x, y,b) \in T\}. \tag{5}$$

Finally, the desirable output requirement set is the set of inputs and undesirable outputs that are feasible given desirable outputs:

$$L(y) = \{(x,b) : (x, y,b) \in T\}. \tag{6}$$

The three technology sets are depicted in Figure 1. Each set is bounded. For the set *V*(*b*), the horizontal extension to the east indicates that there is an upper bound on the amount of desirable output, *y*, that can be produced from input, *x*, given undesirable output *b*. For the output set *P*(*x*), finite amounts of input can only yield finite amounts of desirable and undesirable outputs. For the set *L*(*y*), there is a lower bound on the amount of undesirable output produced and input used given an amount of desirable output. We also note that the pseudo-isoquant for *V*(*y*) can be backward bending because the undesirable output satisfies only weak disposability. Given the technology represented by the sets in Figure 1, suppose we observe a bank, represented by point A. Clearly bank A produces off the frontier of the technology set and is inefficient. That is, bank A should be able to use less input and produce more desirable output and less undesirable output given the technology. To measure inefficiency we use the directional technology distance function proposed by Chambers, Chung, and Färe (1996) as a generalization of the Luenberger (1992) benefit function. Let $g = (g_x, g_y, g_b)$ represent a directional vector. The directional technology distance function seeks the maximum simultaneous expansion of desirable outputs, contraction of undesirable outputs, and contraction of inputs for the directional vector, *g*. This function takes the form:

$$\vec{D}_T(x, y, b; g_x, g_y, g_b) = \max\{\beta : (x - \beta g_x, y + \beta g_y, b - \beta g_b) \in T\}. \tag{7}$$

Adding back the time superscript, the directional technology distance function for bank A in period j is estimated via DEA as:

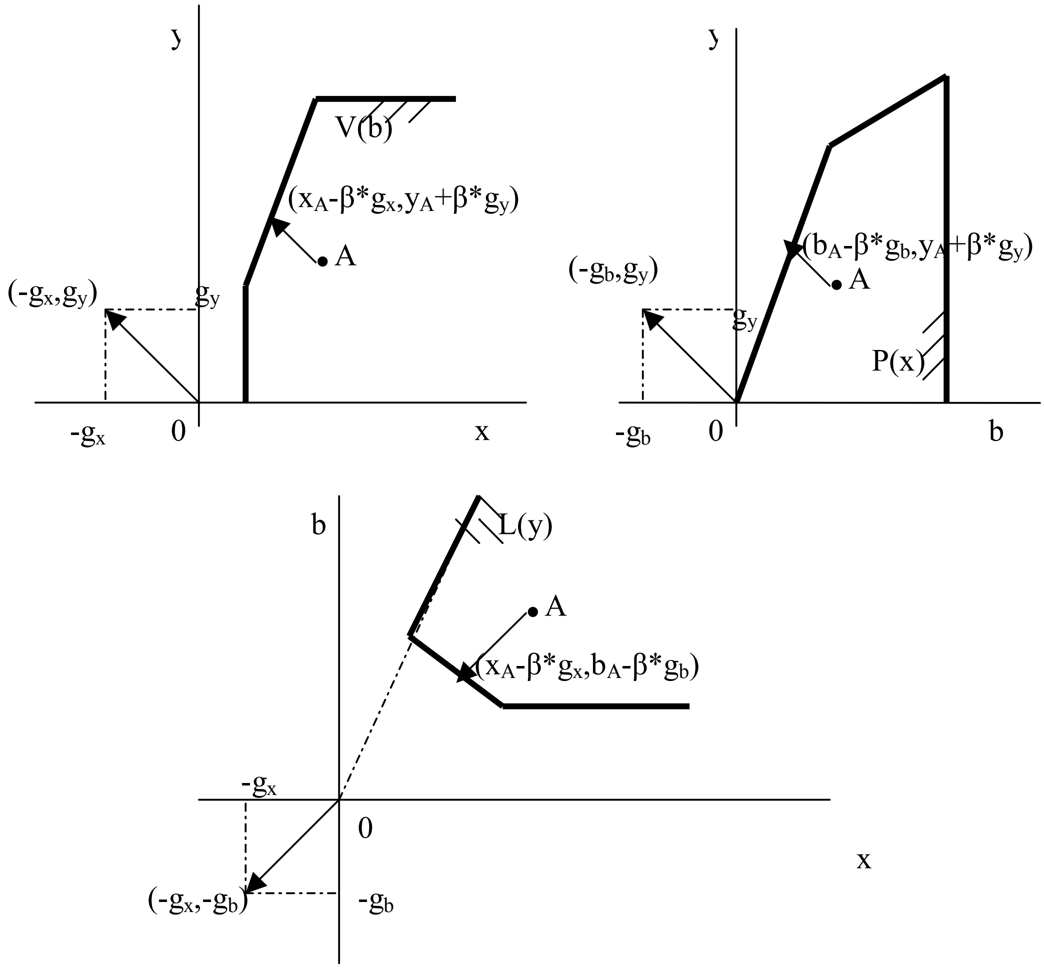
$$\begin{aligned}
&\vec{D}_T^{\,j}(x, y, b; g_x, g_y, g_b) = \max\{\beta : \sum_{t=1}^{j}\sum_{k=1}^{K} z_k^t x_k^t \le x_A^j - \beta g_x, \\
&\sum_{t=1}^{j}\sum_{k=1}^{K} z_k^t y_k^t \ge y_A^j + \beta g_y, \sum_{t=1}^{j}\sum_{k=1}^{K} z_k^t b_k^t = b_A^j - \beta g_b, z_k^t \ge 0, k = 1,\dots,K, t = 1,\dots,j\}.
\end{aligned} \tag{8}$$

Suppose we take the directional vector to be $g = (g_x, g_y, g_b) = (1,1,1)$. For this directional vector, the solution to (8) gives the maximum unit expansion in desirable output and simultaneous unit contraction in undesirable outputs and inputs that is feasible given the technology. Other directional vectors can also be chosen. A directional vector such as g=(x,0,0) would give the percentage contraction in inputs, holding outputs fixed. A direction such as g=(0,y,b) would give the percentage expansion in desirable output and contraction in undesirable output, given inputs.

In Figure 1 we illustrate the movement of an observation such as bank A, with coordinates (x_A, y_A, b_A), toward the frontier of each set given the value of the directional distance function, β*. The frontier coordinates of bank A are

$(x_A - \beta^* g_x, y + \beta^* g_y, b - \beta^* g_b)$. Banks that produce on the frontier are efficient and with $\vec{D}_T(x, y, b; g_x, g_y, g_b) = 0$. Values of $\vec{D}_T(x, y, b; g_x, g_y, g_b) > 0$ indicate inefficiency for the *g*-directional vector.

Figure 1. The Directional Technology Distance Function



The directional technology distance function is a generalization of Shephard output or input distance functions. Shephard's input distance function is defined as

$$D_i(y,x,b) = \max\{\lambda : \frac{x}{\lambda} \in L(y)\}. \tag{9}$$

The Shephard input distance function seeks the maximum proportional contraction of inputs that can still produce the output vector (y,b) and can be derived from the directional distance function by setting $g = (x,0,0)$. That is,

$$\vec{D}_T(x,y,b;x,0,0) = 1 - \frac{1}{D_i(y,x,b)}. \tag{10}$$

Shephard's output distance function is defined as

$$D_o(x,y,b) = \min\{\delta : \frac{(y,b)}{\delta} \in P(x). \tag{11}$$

The reciprocal of the output distance function yields the proportional expansion in desirable outputs and undesirable outputs that is feasible given inputs. The output distance function can be obtained from the directional distance function by setting $g = (0, y, -b)$:

$$\vec{D}_T(x,y,b;0,y,-b) = \frac{1}{D_o(x,y,b)} - 1. \tag{12}$$

We note that we take a negative direction for the undesirable output since our definition in (7) subtracts βg_b in computing the directional distance function. While the Shephard output distance function can be used to measure bank efficiency, banks are generally not interested in maximizing desirable and undesirable outputs simultaneously. Instead, banks seek to expand desirable outputs and contract undesirable outputs, such as non-performing loans providing the rationale for our use of the directional distance function.

When all banks are evaluated for a common direction, Färe and Grosskopf (2004) show that an industry measure of inefficiency can be obtained as the sum of each firm's directional distance function. Here we note that although Shephard output or input distance functions can be derived from the directional distance function, these Shephard distance functions use directional vectors that are not common for all firms and thus cannot be aggregated to the industry level. Fukuyama and Weber (2004) provide an example of the aggregation property of directional distance functions for Japanese banks.

To measure productivity growth, the directional distance function must be evaluated in different periods. Caves, Christensen, and Diewert (1982) develop a Malmquist index, equal to the ratio of two Shephard distance functions, to measure total factor productivity growth. Extending the work of Caves et al. by accounting for undesirable outputs Chung, Färe, and Grosskopf (1997) and Weber and Domazlicky (2001) define a productivity change index equal to the geometric mean of two Malmquist indexes and decompose productivity change into the product of an index of efficiency change and an index of technical change. Given the additive nature of the Luenberger directional technology distance function, productivity change is more naturally decomposed into additive indicators of efficiency change and technical change. Färe and Grosskopf (2004) derive additive Luenberger productivity measures. They use the term "indicator" to denote the difference in two efficiency measures, rather than "index," which commonly refers to the ratio of two efficiency measures. We follow Färe and Grosskopf and evaluate the directional distance function in period j and period j+1 to measure efficiency change. We also estimate how far an observation (x^j, y^j, b^j) is from the period j+1 frontier, and how far an observation $(x^{j+1}, y^{j+1}, b^{j+1})$ is from the period j frontier, so that we can estimate technical change. The efficiency change component measures "catching up" to the frontier and the technical change component measures the shift in the frontier from period to period. The two inter-period directional distance functions are estimated as:

$$\vec{D}_T^{\,j+1}(x^j, y^j, b^j; g_x, g_y, g_b) = \max\{\beta : \sum_{t=1}^{j+1}\sum_{k=1}^{K} z_k^t x_k^t \le x_A^j - \beta g_x,$$
$$\sum_{t=1}^{j+1}\sum_{k=1}^{K} z_k^t y_k^t \ge y_A^j + \beta g_y, \sum_{t=1}^{j+1}\sum_{k=1}^{K} z_k^t b_k^t = b_A^j - \beta g_b, z_k^t \ge 0, k = 1,\ldots,K, t = 1,\ldots, j+1\} \tag{13}$$

And

$$\vec{D}_T^{\,j}(x^{j+1}, y^{j+1}, b^{j+1}; g_x, g_y, g_b) = \max\{\beta : \sum_{t=1}^{j}\sum_{k=1}^{K} z_k^t x_k^t \le x_A^{j+1} - \beta g_x,$$
$$\sum_{t=1}^{j}\sum_{k=1}^{K} z_k^t y_k^t \ge y_A^{j+1} + \beta g_y, \sum_{t=1}^{j}\sum_{k=1}^{K} z_k^t b_k^t = b_A^{j+1} - \beta g_b, z_k^t \ge 0, k = 1,\ldots,K, t = 1,\ldots, j\}. \tag{14}$$

Problem (13) estimates how far the period t observations on inputs and outputs are from the period t+1 technological frontier. Problem (14) estimates how far the period t+1 observations on inputs and outputs are from the period t technological frontier.

The Luenberger productivity indicator is

$$L(x^j,y^j,b^j,x^{j+1},y^{j+1},b^{j+1};g_x,g_y,g_b)=\frac{1}{2}\{\vec{D}_T^{j+1}(x^j,y^j,b^j;g_x,g_y,g_b)-\vec{D}_T^{j+1}(x^{j+1},y^{j+1},b^{j+1};g_x,g_y,g_b)$$
$$+\vec{D}_T^{j}(x^j,y^j,b^j;g_x,g_y,g_b)-\vec{D}_T^{j}(x^{j+1},y^{j+1},b^{j+1};g_x,g_y,g_b)\}. \quad (15)$$

The Luenberger productivity indicator can be decomposed into the sum of an indicator of efficiency change, EFFCH, and an indicator of technical change, TECH. These indicators take the form:

$$EFFCH=\vec{D}_T^{j}(x^j,y^j,b^j;g_x,g_y,g_b)-\vec{D}_T^{j+1}(x^{j+1},y^{j+1},b^{j+1};g_x,g_y,g_b), \quad (16)$$

$$TECH=\frac{1}{2}\{\vec{D}_T^{j+1}(x^j,y^j,b^j;g_x,g_y,g_b)+\vec{D}_T^{j+1}(x^{j+1},y^{j+1},b^{j+1};g_x,g_y,g_b)$$
$$-\vec{D}_T^{j}(x^j,y^j,b^j;g_x,g_y,g_b)-\vec{D}_T^{j}(x^{j+1},y^{j+1},b^{j+1};g_x,g_y,g_b)\} \quad (17)$$

where $L(x^j,y^j,b^j,x^{j+1},y^{j+1},b^{j+1};g_x,g_y,g_b)=EFFCH+TECH$. Values of the indicators greater than zero indicate productivity growth, greater efficiency, or technical progress. Values of the indicators less than zero indicate a decline in productivity, less efficiency, or technical regress.

