國立交通大學

經營管理研究所

碩士論文

所有權改革與中國大陸全域型銀行之效率

Ownership Reform and Efficiency of Nationwide Banks in China

研　究　生：陳疆平

指 導 教 授：胡均立 教授

中華民國　九十五　年　六　月

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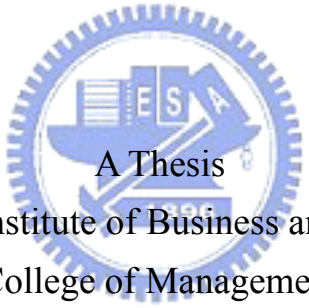

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Student: Chaing-Ping Chen Advisor: Prof. Jin-Li Hu

Institute of Business and Management

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Abstract

This research investigates the efficiency of China's banks using data envelopment analysis (DEA). The Chinese government began its reforms of its banking industry reform starting in 1978. Our dataset contains twelve banks in China during the period 1996 to 2003. All nominal variables are transformed into real variables in the 2003 prices. There are twelve banks: four state-owned specialised banks, three policy-related banks, and five nationwide joint-equity commercial banks. First, the DEA approach is used to estimate the efficiency scores of these twelve banks for each year in China. Second, the seemingly unrelated regression (SUR) is used to analyse how the environmental variables affect the efficiency scores of them. The following are the study's empirical findings: (1) Nationwide joint-equity commercial banks have significantly higher overall technical and scale efficiencies, but lower pure technical efficiency than state-owned specialised banks. (2) A marginal increasing relation exists between the deposit-loan ratio and cost efficiency. (3) An inverted U-shape relation exists between the deposit-loan ratio and overall technical and scale efficiencies. (4) Small-sized banks have higher cost and allocative efficiencies than large-sized banks. (5) The twelve banks have lower cost, overall technical, pure technical, and scale efficiencies after 2001's WTO participation. (6) These twelve banks have lower cost efficiencies after the 1997 Asian financial crisis. (7) As a whole, these Chinese twelve banks have significantly increasing overall technical and scale efficiencies from 1996 to 2003.

Keywords: data envelopment analysis (DEA), ownership, cost efficiency, allocative efficiency, overall technical efficiency, pure technical efficiency

所有權改革與中國大陸全域型銀行之效率

研究生: 陳疆平　　指導教授: 胡均立教授

國立交通大學經營管理所碩士班

摘要

本研究使用資料包絡分析法分析中國大陸全域型銀行效率。中國大陸政府自從 1978 年便開始許多銀行產業改革其中包括所有權的改革。本研究資料主要包含 1996 年至 2003 年中國大陸 12 家全域型銀行的資料。所有的名目變數皆已藉由 2003 年為基期的 GDP 平減指數轉成實質變數。本研究所蒐集到的中國大陸 12 家全域型銀行包含: 3 家國家專業性銀行、4 家政策性銀行與 5 家全國型股份制商業銀行。首先，我們利用資料包絡分析法，估計中國大陸 12 家銀行各年的各項效率值。再來，我們運用 SUR 迴歸分析法，探討環境變數如何影響中國大陸 12 家全域型銀行的各項效率值。我們主要發現為: 第一，股份制銀行相較於國有專業銀行擁有較高的成本效率、規模效率與整體技術效率，但是卻有較低的純粹技術效率。第二，銀行存放比與成本效率存在者邊際遞增的關係。第三，銀行存放比與整體技術效率和規模效率存在者倒 U 型的關係。第四，銀行規模較小的銀行相對於規模大的銀行擁有較高的成本效率與配置效率。第五，加入世界貿易組織後，中國大陸 12 家銀行呈現較低的成本效率、整體技術效率、純粹技術效率與規模效率。第六，亞洲金融風暴後，中國大陸 12 家全域型銀行呈現較低的成本效率。第七，整體而言，中國大陸 12 家全域型銀行的整體技術效率與規模效率從 1996 年至 2003 年普遍顯示出增加的趨勢。

關鍵詞: 資料包絡分析法, 所有權, 成本效率, 配置效率, 整體技術效率, 純粹技術效率

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于交大經營管理研究所

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1. Introduction

1.1 Research Background and Motivation

In the modern economic society, economic growth enhances capital flow. Every productive unit can achieve the goal of economic growth either by preceding the measures of saving and investment to accumulate its capital or improving its production capacity. The economic growth encourages the circulation of capital. Hence, the integrity of the financial system has closely linked to this process.

The economy of China begins to carry out the transition from socialist market economy to planned economy. In the logic of the economy dominating the finance and the finance influencing the economy, the financial system of China has changes in past two decades. However, in the progress of economic development, the financial system of China limited by the past policy and social aspects still exist many problems of structure and operation. After 1985, the China government realized the stated-owned banks bore huge management and financial risks. The State Council of People's Republic of China (PRC) then made the policy to establish the nationwide joint-equity commercial banks that we called share-allocation policy. This policy can be taken as one of the bank's ownership reforms. After WTO participation, the China's financial institutions, especially banking industry, must face the competitive impact in the future. Moreover, the interaction of economic activities between Taiwan and China become more frequent. Taiwanese banks and foreign banks will try to enter the China's banking industry if the law permitted.

In such competitive environment, we are interesting to know how the efficiency can be improved by share-allocation policy and what the inefficiency factors of

China's banks are. Therefore, our important issues focus on evaluating the efficiency of China's banks, finding the factors of banks' inefficiency scores in China, and observing the bank of share-allocation are more efficient or not.

1.2 Research Objectives

The objectives of this study are as follows: First, we review the reform processes and reform policy of China's banking industry. Second, we collect financial information and build the database of China's banking industry. Third, we evaluate the cost, allocative, overall technical, pure technical, and scale efficiencies of banks in China. Forth, we study the factors of bank efficiency scores in China. Fifth, we observe the impacts of the Asian financial crisis in 1997 and WTO participation in 2001.

1.3 Research Subjects

As Table 1 shows, there are twelve banks including four state-owned specialised banks, three policy-related banks, and five nationwide joint-equity commercial banks.

The ABC's main responsibility is to receive deposits in rural areas and extend loans to agricultural production projects and township industries. The PCBC focuses on appropriating funds for capital construction from the state budget through the Ministry of Finance. The BOC focuses on deposits and loans for foreign currency exchange and international transactions. The ICBC focused on the financing of commercial and industrial activities in urban areas.

The policy-related banks were China Development Bank (CDB), Export-Import Bank of China and Agricultural Development Bank of China (ADBC). They were

all established in 1994 and designed to engage in specific and policy-oriented investment and loan business. The policy-related banks still have not sufficient branch networks and capitals to engage in every level of policy lending which previously provided by the state-owned specialised banks. Hence, even the policy announced the transition of specialised banks, the policy-related banks continue to engage in policy lending by pressures from central and local governments.

Table 1. Classification and Names of Subject Banks

Classification	Name of Banks
A. State-owned specialised banks	1. Industrial and Commercial Bank of China (ICBC)
	2. Agriculture Bank of China (ABC)
	3. People's Construction Bank of China (PCBC)
	4. Bank of China (BOC)
B. Policy-related banks	5. China Export-Import Bank (CEXIMB)
	6. Agricultural Development Bank of China (ADBC)
	7. China Development Bank (CDB)
C. Nationwide joint-equity commercial banks (share-allocation)	8. China Minsheng Banking Corporation (CMBC)
	9. Bank of Communication (BOCOM)
	10. CITIC Industrial Bank (CITICB)
	11. Hua Xia Bank (HXB)
	12. China Everbright Bank (CEB)

1.4 Research Procedure

In our study, we first review the Chinese banking system and some literature about bank efficiency including China and other countries. Moreover, we review related literature about the issue of ownership in past study.

After that, we evaluate each bank's relative efficiency scores including cost,

allocative, overall technical, pure technical, and scale efficiency in every year. Then, we try to use some environmental variables by seemingly unrelated regression (SUR) analysing how affect these inefficiency scores and use the Mann-Whitney U test analysing what the efficiency scores differ before and after WTO participation in 1997 and Asian financial crisis in 2001. As Figure 1 shows the procedure of this research.

