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Performance of Thailand Banks after the 1997 East Asian Financial Crisis

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Abstract: The performance of commercial banks and government-owned specialized banks in Thailand are estimated after the 1997 East Asian Financial crisis. Commercial banks exhibit increasing returns to scale whereas government owned specialized banks exhibit decreasing returns to scale, implying further increases in bank size and market concentration in the commercial bank sector but not for government specialized banks. Cost inefficiency varies by bank and is a function of the ratio of non-performing loans to total loans, equity to total assets, and liquid assets to total assets, as well as the number of branches. On average, banks with fewer non-performing loans, well capitalized, and with adequate liquidity are efficient. Thus stricter rules to regulate credit risk management, and ensure capital and liquidity adequacy would enhance efficiency in the banking sector. Although estimated input substitutability appears to be low, labor and loanable funds are substitutes, labor and physical capital as well as physical capital and loanable funds are complements in commercial banks. All three inputs of labor, physical capital and loanable funds are substitutes for the government specialized banks.

JEL codes: D24, G21, G32, L33, O53

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1. Introduction

Thailand requested financial support from the International Monetary Fund (IMF) during the 1997 East Asian Economic Crisis and received a rescue package of 20.3 billion US dollars conditional on programs of internal economic stabilization and financial sector restructuring. The financial restructuring initially focused on the identification and closure of non-viable financial institutions, intervention in weak banks, and recapitalization of the banking system. As a consequence of these reforms, there were significance changes in the ownership structure of financial institutions. The government nationalized and liquidated a number of distressed banks. It also abolished the restriction on foreign ownership of commercial banks, which had been restricted to less than 25% of the equity capital, to attract foreign banks and investors to recapitalize the distressed banks. Before the crisis, founding families were the largest shareholders in 5 of the largest 8 banks; however, by 2003, foreign investors were the largest shareholders in two banks including the largest bank. Two other banks had been either nationalized or liquidated. These activities certainly affected the structure and efficiency of Thai banks.

After the IMF mandates the Thai government further announced the Financial Sector Master Plan in January 2004. The substantial part of this plan included measures to increase efficiency of the financial sector by enhancing market mechanisms. These included easing entry into the banking sector by promoting the conversion of finance companies to commercial banks, relaxing regulations on new branches in densely populated areas, and relaxing restrictions on foreign financial institutions' scope of business and number of branches allowed. These changes may have further lead to the intensification of competition within the industry and impacted efficiency.

Thailand's banks are currently fully recovered and reformed and continue to play important roles in the Thai economy. In 2005, over 6 trillion baht (approximately 180 billion USD) of total deposits or deposit equivalents were in the banking sector, accounting approximately for 76 percent of total deposits or deposits equivalent in all Thailand's financial institutions. This amount is roughly 88 percent of GDP in 2005. Moreover, as the most prevalent source of credit in the economy, banks provide lending of approximately 5.5 trillion baht, roughly 77 percent of total credit provided by all of Thailand's financial institutions.

Because of the continued importance of banks in the Thai economy it would be informative and beneficial to measure bank performance over this financial adjustment period to determine productivity and efficiency changes. Also, knowledge of scale economies and the extent of substitutability of bank inputs would permit determining structural changes and the extent that banks can adjust to price changes. These results would provide insights into the future structure of the banking industry in Thailand. Policy from these empirical results could be pursued to encourage good practices and discourage bad practices to enhance performance. Further bank sector changes if warranted could benefit not only the banking industry but also the entire economy. Although the use of Data Envelopment Analysis (DEA) has also been used to estimate bank efficiency (Casu and Molyneux, 2003), we estimate a stochastic frontier analysis (SFA) function and use the parameter estimates to obtain measures of efficiency, productivity, input substitutability, and economies of scale, which collectively define bank performance.

The rest of this article is organized as follows; Section 2 provides a brief literature review focused on financial institutions, Section 3 concentrates on a description of the methodology, empirical specification and data, Section 4 and 5 provide results and conclusions, respectively.

2. Literature Review

There have been numerous bank efficiency estimates for various countries in the world and many of those are summarized in Berger and Humphrey (1997). One of the earliest Thailand bank efficiency study was done by Leightner and Lovell (1998), who analyzed the impact of financial liberalization on the performance of Thai banks during 1989-1994, and reported that the average bank in Thailand experienced relatively rapid growth in total factor productivity. Subsequently, Kwan (2003) examined the banking industries' operating costs in seven Asian economies including Thailand from 1992 to 1999, and concluded that bank operating efficiency appeared to be unrelated to the degree of openness of the banking sector.

Chansarn (2005) investigated the Thai financial sector after the 1997 financial crisis by looking at total factor productivity (TFP) growth, and found that efficiency in the commercial bank sector diminished as did the efficiency of the finance and securities company sector. Chantapong and Menkhoff (2005) also studied the effect of foreign bank entry on banking efficiency in Thailand after the financial crisis in 1997 and found that the cost efficiency of domestic banks improved, resulting from an increase in competition arising from the foreign bank entry through acquisition. Rangkakulnuwat (2007) utilized an output distance function approach to estimate the technical efficiency of seven Thai commercial banks from 1980 to 2005 who survived the 1997 crisis. The author found that the financial liberalization plan between 1987 and 1997, as well as the economics and financial reform programs financially supported by IMF, lead to improved efficiency of Thai commercial banks.

Recently, Thoraneenitiyan and Avkiran (2009) employed an approach integrating Data Envelopment Analysis and Stochastic Frontier Analysis to measure the impact of restructuring and country-specific factors on bank efficiency in East Asian including Thailand from 1997 to 2001. The results indicated that although domestic mergers produced more efficient banks, overall, restructuring did not lead to a more efficient banking system. Banking system inefficiencies were mostly attributed to country-specific conditions, particularly high interest rates, concentrated markets and economic development. Chunhachinda (2010) also measured Thai commercial bank efficiency between 1990 and 2008 by estimating both parametric and non-parametric cost frontiers. Results revealed that average cost efficiency levels of the post-1997 crisis were significantly lower than from the pre-crisis period. The emphasis on all of these studies were on productivity and efficiency, but none of the authors report the characteristics of the frontier function, which is unfortunate because economies of scale and knowledge of input substitutability would be useful to determine production changes from prices changes.

