Measuring the Relative Efficiency of Banks: A Comparative Study on Different Ownership Modes in China

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Abstract
It is an important issue for banks to be operated efficiently. This paper uses DEA models to evaluate the relative efficiency of banks in China. The input variables include capital and total assets, and the output variables include net profit, ROE and ROA. The analysis models of DEA include CCR, BCC, Bilateral, Slack-Based Measure, and the FDH model. We analyze overall efficiency, pure technique efficiency and scale efficiency of the commercial banks in China. We also use Bilateral model to measure and compare efficiency between the state-owned banks and private banks; the foreign joint ventures and non-foreign joint ventures; the listed commercial banks and non-listed commercial banks; the headquarters of commercial banks located in the area along the coast and the headquarters of commercial banks located in the hinterland. And we investigate the most productive scale size for the commercial banks. Finally, we provide some management suggestions for the commercial banks.

Keyword: *Performance Evaluation, Data Envelopment Analysis, SBM, FDH, Bilateral Model*

Introduction

In recent years, the banking business in China has become more and more competitive. Under the present liberalization of the economy, commercial banks now play important roles as savings institutions and as providers of credit and capital. In the current phase of globalization and market economic liberalization, competition between state-owned banks and private banks is getting serious. Thus, It is an important issue for banks to be operated efficiently.

In this study, we measure relative efficiency of state-owned banks, private banks and foreign joint venture banks in China. The purposes of this study to measure and evaluate the productive efficiency of banks in a developing country. Many similar researches and studies have measured or evaluated the efficiency of commercial banks in the U.S. and other developed countries, but very few studies have been done in developing countries or economies（i.e. Saha and Ravisankar , 2000 ; Sathye , 2003）. The methodology used to perform efficiency analysis of the state-owned banks and private banks is Data Envelopment Analysis（DEA）. DEA is a linear programming-based technique that converts multiple input and output measures into a single comprehensive measure of productivity efficiency (Epstein and Henderson, 1989). One of its most important features is its ability to handle multidimensional inputs and outputs, unlike traditional performance indicators that generally use one input-one output measures. DEA is a mathematical programming approach developed to measure the relative efficiency of units in an observed group of similar units. Since DEA was developed by Charnes, Cooper, and Rhodes（1978）, it has been widely applied to

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industries as finance（Pastor,2002）, and medical care（Finkler and Wirtschafter, 1993）. Recently, there have been several studies examining the performance and the efficiency of banks using DEA such as Aly et al.（1990）; Miller and Noulas（1996）; Chu and Lim（1998）; Mercan, Reisman, Yalalan and Emel（2003）. So far, no similar studies on relative efficiency of the different ownership modes in China have been done. This study we discuss the relative efficiency between inputs and outputs for the different ownership mode of commercial banks in China. The commercial banks can be partitioned into 3 clusters based on the bank ownership. The banks include state-owned banks, private banks and foreign joint venture banks in China. The input variables include capital and total assets, and the output variables include net profit, ROE and ROA. The analysis models of DEA include CCR, BCC, Bilateral, Slack - Based Measure（SBM）, the FDH model. We also investigate the most productive scale size for commercial banks. Finally, we provide some management suggestions for bank

Review of Data Envelopment Analysis (DEA)

Farrell（1957）introduced a framework for efficiency evaluation and measurement, which was subsequently studied such as those by Charnes, Cooper, and Rhodes（1978）, Banker, Charnes, and Cooper（1984）etc.

(1) CCR Model and BCC Model

For any special DMUs, the CCR model with constant return to scale can be formulated as follows to obtain a score of technical efficiency：

Maximize $w_0 = \sum_r u_r y_{rj_0}$ (1)

Subject to $\sum_i v_i x_{ij_0} = 1$, $\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \le 0, j = 1,\ldots,n,$

$u_r \ge \varepsilon, r = 1,\ldots,s,$, $v_i \ge \varepsilon, i = 1,\ldots,m$

（where m is the number of inputs, and s is the number of outputs）.