Ⅴ. Data and Empirical Estimates: Efficiency and Productivity

The data we use to estimate efficiency and productivity change during the period 1992-2002 are from *Bank Management Statistics* of the Bank of Korea and the financial statements of individual banks. The names of the nationwide and regional banks are included in Appendix 1. We confine our analysis to banks that report positive equity capital and positive amounts of non-performing loans in a year. A loan is defined as non-performing if no payment has been received by the bank in the past ninety days or if the borrower has declared bankruptcy. While several new banks opened in the latter part of the period, they report zero amounts of non-performing loans in their first year of operation. In subsequent periods the non-performing loans of these banks are positive, and we include them in our estimation of efficiency and productivity growth. In 1992-1994 twenty-four banks operated in the Korean banking industry. This number grew to twenty-five in 1995 and 1996, and to twenty-six in 1997. The financial crisis of 1997-1998 brought about a significant transformation of the Korean banking industry which we describe in section 2. In 1998 two new banks joined twenty surviving banks, but by 1999 and 2000 seventeen banks remained in operation, declining to fifteen in 2001 and fourteen in 2002.

Berger and Humphrey (1992, 1997) provide a review of the numerous financial institution efficiency studies and the various methods used to define inputs and outputs in financial services. The intermediation approach defines loans and other assets as outputs, while deposits, other liabilities, labor and physical capital are treated as inputs. The value-added approach defines outputs as those assets and liabilities that add substantial value to the bank and includes labor and the value of premises and fixed assets (physical capital) as inputs. The user-cost approach of Hancock (1985) defines outputs as those assets or liabilities that contribute to a bank's revenues and defines inputs as labor and those assets or liabilities that contribute to a bank's cost of production. Tortosa-Ausina (2002) finds significant differences in measured bank efficiency for the asset approach and a variant of the value-added approach.

Banks also engage in various off-balance sheet activities such as buying and selling interest rate options or foreign exchange options and making loan commitments that generate fee income and contingent obligations. Berger and Mester (1997) include the credit equivalent amount of off-balance sheet activity as a fixed netput that impacts bank profitability. Rogers (1998) includes fee income as a non-priced output to proxy off-balance sheet activity in his model of US commercial bank profit efficiency. He finds that models that ignore off-balance sheet activity tend to understate bank efficiency.

Banks also operate in a regulatory environment which requires them to maintain minimum amounts of equity capital. Bank managers, in deciding the appropriate output-input mix, must also account for the risk-return preferences of bank owners. Some banks might choose to employ larger amounts of labor to monitor risky loans and investments to preserve equity capital. Other banks might use less labor, resulting in lower costs but greater risk. Färe, Grosskopf, and Weber (2004) test for the effects of bank regulatory requirements and the risk-return tradeoff on bank profit efficiency and find that using bank equity capital as a quasi-fixed input is sufficient to account for both risk-based capital requirements and the risk-return tradeoff that bank owners face. We follow the work of Färe, Grosskopf, and Weber (2004) and add an equity capital constraint to our DEA estimate of the directional distance function in (8) and the mixed period problems given in (9) and (10). This equity capital (*eq*) constraint takes the form: $\sum_{t=1}^{j}\sum_{k=1}^{K} z_k^t eq_k^t \le eq_A^j$.

Given the sensitivity of efficiency estimates to output and input specification, we estimate five alternative models. In Model 1, we assume that Korean banks produce three desirable outputs and one undesirable output, using three variable inputs and one fixed input. The desirable outputs are commercial loans (y_1), personal loans (y_2), and securities (y_3). The undesirable output (b_1) is non-performing loans. The three variable inputs are full-time labor (x_1), physical capital which is measured as the asset value of premises and fixed assets (x_2), and total deposits (x_3). In Model 2 we follow Rogers (1998) and include fee income (y_9) as an additional output. Models 1 and 2 represent the intermediation approach. In Model 3 we follow Tortosa-Ausina (2002) and include demand deposits (y_4) along with the outputs from Model 2. The output specification for Model 3 is also similar to that of Hao et al. (2001) in their estimation of a cost function for Korean banks.

In models 1, 2, and 3 the same inputs (x_1, x_2, x_3) are used to produce non-performing loans and various desirable outputs. The DEA technology defined by (3) depends on the number of input and output constraints. A consequence of the increase the number of desirable outputs as we move from Model 1 to Model 3 is that the technology, T, becomes more constrained and thus, measured inefficiency will not increase.

Two other output-input specifications are also considered. In Model 4, we follow the work of Hunter and Timme (1986) and define outputs as securities investments (y_3), total loans less non-performing loans ($y_5=y_1+y_2-b_1$), total deposits (y_6) and fee income (y_9). Model 4 inputs include labor (x_1) and physical capital (x_2). Model 4 represents the production approach. In Model 5 we follow the work of Sturm and Williams (2004) and assume that interest income (y_7) and non-interest income (y_8) are produced from interest expense (x_4) and non-interest expense (x_5). After the crisis, the number of part-time and contractual workers increased relative to full-time labor as banks tried to reduce costs. In 1992, less than 3% of total workers were part-time. This average increased to 5% in 1995, 11% in 1996 and 1997, and to over 20% during 1999-2002. Unfortunately, our data do not provide the number of hours worked for these part-time and contractual workers. However, the expenses for these workers are included in non-interest expenses in Model 5 and will provide a comparison with the estimates of Models 1-4.

Descriptive statistics on each of the outputs and inputs for our pooled sample of 229 banks are provided in Table 1. We deflate the desirable outputs, non-performing loans, value of physical capital, deposits, financial equity capital, interest income, non-interest income, interest expense, and non-interest expense by the Korean GDP deflator in each year. Labor is measured as the number of full-time employed workers, and the other inputs and all outputs are in 100 million Korean won. As a percent of total bank assets, commercial loans (y_1) averaged 33.5% in the years 1992-96 before the financial crisis, but averaged only 27% of total assets in the years 1999-2002 following the Asian financial crisis. Personal loans (y_2) and securities (y_3) grew from an average of 5% and 16% of total assets in the years before the crisis to 14% and 26% in the years following the financial crisis. Non-performing loans (b_1) averaged 3.6% of assets in the years before the crisis, grew to 6.4% of total assets in the crisis years of 1997 and 1998, and then fell back to 3.6% of assets in the years following the crisis. Financial equity capital as a percent of total assets averaged 10% in the years preceding the financial crisis, fell to 4.5% of total assets in the two-year crisis period, and then recovered to 4.9% of assets in the post-crisis years. Net income, derived from the outputs and inputs of Model 4 ($y_7+y_8-x_3-x_4$), is positive but decreasing in the period 1992-1996, turns negative during 1997-2000 reaching a low point 1998, and then turns positive again in 2001-2002. Taken as a percent of equity capital, net income averaged between 4% and 7% during 1992-1996 and was about 12% percent during 2001-2002. During 1997-2000 banks incurred a negative return on equity which reached five times the level of equity capital in 1998. Fees (y_9) averaged 6% of the sum of interest income and non-interest income. Banks employed an average of 4094 full-time workers, used physical capital equal to 6457 x100 million Korean won, and used 119,851 x 100 million won in deposits to produce the outputs.

To estimate directional technology distance function and productivity change, a directional vector must be chosen. For each model, we choose a directional vector equal to the mean output-input values as reported in Table 1. That is, we take $g=(\bar{x},\bar{y},\bar{b})$. For instance, in Model 1, with three inputs, three desirable outputs, and nonperforming loans, $g=(\bar{x}_1,\bar{x}_2,\bar{x}_3,\bar{y}_1,\bar{y}_2,\bar{y}_3,\bar{b}_1)$=(4094, 6457, 119851, 43472, 18882, 34939, 7049). For this directional vector, suppose that a bank has measured inefficiency of

$\vec{D}_T(x, y, b; g_x, g_y, g_b) = 0.02$. The directional distance function gives the expansion in desirable outputs, contraction in undesirable outputs, and simultaneous contraction in inputs multiplied by the directional vector. Thus, if this hypothetical bank were to operate efficiently on the frontier of the *T*, it could expand commercial loans by 0.02 x 43472=869, expand personal loans by 0.02 x 18882=378, expand securities by 0.02 x =34939=699, contract non-performing loans by 0.02 x 7049=141, while using 0.02 x 4094=82 fewer workers, having 0.02 x 6457=129 less in physical capital, and having 0.02 x 119851= 2397 fewer deposits.

Banks with an estimate of $\vec{D}_T(x, y, b; g_x, g_y, g_b) = 0$ are efficient and produce on the frontier. Table 2 reports the number of banks that define the frontier in each year for each model and divides the number of frontier banks into national banks and regional banks. National banks are large, have offices throughout the country, and tend to have more diversified loan portfolios than regional banks. For Models 1, 2, and 3 there was a decline in the number of frontier banks from 1992 until 1998. A higher percentage of regional banks were on the frontier than national banks during 1992-1995, but by 1996 and especially in 1998, a lower percentage of regional banks were on the frontier. During 1999-2001 the number of frontier banks increased but then fell in 2002. In Models 4 and 5 a smaller number of banks defined the frontier. For Model 4, a higher percent of nationwide banks were on the frontier than regional banks. For Model 5, a higher percent of regional banks produced on the frontier in the early part of the period and in 2002. The difference in the number of frontier banks for Model 4 versus Models 1, 2, and 3 can be at least partially explained by the treatment of total deposits which are an input in the first three models and an output in Model 4. Banks that are successful in minimizing the input of deposits will appear to be inefficient when deposits are taken as an output.

When the directional technology distance function for each bank is estimated for a common directional vector, the sum of the directional distance functions is a measure of industry performance. (Färe and Primont 2003, Färe and Grosskopf 2004) In Table 3 we report the annual estimates of industry inefficiency and Figure 2 depicts this performance graphically. Industry inefficiency before the Asian financial crisis increased rather dramatically, more than doubling from 1992 to 1995 (except for Model 4) and then doubling again from 1995 to 1998 (except for Model 5). This increase in inefficiency might be partly explained by the fact that during the financial liberalization period before the crisis, the Korean government maintained an anti-merger policy. As a consequence, inefficient banks that might have been acquired remained in business, diluting the market share of efficient banks. After the crisis, industry inefficiency declines from 1998 to 1999 and declines even further in Models 3 and 5 during 2000. This decline in industry inefficiency can be explained in part by the Korean government abandoning the anti-merger policy which brought about an exodus of inefficient banks by closure and through mergers and acquisitions. From 2000-2002, industry inefficiency rises for Models 1, 2, and 3, remains constant for model 4 and declines for Model 5. As expected, industry inefficiency for Model 3 is less than that estimated for Models 1 and 2 given the larger number of outputs in Model 3 relative to models 1 and 2.

Table 4 presents the estimates of the components of industry productivity growth (L) and its decomposition into the sum of an efficiency change indicator (EFFCH) and a technical change indicator (TECH). To interpret the results, we examine the industry productivity growth during 1992-93 for Model 1, where productivity growth (L = 0.466) equals the sum of efficiency change (EFFCH = -0.047) and technical change (TECH = 0.513). Efficiency change was negative, indicating that Korean banks became less efficient from 1992 to 1993. Multiplying EFFCH by the directional vector *g*, gives the change in outputs and inputs for the period 1992 to 1993. That is, $dy = EFFCHx(g_{y_1}, g_{y_2}, g_{y_3})$, $db = EFFCHx(g_b)$, and $dx = EFFCHx(g_{x_1}, g_{x_2}, g_{x_3})$.