Despite the huge popularity of the conventional translog cost frontier, recent papers have adopted more flexible functional forms such as the Fourier to estimate cost efficiency of banks. Girardone, Molyneux and Gardener (2004) estimated a Fourier cost frontier for Italian banks. They found that the average bank-inefficiency levels ranged between 13% and 15% of total cost, which trended to decrease over time. Scale economies appeared to be present in the Italian bank industry.

This paper fills gaps in the research on Thai-bank efficiency. The use of the Fourier flexible functional form is more flexible than the conventional translog form and thus conceptually more able to fit the data and produce more accurate estimates. Another contribution is to compare banking production costs among different bank types in Thailand -- the commercial banks and the government-owned specialized banks. Elasticities from the cost frontier are also calculated, which are typically absent in past efficiency studies. Finally, more recent years are added to a longitudinal data set allowing a discussion of the most recent performance.

3. Methodology and Data

3.1 Methodology

A stochastic cost frontier with fourier components is estimated and the coefficients are used to derive returns to scale, efficiency, productivity, and input demand elasticities. The fourier (FF) functional form embedded into the translog is a global approximation whose performance has been shown to dominate the local-approximation of the translog functional form alone (Altunbas, Gardener, Molyneux and Moore, 2001). The global property is important in banking where scale, product mix and other inefficiencies are often heterogeneous. The FF is specified as:

$$\ln TC = \alpha_0 + \sum_i \alpha_i \ln Q_i + \sum_l \beta_l \ln P_l + t_1 T$$

$$+\frac{1}{2}\left[\sum_i \sum_j \delta_{ij} \ln Q_i \ln Q_j + \sum_l \sum_m \gamma_{lm} \ln P_l \ln P_m + t_2 T^2\right]$$

$$+\sum_i \sum_m \rho_{im} \ln Q_i \ln P_m + \sum_i \left[a_i \cos(y_i) + b_i \sin(y_i) \right]$$

$$+\sum_i \sum_j \left[a_{ij} \cos(y_i + y_j) + b_{ij} \sin(y_i + y_j) \right] + u + v \qquad (1)$$

where TC is observed total cost of production, Q_i is a vector of outputs, P_i is an input-price vector, y_i is the adjusted values of the log output, $\ln Q_i$, such that they span the interval $[0, 2\pi]$, T is the time trend, and u is assumed to be distributed as half normal, $u \sim N(\mu, \sigma_u^2)$, capturing the effects of inefficiency when μ is defined as

$$\mu_i = \theta_0 + \sum_j Z_{ji} \theta_j \qquad (2)$$

where Z_{ji} is the jth inefficiency determinant of bank ith. The cost frontier model, equation (1), and the inefficiency model, equation (2), are estimated simultaneously via a maximum likelihood procedure.

The data must be scaled because a Fourier series approximation near a point of discontinuity can oscillate wildly. To avoid this problem, as recommended by Kauko (2009), the output data were rescaled as:

$$y_i = 1.8\pi \left[Q_i - \min(Q_i) \right] / \left[\max(Q_i) - \min(Q_i) \right] + 0.1\pi \qquad (3)$$

Like Berger, Leusner and Mingo (1994), the Fourier terms are applied only to the outputs, leaving the input price effects to be defined entirely by the translog terms. The primary goal is for a limited number of Fourier terms to describe the scale and inefficiency measures associated with differences in bank size. Moreover, the usual input price homogeneity restrictions can be imposed on logarithmic price terms, whereas they cannot be easily imposed on the trigonometric terms.

Since the duality theorem requires that the cost function be linearly homogeneous in input prices and that second-order parameters be symmetric, the following restrictions are applied to the parameters of the cost function:

$$\sum_l \beta_l = 1; \qquad \sum_l \gamma_{lm} = 0; \qquad \sum_i \rho_{im} = 0; \qquad \delta_{ij} = \delta_{ji}; \qquad \gamma_{lm} = \gamma_{ml}$$

Within sample scale economies are calculated and evaluated at the mean output, input price and financial capital levels.[2] A measure of economies of scale (*SE*) is given by the following cost elasticity by differentiating the cost frontier, equation (2), with respect to output, producing equation 4.

$$SE = \sum_i \frac{\partial \ln TC}{\partial \ln Q_i} = \sum_i \alpha_i + \sum_i \sum_j \delta_{ij} \ln Q_j + \sum_i \sum_m \rho_{im} \ln P_m$$

$$+1.8\pi \sum_i \left(\frac{Q_i}{\max(Q_i) - \min(Q_i)} \right) \left[-a_i \sin(y_i) + b_i \cos(y_i) \right]$$

$$+3.6\pi \sum_i \sum_j \left(\frac{Q_i}{\max(Q_i) - \min(Q_i)} \right) \left[-a_{ij} \sin(y_i + y_j) + b_{ij} \cos(y_i + y_j) \right] \quad (4)$$

The price responsiveness of inputs can be measured by estimating the price elasticity of conditional demands (η_{ij}) using the following formulas:

$$\eta_{ii} = S_i \sigma_{ii}, \qquad \eta_{ij} = S_j \sigma_{ij} \quad (5)$$

$$\sigma_{ii} = \frac{\gamma_{ii} + S_i(S_i - 1)}{(S_i)^2}, \qquad \sigma_{ij} = \frac{\gamma_{ij} + S_i S_j}{S_i S_j} \quad (6)$$

where σ_{ij} is the Allen-Uzawa partial elasticity of substitution and S_i is the cost share of input i^{th}.

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[2] It is common to evaluate the elasticity at the geometric mean, $\bar{a} = \left(\prod_{i=1}^{n} a_i \right)^{\frac{1}{n}}$.

A time trend variable, T, is incorporated into the cost function to capture the disembodied technological change which allows a bank to produce a given level of output, Q, at a lower (or higher) cost over time, holding input prices constant (Lang and Welzel, 2006). This change can be measured by taking the partial derivative of the estimated cost frontier with respect to the time trend variable (T):

$$T_c = \frac{\partial \ln TC}{\partial T} = t_1 + t_2 T \qquad (7)$$

3.2 Data

The intermediation approach commonly used in bank cost estimates is used to model inputs and outputs. Under this approach, the defined inputs of deposits and acquired funds, labor, and capital are employed in the production of loans and investments. Thai banks can also be classified into two groups: commercial banks and government-owned specialized banks, similar to the approach utilized by Mobarek and Kalonov (2013) in comparing conventional and Islamic banks. Because these entities are different in terms of business structures, management styles and customer bases, they may operate under different production technology or different environments, and thus are estimated separately after statistically testing verified that they were different.