The BCC model, named after Banker,, Charnes, and Cooper（1984）,was developed by relaxing the CCR model or the constant returns to scale assumption on the envelopment surface.

(2) Slacks-Based Measure (SBM Model)

Tone（2001）has proposed a slacks-based measure（SBM）,which is non-radial and deals with input/output slacks directly. The SBM returns an efficiency measure between 0 and 1, and gives unity if and only if the DMU concerned is on the frontiers of the production possibility set with no input/output slacks.

In order to estimate the efficiency of a DMU（x_0, y_0）,we formulate the following fractional program in λ, s^-,and s^+:

Min $\rho = \dfrac{1 - \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{i0}}{1 + \frac{1}{s}\sum_{r=1}^{s} s_r^+ / y_{r0}}$ (2)

s.t. $x_0 = X\lambda + s^-, y_0 = Y\lambda + s^-, \lambda \ge 0, s^- \ge 0, s^+ \ge 0$.

(3) Free Disposal Hull (FDH Model)

In this section we take discussion with FDH (Free Disposal Hull). The purpose of FDH is to measure and evaluate the performance of a producer. FDH is a mathematical programming technique, developed by Deprins, Simar and Tulkens

(1984). Denote a set of n actually observed production plans, to which the origin of the input-output space is added by convention (O^I and O^J are the $I-$ and $J-$dimensional null vectors); for brevity we call Y_0 the observations set or the data set. Let also $Y(Y_0)$ denote a reference production set constructed from Y_0. Then a free disposal hull (FDH) reference production set (Y_{FDH}) constructed from Y_0 can be written as follows:

$$Y_{FDH}(Y_0)=\left\{\begin{bmatrix}u\\x\end{bmatrix}\in R_+^{I+J}\left|\begin{bmatrix}u^h\\x^h\end{bmatrix}+\sum_{i=1}^{I}u_i\begin{bmatrix}o^J\\e_i^J\end{bmatrix}-\sum_{i=1}^{J}v_j\begin{bmatrix}e_j^J\\o^I\end{bmatrix}\right.,\right.$$

$$\left(x^h,u^h\right)\in Y_0;u_i\geq 0;v_j\geq 0,$$

$$\left. i=1,2,\ldots,I;\ j=1,2,\ldots,J\ \right\} \qquad (3)$$

Where e_i^I denotes an I-dimensional zero vector with the i-th component equal to 1, and similarly, e_j^J denotes a J-dimensional zero vector with the j-th component equal to 1.

(4) Bilateral Model

This code solves the bilateral comparison model expressed as follows. It tests the null hypothesis that the efficiency of DMUs in two groups of concern belongs to the same statistical distribution obtained using nonparametric rank-sum statistics. The data format is the same as that for the CAT model, where the only level numbers permitted to be assigned are 1 or 2. We can formulate this idea in the following way for each DMU:

Min θ_B (4)

s.t. $\sum_{j\in II}X_j\lambda_j\leq\theta_B X_k$, $k\in I$, $\sum_{j\in II}Y_j\lambda_j\geq\theta_B Y_k$, $k\in I$, $\lambda_j\geq 0\quad(\forall j\in II)$.

Research Data and Input-Output Variables

China banks can be classified into three ownership groups; state-owned banks, private banks and foreign joint venture banks. Sixteen commercial banks were subjected to empirical analysis and in this study. Data from the China bank statistics data were used to determine the relative efficiency of the commercial banks in China. This measure of efficiency is based on the level of output produced for each unit of input. The financial information was based on surveys of the state-owned banks and private banks in China. The financial information was collected in 2002. In this study, we choose all banks in top-200 banks of Asia in China. Of the 16 banks involved in this study,4 (25□) banks are state-owned banks, 12 (75□) banks are private banks. Of all commercial banks, the listed-banks are no more than 4 banks in China since 1990s.