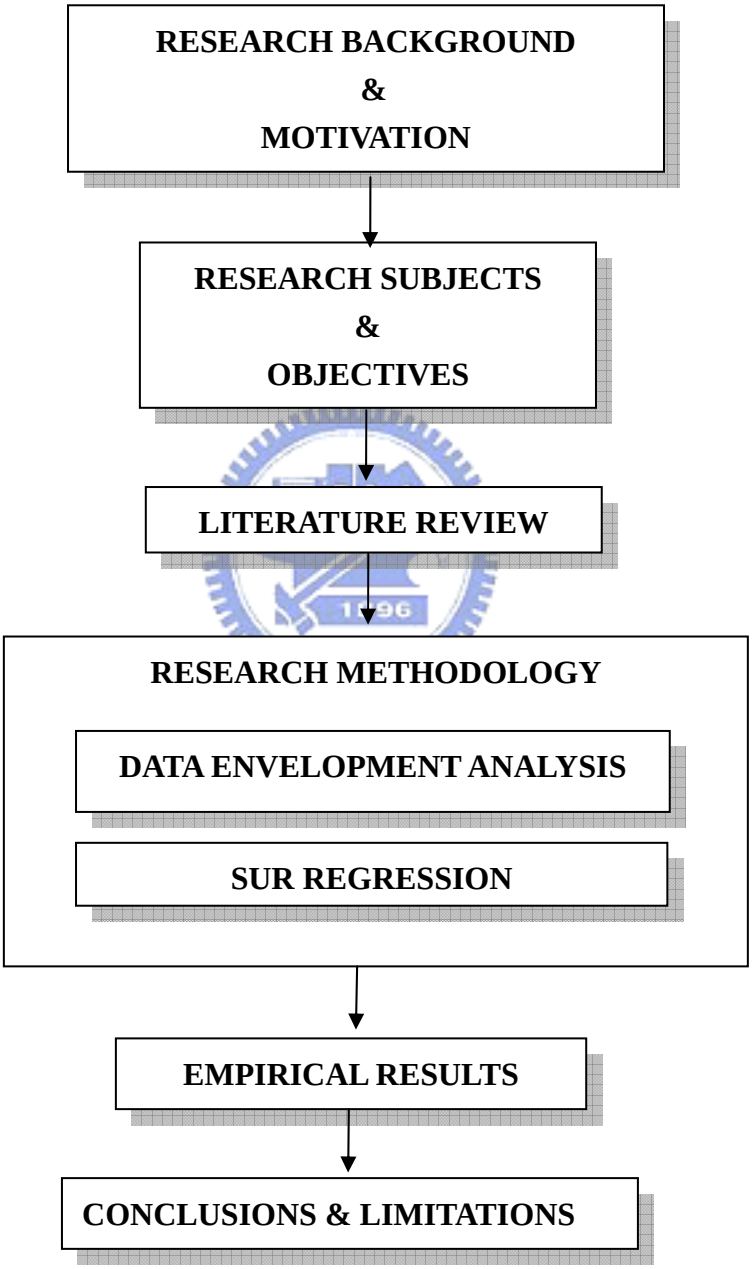


Figure 1. Research Procedure

2. LITERATURE REVIEW

2.1 Review of the Chinese Banking System

Before China's banking reform activities in 1978, there was a mono-banking system. There were only two foreign banks which were both located in Shanghai: Hong Kong and Shanghais Banks Corporation (HSBC) and Standard Chartered Bank (HK), Ltd. All banks are treated as a financial agency or division of local administration. The People's Bank of China (PBC) combined the function of monetary, banking and commercial business affairs. The whole banking industry was regulated by strictly cash and credit plans formulated by the State Planning Commission. Banks were part of the administrative hierarchy: The banking system guaranteed the fulfilment of the national production plans but had no incentive to compete with each other.

The 1978 Third Plenary Session of Eleventh Central Committee of the Communist Party of China (CPC) made the decision to shift the policy stress to economic system reform and open. The Committee created four specialised banks, which were split from the PBC to provide specific services for designated sector of the economy. After that decision, PBC became the only central bank of Mainland China and its banking functions in guidance loans and others function were replaced by those specialised banks. Those four specialised banks are Agriculture Bank of China (ABC), People's Construction Bank of China (PCBC), Bank of China (BOC) and Industrial and Commercial Bank of China (ICBC).

After 1985, the China government realized the specific designed services made those four state-owned specialised banks bore huge management and financial risks and liabilities in operation. Hence, the State Council of People's Republic of China

(PRC) permitted the establishment of nationwide joint-equity commercial banks in the same year. The equity was invested by state-owned companies or enterprises and the investment was identified by shares, which is the most different than ever. For instance, the Guangdong Development Bank (GDB) was established in 1988 and converted into a shareholding bank in 1992. Its shareholders are the Ministry of Finance of PRC, the Bank of China Group in Hong Kong and the Hong Kong Chinese Banking Group and they are state agency or state-owned entities. The ownership still belongs to the central government but reallocated to different agency divisions by expression of stock. The stocks are neither able being trade nor procured by individual or private companies in market. This policy was named as 'share allocation' and we also adopt this specific reform behaviour in the following discussion. By the end of 1999, there were fourteen nationwide joint-equity commercial banks.

In 1993, the Third Midterm Meeting of the Fourteenth Convention of the Chinese Communist Party concluded (1) to create three state policy-related banks to replace the guidance loans task from specialised banks; and (2) to transform the state-owned specialised banks into exclusive stated-owned commercial banks. The separation between policy-related banks and state-owned commercial banks was, however, far away from being neat and complete.

The financial regulations reform followed the transition of physic entities. China government published its financial accounting system and rules in 1993 for the transparency of cash flow and financial statement of banking industry. Late until 2000, the Ministry of Finance of PRC announced the 'Baking Finance Accounting System' because of its important and specific character than others. It is obvious the all levels of banks in China did not have uniformed accounting regulations before 2000

and it also created the difficulties of data collection.

In the China's transition process from a socialist market economy to a planned economy (i.e., a command economy), the improving of economy also evoked the restructuring of its financial system. A mature financial system plays an important rule because it can restricts or changes the economy developing speed or scale in China. China joined the World Trade Organization (WTO) in October 2001. China then became the world's third-largest trading economy, only behind the US and Japan in 2004 (Alibaba.com 2005). The WTO commitments (with their promise of finance market access and obedience of Principle of Nation Treatment) have also force China government to decrease its policy interference, protection and financial aid to the banks, and enhance global competitive abilities. For economic transition in China, the banking system reform plays a decisive role. To make the transition process smooth, before massive privatisation the economic environment must be improved first (Tian 2000).

2.2 Literature Review of Bank Efficiency

In earlier research, bank efficiency has received much attention in the literature. Most researchers aim different topics or issues on bank efficiency such as specific country, financial management system, and impacts of the policy-making, etc. In this section, we collect some literature focusing on bank efficiency and introduce them one by one in terms of different topics as follows:

In respect of specific countries on bank efficiency, Aly et al. (1990) calculate the overall technical, pure technical, allocative, and scale efficiencies of 322 banks in U.S. by the non-parametric approach (DEA). Their major findings are: First, there exists a low level of overall technical efficiency in U.S. banking. Second, the

distribution of efficiency measures for branching and non-branching banks are not found to be different.

Maudos, Pastor, and Perez (2002) analyses cost and profit efficiency of banks in ten countries of the European Union during the period of 1993 to 1996 by the panel data frontier approach. Their major findings are as follows: First, we find high levels of efficiency in costs and lower levels in profits, verifying the importance of inefficiencies on the revenue side of banking activity. Second, medium-sized banks reach the highest levels of efficiency in both costs and profits. Third, the banks with a higher loans/assets ratio are more efficient.

Jemric and Vujcic (2002) evaluate bank efficiency in Croatia using the DEA approach during the period of 1996 to 2000. They major findings are: First, new banks are more efficient than old Second, smaller banks are globally efficient, but large banks appear to be locally efficient. Third, foreign banks are on average the most efficient.

Sathye (2003) measure the productive efficiency of banks in India during the period of 1997 to 1998 by DEA approach. His major findings are: First, the efficiency of private banks as a group is lower than that of public banks and foreign banks. Second, he suggests that policy should be reducing non-performing assets, staff, and branches to improve the efficiency.