The panel nature of the data set provides a large sample size and thus allows analyzing productivity growth as well as ranking efficiency among banks. Panel data for 13 commercial banks were collected from their quarterly financial reports to the stock exchange of Thailand, beginning from the first quarter of 1998 to the fourth quarter of 2010, while data from 5 government-owned specialized banks were collected from their financial reports to the ministry of finance. One government specialized bank, the Islamic bank, is excluded from the data set because it has been newly established, with an insufficient number of observations available. The panel data for government-owned specialized banks are unbalanced because unlike the commercial banks, only recently beginning in 2003 were they required by law to provide the ministry of finance quarterly balance sheet and income statements.

In order to estimate the cost frontier, the following variables were constructed. Total cost (TC) is composed of interest expense, non-interest expense on personnel, and non-interest expense on premises and equipment. Loan (Q_1) consists of quantity of loans, inter-bank and money market items. Investment (Q_2) is comprised of government and state enterprise securities, and other securities. Unit price of labor (P_1) is obtained from non-interest expense on personnel divided by the number of employees[3]. Unit price of physical capital (P_2) is computed from expenses on buildings and equipment divided by their book value[4]. Unit price of deposits and acquired funds (P_3) is calculated by dividing interest expense by the sum of amount of deposits, short term and long term borrowing, bonds and other borrowed money. All items were adjusted to real values (year base 1988).

Table 1 shows summary statistics for the output quantities and input prices, separately for commercial and government banks. On average, commercial banks' total cost, loans, and investments are twice the size of government banks. However, prices of

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[3] The number of employees is reported at the end of each year only and is assumed to be constant throughout any year.
[4] The original cost less depreciation and amortization.

inputs paid by commercial banks are slightly less than those of government banks, except for wages and salary.

Table 1

Variables defining management and the operating environment are assumed to determine inefficiency. Dummy variables are used to represent ownership and governance; TAKEOVER = 1 if a bank is taken over by foreign investors, zero otherwise. Foreign investors may have superior managerial quality, tacit knowledge and informational advantage, allowing them to outperform local bankers. In addition, STATE = 1 if a major shareholder of a bank is the government. According to incentive theory, state-owned banks may suffer from lack of ownership incentives and hence may be prone to poor performance. Banks owned by private stockholders might also face stronger incentives to control cost and be more efficiency than state-owned banks.

Several other factors that may impinge on efficiency are added to the model. First, the ratio of non-performing loans to total loans is used to control for differences in banks' loan quality. Under the "bad management hypothesis" of Berger and DeYoung (1997), loan quality is an indicative of the quality of bank management.

Also, according to Fillipaki, Margaritis and Staikouras (2009), the number of branches of each bank should be included because the major reason banks may open up new branches is for efficient utilization of excess capacities. Banks may also have a strategic motivation to expand their branch network to defend market share. In this case, opening up new branches is not expected to increase banks' efficiency.

The ratio of equity to total assets is reflective of capital adequacy of a bank and is included in the inefficiency analysis as suggested by Altunbas, Lui, Molyneux and Seth

(2000). Well-capitalized banks are perceived to be relatively safe, which in turn lowers the cost of borrowing, and consequently enhances efficiency. Therefore, higher levels of capital adequacy are expected to impinge positively on efficiency.

Fillipaki, Margaritis and Staikouras (2009) state that the ratio of liquid assets to total assets, accounting for different risk preference and risk management practices, should be incorporated into the specification of the inefficiency model because it directly affects cost efficiency by providing an alternative to deposits as a funding source for loans; it may also reflect the risk-return trade-off that banks face.

Summarily, the determinant of Thai commercial banks' inefficiency, equation (2), is written in the specific form as:

$$\mu_i = \theta_0 + \theta_1 \text{TAKEOVER}_i + \theta_2 \text{STATE}_i + \theta_3 \left(\text{NPL/LOAN}\right)_i + \theta_4 \text{BRANCH}_i + \theta_5 \left(\text{EQUITY/ASSET}\right)_i + \theta_6 \left(\text{LIQUID/ASSET}\right)_i \qquad (8)$$

where TAKEOVER_i is a binary variable taking value of 1 in subsequent years if the ith bank is taken over or acquired by foreign investors. STATE_i is a binary variable to distinguish between private banks and state banks, $\left(\text{NPL/LOAN}\right)_i$ is the ratio of non-performing loans to total loans, BRANCH_i is the number of branches. $\left(\text{EQUITY/ASSET}\right)_i$ is the ratio of share-holder equity to total assets, and $\left(\text{LIQUID/ASSET}\right)_i$ is the ratio of liquid assets to total assets.

The inefficiency model for government banks is specified differently. The dummy variables for takeover and a state bank are null sets because no government bank has been taken over and all are also 100-percent owned by the Thai government. Additionally, the variable $\left(\text{NPL/LOAN}\right)_i$ is dropped due to incomplete data on the amount of non-performing loans. Hence, the three remaining variables determining inefficiency for the government banks are the number of branches, the ratio of shareholder equity to total assets, and the ratio of liquid assets to total assets. The means and standard deviations of these variables are summarized in table 2.

Table 2

4. Estimation results

A common frontier for both commercial banks and government banks was first estimated and tested to determine if separate frontiers were justified based upon the distribution of the efficiency scores. A number of parametric and non-parametric tests based upon the distribution of efficiency scores as specified by Havrylchyk (2006) were performed to test whether commercial and government banks come from the same population frontier. These tests all rejected the null of a common frontier[5].

These tests have limitations because they test against the null hypothesis whether the efficiency distributions are similar rather than directly testing whether the underlying technologies are different. To extend these tests, we performed these tests again on the predicted total cost expenditure rather than simply the efficiency scores. These test results reaffirms the statistical conclusions that the frontiers are different. Therefore, we conclude that commercial banks and government banks operate under different technologies and it is appropriate and necessary to estimate separate cost frontiers. These separate frontier estimates are reported in tables 3 and 4, respectively.