For the directional vector $g = (\bar{x}, \bar{y}, \bar{b})$ the decline in efficiency resulted in the industry producing $0.047x(43472, 18882, 34939) = (2043, 887, 1642)$ fewer desirable outputs (commercial loans, personal loans, securities) and $0.047\ x\ 7049 = 331$ more non-performing loans, using $0.047x(4094, 6457, 119851) = (192, 303, 5633)$ more inputs (labor, capital, deposits) than in 1992. However, technical change was TECH=0.514, so the decline in efficiency was more than offset by gains in outputs and declines in non-performing loans and input usage brought about by technical progress. Therefore, by 1993, more commercial loans, more personal loans, more securities, and fewer non-performing loans could be produced from fewer inputs than in 1992 in the Korean banking industry.

In Figures 2, 3, and 4 we graph industry inefficiency and the two components of industry productivity change. First, we note that by construction, our indicator of technical change is positive in each period. Second, although industry efficiency frequently declines from period to period those declines are offset by positive technical change. In fact, the magnitude of the technical change indicator is such that with the exception of Model 5 during 1992-1995, Model 2 in 1999-2000, and Model 4 in 2000-2001, the Korean banking industry experienced productivity growth in every year, including the years of the Asian financial crisis.

Given the importance of technical progress in driving productivity growth, how can we be sure that technical progress actually occurred? In 1992 the Korean banking industry consisted of 24 banks. If those 24 banks from 1992 were able to face the 2002 production technology, how inefficient would they be relative to their inefficiency in 1992? In Table 5 we present the number of banks in years prior to 2002 that would be deemed efficient for the 2002 technology. For instance, for Model 1, the 1992 observations of outputs and inputs for only two banks would have been efficient relative to the 2002 technology. As the years progress and become closer to 2002, the number of banks that are efficient relative to the 2002 technology increases. We also re-estimated each of the five models using the standard DEA method by assuming a technology in the current year that does not depend on prior years. We find that in some years, notably

1997-98 and 1998-99, more than half of all the banks experienced technical regress. Since the "blue-prints" were not likely lost but maybe only misplaced for a short while given the Asian financial crisis, we think that our newer method of incorporating prior year's data in constructing the current year's technology provides a better measure of technical progress from year to year.

To further examine the issue of technical progress we examine the distributions of inefficiencies of the 1992 observations of bank outputs and inputs relative to the 1992 technology and relative to the 2002 technology. Since our method is nonparametric, standard *t*-tests are not valid. Instead, we use the T-test proposed by Li (1996) to evaluate the difference in two kernel distributions of inefficiency. We estimate a standard normal kernel distribution following Pagan and Ullah (1999). Let $f(\vec{D}_T^{1992}(x^{1992}, y^{1992}, b^{1992}; g_x, g_y, g_b))$ represent the kernel distribution of 1992 inefficiencies and let $g(\vec{D}_T^{2002}(x^{1992}, y^{1992}, b^{1992}; g_x, g_y, g_b))$ represent the distribution of inefficiencies for the 1992 observations relative to the 2002 frontier technology. We wish to test whether $f(.) = g(.)$. If the two distribution functions of inefficiencies are the same, then no technical progress has occurred. On the other hand, if the distribution of inefficiencies for 1992 lies to the left of the distribution of inefficiencies if the banks faced the 2002 technology, then it is a greater distance from the 1992 observations to the 2002 frontier than it is from the 1992 observations to the 1992 frontier, indicating technical progress. For each model, Li's statistic for differences in the two distributions are provided in Table 5 (critical T=1.71 for α=.05 and a one-tail test). The test results indicate that technical progress occurred during the period. By the year 2002, only fourteen banks remained in the Korean banking industry. We performed a similar kernel distribution test for these banks to test the hypothesis whether or not $f(\vec{D}_T^{1992}(x^{2002}, y^{2002}, b^{2002}; g_x, g_y, g_b))$= $g(\vec{D}_T^{2002}(x^{2002}, y^{2002}, b^{2002}; g_x, g_y, g_b))$. If technical progress has occurred, then we would expect the 2002 observations to lie outside the 1992 frontier with $\vec{D}_T^{1992}(x^{2002}, y^{2002}, b^{2002}; g_x, g_y, g_b)$ <0 for the fourteen banks.

Our productivity estimates indicate that technical progress was strong enough during the period to offset declines in efficiency. That is, the frontiers of the sets *V*(*b*) and *P*(*x*) have been pushed to the northwest, and the frontier of the set *L*(*y*) has been pushed to the southwest in Figure 1. Our results indicate that the bank reforms implemented in the 1990s and early 2000s were successful in generating productivity growth. While all the banks experienced technical progress during the period, most of the banks failed to keep pace with the pacesetting banks, resulting in greater inefficiency. Our results are also consistent with accounting measures of profitability such as return on equity (ROE) and return on assets (ROA). The ROE of Korean banks ranged from 6.7% in 1992 and declined to 3.8% in 1996. By 1997, ROE turned negative and reached a low of -53% in

1998. During 1999 and 2000, ROE remained negative, but losses narrowed. By 2001 and 2002, ROE recovered to 16% and 11.7%. A similar pattern was seen with ROA.

Ⅵ. Profitability Estimation Model

According to the market power hypothesis, profits are mainly determined by market power. There are two variants under the market power model. The collusion hypothesis states that the degree of market concentration is an important exogenous variable in determining profits while market share is the major determinant of profits according to the relative market power hypothesis. Some argued that the significance of market share supports the relative market power hypothesis (Shepherd, 1986; Kurtz & Rhoades, 1991). This model does not exclude the effects of X-efficiency or scale-efficiency on profitability through their inclusion as a control variable. However, they argue that market structure or market power has more significant influence on profitability than efficiency. The theory of contestable markets proposed by Baumol, et al. (1982) indicates that the performance of firms does not depend on market concentration.

The proponents of the efficient structure hypothesis also used market share as an intermediary variable between efficiency and profit because of the difficulty of measuring efficiency, and argued that the significance of market share supports their hypothesis (Smirlock, 1985; Evanoff & Fortier 1988; Molyneux & Forbes, 1995). According to the efficient structure model, a positive relationship between market share and profit is a spurious effect because both market share and profit are affected by efficiency. In the past market share was used to support both the market structure hypothesis and the efficient structure hypothesis. To resolve this issue, more recent studies have applied several direct measures of efficiency in determining bank profitability (Berger, 1995; Maudos, 1998; Park & Weber, 2006b).

In order to test these different hypotheses, it is necessary to develop a model that nests these two hypotheses. Berger (1995) constructed a structural model that can be tested for the above two hypotheses. The reduced equation for profits can be derived from either the structural models of Berger (1995) or Park and Weber(2006b) as

$$\pi_i = f_1 \ (P_i, EFF_{i,} MS_{i,} HHI, Z_i \ ) + \varepsilon_i \tag{18}$$

where π_i is a measure of profitability of bank i, P is a vector of output prices, EFF is a measure of efficiency, either X-efficiency or scale efficiency depending on the version of the efficient structure hypothesis used. MS represents market share while HHI which is the Herfindahl-Hirschman index represents market concentration ratio. Z is a vector of control variables and ε is a random error term. See Appendix 2 for a more detailed description of the structural and reduced equations.

One specific variable is important while the other explanatory variables are irrelevant, depending on the hypothesis adopted. Under the collusion version of the market power hypothesis, HHI is expected to be statistically significant and have a positive sign. Under the relative market power hypothesis, MS is expected to have a statistically significant and positive effect on profitability. Under the efficient structure hypothesis, EFF, whether X-efficiency or scale efficiency, should be statistically significant while the other variables are irrelevant. Under this hypothesis, MS, in the absence of EFF, may have a spurious effect on profitability because MS is a mediating variable through which effects of EFF are transmitted to profitability. However, MS should be statistically insignificant when EFF is included in the model. This reduced form equation allows for the validity of more than one hypothesis.

Ⅶ. Data and Empirical Estimates: Profitability

The data sources are same as in section 5. We use panel data including all Korean banks in operation in any year during the period 1992-2002. As the Korean banking sector went through financial liberalization in the early 1990s, the Korean currency and financial crisis of 1997-1998, and restructuring since the crisis, the number of Korean banks rose in the early 1990s, but declined after the crisis due to bank closures, purchases and assumptions (P&As), and mergers and acquisitions (M&As). In 1992 there were fourteen nationwide commercial banks and ten regional banks. Just before the crisis, twenty-six commercial banks were in existence as two more nationwide banks were added. The number of commercial banks was reduced to seventeen by the end of 1999 and declined to fourteen by the end of 2002 (see Appendix 1 for the list of banks and their closures and mergers).

As a dependent variable representing profits, three variables are used: (1) ROA1, the ratio of net after-tax income to assets for both banking and trust businesses; (2) ROA2, the ratio of net after-tax income to assets for banking business only; and (3) ROE, the ratio of net after-tax income to equity for both banking and trust businesses.

Market share, MS, is measured in two ways: (1) MS1 is the bank's share of total industry assets for both banking and trust businesses and is used in explaining ROA1; and (2) MS2 is the bank's share of total industry assets for banking business only and is used in explaining ROA2. The degree of market concentration (HINDEX) is measured by the sum of the squares of each bank's market share in total industry assets, where HINDEX1 is for both banking and trust businesses while HINDEX2 is for banking business only (HINDEX1 = Σ $MS1_k^2$ and HINDEX2 = Σ $MS2_k^2$). HINDEX1 decreased continuously until 1997 as financial liberalization in the early 1990s allowed easy entry of new banks. However, this index increased after the crisis of 1997-1998 as the Korean government promoted mergers as a part of its restructuring policy.

Efficiency can be measured in many different ways. A frontier cost function or input or output distance functions can be estimated using stochastic methods or using a non-parametric approach, such as data envelopment analysis (DEA). The DEA method has the advantage of identifying best management practices based upon observed management practices, rather than some hypothetical average derived from an imposed functional form and assumed error distribution. However, unlike stochastic methods, DEA attributes all deviation from the production frontier as inefficiency, rather than measurement error or white noise. In this study we use DEA to estimate the directional distance function which serves as a measure of X-inefficiency or technical inefficiency. We use our estimates of the directional distance function discussed in Section 4 to estimate bank profitability. See Appendix 3 for graphical explanation of the directional distance.

Alternatively, a simple, though rudimentary, approach is to approximate operating efficiency directly from the financial statements of each bank. We use two alternative proxies for operating inefficiency: OPEFF/W equals the operating expenses per employee (in log) and OPEFF/B equals the operating expenses per branch (in log). Similarly, we use two alternative proxies for asset efficiency: ASEFF/W equals total assets per employee (in log) and ASEFF/B equals total assets per branch (in log). The ratio of total loans to employees is suggested as a measure of efficiency by Koch and MacDonald (2003). However, with deregulation and universal banking practice, the financial intermediation function of banks through loans has weakened. Therefore, it would be desirable to use total assets which include securities, foreign exchanges and other investments in addition to loans.

Four control variables (Z_{7k}) are used in the estimation. The first variable is the net interest margin (MARGIN), estimated as the average earning on loans minus the average interest expense on deposits. Because loans are the major type of earning asset and deposits are the major type of liability, MARGIN should be a crucial variable affecting bank performance. The second variable is the ratio of equity capital to total assets. We use EQRATIO1 for both banking and trust businesses and EQRATIO2 for banking business only, to capture the impact of leverage on banking performance. Traditionally, a negative relationship between the equity ratio and return on capital was hypothesized for two reasons: (1) higher equity ratio results in a smaller tax deduction of interest expenses and (2) investors have lower expected return on their investment because there is less risk on their equity with a higher equity ratio. However, after finding a positive relation of equity on bank profitability in US bank data, new theories were developed. Specifically, a higher equity ratio might reduce portfolio risk along with the expected costs of financial trouble, thereby increasing confidence among bank customers, leading to higher profitability. According to the signal theory, banks that expect to have better performance credibly transmit this information through a higher equity ratio (see Berger, 1995).

The third variable is non-performing loans as a percentage of total loans (NPLS) which is used to capture the deficiency in credit risk management and the resultant quality of assets. Inclusion of this variable is essential because loans are the major type of earning assets. The fourth control variable is an indicator variable, NATIONAL, defined as 1 for nationwide banks and 0 for regional banks. Nationwide banks might be able to diversify loans more fully than regional banks, resulting in lower risk. Table 6 shows summary descriptive statistics for the major variables used in profitability estimation, and Table 7 shows trend over time for a few selected variables.

We now turn to the estimation of bank profitability and the tests of the two structure hypotheses. Hsiao (1986) showed that pooled OLS results in biased and inconsistent coefficient estimates because omitted cross-section specific variables may be correlated with the explanatory variables. Use of either a fixed-effects model or a random-effects model can solve this problem. The fixed-effects model is more appropriate when the whole population is used in the study. Because all Korean nationwide and regional banks are included in our panel data, the fixed-effects model is used for this study. Therefore, unobserved differences across banks are reflected in different intercept estimates for each bank.