Selection of proper variables to define and to evaluate efficiency is always an extremely important decision. It is especially in using DEA for such evaluation and measurements as different outcomes may result from different set of variables used on the very same set of institutions. In this research, the state-owned banks and private banks employ the two inputs capital and total assets, which produce the outputs net profit, ROE and ROA. Table 1 shows a summary statistics of the output and inputs statistics that were used to construct the DEA models. Constructing of the models allowed us to investigate the relative efficiency scores for the state-owned banks and private banks. The above two inputs have generally been used throughout the literature. The two inputs in the operational performance model are capital and total assets. They are defined as follows:1. *Capital*（million）: capital is proved either by the bank's shareholder or by its depositors. 2. *Total assets* （million） : Assets are resources owned by a bank. The common characteristic possessed by all assets is the capacity to provide future services or benefits for a commercial bank.

Insert Table1

Identifying the output of productive activities in general and the state-owned banks and private banks in particular, present difficulties for cost measurement also production performance. The three outputs used here were net profit, ROE, and ROA . They are defined as follows:1. *Net profit*: Net profit after taxes for the commercial banks.2.*ROE*: An over measure profitability of owner's investment is return on equity for the commercial banks. This ratio is computed by dividing net income by average stockholders' equity. 3. *ROA:* An over measure of profitability is return on assets for the commercial banks. This ratio is computed by dividing net income by average assets.

Empirical Results and Analysis

Efficiency analysis

In this research, the analysis models of DEA include CCR, BCC, Slacks-Based Measure（SBM）, and FDH. DEA provides a comprehensive evaluation of overall performance. The results for each DEA model are summarized in Table 2. Table 3 shows the Pearson correlation coefficients for the DEA models. The results for each DEA model are shown in Table 4.

Insert Table2

First, an elementary insight is obtained by considering the dichotomous classification of DMUs as either efficient or inefficient. The number of efficient DMUs resulting from the use of different reference technologies is shown in the last row of Table 2. Clearly, and consistent with expectations, the FDH model turns out to be no better than other reference technologies. It results in 62.5□ efficient DMUs, compared with 12.5□for the CCR model, 25□for the BCC model, and 12.5□ for the SBM model. It is interesting to consider the extent to which the different methodologies agree on this basic dichotomous classification. All of the DMUs that are efficient for CCR, BCC and SBM are efficient for FDH also. The results also clearly illustrate the implications imposing convexity for non-parametric technical efficiency measurement. Of 10 efficient DMUs for FDH only 2（12.5□）are efficient for CCR, and SBM, and 4（25□）are efficient for BCC. In addition, Table 2 contains some descriptive statistics for each of the five DEA models. The FDH-based index exceeds all others for average mean efficiency scores.

Insert Table3

Table 3 shows the Pearson correlation coefficients for several of these DEA models, including CCR, BCC, SBM and FDH. The correlation analysis results show a positive relationship among the DEA models investigated in this study.

Insert Table4

Table 4 presents the CCR efficiency score under constant returns-to-scale, the BCC technical efficiency scores, the scale efficiency scores, the slacks-based measure efficiency scores and FDH efficiency scores. As the measurement items of efficiency we use the capital and total assets as inputs and net profit, ROE and ROA as outputs. The main findings can be summarized as follows. The CCR efficiency score analysis shows that 2 banks (i.e., China Merchants Bank Co., Ltd. and Xiamen International Bank) are relatively efficient; the results have the same with scale efficiency scores and SBM efficiency scores. Their efficiency scores are equal to 1. This shows that the resource utilization of these banks is functioning well. There were 14 inefficient banks, identified by an efficiency score of less than 1.