Table 3

Table 4

[5] These tests are available from the authors and comprised of various nonparametric tests to determine if the cost efficiency distributions were different between commercial and government banks

Using the estimated coefficients of the cost frontiers reported in tables 3 and 4, the scale economies of commercial banks and government banks at geometric means of outputs and factor prices are calculated to be 0.92 and 1.73, respectively, implying commercial banks experience economies of scale while government banks experience diseconomies of scale. From the summary statistics given in table 1, it is clear that government banks are much smaller than private commercial banks, and this smaller size may be a reflection of diseconomies. This has implications for bank structure in Thailand. The commercial bank sector will be expected to increase their market share but not the specialized government bank sector unless additional government banks are formed. The commercial bank sector is likely to become a more concentrated market, resulting in intensified market power of larger banks and higher interest-rate spreads, which would be detrimental to customers unless the government closely monitors and regulates the market.

Allen-Uzawa substitutions as defined in equation (6) are computed and used to derive price elasticities at the geometric means of input prices as defined in equation (5). Tables 5 and 6 present the own and cross price input demand elasticities experienced by commercial banks and government banks, respectively.

Table 5

Table 6

For commercial banks, every own price elasticity is negative as expected, with the own price elasticity of labor demand being close to negative unity. The implication is that expenditures on labor will remain fairly constant as wage rates change. The own price elasticity of demand for physical capital is substantially greater than negative one implying that physical capital is very sensitive to the price of capital. Demand for loanable funds is inelastic with close to a zero own price elasticity. This is not surprising given that banks require funds to write loans and thus demand is not sensitive to price. Labor and loanable funds are weak substitutes, whereas labor and physical capital, and physical capital and loanable funds are weak complements, with all cross price elasticities being very close to zero. So although capital is negatively responsive to capital price, there would be little substitution of labor for capital given that labor and physical capital are weak complements This set of elasticities of substitution implies a fixed proportion technology, meaning that it would be difficult for commercial banks to substitute inputs in response to input prices changes.

For government banks, own and cross price elasticities shown in table 6 are very similar to those of commercial banks; all input demands have negative slopes with own-price elasticity of demand for labor close to unity. The demand for physical capital is highly elastic but demand for loanable funds is inelastic.

Estimates of technical change are derived using equation (7) and are summarized in figure 1. For commercial banks, technical change resulted in a decline in the cost of production throughout the period of study, but these cost declines occurred at a slower rate as time passes, from 0.53% in the first quarter of 1998 to only 0.02% in the fourth quarter of 2010. On the other hand, government banks suffered from an increase in cost of production, but the rate of this rising trend decreased over time, from 0.63% in the first quarter of 1998 to 0.49% in the fourth quarter of 2010. Therefore, commercial banks experienced cost decreases over this time period but those cost decreases appear to have been mostly captured. In contrast the government banks experienced cost increases over time.

Figure 1

Table 7 presents the average cost-inefficiency score for each commercial bank together with the average of the inefficiency-determinant variables, while the determinants of cost inefficiency are reported towards the end of table 3. The ratio of non-performing loans to total loans (NPL/LOAN), and whether a bank was taken over during the financial crisis (TAKEOVER), have positive effects on cost inefficiency, whereas other variables, including the dummy variable representing the state-enterprise bank (STATE), the ratio of equity to total assets (EQUITY/ASSET), the ratio of liquid assets to total assets (LIQUID/ASSET), and the number of branches (BRANCH) have negative impacts on cost inefficiency.

Table 7

The fact that the ratio of non-performing loans to total loans is positively related to cost inefficiency broadly supports the bad management hypothesis of Berger and DeYoung (1997), which suggests that efficient banks tend to perform better because they are better in evaluating credit risks. That the equity-to-total-asset ratio has a negative relationship with cost inefficiency suggests that a better capitalized bank tends to be more cost efficient than a bank highly leveraged, perhaps because ownership incentives induce higher quality cost management. In addition, the coefficient on the ratio of liquid-asset-to-total-asset is negative, suggesting banks that can retain large amounts of liquid assets are likely to be successful in lowering their financial risks and hence tend to perform more efficiently. Hence, policies to regulate banks' credit risk management, capital adequacy and liquidity, are beneficial for enhancing cost efficiency. Thus the bank of Thailand may consider increasing the required allowance for doubtful accounts[6] and liquidity retention[7]. Furthermore, the fact that the number of branches has a negative impact on bank inefficiency is consistent with the presumption that banks are likely to open up new branches for efficient utilization of excess capacities. Relaxing the rules to establish new branches might provide further incentives for banks.

Surprisingly, the coefficient on the dummy variable representing state-enterprise banks is negative, suggesting that state-enterprise banks trend to outperform private-owned banks. This fact seems to contradict the presumption that state ownership is associated with poor economic performance. Banks are categorized as state-enterprises if the Thai government holds more than 50% of their shareholder equity. According to this definition, only one bank, Krung Thai Bank, is labeled as a state-enterprise bank, which limits the inference, but with 52 quarterly observations, it appears that the result is consistent over time. Other banks like Siam City Bank and Bank Thai, are not classified as state enterprises even though their major shareholder is the Financial Institution Development Fund (FIDF) because those banks are independently managed by the board appointed by the government. The Thai Military Bank is not considered a state enterprise because the government is only a significant shareholder at 26% of the stock. After the 1997 Asian financial crisis, by the prescription of the government, Krung Thai Bank merged with smaller insolvent banks. Moreover, Krung Thai Bank was better-capitalized than other banks during the period of the crisis because of government financial support.

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[6] Currently, the bank of Thailand sets the requirements of capital adequacy ratio and allowance for doubtful accounts according to the Basel II accord, International Accounting Standards (IAS 39) and Bank for International Settlements (BIS).

[7] Presently, according to the bank of Thailand's rules, commercial banks are required to retain at least 6% of liquid assets to total deposits.

The government provided the bank with low-cost funding to stimulate the slowed economy. This might be why Krung Thai Bank was more efficient than private-owned banks.