Table 8 shows the parameter estimates of Equation (18), using ROA1 as the dependent variable and introducing HINDEX1, MS1 and EFF progressively. Model A shows the estimated results of a model representing the collusion hypothesis where HINDEX1 is expected to have a positive sign. Most of the previous studies found a positive, but insignificant relationship between market concentration and profits. By contrast, we found a significant negative effect of market concentration on profitability. This finding is peculiar to Korean banks during this sample period. After the crisis, market concentration steadily increased because of government restructuring policy to promote P&As or M&As. On the other hand, from 1997 to 2000, returns on assets and returns on equity were negative due to the crisis and magnitude of non-performing loans (see Table 7).

The significance of MS1 in model B can be used in support of the relative market power hypothesis or efficient structure hypothesis, depending on interpretations. Further examination is necessary. Model C, with inclusion of both HINDEX1 and MS1, is commonly used in the previous studies as an indirect test of the efficient structure hypothesis, using market share as a proxy for efficiency. However, market share in Model C could also be used in support of the relative market power hypothesis. Most of the previous studies found that market share has a statistically significant positive effect on profitability, while the effect of concentration is insignificant. Our study confirms the previous findings on MS1, but contradicts the previous findings on HINDEX1 because of the peculiarity of Korean banks in the wake of the Asian financial crisis.

In model D we include two direct measures of efficiency, with OPEFF/W representing operating inefficiency and ASEFF/W1 representing asset efficiency. Both variables have their expected signs, negative for operating inefficiency and positive for asset efficiency, and they are statistically significant. When OPEFF/W and ASEFF/W1 are replaced by OPEFF/B and ASEFF/B1 in model E, similar results as in model D are obtained. Models F and G are a re-estimation of models D and E with inclusion of X-INEFF as an additional independent variable. The average X-inefficiency increased mildly in the early 1990s, but has gradually diminished since the financial crisis. X-INEFF has an expected negative sign and is statistically significant, though its t-value is not as high as the t-values of operating inefficiency (OPEFF) or asset efficiency (ASEFF). In models F and G all the variables entered into the model show statistically significant effects on ROA1, except for HINDEX1, for the reason explained above. All the measures of efficiency used in this study - OPEFF, ASEFF, and X-INEFF - are found to be important variables in explaining bank profitability. MS1 has a significant positive effect on profitability in models B and C. However, when the efficiency variables are included in models D, E, F and G, MS1 becomes statistically insignificant. This result indicates that the spurious association between MS1 and π disappears as efficiency variables enter into the model, thus supporting the efficient structure hypothesis. The explanatory power (R^2) also increased from 0.62 to 0.74 - 0.76 as the EFF variables are included in the model.

Now we turn to the three control variables included in the models. First, MARGIN, which is the difference between earnings on loans and the cost of deposits, exhibits a significant positive effect on ROA1 at the 1% or 5% levels, except for model B. This finding indicates that loans are still the major income earning asset of banks, even though the financial intermediation function of banks has weakened over time because of deregulation and universal banking practices. Second, EQRATIO1 has a significant positive effect on bank profitability as expected in all seven models and is consistent with the signaling theory. Third, NPLS has a strong negative effect on profitability and is significant at the 1% level in all seven models, although its marginal contribution is lessened with the inclusion of EFF variables. As can be seen from Table 7, there is an inverse relationship between NPLS and ROA1 or ROA2. Loans are the major income-earning asset of banks, and higher percentages of non-performing loans during 1997-2000 critically affect bank profitability, resulting in negative returns on assets.

The fourth control is a dummy variable differentiating nationwide banks and regional banks. It is positive and significant only in model A, but becomes insignificant when the market share variable is included in the model. This finding may be due to the spurious effect of the dummy variable in the absence of the market share variable in the model. Because regional banks are small and geographically restricted compared to nationwide banks, the dummy variable, NATIONAL, captures the effect of market share when MS is not included in the model. We did not find high correlation among the independent variables. Furthermore, the results of diagnostic test statistics by VIF (variable inflation factor) indicate no serious problem of multicollinearity in all seven models. However, autocorrelation may be present for models A-C and the DW statistics are inconclusive for models D-G. This problem will be re-examined with a breakdown of the sample period into three separate periods later.

We now switch our analysis from the combined business of banking and trust to banking business only. Table 9 shows the parameter estimates of Equation (18), using ROA2 as the dependent variable. With a change in the dependent variable, we use MS2 instead of MS1, HINDEX2 instead of HINDEX1, EQRATIO2 instead of EQRATIO1, ASEFF/W2 instead of ASEFF/W1, and ASEFF/B2 instead of ASEFF/B1. Similar results as in Table 8 are obtained. Compared to Table 8, the explanatory power of models D-G increased from 0.74 - 0.76 to 0.79 - 0.81, and there is no presence of autocorrelation for models D-G. Although not reported here, we obtained similar results as Table 8 when we estimated Equation (18) using ROE as the dependent variable.

The estimation results of Equation (18) separately for nationwide banks and regional banks are not reported here, but we want to point out a noteworthy finding. Another explanation for the negative sign of HINDEX in Tables 8 and 9 can be found from the regressions of ROA1 and ROA2 separately for nationwide banks and regional banks. The negative sign of HINDEX in Tables 8 and 9 is explained above by the peculiarity of Korean banks during the sample period. Another explanation for the negative sign of HINDEX can be offered here. Positive, though insignificant, coefficients of HINDEX1 are obtained for nationwide banks, whether ROA1 or ROA2 is used as the dependent variable. This finding is in line with previous studies. However, strong negative coefficients of HINDEX, which are also statistically significant, are found for regional banks. Thus, the more dominant nationwide banks are as a group, the higher is market concentration, and the less profitable regional banks are. This strong negative association between market concentration and profitability of regional banks affects the overall sign and significance of HINDEX for the pooled data for both nationwide and regional banks.

The peculiarity of the Korean banking sector during the sample period is mentioned above. Until the crisis, both market concentration and rates of return declined with increasing competition. However, after the crisis, market concentration increased because of liberal merger policy while rates of return were negative for the first few years due to the crisis and magnitude of non-performing loans. This peculiarity may necessitate a breakdown of the sample period into three periods. Korean banks underwent many changes during the sample period, including the pre-crisis financial liberalization period from 1992 to 1996, the crisis period of 1997-1999, and the post-crisis restructuring period of 2000-2002. Although the currency crisis was over by the middle of 1998, bank closures, injections of public funds to troubled banks, and mergers continued until 1999. Given the instability during the entire period, we re-estimate the models for the three separate periods. Table 10 presents the estimated results of Equation (18) (only models D, E, F and G), using ROA1 as the dependent variable. The estimated results of Equation (18) for three separate periods, using ROA2 instead of ROA1 as the dependent variable, are not much different from Table 10 and are not reported here. The Chow breakpoint test is used to see whether there are significant differences in the estimated equations. With three-sub samples, our test rejects the null hypothesis of no structural change. F-statistics for the Chow breakpoint test for models D-G are 16.35 or higher.

For the first period of 1992-1996, when the economy was expanding, banking was normal and stable, and financial liberalization continued, all the explanatory variables, except for EQRATIO, have their expected signs and are statistically significant. Even the market concentration ratio (HINDEX), which previously had the wrong sign or was insignificant with the pooled data, becomes significant with the right sign. During this period, all of the competing hypotheses - the collusion hypothesis, the market power hypothesis and the efficient structure hypothesis - seem to be at work. However, during the second period (1997-1999) and third period (2000-2002), the coefficients of MARGIN, HINDEX, and MS changed from statistically significant to insignificant, while EQRATIO became statistically significant, indicating a strong signaling effect of equity on profitability.

During the early 1990s when the economy grew and bank deposits and loans expanded rapidly, the equity ratio did not matter for bank profitability. However, when the economy slows down and the prospects of banking business are bleak, the equity ratio affects the credit rating of banks and their financing costs. The equity ratio became more important as government bail-out was no longer guaranteed after the crisis. The magnitude and significance of the coefficients of operating inefficiency, asset efficiency and X-inefficiency increased from the first period to the second period and through the third period. Three variables, EFF, EQRATIO and NPLS, are significant during the second period, but only EFF and EQRATIO are significant determinants of profitability during the third period. With the non-performing loan ratio of 2-3% in the third period, NPLS plays a less significant role in determining profitability of Korean banks.

As mentioned above, the relationship between HINDEX1 and ROA1 is negative for the entire period. However, their relationship is significantly positive for the first period, positive but insignificant for the second period, and insignificantly negative for the third period. In fact, the negative impact for the third period manages to dominate the overall effect of HINDEX1 on ROA1 for the entire period. This necessitates partition of the entire sample into three periods because the underlying structure changed. Furthermore, when the sample period is divided into three separate periods, there is no problem of autocorrelation as indicated by the DW statistics in Table 10.

The findings of Chun and Kim (2004) seem to be in conflict with our findings. However, they are not. Chun and Kim found that monopoly power of Korean banks increased after the financial crisis. According to the efficient structure hypothesis, efficient banks can obtain higher profitability as well as greater market share, thus leading to higher market concentration, because of their efficiency. In the absence of an efficiency variable in the model as in the case of Chun and Kim, market share or market concentration, being an intermediary variable between efficiency and profit, may exhibit a significant effect on profitability. However, when both variables are included in the model as in our paper, the significance of market share or market concentration disappears. Another study by Cho and Shin (2004) supports our conclusion. They compared technical efficiency, allocative efficiency and scale efficiency of five big banks with those of all other Korean banks during 1992-2001. They found that the anti-merger policy of the Korean government before the crisis contributed to excessive competition and diseconomies of scale for larger banks. On the other hand, after the crisis, the liberal merger and acquisition policy enhanced scale efficiency of larger banks.

Ⅷ. Conclusions

In 1997-1998 the Asian economies experienced a financial crisis and contagion brought on by lax regulatory oversight, government-subsidized lending, moral hazard, and global financial integration. In Korea, the financial crisis was preceded by government deregulation and privatization of banks and in its wake, by re-regulation, restructuring, government and foreign equity capital injections, and a refocusing on bank efficiency and profitability. In this process, industry concentration has increased through mergers and consolidation, and the composition of bank assets has changed in favor of consumer loans and securities, particularly securities.

These changes brought by the financial crisis have contributed to improvement of bank performance as well as weakening financial intermediation function of banks. First, big banks that were created through mergers and acquisitions reduced loans to SMEs because of an increase in agency costs of relationship lending and because of difficulty in information producing activities associated with SMEs. Second, increased representation and influence of outside shareholders resulting from a reform in bank governance structure caused a shift in the focus of bank profitability from long-term to short-term. This consequence was reflected in a reduction of long-term loans. Third, banks experiencing large non-performing loans during the financial crisis became risk-averse and preferred securer investment such as securities to commercial loans.

In this paper we have examined the efficiency, productivity growth and profitability in Korean banking, 1992-2002 during which period the Korean banking system experienced weakening financial intermediation. We measure efficiency and productivity change using the directional technology distance function, which allows us to aggregate our efficiency and productivity measures from the bank level to the industry level. Furthermore, our method allows us to control for the fact that banks in the process of making security investments and loans, generate an undesirable by-product: non-performing loans. These two features of our paper, aggregation of efficiency and productivity measures from the firm to the industry level and the modeling of desirable and undesirable bank outputs, are our unique contribution to the study of the Korean banking system.

Our findings indicate that in the years before the Asian financial crisis, inefficiency in the Korean banking system increased dramatically. Although the banking system became less efficient throughout the period, technical change which can be thought of as shifting the production technology in a welfare enhancing direction, more than offset declines in efficiency. We also find that the banking system experienced productivity growth during the period, brought about primarily by technical change. Weakening financial intermediation of Korean banks might be the result of their efforts to increase productivity growth in the face of efficiency declines. A limitation of this paper is that our method does not measure efficiency relative true unobservable technology, but instead constructs the frontier technology from the best practice techniques of observed banks.