In respect of financial management system on bank efficiency, Timme (1992) researches how influence the cost efficiency of banks if the banks set up the CEO position or not. He uses the econometric frontier approach to analyse this issue during the period of 1988 to 1990. His major findings are as follows: First, the cost efficiency and return on assets of banks which have the CEO position are lower

than those have non-CEO position. Second, the cost efficiency and return on assets are positively related to non-CEO position. Third, he suggests top management team structure affects performance may not be as effective as envisioned.

Mester (1995) investigate efficiency of banks operating in the Third Federal Reserve District and account for the quality and riskiness of the output by stochastic cost frontier approach during the period of 1991 to 1992. His major finding indicates that banks in Third District appear to be operating at cost-efficient output size and product mixes but there appears to be a significant level of X-inefficiency at the banks.

Beccalli, Casu and Girardone (2003) investigate the link between efficiency measures and the market performance of financial institutions, which is stock market performance in their study, and provide the further evidence on bank efficiency by defining alternative efficiency measures. They apply data envelopment analysis and stochastic frontier approach to estimate the cost efficiency of banks in Europe in 2000. They major finding indicates that DEA measure can obviously show the changes in the price of bank shares how influence the changes in cost efficiency of banks.

In respect of the impact before and after policy-making on bank efficiency, Hardy and Patti (2001) evaluate the efficiency of banks after the major financial reform in the last 1980s by regression analysis in Pakistan during the period of 1981 to 1992. Their major findings indicate that the revenue performance of private banks has a significant improvement than other banks, but simultaneously bring about high cost.

Sturm and Williams (2003) take the impact of foreign bank entry in account on banking efficiency in Australia during the post-deregulation period of 1988 to 2001 by data envelopment analysis, Malmquist indices, and stochastic frontier analysis.

Their major findings are: First, foreign banks more efficient than domestic banks. Second, bank efficiency has increased post-deregulation and the competition resulting from diversity in bank types was important to improve the efficiency. Third, the recession of the early 1990s resulted in the obvious changes of efficiency.

Chen, Skully and Brown (2005) evaluate the cost, technical, and allocative efficiency of forty-three banks in China during the period of 1993 to 2000 by DEA approach. Their main objectives are to identify the change in bank's efficiency of China following the government announcing the program of deregulation in 1995. Their major findings are as follows: First, the cost, technical, and allocative efficiencies after the deregulation announced in 1995 are better than before. Second, technical efficiency consistently dominates the allocative efficiency of banks in China.

2.3 Literature Review of Bank Ownership

In china and other countries, the ownership of industries including banking industry can be probably classified into two forms: state-owned and private. There exists a great deal of literature about ownership in earlier studies. In this part, we collect some literature discussing ownership and introduce them one by one as follows.

Mercan et al. (2003) present a financial performance index for commercial banks. The index provides one to observe effect of scale and of ownership mode such as domestic, private, and foreign on bank behaviour on bank performance in developing economies. Moreover, they use data envelopment analysis to selected basic financial ratios from the Bank Association of Turkey during the period of 1989 to 1999. In their study, basic financial ratios include personnel expenses/earning

assets, total expenses/total income, earning assets/total assets, (shareholders' equity + net profit)/total liabilities, and average return on equity. In DEA, the input set contains the former three variables and others belong to the output set. Their major findings are as follows: First, the average DEA performance-index values of state-owned banks represent lower performance than private and foreign banks within 11-year period except for 1989. Second, the efficiency index of large-scale banks is lower than median-scale and small-scale banks. Third, the average DEA performance-index values of state-owned banks are worst after the financial crisis in 1994.

Li, Hu and Chiu (2004) derive a theoretical framework to predict possible rankings in bank's technical efficiency of different ownership structure. They classify the ownership of banks into three types such as public, mixed, and private banks. They use data set including 43 Taiwanese banks from financial releases, public statement, and Taiwan Economical Journal database in the period of 1997 to 1999 and then apply a translog distance function to estimate technical efficiency. The input set contains three variables, namely bank staff, fixed assets, and total deposits. The output set includes three variables, namely the provision of loan services (including business and individual loans), portfolio investment (mainly government securities and shares, along with public and private enterprises securities), and other real revenues. Their major findings are as follows: First, the ranking of overall mean efficiency in each year, from highest to lowest, is mixed banks, public banks, and private banks besides in 1998. Second, the efficiency of commercial banks in Taiwan performs worse after Asian financial crisis in 1997. Third, an inverted U-shape relation exists between government shareholding and technical efficiency.

Hu, Li and Chiu (2004) derive a theoretical model to predict that the relation between non-performing loan ratios (NPLs) and government shareholdings can be downward-sloping, upward-sloping, U-shaped, and inverted U-shaped. In their research, the ownership of banks is classified into three types such as public, mixed, and private banks. Their data set contains forty Taiwanese commercial banks during the period of 1996 to1999. Owing to heterogeneity existing across firms the ordinary least squares estimators will be inconsistent, so they adopt the panel data analysis to estimate the estimator of all variables. All variables are non-performing loan ratios, the percentage of government shareholdings and its square, real assets and its square, entropy index for revenues, dummy variable of deregulation, and time. Their major findings are as follows: First, the rate of NPLs decreases as government shareholdings in a bank rises, while thereafter it increases. Second, bank size is negatively related to the rate of NPLs. Third, banks established after deregulation have a lower rate of NPLs than those established before deregulation.

Wang, Huang and Lai (2005) apply several DEA models including CCR, BCC, Bilateral, Slack-Based Measure, and the FDH model to evaluate the relative efficiency of banks in China. They classify the ownership of China's banks into two types: state-owned banks and private banks. They collect data set including sixteen Chinese commercial banks, four state-owned banks and twelve private banks, from the China bank statistics in 2004. In their research, three output variables are net profit, return of equity, and return of assets. Two input variables are capital and total assets. Their major findings are as follows: First, private banks have high efficiency than state-owned banks. Second, of the sixteen banks investigated in their study, two banks showed constant return to scale, seven banks showed decreasing return to scale, seven banks showed increasing return to scale. Third, the result of FDH model cannot distinguish between efficient banks and inefficient banks correctly,

compared with the CCR, BCC, and SBM models.

2.4 Hypotheses Development

This research aims to extend the established literature to analyse the cost, allocative, overall technical, pure technical, and scale efficiency of China banking industry by using a nonparametric approach - data envelopment analysis (DEA). We classify the ownership of banks into three types: state-owned specialised, policy-related, and nationwide joint-equity commercial banks in China. According to the existing literature, we propose seven hypotheses:

Hypothesis 1: The bank efficiencies of different ownership structure are not the same.

Hypothesis 2: The bank efficiency in China can be improved by ownership reform.

Hypothesis 3: Banks with longer founding periods of banks in China will be more efficient than those with shorted founding periods.

Hypothesis 4: Small-sized banks in China are more efficient than the large-sized ones.

Hypothesis 5: After WTO participation in 2001, the efficiency of banks in China becomes better than before.

Hypothesis 6: After the 1997 Asian financial crisis, the efficiency of banks in China becomes worse than before.

Hypothesis 7: There exists an inverted U-shape relation between deposit-loan ratio and efficiency scores.

In our research, we use the efficiency scores from DEA approach and then apply the seemingly unrelated regression to examine the above hypotheses.

3. Methodology

3.1 Methodology of Data Envelopment Analysis

Data envelopment analysis involves the use of linear programming methods to construct a non-parametric piece-wise surface over the data. Efficiency measures are then calculated relative to this surface.

Farrell (1957) propose the piece-wise linear convex approach to frontier estimation but only a few authors in the two decades following his paper. Boles (1996) and Afrait (1972) advise mathematical programming methods which could achieve the task, but not achieve very wide attention until the paper by Charnes, Cooper, and Rhodes (1978) in which the terms data envelopment analysis was first used. Similar reviews of the methodology were presented by Seiford and Thrall (1990) and Seiford (1996). Nowadays, there exists a large amount of papers which extended and applied the DEA methodology.