The coefficient on the dummy variable representing banks which are acquired by foreign banks has a positive sign, opposite of findings by Kasman and Yildirim (2006) of banks in the new EU countries during transition. The banks that were acquired or majority owned by foreign investors include Bank Thai[8], United Overseas Bank[9], and Standard Chartered Nakornthon[10]. The reason why foreigner-owned banks show lower efficiency than domestically owned banks might be that although foreign banks may have superior management skill and culture, they might have less knowledge about the local market and success in meeting the needs of that market.

The Krung Thai Bank appears to be the most efficient bank whose average cost-inefficiency score is the lowest at 1.008. Since cost-inefficiency score represents how much firms could reduce costs if they had produced on the cost frontier, this implies that on average Krung Thai Bank produces output at only a 0.8% higher cost relative to the cost frontier. Figure 2 illustrates the plots of cost-inefficiency scores of the four most efficient banks including Krung Thai Bank, Siam Commercial Bank, Bangkok Bank, and Kasikorn Thai Bank. These findings are very similar to previous studies; for example, Rangkakulnuwat (2007) found that Krung Thai Bank was the most efficient bank; Chansarn (2008) found the average efficiency of Siam Commercial Bank and Kasikorn Bank was equal to one throughout the period (2003-2006) while Krung Thai Bank was the most efficient bank in the years 2004 to 2006. It is also noteworthy that these four

[8] On November 5, 2008 Bank Thai was acquired by Malaysian CIMB group.
[9] UOB bank was initially Ratanasin Bank. It was acquired by Singaporean United Overseas Banks in 1998.
[10] In 1999, Singaporean Standard Chartered bank acquired 75% of the shares of Nakornthon Bank.

banks have been consistently labeled the Big 4 banks in Thailand for many years because of their enormous assets and market share[11]. Figure 2, shows the vast gaps between the most efficient bank and the other 3 banks during the early period of the study, but these gaps trend to disappear as time passes, implying that the less efficient banks are catching up with the most efficient bank.

Figure 2

The efficiency of government-owned specialized banks can be derived from the cost-frontier estimation results in table 4. Table 8 reports the means and standard deviations of cost inefficiency together with the inefficiency-explanatory variables of each government-owned specialized bank.

Table 8

The equity-to-total-asset ratio has a negative effect on cost inefficiency, the same result was found for commercial banks. However, an increase in the liquid-asset-to-total-asset ratio will increase cost inefficiency. This implies that government banks face the financial constraint of the tradeoff between retaining liquid assets and holding less-liquid and higher-risk assets; they must choose between liquid assets which improve their cost efficiency but provides only little return, or less liquid assets which gives higher returns but potentially lower cost efficiency. Government banks' branch expansion appears to have resulted in higher inefficiency.

The Export-Import Bank of Thailand is the most efficient government bank throughout the period, which is due to few branches and a high equity-to-total-asset ratio.

[11] Chansarn (2008), for example, categorizes Thai commercial banks into 3 groups: large banks consisting of Bangkok Bank, Kasikorn Bank, Siam Commercial Bank, and Krung Thai Bank: medium bank consisting of Bank of Ayudhaya, Thai Military Bank, Siam City Bank, Bank Thai, and Thanacart Bank: small banks consisting of Standard Charter Nakornthon Bank, TISCO Bank, and Kaitnakin Bank.

On the other hand, the Bank of Agriculture and Cooperatives shows a low although upward trend in efficiency over time. This lower efficiency might be attributed to low equity and an enormous number of branches (861 branches on average over the period). The government encourages the Bank of Agriculture and Cooperatives to establish branches in many districts throughout the country in order to facilitate farmer's broad accessibility to loans, but this accessibility comes at a cost to that bank. The time trends of government bank's efficiencies are much different from those of commercial banks and are unsystematic; only Export-Import Bank of Thailand is consistently ranked as the most efficient bank throughout the period.

5. Conclusion

The objective of this paper was to estimate the performance of individual banks in the Thailand banking industry. That information can help guide policy to induce continued improved performance of the banking sector. To accomplish this objective, separate cost efficiencies for Thai commercial banks and government-owned specialized banks were estimated using quarterly data from 1998 through 2010 employing a Fourier-specified stochastic cost function. Determinants of cost inefficiency are included in the specification and estimations. The hypothesis that both commercial banks and government banks data are drawn from the same population is rejected; therefore, the cost frontiers for commercial banks and government banks were estimated separately.

In the very first years after the 1997 East Asian financial crisis, there were wide gaps between the most and least efficient banks. However, these gaps among the group of big banks disappeared in recent years, although the small banks failed to catch up to the big banks. This has implications for the ability of small banks to survive. In addition, Thai commercial banks' production technology exhibits increasing returns to scale at their current size. Hence, the results suggest that additional growth in bank size, more concentrated market and intensified market power of big banks are plausible. Unless the government monitors and regulates the market, consumers might suffer from raising interest rate spreads.

Commercial banks with a lower non-performing loan-to-total-loan ratio, a higher equity-to-total-asset ratio, a higher liquid-asset-to-total-asset ratio, and more branches are found to be more efficient. Hence, policies to induce strict credit-risk management, to discourage leverages and to encourage banks to establish new branches are recommended.

Estimated price elasticities of demands for inputs show that labor and loanable funds appear to be substitutes to each other; however, labor and physical capital as well as physical capital and loanable funds are complements. There is poor substitutability between labor and physical capital implying a fixed proportion technology and an inability to substitute capital for labor or vice versa.

For government-owned specialized banks the factors increasing cost inefficiency were a higher equity-to-total-asset ratio, a lower liquid-asset-to-total-asset ratio, and fewer branches. In contrast to commercial banks, government-owned banks seem to suffer from diseconomies of scale. In their production of loans and investments, all three inputs including labor, physical capital and loanable funds appear to be substitutes for each other.

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Table 1. Summary statistics of variables for frontier cost function

		C	Q_1	Q_2	P_1	P_2	P_3
		Cost	Loans	Investments	Labor	Capital	Funds
Commercial	Mean	5,620	466,000	80,500	160,723	0.06	0.01
Banks	Std	5,930	366,000	82,600	222,788	0.04	0.01
Government	Mean	3,050	2,590	536	155,191	0.07	0.01
Banks	Std	2,300	1,970	996	52,245	0.06	0.00

Note: cost and output (C, Q_1 and Q_2) units in million baht; unit of wage and salary (P_1) in baht per quarters.
Data are collected from individual banks' quarterly financial reports.