The scale efficiency score as defined by the ratio CCR/BCC, exhibits large difference between the two groups. The average of scale efficiency score is 0.8321. All banks are above average whereas 14 banks are below it. Of 16 commercial banks, 6 banks (Agricultural Bank of China, Bank of Communications, China Everbright Bank, China Industrial Bank, Guangdong Development Bank and Shenzhen Development Bank Co., Ltd.) have low BCC efficiency scores and relatively high scale efficiency scores among the group, meaning that the overall inefficiency in the CCR column of these banks are caused by inefficient operations rather than the scale inefficiency.

Of 16 commercial banks, 2 banks (Bank of China and China Minsheng Banking Corp Ltd.) have fully BCC efficiency scores and relatively low scale efficiency scores among the group. This can be interpreted to mean that the CCR inefficiency score is mainly attributed to disadvantageous conditions.

Another model which has received a considerable amount of research attention is FDH (Free Disposal Hull). The result of FDH is that from16 commercial banks in FDH, 10 (62.5□) commercial banks have efficient scores. The result cannot distinguish efficient commercial banks from inefficient banks correctly comparison with CCR, BCC and SBM model.

The reference set and their frequencies for the 16 commercial banks are given in Table 6. The most frequent bank was found to be China Merchants Bank Co., Ltd. The results also show that China Merchants Bank Co., Ltd., Xiamen International Bank are efficient and are in the reference set of all of the other banks.

Bilateral analysis

We applied the bilateral comparison method to the banks to determine the statistical difference in efficiency among the state-owned banks and private banks, the joint ventures and non- joint ventures, the listed commercial banks and non-listed commercial banks, the headquarters of commercial banks located in the area along the coast and the headquarters of commercial banks located in the hinterland. The results are shown as Table 5.

Insert Table5

1. Model 1: The difference between the state-owned banks and private banks

We applied the bilateral comparison method to the banks to determine the statistical difference in efficiency between state-owned banks (GroupⅠ) and those are private banks （Group Ⅱ）. Thus, Group Ⅰ consisted of 4 banks, and Group Ⅱ consisted of 12 banks. We construct the hypothesis as follows:

Hypothesis 1:Group Ⅰ and Group Ⅱ have the same population of efficiency score

Rank-Sum-Test (Wilcoxon-Mann-Whitney) method is a nonparametric test that is based on the ranking of data. Given independent data belonging to two groups, this test can be used to test serves the hypothesis that the two groups belong to the same population. Using T, we can check the null hypothesis that the two groups have the same population at a given level of significance α. We will reject the hypothesis if $T \le -T_{\alpha/2}$ or $T \ge T_{\alpha/2}$, where $T_{\alpha/2}$ corresponds to the upper $\alpha/2$ percentile of the standard normal distribution. In this research, the rank sum of state-owned banks was 58, while that of the private banks was 78. The test statistic T is given by：

$$T = \frac{58 - 4(4 + 12 + 1)/2}{\sqrt{4 \times 12 (4 + 12 + 1)/12}} = 2.9104 .$$

In this case the null hypothesis is rejected at a significance level of 5%. The results show group Ⅱ outperforms group Ⅰ, it means that private banks have high efficiency than state-owned banks.

2. Model 2: The difference between the joint ventures and non- joint ventures

We applied the bilateral comparison method to the banks to determine the statistical difference in efficiency between the joint ventures（Group Ⅰ）and those are non- joint ventures （Group Ⅱ）. We construct the hypothesis as follows:

Hypothesis 2:Group Ⅰ and Group Ⅱ have the same population of efficiency score

In this research the rank sum of the joint ventures was 2, while that of non- joint ventures was 134. The test statistic T is given by：

$$T = \frac{2 - 1(1 + 15 + 1)/2}{\sqrt{1 \times 15 (1 + 15 + 1)/12}} = -1.41 .$$

In this case the null hypothesis cannot be rejected at a significance level of 5%. The results provide no evidence that the joint ventures and non- joint ventures have the different populations of efficiency scores.