3.1.1 CRS DEA Model

Charnes, Cooper and Rhodes (1978) propose a model which is an input-oriented and assumes constant returns to scale (CRS). In the input-orientated CRS DEA model, we can assume there are data on K inputs and M outputs for each of N firms. For the i-th firm these are represented by the column vectors x_i and y_i. The K×N input matrix X and the M×N output matrix Y represent the data for all N firms. The input-oriented CRS DEA model then solves the following linear programming problem for *i* firm in each year:

$$\begin{aligned} &\min_{\theta,\lambda} \ \theta, \\ &\text{s.t. } -y_i + Y\lambda \geq 0, \\ &\quad \theta x_i - X\lambda \geq 0, \\ &\quad \lambda \geq 0, \end{aligned} \tag{1}$$

where θ is a scalar and λ is a N×1 vector of constants.

The value of θ is used as the efficiency score for the *i*-th firms that satisfied $0 \leq \theta \leq 1$. The value of unity indicates a point on the frontier and hence a technically efficient firm, according to Farrell's (1957) definition. The DEA problem in equation 1 takes the i-th firms and then seeks to radially contract the inputs vector, x_i, as much as possible, while still remaining within the feasible input set. The inner-boundary of this set determined by the observed data points is a piece-wise linear iso-quant. The radial contraction of the input vector, x_i, produces the projected point, (Xλ, Yλ), on the frontier of this technology. This projected point is a linear combination of these observed data points. The constraints in equation 1 make sure that this projected point cannot lie outside the feasible set. To illustrate the efficiency measurement, for example, Figure 2 can interpret that C and D are the efficient firms which define the frontier such that A and B are inefficient firms. The Farrell's (1957) measure of overall technical efficiency (OTE) explains the efficiency of the firms A and B as $\overline{OA'} / \overline{OA}$ and $\overline{OB'} / \overline{OB}$.

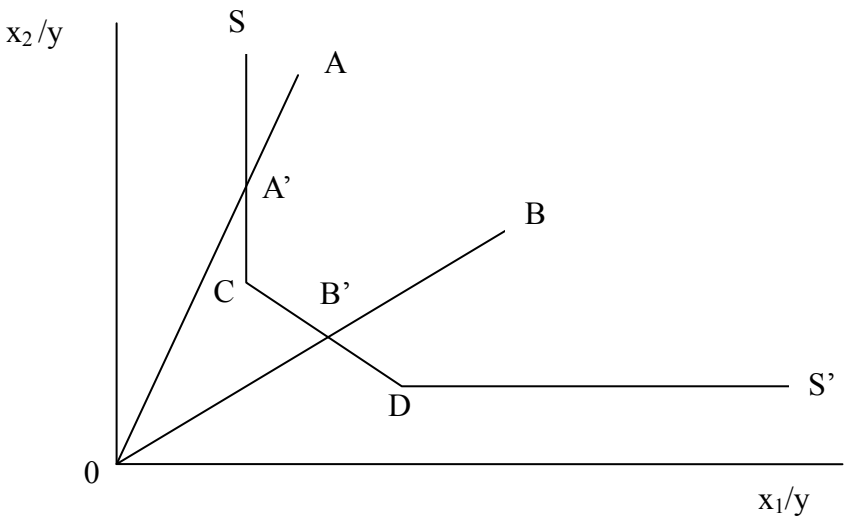


Figure 2. Efficiency Measurement in the CRS DEA Model

3.1.2 VRS DEA Model

Banker, Charnes and Cooper (1984) suggested an extension of the CRS DEA model to account for variable returns to scale (VRS) situation. Since not all firms are operating at the optimal scale, they may further decompose the overall technical efficiency into pure technical efficiency (PTE) times scale efficiency (SE). In the VRS model, there is one differentiation from CRS by adding the convexity constraint, N1'λ, to equation 1. Hence, the input-oriented VRS model then solves the following linear programming problem for *i* firm in each year:

$$\begin{aligned} &\min_{\theta,\lambda} \ \theta, \\ &\text{s.t. } -y_i + Y\lambda \geq 0, \\ &\quad \theta x_i - X\lambda \geq 0, \\ &\quad N1'\lambda = 1, \\ &\quad \lambda \geq 0, \end{aligned} \tag{2}$$

where N1 is an N×1 vector of ones. The convexity constraint ($N1'\lambda=1$) ensures that an inefficient firm is only benchmarked against firms of the similar size. The scale

efficiency measure for each firm can be done by conducting both CRS and VRS DEA computations. The TE scores obtained from CRS DEA can be decomposed into two components: scale efficiency (SE) and pure technical efficiency (PTE). If there is a difference in the OTE and PTE scores for i-th firms, this indicates that the firms have scale efficiency. However, we can be used to calculate the difference between the OTE and PTE scores to evaluate the scale inefficiency. In Figure 3, we use a one-input and one-output example to illustrate scale efficiency.

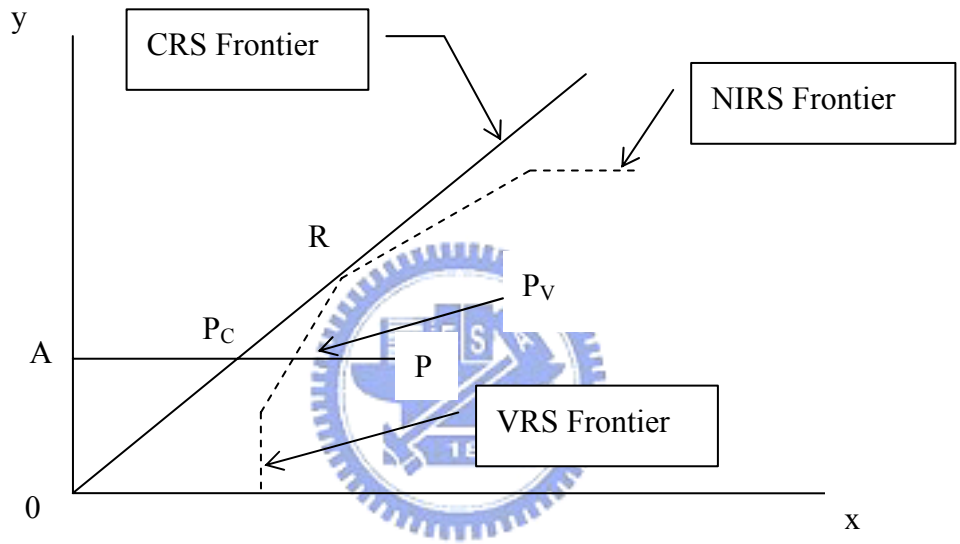


Figure 3. Pure Technical Efficiency and Scale Efficiency

The difference between these two TE measures, $\overline{P_C P_V}$, is due to scale inefficiency. These concepts can be expressed in ratio efficiency measures as:

$$\text{OTE} = \overline{AP_c} / \overline{AP}, \text{PTE} = \overline{AP_V} / \overline{AP}, \text{SE} = \overline{AP_c} / \overline{AP_V}; \quad (3)$$

$$\text{OTE} = \text{PTE} \times \text{SE}. \quad (4)$$

That is, overall technical efficiency can be further decomposed into pure technical efficiency and scale efficiency. This scale efficiency measure can be approximately

explained to the ratio of the average product of a firm operating at the point P_V to the average product of the point operating at a point of optimal scale (point R).

3.1.3 Cost Minimisation DEA

There are some extensions of these basic CRS and VRS DEA models. If price information is available, such as cost minimisation, then it can measure allocative efficiency and technical efficiency. This study also uses data envelopment analysis to estimate the cost efficiency of China banking industry. The cost minimisation CRS DEA model solves the following linear programming problem for *i* firm in each year:

$$\begin{aligned} &\min_{\lambda, x_i} w_i' x_i^* \\ &\text{s.t.} \quad -y_i + Y\lambda \geq 0, \\ &\quad x_i^* - X\lambda \geq 0, \\ &\quad \lambda \geq 0, \end{aligned} \tag{5}$$

where w_i is a vector of input prices for the i-th firms and x_i^* is the cost-minimising vector of input quantities for i-th firms. The cost efficiency of DMU i may be obtained from:

$$CE_i = w_i' x_i^* / w_i' x_i. \tag{6}$$

The allocative efficiency of DMU i can also be defined as:

$$AE_i = CE_i / OTE_i. \tag{7}$$

Farrell (1957) proposes a definition of 'economic efficiency' which is actually the cost efficiency, consisting of technical efficiency and allocative efficiency. Farrell uses two inputs and a single output under the assumption of constant returns to scale. In Figure 3, we use Farrell's concept to illustrate the

construction and decomposition of cost efficiency.