Table 2. Summary statistics of variables explaining banks' inefficiency

		NPL/Total loan	Branches	Equity/ Total assets	Liquidity/ Total assets
Commercial	Mean	0.14	354	0.08	0.12
Banks	Std	0.16	257	0.04	0.12
Government	Mean		357	0.10	0.06
Banks	Std		349	0.04	0.06

Table 3. The estimated cost frontier for commercial banks

	Variable	Coefficient	Standard error	t-statistic
Stochastic Cost frontier (equation 3)				
α_0	constant	-47.492***	13.1838	-3.60
α_1	$\ln Q_1$	4.94398***	0.99402	4.97
α_2	$\ln Q_2$	0.18515	0.33746	0.55
β_1	$\ln P_1$	-0.9232**	0.37213	-2.48
β_2	$\ln P_2$	0.54707	0.35509	1.54
β_3	$\ln P_3$	1.37617***	0.24601	5.59
δ_{11}	$1/2(\ln Q_1)^2$	-0.0638	0.04847	-1.32
δ_{22}	$1/2(\ln Q_2)^2$	0.11285***	0.01888	5.98
δ_{12}	$\ln Q_1 \ln Q_2$	-0.1122***	0.01863	-6.02
γ_{11}	$1/2(\ln P_1)^2$	-0.0279**	0.01403	-1.99
γ_{22}	$1/2(\ln P_2)^2$	-0.3606***	0.03867	-9.32
γ_{33}	$1/2(\ln P_3)^2$	0.09546***	0.00984	9.70
γ_{12}	$\ln P_1 \ln P_2$	-0.0891***	0.02325	-3.83
γ_{13}	$\ln P_1 \ln P_3$	-0.0672***	0.01353	-4.97
γ_{23}	$\ln P_2 \ln P_3$	-0.1063***	0.01951	-5.45
ρ_{11}	$\ln Q_1 \ln P_1$	0.02119	0.01856	1.14
ρ_{12}	$\ln Q_1 \ln P_2$	-0.0383*	0.0204	-1.88
ρ_{13}	$\ln Q_1 \ln P_3$	0.01715	0.01386	1.24
ρ_{21}	$\ln Q_2 \ln P_1$	0.01026	0.01777	0.58
ρ_{22}	$\ln Q_2 \ln P_2$	0.00034	0.01765	0.02
ρ_{23}	$\ln Q_2 \ln P_3$	-0.0106	0.01018	-1.04
t_1	T	-0.0054***	0.0019	-2.86
t_2	T^2	0.0001***	3.2E-05	3.16
a_1	$\cos(y_1)$	-0.0596***	0.01727	-3.45
b_1	$\sin(y_1)$	-0.144***	0.03555	-4.05
a_2	$\cos(y_2)$	-0.0164	0.01369	-1.20
b_2	$\sin(y_2)$	0.05799***	0.01878	3.09
a_{11}	$\cos(y_1 + y_1)$	0.02726***	0.00931	2.93

	Variable	Coefficient	Standard error	t-statistic
a_{12}	$2\cos(y_1 + y_2)$	-0.0248***	0.00763	-3.25
a_{22}	$\cos(y_2 + y_2)$	0.02509**	0.01068	2.35
b_{11}	$\sin(y_1 + y_1)$	-0.0236***	0.01168	-2.02
b_{12}	$2\sin(y_1 + y_2)$	0.02284***	0.00668	3.42
b_{22}	$\sin(y_2 + y_2)$	0.00819	0.01217	0.67
$\ln(\sigma_v^2)$		-5.7701	0.116595	-49.49
	Inefficiency model (equation 10)			
θ_0	CONSTANT	-1.03717***	0.372453	-2.78
θ_1	TAKEOVER	1.080186***	0.431281	2.50
θ_2	STATE	-1.46906***	0.391788	-3.75
θ_3	NPL/LOAN	1.279289**	0.653876	1.96
θ_4	EQUITY/ASSET	-14.2237***	3.300632	-4.31
θ_5	LIQUID/ASSET	-3.23623***	1.088508	-2.97
θ_6	BRANCH	-0.00847***	0.000881	-9.62
σ_u		0.055852	0.003256	

Note: *, **, *** represents statistical significance at the 10%, 5% and 1%, levels.
The number of observations is 523.
The log likelihood is 579.92.
The distribution of inefficiency term is assumed to be half normal.

Table 4. The estimated cost frontier for government specialized banks

	Variable	Coefficient	Standard error	t-statistic
Stochastic Cost frontier (equation 3)				
α_0	constant	-85.1997**	39.67668	-2.15
α_1	$\ln Q_1$	11.28217***	4.001251	2.82
α_2	$\ln Q_2$	-0.38396	0.45816	-0.84
β_1	$\ln P_1$	-1.43976*	0.745476	-1.93
β_2	$\ln P_2$	2.582125*	1.365805	1.89
β_3	$\ln P_3$	-0.14236	1.05888	-0.13
δ_{11}	$1/2(\ln Q_1)^2$	-0.68353***	0.205355	-3.33
δ_{22}	$1/2(\ln Q_2)^2$	0.013633	0.011959	1.14
δ_{12}	$\ln Q_1 \ln Q_2$	0.007238	0.016059	0.45
γ_{11}	$1/2(\ln P_1)^2$	-0.1488**	0.059209	-2.51
γ_{22}	$1/2(\ln P_2)^2$	-0.07091	0.06074	-1.17
γ_{33}	$1/2(\ln P_3)^2$	0.217084**	0.090458	2.40
γ_{12}	$\ln P_1 \ln P_2$	0.114185	0.094648	1.21
γ_{13}	$\ln P_1 \ln P_3$	0.221348**	0.092159	2.4
γ_{23}	$\ln P_2 \ln P_3$	0.025615	0.041903	0.61
ρ_{11}	$\ln Q_1 \ln P_1$	0.222433***	0.03235	6.88
ρ_{12}	$\ln Q_1 \ln P_2$	-0.19234***	0.032216	-5.97
ρ_{13}	$\ln Q_1 \ln P_3$	-0.03009	0.037071	-0.81
ρ_{21}	$\ln Q_2 \ln P_1$	0.004259	0.017635	0.24
ρ_{22}	$\ln Q_2 \ln P_2$	-0.00193	0.022706	-0.09
ρ_{23}	$\ln Q_2 \ln P_3$	-0.00233	0.02236	-0.10
t_1	T	0.006367	0.010421	0.61
t_2	T^2	-2.8E-05	0.000152	-0.19
a_1	$\cos(y_1)$	-0.05257	0.119746	-0.44
b_1	$\sin(y_1)$	-0.31278	0.232779	-1.34
a_2	$\cos(y_2)$	-0.27615**	0.11839	-2.33
b_2	$\sin(y_2)$	-0.4121***	0.106224	-3.88
a_{11}	$\cos(y_1 + y_1)$	-0.06747	0.090338	-0.75