3. Model 3: The difference between the listing commercial banks and non-listing commercial banks

We applied the bilateral comparison method to the banks to determine the statistical difference in efficiency between listed commercial banks （Group Ⅰ） and those are non-listed commercial banks （Group Ⅱ）. We construct the hypothesis as follows:

Hypothesis 3:Group Ⅰ and Group Ⅱ have the same population of efficiency score

In this research the rank sum of the listing commercial banks was 19, while that of the non-listing commercial banks was 117. The test statistic T is given by：

$$T = \frac{19 - 4(4 + 12 + 1)/2}{\sqrt{4 \times 12 (4 + 12 + 1)/12}} = -1.819 .$$

In this case the null hypothesis can be rejected at a significance level of 5%. The result shows that listed commercial banks outperform non-listed commercial banks.

Model 4: The difference between the headquarters of commercial banks located in the area along the coast and the headquarters of commercial banks located in the hinterland.

We applied the bilateral comparison method to the banks to determine the statistical difference in efficiency between the headquarters of commercial banks located in the area along the coast（Group Ⅰ）and the headquarters of commercial banks located in the hinterland（Group Ⅱ）. We construct the hypothesis as

follows:
Hypothesis 4:Group Ⅰ and Group Ⅱ have the same population of efficiency score

In this research the rank sum of the headquarters of commercial banks located in the area along the coast was 44, while that of the headquarters of commercial banks located in the hinterland was 92. The test statistic T is given by：

$$T = \frac{44 - 8(8+7+1)/2}{\sqrt{8 \times 7(8+7+1)/12}} = -2.5205 \ .$$

In this case the null hypothesis can be rejected at a significance level 5%. The result shows that the headquarters of commercial banks located in the area along the coast outperform non-listed the headquarters of commercial banks located in the hinterland.

Returns to scale and most productive scale size

We will discuss the returns to scale of the 16 banks in this section. Then, a DMU_0 found to be efficient with a CCR model will also be found to be efficient for the corresponding BCC model, and constant returns-to-scale means that DMU_0 is the most productive scale size （Ahn, Charnes and Cooper; 1989）.Of the 16 banks investigated in this study, 2（12.5%）showed constant returns-to-scale, 7（43.75%）showed decreasing returns-to-scale, 7 （43.75%）showed increasing returns-to-scale. When a bank exhibits decreasing return-to-scale（$\sum_{j=1}^{n}\lambda_j^* > 1$）, it is likely that the bank can improve its performance by decreasing its size. In general, the proportion of bank showing increasing return-to-scale has increased over time, and the average size of bank in the sample has increased monotonically over time, which suggests changing technology over time. On the other hand, when a bank exhibits increasing returns-to-scale（$\sum_{j=1}^{n}\lambda_j^* < 1$）, it is likely that the bank can improve its performance by increasing its size. Table 6 shows the results, China merchant's bank and Xiamen international bank are most productive scale sizes.

Insert Table6

Relationship between size and efficiency

Finally, we will discuss the relationship between size and efficiency of the banks. Scatter plots of the correlation analysis exhibit a relation between the size of banks and the relative efficiency shown as figure 2, figure 3, figure 4 and figure 5.

Insert figure 1-4

（1）state-owned banks

State-owned banks include Industrial and Commercial Bank of China, Bank of China, Agricultural Bank of China and China Construction Bank. Figure 2 shows the negative relationship between size of state-owned bank and efficiency in this study. Those banks have great size and low efficiency to operation. In general, the analysis results show the negative relationship between the size of state-owned banks and the relative efficiency in this study.

（2） private banks

Private banks include Bank of Communications, China Everbright Bank, etc. In general, the size of private banks is small. The most private banks have relative efficiency values higher than mean score.