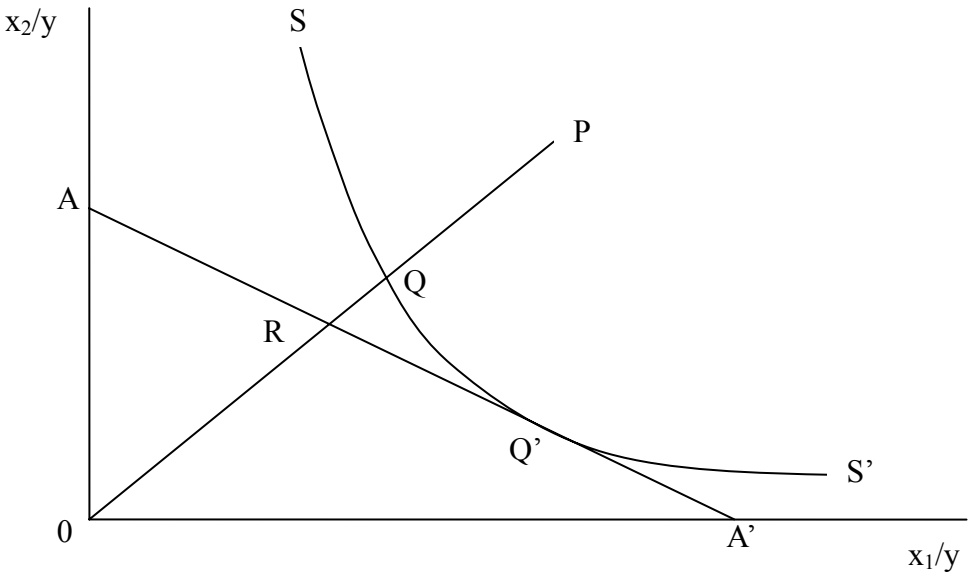


Figure 4. Cost Efficiency, Technical Efficiency, and Allocative Efficiency

The overall technical efficiency of a bank is measured by the ratio $\overline{0Q}/\overline{0P}$. It also takes a value between zero and one. If the input price ratio, represented by the slope of the iso-cost line, is also known, allocative efficiency may be calculated. The allocative efficiency of the firm operating at point P is defined to be the ratio $\overline{0R}/\overline{OQ}$. However, the economic efficiency, also represented by cost efficiency, is defined to be the ratio $\overline{0R}/\overline{OP}$. All three efficiency indices lie between zero and one.

3.2 Methodology of the Seemingly Unrelated Regression

In econometrics, seemingly unrelated regression (SUR) proposed by Zellner (1962) is a technique for analysing a model with multiple equations and correlated error terms. An economic model may contain multiple equations which are independent of each other on the surface: They are not estimating the same

dependent variable or they have the same independent variables, etc. However, if the equations are using the same data, the errors may be correlated between the two equations. SUR is an extension of the linear regression model which allows correlated errors between equations.

3.3 Data Description

This study uses panel data from 1996 to 2003 that includes two outputs, three inputs, and input prices to estimate the cost, allocative, overall technical, pure technical, and scale efficiency of twelve banks by means of data envelopment analysis.

Two output variables include the investment (Y_1) and lending (Y_2). Three input variables include savings (X_1), member of employee (X_2), and the net fixed assets (X_3). Three input price variables include funding price (P_F), labour price (P_L), and capital price (P_K). All data is compiled from the balance sheets, income statements and employment calculation which disclosed in Almanac of China's Finance and Banking from 1984 to 2004. Variables Y_1, Y_2, X_1, X_2, X_3, P_F, P_L, and P_K have been transformed into real variables by the GDP deflators using 2003 as the base year.

3.4 Definition of Output Variables

(1) Investment (Y_1) is defined by the items of long-term, short-term, and securities investment shown in the balance sheets of each bank.

(2) Lending (Y_2) is made by the items of lending but deducts the number of non-performing loans shown in balance sheet of each banks.

3.5 Definition of Input and Input Price Variables

(1) Saving (X_1) and funding price (P_F)

Savings (X_1) stands for the number of every deposit, loans from other banks and the interests that banks paid for loans or deposits. It is defined as total input of banks. The interest expenses of banks also defined as 'Cost of Funds'. The number of interest expenses can be found in the Income Statement disclosed by each bank in the Almanac of China's Finance and Banking. The funding price (P_F) stands for the price of each unit of saving the banks collected from others:

Funding Price (P_F) = cost of funds / savings (X_1).

(2) Employees (X_2) and labour price (P_L):

The expenses paid to their employees by banks are defined as labour cost. The labour price (P_L) is labour cost divided by member of employees:

Labour price (P_L) = labour cost / employee (X_2).

(3) Net fixed assets (X_3) and capital price (P_K):

The net fixed assets disclosed in the balance sheets of banks. Operating expenses without labour cost are defined as capital cost. The capital price (P_K) is capital cost divided by net fixed assets:

Price of fixed assets (P_K) = operating expenses / net fixed assets (X_3).

The definition and description of these variables are as depicted in Table 2.

Table 2. Description of Input-Output Variables

Variable	Definition	Unit	Explanation
Y_1	Investment	100 million RMB	The sum of investment, bonds, and stocks held by each bank.
Y_2	Lending	100 million RMB	The total lending minus default loans.
X_1	Savings	100 million RMB	The amount of every deposit, loans from other banks and the interests which banks pay for loans or deposits.
X_2	Employees	Person	Annual employment of each bank.
X_3	Funds	100 million RMB	The net fixed assets.
P_F	Funding price	100 million RMB	Cost of funds divided by savings.
P_L	Labour price	100 million RMB	The labour cost divided by employees.
P_K	Capital price	100 million RMB	Cost of capital divided by net fixed assets.

3.6 Definition of Environmental Variables

(1) Duration (DUR): It stands for the establishment duration of a bank and is calculated from the year its license was issued by People Bank of China to the year 2003.

(2) Bank classification (SHARE, POLICY): This variable represented by dummy variable because the classification of China's banks in our data categorized to state-owned specialized banks, state policy-related banks, and state-owned joint-equity commercial banks. The state-owned joint-equity commercial banks belong to the share-allocation system but the state-owned specialized banks and the state policy-related banks don't. Therefore, in our study, the nationwide joint-equity commercial banks can be represented by SHARE = 1 and the state policy-related bank can be represented by POLICY = 1. Finally, the state-owned specialized banks can be represented by SHARE = 0 and POLICY = 0 in

regression.

(3) Deposit-loan Ratio (DLR, DLR^2): At first, according to balance sheet of twelve banks from 1996 to 2003 in the Almanac of China's Finance and Banking, we calculate each bank's deposit-loan ratio for eight years period. The deposit-loan ratio of banks is total loans divided by total deposits:

Deposit-loan ratio (DLR) = total loans / total deposits.

Second, we want to know what relationship between deposit-loan ratio and value of efficiency scores. Therefore, we use deposit-loan ratio squared (DLR^2) and deposit-loan ratio into regression to identify their relations.

(4) Bank size (SIZE): At first, according to balance sheet of twelve banks from 1996 to 2003 in the Almanac of China's Finance and Banking, we calculate average assets of each bank for eight years periods from 1996 to 2003. We classified these twelve banks into two groups. The dummy variable, SIZE = 0, represents those banks whose average assets over five hundred billions RMB. Otherwise, SIZE = 1 represents those bank whose total assets under five hundred billions RMB.

(5) WTO participation (WTO): The dummy variable WTO = 0 represents the period before China participating the World Trade Organization. The dummy variable WTO = 1 represents the period after China participating the World Trade Organization.

(6) Asian financial crisis (CRISIS): The dummy variable, CRISIS = 0, represents the period before 1997 Asian financial crisis happens and the dummy variable. Otherwise, CRISIS = 1 represents the period after the 1997 Asian financial crisis.