	Variable	Coefficient	Standard error	t-statistic
a_{12}	$2\cos(y_1+y_2)$	-0.10174	0.063357	-1.61
a_{22}	$\cos(y_2+y_2)$	0.109957	0.0693	1.59
b_{11}	$\sin(y_1+y_1)$	-0.1847**	0.085613	-2.16
b_{12}	$2\sin(y_1+y_2)$	-0.18255***	0.048231	-3.78
b_{22}	$\sin(y_2+y_2)$	-0.04983	0.079832	-0.62
$\ln(\sigma_v^2)$		-5.97734	0.394597	-15.15
	Inefficiency model (equation 10)			
θ_0	CONSTANT	-3.55694***	1.277006	-2.79
θ_4	EQUITY/ASSET	-30.4118	23.9808	-1.27
θ_5	LIQUID/ASSET	4.311321	4.478098	0.96
θ_6	BRANCH	0.002009	0.001453	1.38
σ_u		0.050355	0.009935	

Note: *, **, *** and represent statistical significance at 10%, 5% and 1% levels.
The number of observations is 134.
The log likelihood is 171.69.
The distribution of inefficiency term is assumed to be half normal.

Table 5. Own and cross price elasticities of demand for inputs of commercial banks

input i	input j: Own and cross price elasticities of demand for inputs (η_{ij})		
	labor	physical capital	loanable funds
labor	-0.893	-0.003	0.154
physical capital	-0.007	-3.959	-0.108
loanable funds	0.053	-0.019	-0.199

Table 6**.** Own and cross price elasticities of demand for inputs of government banks

input i	input j: Own and cross price elasticities of demand for inputs (η_{ij})		
	labor	physical capital	loanable funds
labor	-1.245	0.002	0.619
physical capital	0.008	-2.071	0.457
loanable funds	0.266	0.043	-0.013

Table 7. Average cost inefficiencies and causation factors for commercial banks

Name	Inefficiency	NPL/ Loan	Equity/ assets	Liquid/ Assets	Branches	Takeover
Krung Thai Bank*	1.01	0.17	0.07	0.14	666	no
Siam Commercial Bank	1.02	0.15	0.09	0.11	629	no
Bangkok Bank Limited	1.02	0.19	0.07	0.13	655	no
Kasikorn Bank	1.02	0.13	0.07	0.14	557	no
Siam City Bank	1.04	0.19	0.06	0.09	325	no
Thai Military Bank	1.05	0.17	0.06	0.07	406	no
Bank of Ayudaya	1.06	0.16	0.07	0.09	464	no
Thanachart Bank	1.11	0.03	0.10	0.13	99	no
Bank Thai	1.13	0.19	0.03	0.12	110	yes
Kaitnakin Bank	1.13	0.12	0.18	0.06	28	no
UOB Bank	1.19	0.10	0.09	0.21	85	yes
TISCO Bank	1.19	0.04	0.12	0.04	26	no
Satndard Charter Nakornthon Bank	1.37	0.10	0.07	0.15	47	yes
Mean	1.09	0.13	0.08	0.12	315	-
Std	0.10	0.05	0.03	0.04	249	-

Note: * Only Krung Thai Bank is considered state-enterprise commercial bank because over 50% of its equity is hold by the Thai government.

Table 8. Average cost inefficiencies and causation factors for government banks

Name	Inefficiency	Equity/ Assets	Liquid/ Assets	Number of Branches
Export-Import Bank of Thailand	1.02	0.16	0.11	11
Small-and-Medium Enterprise Bank	1.04	0.11	0.07	94
Government Saving Bank	1.06	0.10	0.05	595
Government Housing Bank	1.08	0.05	0.03	130
Bank of Agriculture and Cooperatives	1.12	0.09	0.07	862
Mean	1.06	0.10	0.07	338
Std	0.04	0.04	0.03	332

Figure 1. Technical change for commercial banks and government banks over the period 1998Q1-2009Q4