（3） listed banks

Listed banks include Shanghai Pudong Development Bank Co., Ltd., China Minsheng Banking Corp Ltd., China Merchants Bank Co., Ltd. and Shenzhen Development Bank Co., Ltd. The listed banks have high efficiency. In general, the analysis result shows the positive relationship between the size of listed banks and the relative efficiency in this study.

（4） the headquarters of commercial banks located in the area along the coast

Those banks include Bank of Communications, Shanghai Pudong Development Bank etc. In general, those banks were newly entered financial market; the sizes of private banks were small. The most private banks have relative efficiency values higher than mean score.

Summary and conclusions

The purpose of this study is to measure and to evaluate the measured variation in the performance and therefore the productive efficiency of China commercial banks. In this study, we have used nonparametric DEA methods to analyze the efficiency commercial banks. The main findings can be summarized as follows. The CCR efficiency score analysis results show that 2 banks are relatively efficient the results were scale efficiency scores and SBM efficiency scores. The result of FDH analysis cannot distinguish between efficient banks and inefficient banks correctly, compared with the CCR, BCC and SBM model. As a result, the private banks have high efficiency than state-owned banks; the listed commercial banks outperform the non-listed commercial banks; the headquarters of commercial banks located in the area along the coast outperform non-listed the headquarters of commercial banks located in the hinterland.

Of the 16 commercial banks investigated in this study, 2（12.5%） exhibit constant returns-to-scale, 7（43.75%） exhibit decreasing returns-to-scale, those banks can improve their performance by decreasing their size. Of the16 commercial banks, 7 （43.75%） exhibit increasing returns-to-scale, those banks can improve their performance by increasing their size. There were 2 commercial banks are most productive scale size. The results of this study highlight the importance of inputs and outputs used in determining relative efficiency. Throughout the study, special emphasis has been placed on quantifying and discussing the impact of model choice on the results. For this purpose, we have also introduced a framework for model comparison; we have also used several simple techniques to analyze the results. The result of this research can help the managements of the banks involved to realize their relative operating performances, and therefore respond in time by appropriately regulating the levels of the input and output items.

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Table 1 Summary statistics for 16 DMUs in banks of China

	Capital	Total Asset	Net Profit	ROE	ROA
Max	23107	524235	1319	38.7	1.05
Min	152	1230	11	12.975	0.05
Average	5489.56	116601.5	275.5	12.975	0.50875
SD	8029.87	165645.5	336.5107	9.536	0.30450

Table 2 Summary statistics for efficiency measures (N=16)

	CCR	BCC	SBM	FDH
Mean	0.52386	0.62920	0.44820	0.84385
S.D	0.32354	0.31342	0.31109	0.27632
Max.	1.00000	1.00000	1.00000	1
Min.	0.04345	0.04382	0.02964	0.06879
No. of efficient DMUs	2 (12.5%)	4 (25%)	2 (12.5%)	10 (62.5%)

Table 3 Correlation analysis for DEA models

	CCR	BCC	SBM	FDH
CCR	1			
BCC	0.84**	1		
SBM	0.97**	0.80**	1	
FDH	0.59**	0.77**	0.56**	1

*Note: * Significant at the 0.01 level.*
*** Significant at the 0.05 level.*
**** Significant at the 0.1 level.*