(7) Time (TIME): The variable TIME indicates the year for an observation.

Table 3. Description of Environmental Variables

Variable	Definition	Unit	Explanation
DUR	Duration	Years	The establishment duration of bank
SHARE, POLICY	Bank classification	0 or 1	SHARE= $\begin{cases} 1 & \text{share-allocation} \\ 0 & \text{otherwise} \end{cases}$ POLICY= $\begin{cases} 1 & \text{policy-related} \\ 0 & \text{otherwise} \end{cases}$
DLR, DLR^2	Deposit-loan Ratio	None	Total loans divided by total deposits.
SIZE	Bank size	0 or 1	SIZE= $\begin{cases} 1 & \text{small} \\ 0 & \text{large} \end{cases}$
WTO	WTO participation	0 or 1	WTO= $\begin{cases} 1 & \text{after WTO} \\ 0 & \text{before WTO} \end{cases}$
CRISIS	Asian financial crisis	0 or 1	CRISIS= $\begin{cases} 1 & \text{after WTO} \\ 0 & \text{before WTO} \end{cases}$
TIME	Time	year	The year for an observation

4. EMPIRICAL RESULTS

At the beginning of the DEA approach, we must use the Pearson correlations to examine whether the relationships of the input and output variables obey the isotonic hypothesis. As Table 4 shows, a significant positive relation exists between an input and an output, implying that the isotonicity property holds. Hence, the DEA approach can be used to evaluate bank efficiency.

Table 4. Pearson Correlations

Correlations	Investment	Lending	Savings	Employees	Funds
Investment	1.000	0.728*** (<0.001)	0.757*** (<0.001)	0.583*** (<0.001)	0.673*** (<0.001)
Lending	0.728*** (<0.001)	1.000	0.944*** (<0.001)	0.904*** (<0.001)	0.900*** (<0.001)
Savings	0.757*** (<0.001)	0.944*** (<0.001)	1.000	0.850*** (<0.001)	0.895*** (<0.001)
Employees	0.583*** (<0.001)	0.904*** (<0.001)	0.850*** (<0.001)	1.000	0.911*** (<0.001)
Funds	0.673*** (<0.001)	0.900*** (<0.001)	0.895*** (<0.001)	0.911*** (<0.001)	1.0000

Note: * represents significance at the 1% level.**

4.1 OTE Analysis

Our empirical findings regarding overall technical efficiency bring forth the following observations.

1. In 1996, Export-Import Bank of China, China Minsheng Banking Corporation, and CITIC Industrial Bank are the three with the most overall-technically efficient banks.
2. In 1997, Export-Import Bank of China, China Minsheng Banking Corporation, CITIC Industrial Bank, Agricultural Development Bank of China, and China Everbright Bank are the five with the most overall-technically efficient banks.
3. In 1998, Export-Import Bank of China, Agricultural Development Bank of China,

China Minsheng Banking Corporation, and China Everbright Bank are the four most overall-technically efficient banks.

4. In 1999, Export-Import Bank of China, China Minsheng Banking Corporation, and Bank of Communication are the three most overall-technically efficient banks.
5. In 2000, Bank of China, Export-Import Bank of China, Agricultural Development Bank of China, China Minsheng Banking Corporation, Bank of Communication, CITIC Industrial Bank, and China Everbright Bank are the seven most overall-technically efficient banks.
6. In 2001, China Everbright Bank is the most overall-technically efficient bank.
7. In 2001, 2002, and 2003, China Development Bank is the most overall-technically efficient bank.

4.2 PTE and SE Analysis

Our empirical findings regarding pure technical efficiency and scale efficiency bring forth the following observations.

1. In 1996, eight banks besides Agricultural Bank of China, Bank of Communication, and China Everbright Bank are the most pure-technically efficient. However, Agricultural Development Bank of China, China Minsheng Banking Corporation, and CITIC Industrial Bank are the most scale-efficient banks.
2. In 1997, nine banks besides Agricultural Bank of China, People's Construction Bank of China, and Hua Xia Bank are the most pure-technically efficient. However, Export-Import Bank of China, Agricultural Development Bank of China, China Minsheng Banking Corporation, CITIC Industrial Bank, and China Everbright Bank are the most scale-efficient banks.
3. In 1998, ten banks are the most pure-technically efficient besides People's Construction Bank of China and Hua Xia Bank. However, Export-Import Bank of China, Agricultural Development Bank of China, China Minsheng Banking Corporation, and China Everbright Bank are the most scale-efficient banks.
4. In 1999, nine banks besides People's Construction Bank of China, China Development Bank, and Hua Xia Bank are the most pure-technically efficient. However, Export-Import Bank of China, China Minsheng Banking Corporation, and Bank of Communication are the most scale-efficient banks.

5. In 2000, nine banks besides Construction Bank of China, China Development Bank, and Hua Xia Bank are the most pure-technically efficient. However, Bank of China, Export-Import Bank of China, Agricultural Development Bank of China, China Minsheng Banking Corporation, Bank of Communication, CITIC Industrial Bank, and China Everbright Bank are the most scale-efficient banks.
6. In 2001, seven banks besides Agricultural Development Bank of China, China Minsheng Banking Corporation, Bank of Communication, CITIC Industrial Bank, Hua Xia Bank, and China Everbright Bank are the most pure-technically efficient. However, China Development Bank and China Everbright Bank are the most scale-efficient banks.
7. In 2002, Industrial and Commercial Bank of China, Bank of China, People's Construction Bank of China, Export-Import Bank of China, and China Development Bank are the most pure-technically efficient. However, China Development Bank is only the most scale-efficient bank.
8. In 2003, Industrial and Commercial Bank of China, Bank of China, Export-Import Bank of China, Agricultural Development Bank of China, China Development Bank, and China Minsheng Banking Corporation are the most pure-technically efficient. However, China Development Bank is only the most scale-efficient bank.
9. State-owned specialised banks are in decreasing returns to scale stage during the period from1996 to 2003, implying that they may reduce their production scale to improve their scale efficiencies.

4.3 CE and AE Analysis

Our empirical findings regarding cost efficiency and allocative efficiency bring forth the following observations.

1. In 1996, Export-Import Bank of China, China Minsheng Banking Corporation, and CITIC Industrial Bank are the most cost efficient and have much higher allocative efficiency than other banks.
2. In 1997, Export-Import Bank of China, Agricultural Development Bank of China, and CITIC Industrial Bank are the most cost efficient and have much higher allocative efficiency than other banks.
3. In 1998, Export-Import Bank of China and China Minsheng Banking Corporation are the most cost-efficient and possess better allocative efficiency

than other banks.

4. In 1999, Export-Import Bank of China, China Minsheng Banking Corporation, and CITIC Industrial Bank are the most cost efficient and have higher allocative efficiency than other banks.
5. In 2000, Bank of China, Export-Import Bank of China, CITIC Industrial Bank, and China Minsheng Banking Corporation are the most cost efficient and have higher allocative efficiency than other banks.
6. In 2001, 2002, and 2003, China Development Bank is the most cost efficient and has higher allocative efficiency than other banks.
7. We also discover that five share-allocation financial institutions have kept reducing their cost efficiency since 2000.