This paper has also investigated the relationship between structure and performance in the Korean banking system during 1992-2002. When bank efficiency is ignored, we find that market share has a significantly positive impact on bank profitability, providing evidence in support of the market structure/conduct/performance hypothesis. However, when bank efficiency is explicitly controlled for, the impact of market share on profits becomes insignificant, providing evidence in support of the efficient structure hypothesis. Furthermore, contrary to the market structure hypothesis we find that market concentration has a negative impact on bank profitability over the entire period. For the entire sample period, banks with greater net interest margin, less operating cost per employee or branch, more assets per employee or branch, less technical inefficiency measured by a distance function, higher equity capital ratio and a smaller non-performing loan share are found to be more profitable. Classification as a nationwide bank is not an important variable in explaining bank profitability.

When the sample period is broken down into three distinct periods, further insight is obtained. During the stable banking period (1992-1996), market concentration, market power, and efficiency are significant in explaining bank profitability. However, during the crisis and recovery periods, bank efficiency stands out as the primary variable affecting bank profits. While market concentration and market share became less significant over time, the importance of the efficiency variable and its magnitude of influence increased as Korean banks went through turbulence. The equity capital ratio is also an important determinant of profitability during the crisis and recovery periods.

This evidence has several policy implications for bank regulation. Under the collusion hypothesis, mergers might be initiated by banks in order to extract consumer surplus, resulting in higher prices to consumers and social inefficiency. On the other hand, according to the efficient market hypothesis, banks are motivated to merge in order to achieve efficiency, and the result is socially optimal. Our findings do not support the collusion hypothesis, and enforcement of antitrust policy in the Korean banking sector is not desirable. In this sense, recent government policy to encourage mergers in the banking sector may be tolerated on the grounds of efficiency and international competition. The two most recent mergers, a voluntary merger between Hana Bank and Boram Bank and an involuntary merger between Commercial Bank and Hanil Bank, appear to be headed in the right direction. An IMF study (2001) found that both merged banks have realized economies of scale by rationalizing their operations or branch networks and employees. The study also found that mergers are not a sufficient condition for improved profitability if the underlying banks are unsound. The government's increasing emphasis on bank consolidation is to improve profitability through realization of economies of scale. Even if merged banks have not yet improved profitability, their realization of economies of scale should result in higher profitability in the long run.

The second implication is that both banks and regulatory agencies such as the Korea Financial Supervisory Commission should focus more on how to improve efficiency and less on market share or market concentration. Prior to the crisis Korean banks focused on expanding their market share instead of reducing costs or improving efficiency. Such strategies were based on a philosophy of "too big to fail" and a moral hazard effect derived from a perception of the government as lender of last resort and implicit bail-out guarantor. These strategies resulted in excessive borrowing of Korean banks from abroad and lending to the Chaebols - the Korean conglomerates, causing overcapacity in sectors such as automobiles, micro-chips, and steel and diversification of their business into areas unrelated to their specialties. The result was low profits for Chaebols and eventually, many non-performing loans for banks. However, the financial crisis of 1997-1998 shook the Korean banking sector and was a warning to Korean banks to re-evaluate their positions. Though the financial crisis caused much trouble to the Korean economy and particularly Korean banks, one good thing that came out of the financial crisis was the focus on cost reduction and efficiency improvement. The restructuring of the Korean banking sector might not have been possible without the crisis, as inertia prevailed in the Korean banking sector. As bank regulations that limited competition before the crisis were gradually removed, the increasing importance of efficiency was clear.

<References>

Berger, A. N., 1995. The Profit-Relationship in Banking - Tests of Market-Power and Efficient-Structure Hypotheses. *Journal of Money, Credit and Banking*, 27, 405-31.

Berger, A. and Humphrey, D., 1992. Measurement and efficiency issues in commercial banking, In Zvi Griliches, ed., *Output Measurement in the Service Industry*. Chicago: University of Chicago Press, National Bureau of Economic Research, 245-296.

Berger, A. and Humphrey, D., 1997. Efficiency of financial institutions: international survey and directions for future research, *European Journal of Operational Research* 98, 175-212.

Berger, A. and Mester, L. 1997. Inside the black box: What explains differences in the efficiencies of financial institutions? Journal of Banking and Finance, 21, 895-947.

Caves, D., Christensen, L., and Diewert, E., 1982. The economic theory of index numbers and the measurement of input, output, and productivity. *Econometrica* 50, 1393-1414.

Chambers, R., Chung, Y., and Färe, R., 1996. Benefit and distance functions. *Journal of Economic Theory* 70, 407-419.

Charnes, A., Cooper, W. W., Golany, B., Seiford, L.M., Stutz, J. 1985. Foundations of Data Envelopment Analysis for Pareto-Koopmans Efficient Empirical Production Functions. *Journal of Econometrics*, 30, 91-107.

Cho, B.T. and Shin, D.J. 2004. A Data Envelopment Analysis of Efficiency in the five Big Banks Before and After the 1997 Banking Crisis in Korea. Joint Economics Conference-Korea Monetary Finance Association.

Chung, Y., Färe, R., and Grosskopf, S., 1997. Productivity and undesirable outputs: a directional distance function approach. *Journal of Environmental Management*, 51, 229-240.

Corsetti, G., Pesenti, P. and Roubini, N., 1999. What Caused the Asian Currency and Financial Crisis? *Japan and the World Economy*, 11, 305-373.

Chun S., & Kim, B., 2004. The Effects of Financial Restructuring on the Degree of Competition in the Korean Banking Industry. Working paper.

Devaney, M. and Weber, W., 2002. Small-business lending and profit efficiency in commercial banking. *Journal of Financial Services Research* 22, 225-246.

Evanoff, D. D., & Fortier, D. L., 1988. Reevaluation of the Structure-Conduct-Performance Paradigm in Banking. *Journal of Financial Services Research*, 1, 277-94.

Färe, R. and Grosskopf, S., 2004. *New Directions: Efficiency and Productivity*, Kluwer Academic Publishers, Boston/London/Dordrecht.

Färe, R., Grosskopf, S., Noh, D.W., and Weber, W. 2005. Characteristics of a Polluting Technology, forthcoming in *Journal of Econometrics*.
Färe, R., Grosskopf, S., and Weber, W. 2004. The effect of risk-based capital requirements on profit efficiency in banking. *Applied Economics* 36, 1731-1743.
Färe, Rolf and Primont, D., 2003. Luenberger productivity indicators: aggregation Across firms. *Journal of Productivity Analysis* 20, 425-435.
Farrell, M., 1957. The measurement of productive efficiency. *Journal of the Royal Statistical Society*, Series A, General 125, Part 2, 252-267.
Fukuyama, H. and Weber, W., 2004. Efficiency and profitability in the Japanese banking industry. In: Färe and Grosskopf, *New Directions: Efficiency and Productivity* Kluwer Academic Publishers.
Gilbert, R. and Wilson, P., 1998. Effects of deregulation on the productivity of Korean banks. *Journal of Economics and Business* 50, 133-155.
Goldberg, L. G., & Rai, A., 1996. The Structure-Performance Relationship in European Banking. *Journal of Banking and Finance*, 20, 745-71.
Greene, W. M., 1993. The Econometric Approach to Efficiency-Analysis. in H. O. Fried, C. A. K. Lovell, and S. S. Schmidt, (eds), *The Measurement of Productive Efficiency: Techniques and Applications*, Oxford: Oxford University Press.
Hao, J., Hunter, W., and Yang, W., 2001. Deregulation and efficiency: the case of private Korean banks. *Journal of Economics and Business* 53, 237-254.
Hancock, D., 1985. The financial firm: production with monetary and non-monetary goods. *Journal of Political Economy* 93, 859-880.
Hsiao, C., 1986. *Analysis of Panel Data*. Cambridge: Cambridge University Press.
Hunter, W.C. and Timme, S. G. 1986. Technical change, organizational form, and the structure of bank production. *Journal of Money, Credit, and Banking* 18, 152-166.
International Monetary Fund, 2001. Republic of Korea: Selected Issues, Washington,D.C.
Jeon, Y. and Miller, S. M. (2004). The Effect of the Asian financial crisis on the performance of Korean national banks, *Applied Financial Economics*, 14, 351-360.
Koch, T. W., & MacDonald, S. S. (2003). Bank Management. Dryden Press.
Korea Financial Supervisory Service, various years, Financial Statements of Korean Commercial Banks (in Korean).
Kumar, S. and Russell, R., 2002. Technological change, technological catch-up and capital deepening: relative contributions to growth and convergence. *The American Economic Review* 92, 527-548.
Kurtz, R. D., & Rhoades, S. A. (1991). A Note on the Market Share-Profitability Relationship. Federal Reserve Board Working Paper, Washington DC.
Lee, S. K. and Kwon, Y.J. 1999. The Sources of Productivity Change in Korean Banking Industry: Application of a Malmquist Approach. *Journal of Korea Monetary Finance*, 4.

Li, Q., 1996. Nonparametric testing of closeness between two unknown distribution functions. *Econometric Reviews* 15, 261-274.
Luenberger, D., 1992. Benefit functions and duality. *Journal of Mathematical Economics* 21, 461-481.
Maudos, J., 1998. Market Structure and Performance in Spanish Banking Using a Direct Measure of Efficiency. *Applied Financial Economics*, 8, 191-200.
Molyneux, P., & Forbes, W., 1995. Market Structure and Performance in European Banking. *Applied Economics*, 27, 155-59.
Pagan, A. and Ullah, A., 1999. *Nonparametric Econometrics* Cambridge University Press: Cambridge: UK.
Panzar, J. C., & Rosse, J. N., 1987. Testing for Monopoly Equilibrium. *Journal of Industrial Economics*, 35, 443-456.
Park, K., 2003. Asian financial crisis of 1997-1998: a tale of two countries. *Global Business and Finance Review* 8, 61-70
Park, K. and Weber, W. 2006a. A note on efficiency and productivity growth in the Korean Banking Industry, 1992-2002, *Journal of Banking and Finance*, forthcoming.
Park, K. and Weber, W. 2006b. Profitability of Korean banks: test of market structure versus efficient structure, *Journal of Economics and Business*, forthcoming.
Park, R. K. and Kim, J. H. 2002. An efficiency analysis of Korean banks: a comparative analysis of DEA, FDH and Malmquist index approach(in Korean). *Kukje Kyungje Yonggu,* 8, 177-201.
Park, S. R., and Yi, I. S. 2002. The technical efficiency and merger effects in Korean commercial banks (in Korean). *Korean Journal of Money and Finance* 7, 31-60.
Rogers, K. E. 1998. Nontraditional activities and the efficiency of US commercial banks, *Journal of Banking and Finance*, 22, 467-482.
Saunders, A., 2000. *Financial Institutions Management: A Modern Perspective*, McGraw Hill, Third edition.
Shephard, R., 1974. *Theory of Cost and Production Function*, Princeton, Princeton University Press.
Shepherd, W. G., 1986. Tobin's *q* and the Structure Performance Relationship: Reply. *American Economic Review*, 76, 1205-10.
Smirlock, M., 1985. Evidence on the (Non)Relationship between Concentration and Profitability in Banking. *Journal of Money, Credit and Banking*, 17, 69-83.
Sturm, J-E., and Williams, B., 2004. Foreign bank entry, deregulation and bank efficiency: Lessons from the Australian experience. Journal of Banking and Finance 28, 1775-1799.
Weber, W., Domazlicky, B., 2001. Productivity growth and pollution in state manufacturing. *Review of Economics and Statistics* 195-199.

Table 1. **Descriptive Statistics I**

Variable	Mean[1]	Std. Dev.	Minimum	Maximum
Commercial Loans (y_1)	43472	48636	377	359634
Personal Loans (y_2)	18882	41673	294	354823
Securities (y_3)	34939	44350	1437	293702
Demand deposits (y_4)	13038	14955	775	114228
Total loans less non-performing loans ($y_5=y_1+y_2-b_1$)	55305	82654	658	692390
Deposits (y_6)	119851	151228	4241	1151634
Interest income (y_7)	11745	13273	211	91752
Non-interest income (y_8)	5171	7576	1	49939
Fee income (y_9)	946	1182	0	8139
Non-performing loans(b_1)[2]	7049	9019	12	54888
Labor	4094	3568	254	19194
Physical capital (x_2)	6457	6344	329	35381
Deposits (x_3)	119851	151228	4241	1151634
Interest expense (x_4)	8589	9455	36	55740
Non-interest expense (x_5)	8848	12380	175	78791
equity (eq)	9145	10461	431	88385

Notes:

1. The year and number of included banks are: 1992-24, 1993-24, 1994-24, 1995-25, 1996-25, 1997-26, 1998-18, 1999-17, 2000-17, 2001-15, 2002-14 for a total of 229 observations. Labor equals the number of workers, and all other variables are measured in 100 million Korean won.
2. Two newly formed banks in 1999 and four newly formed banks in 2001 reported zero amounts of non-performing loans in their first year of operation and were not included in that year, but were included in subsequent years.