Table 4 Efficiency scores for DEA models

DMU	CCR Efficiency	BCC Efficiency	Scale Efficiency	SBM Efficiency	FDH Efficiency
(1) Industrial and Commercial Bank of China	0.1347	0.4080	0.3303	0.0968	0.9557
(2) Bank of China	0.3100	1.0000	0.3100	0.2097	1.0000
(3) Agricultural Bank of China	0.0435	0.0438	0.9918	0.0296	0.0668
(4) China Construction Bank	0.1792	0.4792	0.3739	0.1292	1.0000
(5) Bank of Communications	0.3661	0.3663	0.9994	0.2556	0.3980
(6) China Everbright Bank	0.1489	0.1538	0.9680	0.1049	0.4526
(7) China Industrial Bank	0.5161	0.5182	0.9958	0.4317	0.8874
(8) Shanghai Pudong Development Bank Co., Ltd.	0.7569	0.7587	0.9976	0.5653	1.0000
(9) Shanghai Commercial Bank Ltd.	0.8358	0.8369	0.9986	0.5937	1.0000
(10) China Minsheng Banking Corp Ltd.	0.8170	1.0000	0.8170	0.6087	1.0000
(11) Fujian Industrial Bank	0.5703	0.6546	0.8711	0.5190	1.0000
(12) Guangdong Development Bank	0.2385	0.3288	0.7252	0.2303	0.7389
(13) China Merchants Bank Co., Ltd.	1.0000	1.0000	1.0000	1.0000	1.0000
(14) Shenzhen Development Bank Co., Ltd.	0.5072	0.5185	0.9782	0.4873	1.0000
(15) Huaxia Bank	0.9571	1.0000	0.9571	0.9090	1.0000
(16) Xiamen International Bank	1.0000	1.0000	1.0000	1.0000	1.0000
Average	0.5238	0.6292	0.8321	0.4482	0.8438

Table 5 Bilateral analysis for banks

	Model 1			Model 2			Model 3			Model 4		
DMU	Efficiency score	Rank	Group	Efficiency score	Rank	Group	Efficiency score	Rank	Group	Efficiency score	Rank	Group

(1) Industrial and Commercial Bank of China	0.1347	15	I	0.4425	15	II	0.1347	15	II	0.1347	15	II
(2) Bank of China	0.3100	13	I	0.8252	12	II	0.3100	11	II	0.3100	12	II
(3) Agricultural Bank of China	0.0435	16	I	0.1193	16	II	0.0435	16	II	0.0435	16	II
(4) China Construction Bank	0.1792	14	I	0.5968	13	II	0.1792	13	II	0.1792	13	II
(5) Bank of Communications	7.0688	12	II	1.0936	11	II	0.3661	10	II	0.5294	9	I
(6) China Everbright Bank	7.2935	11	II	0.4563	14	II	0.1492	14	II	0.1489	14	II
(7) China Industrial Bank	63.696	9	II	2.6167	4	II	0.5161	9	II	0.5161	10	II
(8) Shanghai Pudong Development Bank	68.272	8	II	2.4744	5	II	1.0234	4	II	1.1079	4	I
(9) Shanghai Commercial Bank	74.913	7	II	2.0237	6	II	0.9200	6	I	1.1541	3	I
(10) China Minsheng Banking	126.58	4	II	1.2978	9	II	0.9398	5	II	0.8170	7	II
(11) Fujian Industrial Bank	82.531	6	II	1.8452	7	II	0.7683	7	I	0.8195	6	I
(12) Guangdong Development Bank	44.572	10	II	1.1080	10	II	0.2913	12	II	0.3395	11	I
(13) China Merchants Bank	206.41	2	II	7.5351	1	II	2.3089	2	II	2.3089	2	I
(14) Shenzhen Development Bank	89.839	5	II	1.8153	8	II	0.6487	8	I	0.6859	8	I
(15) Huaxia Bank	177.43	3	II	3.2634	3	II	1.1913	3	I	0.9571	5	II
(16) Xiamen International Bank	918.37	1	II	7.2551	2	I	7.2551	1	II	7.2551	1	I