The efficiency scores in DEA approach are shown in Tables 5 to 12:

Table 5. Efficiency Scores of Chinese Banks in 1996

Bank ID	Bank Name	Ownership	CE	AE	OTE	PTE	SE	RTS
1	Industrial and Commercial Bank of China	State-owned	0.131	0.855	0.154	1.000	0.154	drs
2	Agricultural Bank of China	State-owned	0.076	0.767	0.100	0.790	0.126	drs
3	Bank of China	State-owned	0.350	0.741	0.472	1.000	0.472	drs
4	China Construction Bank	State-owned	0.130	0.658	0.198	1.000	0.198	drs
5	Export- Import Bank of China	State-owned	1.000	1.000	0.658	1.000	0.658	irs
6	Agricultural Development Bank of China	State-owned	0.981	0.981	1.000	1.000	1.000	crs
7	China Development Bank	State-owned	0.632	0.861	0.734	1.000	0.734	irs
8	China Minsheng Banking Corporation	Share-allocation	1.000	1.000	1.000	1.000	1.000	crs
9	Bank of Communications	Share-allocation	0.394	0.720	0.547	0.773	0.708	drs
10	CITIC Industrial Bank	Share-allocation	1.000	1.000	1.000	1.000	1.000	crs
11	Hua Xia Bank	Share-allocation	0.465	0.740	0.628	0.941	0.668	irs
12	China Everbright Bank	Share-allocation	0.654	0.833	0.785	0.890	0.882	irs

Table 6. Efficiency Scores of Chinese Banks in 1997

Bank ID	Bank Name	Ownership	CE	AE	OTE	PTE	SE	RTS
1	Industrial and Commercial Bank of China	State-owned	0.174	0.924	0.188	1.000	0.188	drs
2	Agricultural Bank of China	State-owned	0.076	0.600	0.127	0.533	0.238	drs
3	Bank of China	State-owned	0.437	0.834	0.523	1.000	0.523	drs
4	China Construction Bank	State-owned	0.143	0.677	0.212	0.862	0.246	drs
5	Export- Import Bank of China	State-owned	1.000	1.000	1.000	1.000	1.000	crs
6	Agricultural Development Bank of China	State-owned	1.000	1.000	1.000	1.000	1.000	crs
7	China Development Bank	State-owned	0.623	0.954	0.658	1.000	0.653	irs
8	China Minsheng Banking Corporation	Share-allocation	1.000	1.000	1.000	1.000	1.000	crs
9	Bank of Communications	Share-allocation	0.431	0.544	0.792	1.000	0.792	irs
10	CITIC Industrial Bank	Share-allocation	1.000	1.000	1.000	1.000	1.000	crs
11	Hua Xia Bank	Share-allocation	0.281	0.898	0.313	0.359	0.871	irs
12	China Everbright Bank	Share-allocation	0.746	0.746	1.000	1.000	1.000	crs

Table 7. Efficiency Scores of Chinese Banks in 1998

Bank ID	Bank Name	Ownership	CE	AE	OTE	PTE	SE	RTS
1	Industrial and Commercial Bank of China	State-owned	0.291	0.833	0.350	1.000	0.350	drs
2	Agricultural Bank of China	State-owned	0.180	0.758	0.237	1.000	0.237	drs
3	Bank of China	State-owned	0.185	0.926	0.200	1.000	0.200	drs
4	China Construction Bank	State-owned	0.194	0.753	0.257	0.929	0.277	drs
5	Export- Import Bank of China	State-owned	1.000	1.000	1.000	1.000	1.000	crs
6	Agricultural Development Bank of China	State-owned	0.547	0.547	1.000	1.000	1.000	crs
7	China Development Bank	State-owned	0.414	0.672	0.617	1.000	0.617	irs
8	China Minsheng Banking Corporation	Share-allocation	1.000	1.000	1.000	1.000	1.000	crs
9	Bank of Communications	Share-allocation	0.500	0.603	0.829	1.000	0.829	drs
10	CITIC Industrial Bank	Share-allocation	0.773	0.986	0.784	1.000	0.784	drs
11	Hua Xia Bank	Share-allocation	0.437	0.907	0.481	0.500	0.962	irs
12	China Everbright Bank	Share-allocation	0.690	0.690	1.000	1.000	1.000	crs

Table 8. Efficiency Scores of Chinese Banks in 1999

Bank ID	Bank Name	Ownership	CE	AE	OTE	PTE	SE	RTS
1	Industrial and Commercial Bank of China	State-owned	0.291	0.635	0.458	1.000	0.458	drs
2	Agricultural Bank of China	State-owned	0.204	0.418	0.488	1.000	0.488	drs
3	Bank of China	State-owned	0.584	0.755	0.773	1.000	0.773	drs
4	China Construction Bank	State-owned	0.135	0.591	0.228	0.838	0.273	drs
5	Export- Import Bank of China	State-owned	1.000	1.000	1.000	1.000	1.000	crs
6	Agricultural Development Bank of China	State-owned	0.257	0.727	0.354	1.000	0.354	drs
7	China Development Bank	State-owned	0.092	0.473	0.193	0.631	0.306	irs
8	China Minsheng Banking Corporation	Share-allocation	1.000	1.000	1.000	1.000	1.000	crs
9	Bank of Communications	Share-allocation	0.539	0.539	1.000	1.000	1.000	crs
10	CITIC Industrial Bank	Share-allocation	0.835	0.964	0.866	1.000	0.866	drs
11	Hua Xia Bank	Share-allocation	0.512	0.853	0.600	0.628	0.956	irs
12	China Everbright Bank	Share-allocation	0.165	0.219	0.751	1.000	0.751	irs

Table 9. Efficiency Scores of Chinese Banks in 2000

Bank ID	Bank Name	Ownership	CE	AE	OTE	PTE	SE	RTS
1	Industrial and Commercial Bank of China	State-owned	0.625	0.749	0.835	1.000	0.835	drs
2	Agricultural Bank of China	State-owned	0.224	0.451	0.498	1.000	0.498	drs
3	Bank of China	State-owned	1.000	1.000	1.000	1.000	1.000	crs
4	China Construction Bank	State-owned	0.102	0.658	0.154	0.950	0.162	drs
5	The Export- Import Bank of China	State-owned	1.000	1.000	1.000	1.000	1.000	crs
6	Agricultural Development Bank of China	State-owned	0.192	0.192	1.000	1.000	1.000	crs
7	China Development Bank	State-owned	0.075	0.331	0.227	0.837	0.271	irs
8	China Minsheng Banking Corporation	Share-allocation	1.000	1.000	1.000	1.000	1.000	crs
9	Bank of Communications	Share-allocation	0.670	0.670	1.000	1.000	1.000	crs
10	CITIC Industrial Bank	Share-allocation	1.000	1.000	1.000	1.000	1.000	crs
11	Hua Xia Bank	Share-allocation	0.580	0.933	0.622	0.746	0.834	irs
12	China Everbright Bank	Share-allocation	0.283	0.283	1.000	1.000	1.000	crs

Table 10. Efficiency Scores of Chinese Banks in 2001

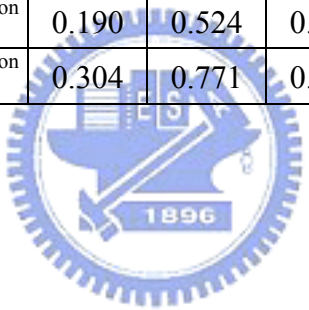
Bank ID	Bank Name	Ownership	CE	AE	OTE	PTE	SE	RTS
1	Industrial and Commercial Bank of China	State-owned	0.119	0.651	0.182	1.000	0.182	drs
2	Agricultural Bank of China	State-owned	0.040	0.512	0.079	0.866	0.091	drs
3	Bank of China	State-owned	0.160	0.746	0.215	1.000	0.215	drs
4	China Construction Bank	State-owned	0.115	0.641	0.180	1.000	0.180	drs
5	Export- Import Bank of China	State-owned	0.490	0.979	0.500	1.000	0.500	irs
6	Agricultural Development Bank of China	State-owned	0.067	0.101	0.659	1.000	0.659	drs
7	China Development Bank	State-owned	1.000	1.000	1.000	1.000	1.000	crs
8	China Minsheng Banking Corporation	Share-allocation	0.143	0.451	0.317	0.575	0.551	irs
9	Bank of Communications	Share-allocation	0.072	0.328	0.218	0.221	0.990	drs
10	CITIC Industrial Bank	Share-allocation	0.220	0.850	0.259	0.275	0.942	irs
11	Hua Xia Bank	Share-allocation	0.072	0.535	0.135	0.337	0.399	irs
12	China Everbright Bank	Share-allocation	0.102	0.102	1.000	1.000	1.000	crs