Table 2. Number of Nationwide Banks (N) and Regional Banks (R) on the Frontier

Frontier banks have $\vec{D}_T(x, y, b; g_x, g_y, g_b) = 0$.

Year	Total =N+R	Model 1	Model 2	Model 3	Model 4	Model 5
1992	24=14+10	19=10+9	19=10+9	22=12+10	9=7+2	8=4+4
1993	24=14+10	17=9+8	18=9+9	17=9+8	7=6+1	4=1+3
1994	24=14+10	15=8+7	18=10+8	19=10+9	9=6+3	4=2+2
1995	25=15+10	11=6+5	12=7+5	15=9+6	8=6+2	3=3+0
1996	25=15+10	10=7+3	10=7+3	14=9+5	7=5+2	4=2+2
1997	26=16+10	12=6+6	14=7+7	15=8+7	5=4+1	10=8+2
1998	18=12+6	7=7+0	9=9+0	11=9+2	6=6+0	8=7+1
1999	17=11+6	14=11+3	13=10+3	15=10+5	7=6+1	4=3+1
2000	17=11+6	12=8+4	13=0+4	15=11+4	6=5+1	5=4+1
2001	15=9+6	10=5+5	11=6+5	13=8+5	3=3+0	3=2+1
2002	14=8+6	8=4+4	9=5+4	11=7+4	3=3+0	5=2+3

Each model takes $g = (\bar{x}, \bar{y}, \bar{b})$ and includes the equity capital constraint

Outputs-y_1=Commercial loans, y_2=personal loans, y_3=securities investments, y_4=demand deposits, y_5=total loans less non-performing loans (y_1+y_2-b_1), y_6=total deposits, y_7=interest income, y_8=non-interest income, y_9=fee income, b_1=non-performing loans.

Inputs-x_1=full-time workers, x_2=physical capital, x_3=total deposits, x_4=interest expense, x_5=non-interest expense.

Model 1. outputs=(y_1,y_2,y_3,b_1), inputs=(x_1,x_2,x_3)
Model 2- outputs=(y_1,y_2,y_3,y_9,b_1) , inputs=(x_1,x_2,x_3)
Model 3. outputs=(y_1,y_2,y_3,y_4,y_9,b_1), inputs=(x_1,x_2,x_3)
Model 4. outputs=(y_3,y_5,y_6,y_9), inputs=(x_1,x_2)
Model 5. outputs=(y_7,y_8), inputs=(x_4,x_5)

Table 3. Industry Efficiency: $\sum_{k=1}^{K} \vec{D}_T^{k}(x^k, y^k, b^k; g_x, g_y, g_b)$

Year	K	Model 1	Model 2	Model 3	Model 4	Model 5
1992	24	0.0434	0.0392	0.0040	0.5925	0.1602
1993	24	0.0904	0.0751	0.0687	0.6220	0.4123
1994	24	0.2572	0.0699	0.0572	0.5415	0.4801
1995	25	0.4418	0.2183	0.1418	0.6261	0.5516
1996	25	0.6258	0.6299	0.4624	1.0119	0.4739
1997	26	1.1390	0.5718	0.5212	1.3741	0.6119
1998	18	1.3474	0.8651	0.5282	1.9150	1.0198
1999	17	0.2418	0.0493	0.0302	1.5667	0.8156
2000	17	0.4615	0.3071	0.0237	1.9359	0.6966
2001	15	0.8006	0.4749	0.1594	3.0931	0.4300
2002	14	1.5389	0.8228	0.1083	1.9379	0.3232

Each model takes $g = (\bar{x}, \bar{y}, \bar{b})$ and includes the equity capital constraint.

Outputs-y_1=Commercial loans, y_2=personal loans, y_3=securities investments, y_4=demand deposits, y_5=total loans less non-performing loans ($y_1+y_2-b_1$), y_6=total deposits, y_7=interest income, y_8=non-interest income, y_9=fee income, b_1=non-performing loans.

Inputs-x_1=full-time workers, x_2=physical capital, x_3=total deposits, x_4=interest expense, x_5=non-interest expense.

Model 1. outputs=(y_1,y_2,y_3,b_1), inputs=(x_1,x_2,x_3)
Model 2. outputs=(y_1,y_2,y_3,y_9,b_1) , inputs=(x_1,x_2,x_3)
Model 3. outputs=(y_1,y_2,y_3,y_4,y_9,b_1), inputs=(x_1,x_2,x_3)
Model 4. outputs=(y_3,y_5,y_6,y_9), inputs=(x_1,x_2)
Model 5. outputs=(y_7,y_8), inputs=(x_4,x_5)

Table 4. Decomposition of the Industry Productivity Indicator
L=productivity indicator, EFFCH =efficiency change indicator,
TECH=technical change indicator

Years		Model 1	Model 2	Model 3	Model 4	Model 5
1992-93	L=	0.4664	0.4180	0.2209	0.3871	-0.2211
	EFFCH+	-0.0470	-0.0359	-0.0647	-0.0295	-0.2521
	TECH	0.5134	0.4539	0.2856	0.4166	0.0311
1993-94	L=	0.9700	0.7476	0.6795	1.2165	-0.0369
	EFFCH+	-0.1668	0.0052	0.0115	0.0805	-0.0678
	TECH	1.1368	0.7424	0.6680	1.1360	0.0310
1994-95	L=	0.3521	0.1519	0.1460	0.4082	-0.0051
	EFFCH+	-0.1846	-0.1484	-0.0846	-0.0846	-0.0715
	TECH	0.5367	0.3003	0.2306	0.4928	0.0665
1995-96	L=	1.1203	1.0559	0.1248	1.1530	0.0945
	EFFCH+	-0.1840	-0.4116	-0.3206	-0.3858	0.0777
	TECH	1.3043	1.4675	0.4454	1.5388	0.0168
1996-97	L=	4.1105	0.9604	2.8313	2.3146	5.1052
	EFFCH+	-0.2878	0.1068	-0.0101	-0.1334	-0.1380
	TECH	4.3983	0.8536	2.8414	2.4480	5.2432
1997-98	L=	2.9569	0.4788	1.0403	3.6172	3.1475
	EFFCH+	-0.3173	-0.4257	-0.1315	-0.8891	-0.4885
	TECH	3.2742	0.9045	1.1718	4.5063	3.6360
1998-99	L=	2.3757	1.1465	0.7974	1.1287	0.3250
	EFFCH+	0.5974	0.3484	0.2783	-0.1688	-0.2382
	TECH	1.7783	0.7981	0.5191	1.2975	0.5632
1999-00	L=	2.0175	-0.1141	0.2469	1.7581	0.2337
	EFFCH+	-0.2197	-0.2578	0.0065	-0.3692	0.1190
	TECH	2.2372	0.1437	0.2404	2.1273	0.1147
2000-01	L=	2.5791	0.1993	0.4722	-0.0789	0.4749
	EFFCH+	-0.3391	-0.1678	-0.1357	-1.2242	0.2666
	TECH	2.9182	0.3671	0.6079	1.1453	0.2083
2001-02	L=	2.5392	1.1761	0.8790	1.5212	0.4057
	EFFCH+	-0.7383	-0.3479	0.0511	0.9320	0.0850
	TECH	3.2775	1.5240	0.8279	0.5892	0.3207

Each model takes $g = (\bar{x}, \bar{y}, \bar{b})$ and includes the equity capital constraint.

Outputs-y_1=Commercial loans, y_2=personal loans, y_3=securities investments, y_4=demand deposits, y_5=total loans less non-performing loans(y_1+y_2-b_1), y_6=total deposits, y_7=interest income, y_8=non-interest income, y_9=fee income, b_1=non-performing loans.

Inputs-x_1=full-time workers, x_2=physical capital, x_3=total deposits, x_4=interest expense, x_5=non-interest expense.

Model 1. outputs=(y_1,y_2,y_3,b_1), inputs=(x_1,x_2,x_3)
Model 2. outputs=(y_1,y_2,y_3,y_9,b_1) , inputs=(x_1,x_2,x_3)
Model 3. outputs=$(y_1,y_2,y_3,y_4,y_9,b_1)$, inputs=$(x_1,x_2,x_3)$
Model 4. outputs=(y_3,y_5,y_6,y_9), inputs=(x_1,x_2)
Model 5. outputs=(y_7,y_8), inputs=(x_4,x_5)

Table 5. Number of frontier banks from previous periods that would be efficient for the 2002 technology and tests for technical change

Previous period	Model 1	Model 2	Model 3	Model 4	Model 5
1992	8	13	21	1	6
1993	2	6	7	0	1
1994	1	6	7	0	2
1995	2	3	4	0	1
1996	2	3	5	0	1
1997	6	9	10	1	1
1998	6	9	9	6	5
1999	6	10	12	3	2
2000	8	11	12	5	3
2001	10	11	12	3	3
2002	8	9	11	3	5
Is $f(\vec{D}_T^{2002}(x^{1992}, y^{1992}, b^{1992}; \bar{x}, \bar{y}, \bar{b}) = g(\vec{D}_T^{2002}(x^{1992}, y^{1992}, b^{1992}; \bar{x}, \bar{y}, \bar{b})$?					
T-value[1]	8.32	0.15	24.31	0.32	5.90
Is $f(\vec{D}_T^{1992}(x^{2002}, y^{2002}, b^{2002}; \bar{x}, \bar{y}, \bar{b}) = g(\vec{D}_T^{2002}(x^{2002}, y^{2002}, b^{2002}; \bar{x}, \bar{y}, \bar{b})$?					
T-value[1]	4.59	3.88	1.64	4.48	2.46

1. Based on Qi Li's (1996) T-test. Critical T=1.71, α=.05

Each model takes $g = (\bar{x}, \bar{y}, \bar{b})$ and includes the equity capital constraint

Outputs-y_1=Commercial loans, y_2=personal loans, y_3=securities investments, y_4=demand deposits, y_5=total loans less non-performing loans (y_1+y_2-b_1), y_6=total deposits, y_7=interest income, y_8=non-interest income, y_9=fee income, b_1=non-performing loans.

Inputs-x_1=full-time workers, x_2=physical capital, x_3=total deposits, x_4=interest expense, x_5=non-interest expense.

Model 1. outputs=(y_1,y_2,y_3,b_1), inputs=(x_1,x_2,x_3)
Model 2. outputs=(y_1,y_2,y_3,y_9,b_1), inputs=(x_1,x_2,x_3)
Model 3. outputs=(y_1,y_2,y_3,y_4,y_9,b_1), inputs=(x_1,x_2,x_3)
Model 4. outputs=(y_3,y_5,y_6,y_9), inputs=(x_1,x_2)
Model 5. outputs=(y_7,y_8), inputs=(x_4,x_5)

Table 6. Descriptive Statistics II

	N	Minimum	Maximum	Mean	S. Deviation
ROA1	231	-10.19	1.48	-.39	2.06
ROA2	231	-11.45	2.62	-.38	2.36
ROE	231	-595.79	34.20	-12.50	65.44
MS1	234	0.002	0.295	0.048	0.047
MS2	234	0.003	0.281	0.048	0.047
HINDEX1	234	0.066	0.154	0.092	0.026
HINDEX2	234	0.069	0.147	0.094	0.023
OPEFF/W1	232	-1.21	2.69	1.1820	0.776
OPEFF/B1	232	2.50	5.47	4.006	0.650
ASEFF/W1	234	2.43	5.06	3.807	0.605
ASEFF/B1	234	5.37	7.80	6.630	0.549
ASEFF/W2	234	2.26	4.89	3.506	0.626
ASEFF/B2	234	5.05	7.65	6.329	0.534
MARGIN	232	-0.019	0.035	0.016	0.008
EQRATIO1	234	-0.062	0.418	0.054	0.038
EQRATIO2	234	-0.075	0.465	0.073	0.049
NPLS	232	0.001	0.246	0.054	0.043
Valid N (listwise)	229				

Ratios and shares are in percentage, and operating expenses and assets expressed in 100 million Korean won are transformed into natural logarithm. Suffix 1 is for both banking and trust businesses and suffix 2 is for banking business only.

ROA: ratio of net after-tax income to total assets.
ROE: ratio of net after-tax income to equity capital.
MS: share of a bank in total industry assets.
HINDEX: sum of square of each bank's market share.
OPEFF/W: operating expenses per employee in log.
OPEFF/B: operating expenses per branch in log.
ASEFF/W: total assets per employee in log.
ASEFF/B: total assets per branch in log.
MARGIN: net interest margin, which is the difference of loan interest rate and deposit rate.
EQRATIO: ratio of equity capital to total assets.
NPLS: non-performing loans as a percentage of total loans.