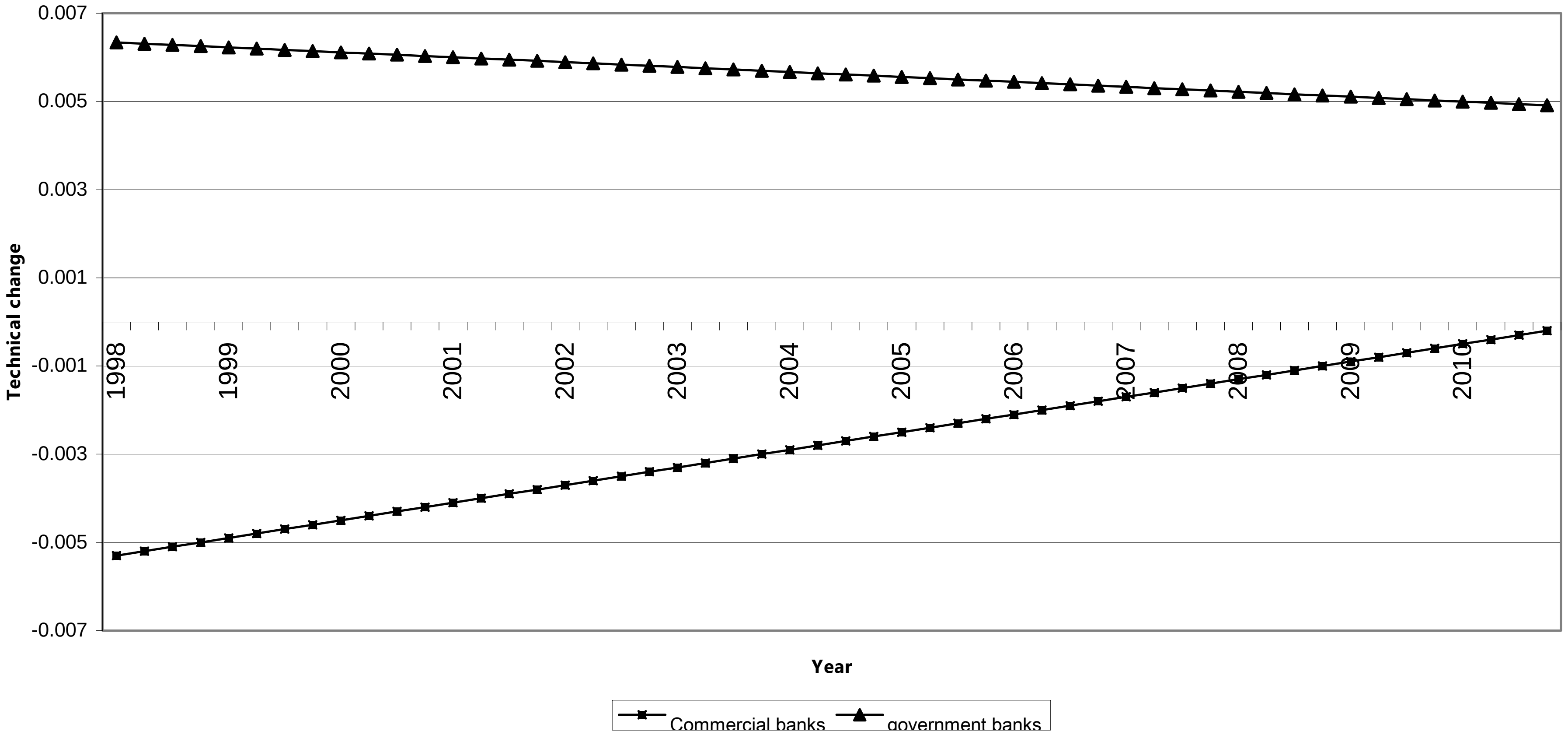
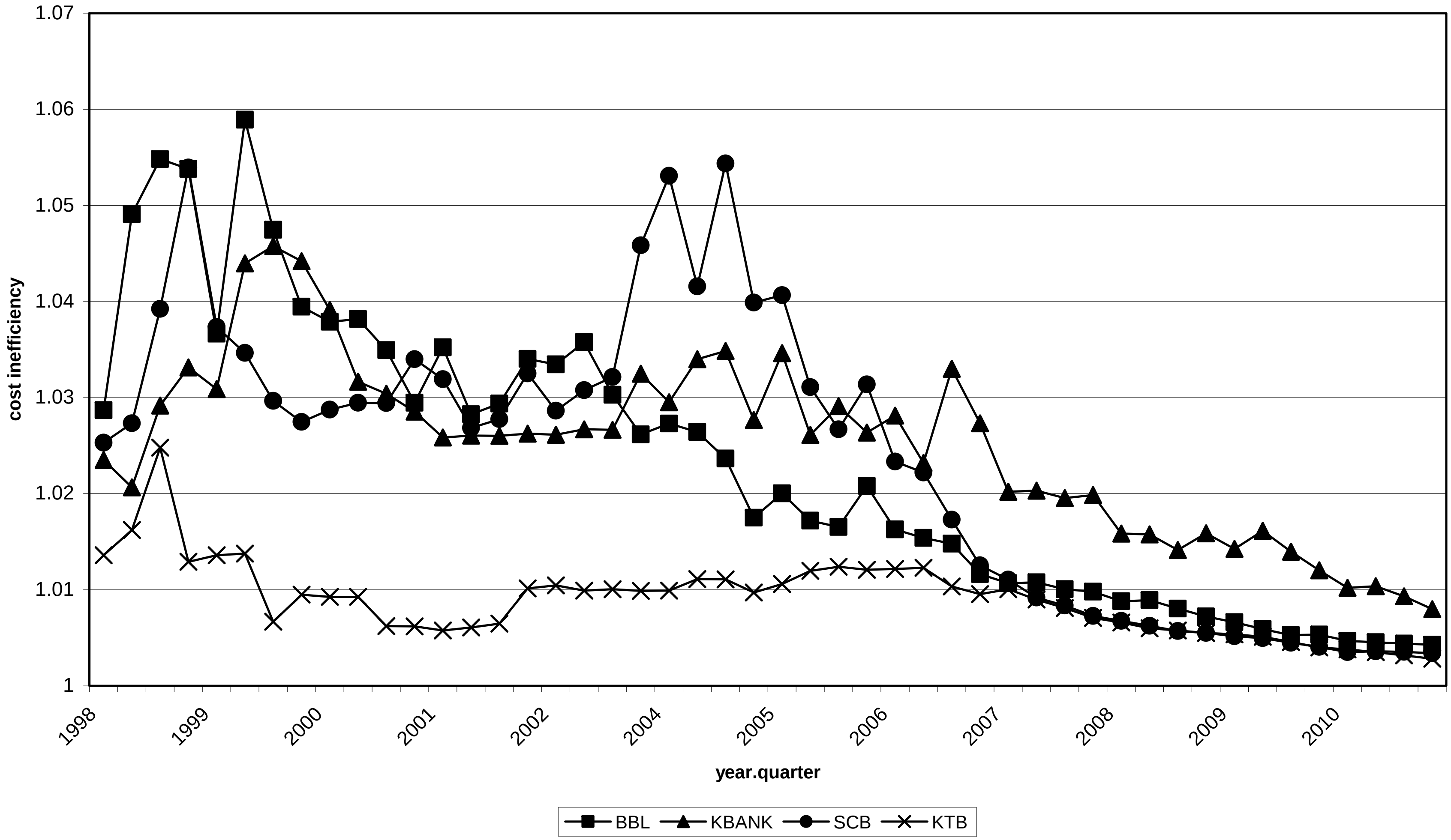


Figure 2. Cost inefficiency of the four most efficient commercial banks



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