Table 6 Reference set analysis and returns to scale

DMU	CCR Efficiency	Reference Set	Frequency in Reference Set	Rank	Returns to Scale	
(1) Industrial and Commercial Bank of China	0.1347	13	0	15	Σλ>1	DRS
(2) Bank of China	0.3100	13	0	11	Σλ>1	DRS
(3) Agricultural Bank of China	0.0435	13	0	16	Σλ<1	IRS
(4) China Construction Bank	0.1792	13	0	13	Σλ>1	DRS
(5) Bank of Communications	0.3661	13	0	10	Σλ<1	IRS
(6) China Everbright Bank	0.1489	13、16	0	14	Σλ<1	IRS
(7) China Industrial Bank	0.5161	13	0	8	Σλ<1	IRS
(8) Shanghai Pudong Development Bank Co., Ltd.	0.7569	13、16	0	6	Σλ<1	IRS
(9) Shanghai Commercial Bank Ltd.	0.8358	13、16	0	4	Σλ<1	IRS
(10) China Minsheng Banking Corp Ltd.	0.8170	13、16	0	5	Σλ>1	DRS
(11) Fujian Industrial Bank	0.5703	13、16	0	7	Σλ>1	DRS
(12) Guangdong Development Bank	0.2385	13、16	0	12	Σλ<1	IRS
(13) China Merchants Bank Co., Ltd.	1.0000	13	14	1	Σλ=1	CRS
(14) Shenzhen Development Bank Co., Ltd.	0.5072	13、16	0	9	Σλ>1	DRS
(15) Huaxia Bank	0.9571	13、16	0	3	Σλ>1	DRS
(16) Xiamen International Bank	1.0000	13	8	2	Σλ=1	CRS

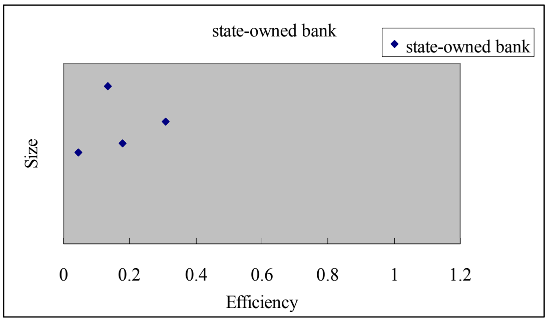

Figure 1: Matrix of size and efficiency of state-owned banks

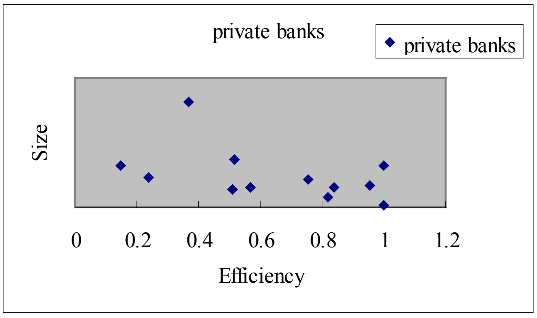

Figure 2: Matrix of size and efficiency of private banks

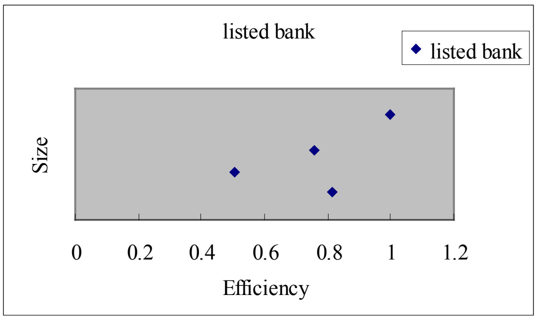

Figure 3: Matrix of size and efficiency of listed banks

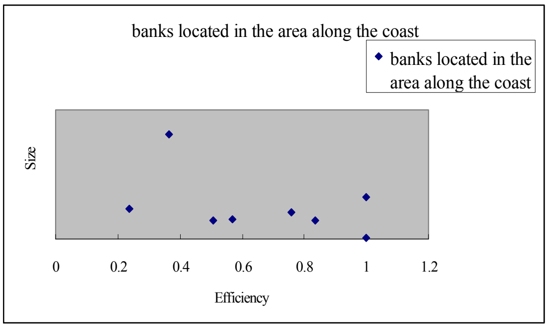

Figure 4: Matrix of size and efficiency of banks located in the area along the coast