Table 7. Trend of A Few Selected Variables

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
ROA1(%)	0.56	0.45	0.42	0.32	0.26	-0.93	-3.25	-1.31	-0.57	0.76	0.59
ROA2(%)	0.72	0.62	0.62	0.38	0.32	-1.1	-3.6	-1.4	-0.59	0.76	0.59
ROE(%)	6.69	5.90	6.09	4.19	3.80	-14.0	-53.0	-23.0	-12.0	15.9	11.7
HINDEX1	0.088	0.083	0.079	0.072	0.071	0.066	0.120	0.094	0.098	0.144	0.154
HINDEX2	0.090	0.088	0.084	0.076	0.074	0.069	0.121	0.093	0.097	0.138	0.147
NPLS(%)	4.4	4.9	5.8	5.2	4.1	6.0	7.4	8.3	6.6	2.9	1.9
X-INEFF	0.007	0.015	0.014	0.020	0.025	0.024	0.030	0.061	0.009	0.013	0.013

Table 8. <u>Panel Regressions of Returns on Assets: 1992-2002</u>
Dependent Variable: ROA1 (n=228)

	Model A	Model B	Model C	Model D	Model E	Model F	Model G
HINDEX1	-9.892*** (-2.727) 1.190		- 12.067*** (-3.338) 1.232	-2.762 (-.771) 1.727	-.680 (-.203) 1.511	-3.136 (-.882) 1.731	-1.031 (-.310) 1.515
MS1		6.936*** (2.611) 1.989	8.573*** (3.242) 2.060	3.571 (1.480) 2.121	3.997* (1.651) 2.463	5.173* (1.923) 2.135	3.690 (1.533) 2.472
OPEFF/W				-2.792*** (-9.715) 8.470		02.764*** (-9.691) 8.487	
ASEFF/W1				3.313*** (8.877) 8.936		3.281*** (8.852) 8.951	
OPEFF/B					-2.723*** (-9.519) 6.702		-2.698*** (-9.492) 6.714
ASEFF/B1					3.389*** (8.550) 8.362		3.338*** (8.492) 8.394
X-INEFF						-2.015** (-2.205) 1.069	-1.948** (-2.128) 1.071
MARGIN	69.125*** (3.782) 2.591	36.430* (1.817) 3.107	42.547** (2.161) 3.134	66.650*** (3.999) 3.202	69.078*** (4.126) 3.229	63.799*** (3.850) 3.224	66.187*** (3.972) 3.252
EQRATIO1	10.323** (2.5130) 2.017	17.306*** (4.431) 1.818	12.521*** (3.069) 2/074	10.995*** (2.617) 3..129	9.931** (2.488) 2.831	10.728** (2.574) 3.141	9.560** (2.411) 2.837
NPLS	-27.584*** (-11.732) 1.343	-27.475*** (-11.690) 1.338	-29.097*** (-12.384) 1.398	-11.316*** (-4.187) 2.644	-11.248*** (-4.141) 2.667	-11.782*** (-4.380) 2.661	-11.762*** (-4.345) 2.689
NATIONAL	0.981*** (4.045) 1.879	0.407 (.329) 3.453	0.262 (.807) 3.516	-0.095 (-.340) 3.682	-0.240 (-.811) 4.171	-0.044 (-.157) 3.707	-0.182 (-.617) 4.206
R^2	0.60	0.60	0.62	0.74	0.74	.76	.76
DW	1.42	1.44	1.53	1.60	1.59	1.62	1.61

t-values in parentheses. Numbers in the third row of each cell are VIF values. * significance at the 10% level, ** significance at the 5% level, and *** significance at the 1% level. The intercept terms which are different for each bank in the fixed-effects model, reflecting bank-specific characteristics, are not reported here and in the rest of tables.

Table 9. Panel Regressions of Returns on Assets: 1992-2002
Dependent Variable: ROA2 (n=228)

	Model A	Model B	Model C	Model D	Model E	Model F	Model G
HINDEX2	-14.336*** (-2.954) 1.284		-16.138*** (-3.381) 1.300	-21.526*** (-5.221) 1.728	-18.853*** (-4.965) 1.489	-21.486*** (-5.206) 1.728	-18.823*** (-4.949) 1.490
MS2		9.249*** (3.033) 2.081	10.357*** (3.454) 2.106	0.572 (0.242) 2.340	-3.265 (-1.268) 2.814	0.535 (0.226) 2.341	-3.229 (-1.251) 2.816
OPEFF/W				-4.148*** (-13.036) 8.408		-4.103*** (-12.688) 8.755	
ASEFF/W2				5.111*** (12.437) 8.747		5.033*** (12.104) 9.113	
OPEFF/B					-4.051*** (-12.957) 6.994		-4.020*** (-12.642) 7.243
ASEFF/B2					5.417*** (12.423) 8.718		5.368*** (12.044) 9.154
X-INEFF						-2.315* (-1.817) 1.101	-1.552* (-1.749) 1.111
MARGIN	79.520*** (4.164) 2.210	40.177* (1.861) 2.830	45.044** (2.13) 2.843	38.328** (2.418) 2.847	41.851*** (2.662) 2.847	37.180** (2.333) 2.875	41.075** (2.594) 2.878
EQRATIO2	7.871** (2.493) 1.806	15.395*** (5.162) 1.615	10.896*** (3.40) 1.952	11.393*** (3.749) 3.131	10.535*** (3.699) 2.792	11.415*** (3.751) 3.131	10.522*** (3.688) 2.793
NPLS	-31.764*** (-11.391) 1.477	-30.88*** (-11.336) 1.413	-33.356*** (-12.079) 1.520	-14.426*** (-5.704) 2.275	-14.152*** (-5.641) 2.273	-14.704*** (-5.750) 2.318	-14.362*** (-5.647) 2.327
NATIONAL	1.002* (1.654) 1.879	0.233 (.619) 3.532	0.128 (.347) 3.557	0.2 (.715) 3.663	-0.077 (-.265) 4.008	0.217 (.772) 3.680	-0.061 (-.208) 4.045
R^2	0.61	0.61	0.63	0.79	0.80	0.81	0.81
DW	1.45	1.46	1.55	1.79	1.76	1.81	1.78

t-values in parentheses. * significance at the 10% level, ** significance at the 5% level, and *** significance at the 1% level.

Table 10. Panel Regressions of Returns on Assets for Three Separate Periods
Dependent Variable: ROA1

1992-1996 (n=120)				
Variable	Model D	Model E	Model F	Model G
HINDEX1	22.235*** (3.788)	17.571*** (3.819)	21.889*** (3.687)	17.406*** (3.747)
MS1	4.472*** (3.194)	3.239** (2.032)	4.425*** (3.156)	3.232** (2.025)
OPEFF/W	-0.790*** (-2.813)		-0.794*** (-2.815)	-0.861*** (-3.380)
ASEFF/W1	1.064*** (3.381)		1.060 *** (4.351)	1.187*** (4.811)
OPEFF/B		-0.860** (-2.390)		
ASEFF/B1		1.194*** (2.858)		
X-INEFF			-0.201* (1.677)	-0.363* (-1.798)
MARGIN	41.949*** (3.808)	45.214*** (4.108)	40.368*** (3.532)	43.863*** (3.828)
EQRATIO1	-0.588 (-0.421)	-0.263 (-0.189)	-0.554 (-0.395)	-0.246 (-0.176)
NPLS	-5.793*** (-3.375)	-5.074*** (-2.887)	-5.958*** (-3.423)	-5.228*** (-2.924)
NATIONAL	-0.237* (-1.701)	-0.263** (-2.033)	-0.244* (-1.739)	-0.268** (-2.057)
R^2	0.59	0.60	0.61	0.62
DW	1.79	1.84	1.78	1.86
1997-1999 (n=61)				
HINDEX1	1.342 (.092)	2.191 (.175)	2.800 (.188)	2.584 (.205)
MS1	7.470 (.836)	6.083 (.646)	7.773 (.862)	6.606 (.693)
OPEFF/W	-4.841*** (-5.195)		-4.853*** (-5.170)	
ASEFF/W1	5.199*** (5.620)		5.038*** (5.131)	
OPEFF/B		-4.818*** (-5.391)		-4.798*** (-5.325)
ASEFF/B1		5.371*** (5.287)		5.216*** (4.874)
X-INEFF			-1.105* (-1.727)	-1.020* (-1.831)
MARGIN	29.344 (0.687)	32.397 (0.750)	27.154 (0.629)	29.979 (0.684)
EQRATIO1	29.949** (2.332)	29.184** (2.268)	30.523** (2.352)	29.922** (2.293)
NPLS	-10.513** (-2.087)	-10.157** (-1.991)	-11.049** (-2.135)	-10.641** (-2.034)
NATIONAL	-0.218 (-0.250)	-0.368 (-0.389)	-0.146 (-0.165)	-0.293 (-0.303)
R^2	0.80	0.78	0.81	0.81
DW	1.97	1.95	2.02	2.01
2000-2002 (n=45)				
HINDEX1	-2.693 (-0.404)	-2.419 (-0.351)	-1.736 (-0.698)	-1.706 (-0.671)
MS1	-2.078 (-0.833)	-2.436 (-0.914)	-2.863 (-1.127)	-3.185 (-1.184)
OPEFF/W	-2.542*** (-3.863)		-2.532*** (-3.884)	
ASEFF/W1	1.791** (2.306)		1.829** (2.376)	
OPEFF/B		-2.374*** (-3.577)		-2.379*** (-3.628)
ASEFF/B1		2.353*** (2.980)		2.320*** (2.972)
X-INEFF			-1.829** (-2.129)	-1.443** (-2.274)
MARGIN	-14.728 (-0.638)	-13.961 (-0.591)	-20.042 (-0.864)	-19.630 (-0.828)
EQRATIO1	35.677** (2.293)	38.418** (2.402)	35.255** (2.288)	37.569** (2.375)
NPLS	-10.636* (-1.842)	-7.998 (-1.353)	-12.388** (-2.109)	-10.223* (-1.686)
NATIONAL	0.536 (1.250)	0.252 (0.508)	0.492 (1.153)	0.250 (0.509)
R^2	0.70	0.70	0.72	0.71
DW	2.21	2.18	2.19	2.13

t-values in parentheses. * significance at the 10% level, ** significance at the 5% level, and *** significance at the 1% level. VIF values for all variables indicate no multicollinearity problem, but they are not reported here because of space limit.

Figure 2 Industry Inefficiency

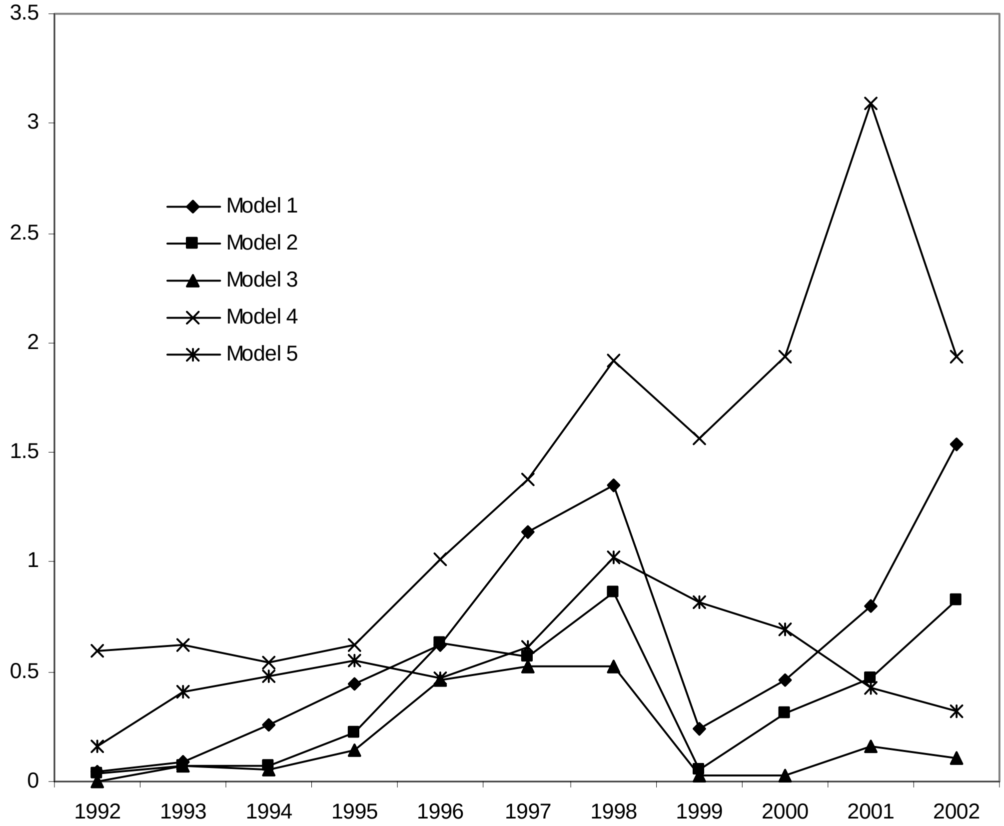


Figure 3 <u>**Industry Efficiency Change**</u>

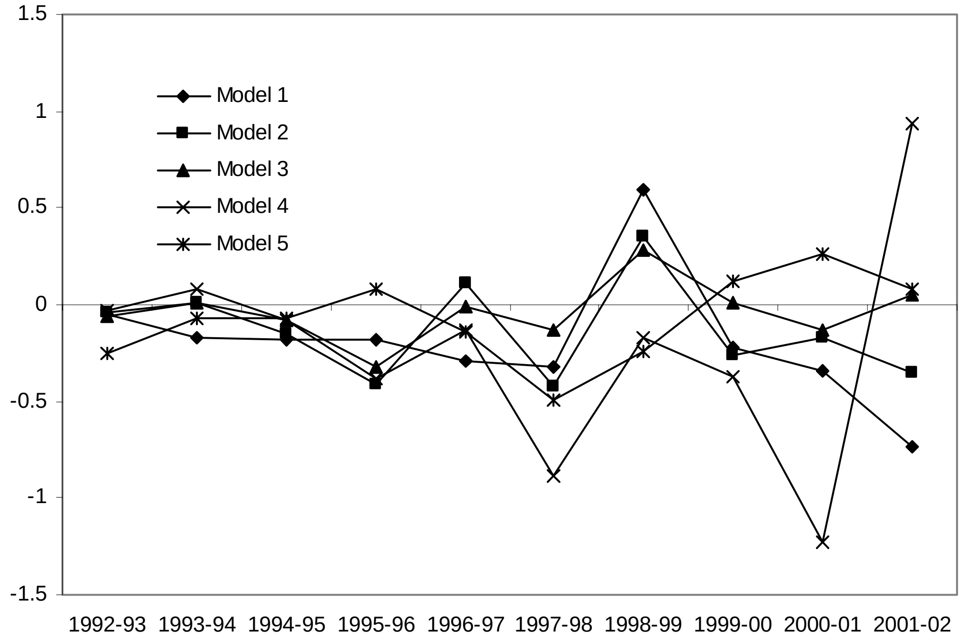
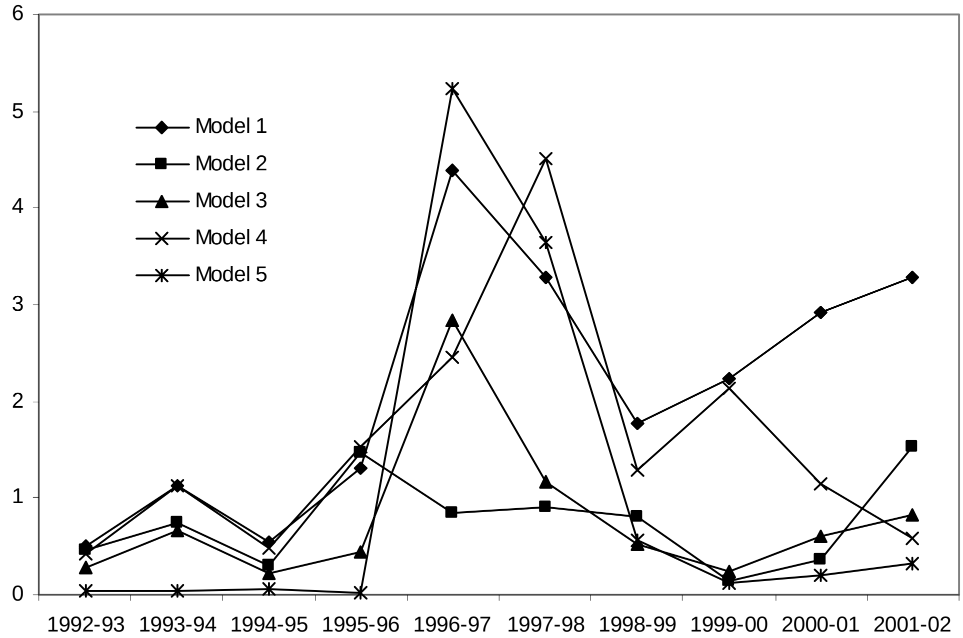


Figure 4 <u>Industry Technical Change</u>



<APPENDIX 1: List of National and Regional Banks>

National Banks	Regional Banks
1. Cho Hung Bank (grouped into Shinhan Financial Holding Co. in 2004) 2. Commercial Bank of Korea (merged with Hanil Bank to form Hanvit Bank in 1999, which was later transformed into Woori Financial Holding Co. in 2002) 3. Korea First Bank (nationalized in 1998 and sold to Newbridge Capital in 1999 and then to Standard Charter Bank and renamed as SC Korea First Bank in 2005) 4. Hanil Bank (merged with Commercial Bank of Korea to form Hanvit Bank in 1999, which was later transformed into Woori Financial Holding Co. in 2002) 5. Bank of Seoul (nationalized in 1998 and acquired by Hana Bank in 2002) 6. Korea Exchange Bank 7. Shinhan Bank (renamed as Shinhan Financial Holding Co. in 2002) 8. Hanmi Bank (acquired by Citi Bank in 2005 and renamed as Korea Citi Bank) 9. Dongwha Bank (acquired by Shinhan Bank in 1998) 10. Dongnam Bank (acquired by Housing and Commercial Bank in 1998) 11. Daedong Bank (acquired by Kookmin Bank in 1998) 12. Hana Bank 13. Boram Bank (merged into Hana bank in 1999) 14. Peace Bank (merged into Woori Holding Co. in 2001) 15. Kookmin Bank (converted from a special bank in 1995) 16. Housing and Commercial Bank (converted from a special bank in 1997 and merged into Kookmin Bank in 2002) 17. Woori Holding Co. (former Hanvit Bank renamed in 2002 when it became a financial holding company)	1. Daegu Bank 2. Pusan Bank 3. Chung Chong Bank (acquired by Hana Bank in 1998) 4. Kwangju Bank (grouped into Woori Financial Holding Co. in 2001) 5. Bank of Cheju (grouped into Shinhan Financial Holding Co. in 2002) 6. Kyungki Bank (acquired by Hanmi Bank in 1998) 7. Jeonbuk Bank 8. Kangwon Bank (merged into Cho Hung Bank in 1999) 9. Kyungnam Bank (grouped into Woori Financial Holding Co. in 2001) 10. Choongbuk Bank (merged into Cho Hung Bank in 1999)

<APPENDIX 2: Specification of the Models>

This appendix shows how Equation (18) is derived . Structural models presented here are similar to those of Berger (1995) and Park and Weber (2006b). In the literature of bank profitability, there are two main competing hypotheses: the market structure hypothesis and the efficient structure hypothesis. Under the traditional market structure hypothesis, market structure – either concentration or market share – influences behavior of banks through the pricing of their products in an imperfectly competitive market, with increased concentration resulting in higher profits. Under the efficient structure hypothesis, market power is not the cause of higher profits, but both market power and higher unit profits are the consequence of greater efficiency in management, operation and technology (X-efficiency hereafter). Banks with superior efficiency can lower their unit costs and increase their profits.

The structural model representing the traditional market structure hypothesis is as follows:

$$\pi_k = f_1\,(P_k, Z_{1k}\,) + \varepsilon_{1k} \qquad \text{(A1)}$$
$$P_k = f_2\,(MS_k \text{ or } CONC, Z_{2k}) + \varepsilon_{2k} \qquad \text{(A2)}$$
$$CONC = f_3\,(MS_k), \qquad \text{(A3)}$$

where π_k is a measure of profitability of bank *k*, P is a vector of output prices, Z is a vector of control variables, and ε is a random error term. Market share is represented by MS, and CONC is a measure of market concentration. According to the market structure hypothesis, output prices are mainly determined by market structure. In equation (A2), either MS or CONC is used depending on the specific hypothesis modeled. According to the collusion hypothesis (or structure-conduct-performance hypothesis) the degree of market concentration is an important determinant of profits. Under the relative market power hypothesis, market share is the major determinant of profits .

On the other hand, the structural model representing the efficient structure hypothesis is as follows:

$$\pi_k = f_4(EFF_k, Z_{4k}) + \varepsilon_{4k} \quad (A4)$$
$$MS_k = f_5 (EFF_k, Z_{5k}) + \varepsilon_{5k} \quad (A5)$$
$$CONC = f_6 (MS_k), \quad (A6)$$

where EFF is a measure of efficiency, either X-efficiency or scale efficiency. According to this hypothesis, a positive relationship between MS and π is a spurious effect because both MS and π are affected by efficiency.

In the past MS was used to support both the market structure hypothesis and the efficient structure hypothesis. Some argued that the significance of MS supports the relative market power hypothesis according to equations (A1) and (A2) (Shepherd, 1982; Kurtz & Rhoades, 1991). On the other hand, the supporters of the efficient structure hypothesis also used MS as an intermediary variable between EFF and π because of the difficulty of measuring EFF, and argued that the significance of MS supports their hypothesis (Smirlock, 1985; Evanoff and Fortier, 1988; Molyneux and Forbes, 1995). More recent studies have applied several measures of efficiency directly in determining bank profitability (for example, Berger, 1995a; Maudos, 1998).

In order to test these different hypotheses, it is necessary to develop a reduced form that nests all the hypotheses. The following equation may be viewed as the reduced form for π of all the hypotheses, where the Herfindahl-Hirschman index, HINDEX, serves as a proxy for CONC:

$$\pi_k = f_7\,(MS_k, \text{HINDEX}, EFF_k, Z_{7k}) + \varepsilon_{7k} \tag{A7}$$

<APPENDIX 3: Graphical Explanation of the Directional Distance>

This appendix provides graphical explanation of the directional technology distance function that is obtained by Equation (8) in section 4 and is used as X-inefficiency in profitability estimation in section 7. Figure A1 shows how the production technology and inefficiency are estimated from the observed input and output with an example of four banks: A, B, C, and D. The piecewise linear technology, T, is bounded by the lines HB, BD, DA, and the horizontal extension from A. Given a direction vector (g_x, g_e, g_y) where g_e is assumed to be zero, the directional distance function is estimated via Equation (8). This function expands output in the direction g_y, contracts inputs in direction g_x, and is a measure of technical inefficiency (X-inefficiency). Banks A, B, and D produce on the frontier of T and are efficient. Bank C operates inside the frontier and is inefficient.

X-inefficiency is measured by the directional distance between F and C in Figure A1. For estimation, we use three variable inputs, which are labor, capital, and deposits, and three outputs, which are commercial loans, consumer loans, and securities. We choose $g_y = (1,1,1)$ and $g_x = (1,1,1)$ so that the estimate of inefficiency from equation (8) is the maximum simultaneous unit expansion in the three outputs and unit contraction in the three inputs that is feasible given the best-practice combinations of outputs and inputs of the banks in our sample. An inefficient bank produces too little output using too much input than it would if it operated on the frontier. To examine the effect of inefficiency on ROA1 and ROA2, we sum inefficiency over the outputs and inputs and divide by total assets. Thus, in this illustration X-inefficiency (X-INEFF) is:

$$\text{X-INEFF}_k = \beta_k \left(\sum_m g_{ym} + \sum_n g_{xn}\right) / \text{Assets}_k = \beta_k\,(1+1+1+1+1+1) / \text{Assets}_k.$$

We report mean estimates of X-inefficiency in Table 7 for 1992-2002. During the period, X-inefficiency increases from less than 1% of total assets in 1992 to 6.1% of total assets in 1999, before falling to about 1% of assets during 2000-2002.

Figure A1. **The Bank Production Technology (T) and the Directional Distance Function**

$$\vec{D}(x, y; -1, 1) = \max\{\beta : (x-\beta, y+\beta) \in T\}$$