Table 11. Efficiency Scores of Chinese Banks in 2002

Bank ID	Bank Name	Ownership	CE	AE	OTE	PTE	SE	RTS
1	Industrial and Commercial Bank of China	State-owned	0.185	0.649	0.285	1.000	0.285	drs
2	Agricultural Bank of China	State-owned	0.070	0.500	0.139	0.857	0.163	drs
3	Bank of China	State-owned	0.252	0.690	0.365	1.000	0.365	drs
4	China Construction Bank	State-owned	0.145	0.560	0.258	1.000	0.258	drs
5	Export- Import Bank of China	State-owned	0.594	0.923	0.644	1.000	0.644	irs
6	Agricultural Development Bank of China	State-owned	0.072	0.153	0.473	0.509	0.930	irs
7	China Development Bank	State-owned	1.000	1.000	1.000	1.000	1.000	crs
8	China Minsheng Banking Corporation	Share-allocation	0.180	0.399	0.452	0.684	0.660	irs
9	Bank of Communications	Share-allocation	0.125	0.352	0.356	0.566	0.628	drs
10	CITIC Industrial Bank	Share-allocation	0.291	0.900	0.323	0.335	0.966	irs
11	Hua Xia Bank	Share-allocation	0.205	0.478	0.428	0.656	0.653	irs
12	China Everbright Bank	Share-allocation	0.274	0.678	0.403	0.463	0.871	irs

Table 12. Efficiency Scores of Chinese Banks in 2003

Bank ID	Bank Name	Ownership	CE	AE	OTE	PTE	SE	RTS
1	Industrial and Commercial Bank of China	State-owned	0.255	0.609	0.419	1.000	0.419	drs
2	Agricultural Bank of China	State-owned	0.102	0.483	0.210	0.823	0.255	drs
3	Bank of China	State-owned	0.332	0.710	0.467	1.000	0.467	drs
4	China Construction Bank	State-owned	0.186	0.583	0.320	0.969	0.330	drs
5	Export- Import Bank of China	State-owned	0.463	0.704	0.658	1.000	0.658	irs
6	Agricultural Development Bank of China	State-owned	0.062	0.093	0.672	1.000	0.672	irs
7	China Development Bank	State-owned	1.000	1.000	1.000	1.000	1.000	crs
8	China Minsheng Banking Corporation	Share-allocation	0.349	0.385	0.907	1.000	0.907	irs
9	Bank of Communications	Share-allocation	0.153	0.612	0.250	0.505	0.496	drs
10	CITIC Industrial Bank	Share-allocation	0.444	0.883	0.503	0.549	0.916	drs
11	Hua Xia Bank	Share-allocation	0.190	0.524	0.362	0.705	0.513	irs
12	China Everbright Bank	Share-allocation	0.304	0.771	0.395	0.467	0.847	irs



4.4 Peer Analysis

According to peer counts of DEA reports, we find that Agricultural Development Bank of China is the most admired in 1996 and 1998. In 1997, Agricultural Development Bank of China, Industrial and Commercial Bank of China, and Bank of China are the most admired, which are also stated-owned specialised and policy-related banks. In 1999 Export-Import Bank of China and China Minsheng Banking Corporation are the most admired, among which China Minsheng Banking Corporation is of share-allocation form. In 2000, Export-Import Bank of China and China Everbright Bank are the most admired. Moreover, share-allocation banks have gradually been learned by other banks. In 2001, China Development Bank and China Everbright Bank are the most to be admired. In 2002 and 2003, China Development Bank is the most to be admired.

4.5 Seemingly Unrelated Regression Results

We incorporate seven environmental variables to find how they influence the efficiency scores of the twelve banks in China. The cost, allocation, overall technical, pure technical and scale efficiency scores are between zero and unity. The higher the efficiency score is, the more efficient the bank will be. Moreover, the error term should be correlated among five equations in the regression analysis because each bank has five efficiency scores. Hence, we use the seemingly unrelated regression (SUR) to estimate the following empirical model:

$$CE_{it} = \beta_0 + \beta_1 DUR_{it} + \beta_2 SHARE_{it} + \beta_3 POLICY_{it} + \beta_4 DLR_{it} + \beta_5 DLR_{it}^2 + \beta_6 SIZE_{it} + \beta_7 WTO_{it} + \beta_8 CRISIS_{it} + \beta_9 TIME_{it} + u_{it},$$

$$AE_{it} = \beta_0 + \beta_1 DUR_{it} + \beta_2 SHARE_{it} + \beta_3 POLICY_{it} + \beta_4 DLR_{it} + \beta_5 DLR_{it}^2 + \beta_6 SIZE_{it} + \beta_7 WTO_{it} + \beta_8 CRISIS_{it} + \beta_9 TIME_{it} + u_{it},$$

$$OTE_{it} = \beta_0 + \beta_1 DUR_{it} + \beta_2 SHARE_{it} + \beta_3 POLICY_{it} + \beta_4 DLR_{it} + \beta_5 DLR_{it}^2 + \beta_6 SIZE_{it} + \beta_7 WTO_{it} + \beta_8 CRISIS_{it} + \beta_9 TIME_{it} + u_{it},$$

$$PTE_{it} = \beta_0 + \beta_1 DUR_{it} + \beta_2 SHARE_{it} + \beta_3 POLICY_{it} + \beta_4 DLR_{it} + \beta_5 DLR_{it}^2 + \beta_6 SIZE_{it} + \beta_7 WTO_{it} + \beta_8 CRISIS_{it} + \beta_9 TIME_{it} + u_{it},$$

$$SE_{it} = \beta_0 + \beta_1 DUR_{it} + \beta_2 SHARE_{it} + \beta_3 POLICY_{it} + \beta_4 DLR_{it} + \beta_5 DLR_{it}^2 + \beta_6 SIZE_{it} + \beta_7 WTO_{it} + \beta_8 CRISIS_{it} + \beta_9 TIME_{it} + u_{it},$$

where β_0 is the constant term; u_{it} is the error term following a normal distribution. The seemingly unrelated regression results are shown as follows:

Table 13. Factors of Cost Efficiency

Variables	Coefficient	Standard Error	t-ratio	P-value
DUR	0.0030	0.0027	1.11	0.266
SHARE	0.1616	0.0960	1.68	0.092*
POLICY	0.0583	0.1154	0.51	0.613
DLR	0.0475	0.0180	2.63	0.009***
DLR^2	-0.0006	0.0007	-0.97	0.332
SIZE	0.2103	0.0675	3.11	0.002***
WTO	-0.4167	0.1112	-.3.75	<0.001***
CRISIS	-0.1781	0.0986	-1.81	0.071*
TIME	0.0422	0.0317	1.33	0.184
Constant	0.1994	0.1099	1.81	0.070*
		R-square	0.5373	

Note: *** represents significance at the 1% level;

* represents significance at the 10% level.

Table 14. Factors of Allocative Efficiency

Variables	Coefficient	Standard Error	t-ratio	P-value
DUR	0.0028	0.0024	1.16	0.245
SHARE	-0.0937	0.0858	-1.09	0.275
POLICY	-0.0775	0.1032	-0.75	0.452
DLR	0.0045	0.0161	0.28	0.779
DLR^2	0.0004	0.0006	0.74	0.462
SIZE	0.2228	0.0603	3.69	<0.001***
WTO	-0.0704	0.0994	-0.71	0.479
CRISIS	-0.0835	0.0881	-0.95	0.343
TIME	-0.0243	0.0284	-0.86	0.392
Constant	0.7855	0.0982	7.99	<0.001***
		R-square	0.3211	

Note: *** represents significance at the 1% level.

Table 15. Factors of Overall Technical Efficiency

Variables	Coefficient	Standard Error	t-ratio	P-value
DUR	0.0018	0.0024	0.74	0.460
SHARE	0.3193	0.0860	3.71	<0.001***
POLICY	0.1354	0.1035	1.31	0.191
DLR	0.0588	0.0161	3.64	<0.001***
DLR^2	-0.0014	0.0006	-2.17	0.030**
SIZE	0.0860	0.0605	1.42	0.155
WTO	-0.5241	0.0997	-5.25	<0.001***
CRISIS	-0.1363	0.0884	-1.54	0.123
TIME	0.0775	0.0285	2.72	0.007***
Constant	0.1788	0.0986	1.81	0.070*
		R-square	0.5890	

Note: *** represents significance at the 1% level;
** represents significance at the 5% level;
* represents significance at the 10% level.

Table 16. Factors of Pure Technical Efficiency

Variables	Coefficient	Standard Error	t-ratio	P-value
DUR	0.0006	0.0020	0.32	0.748
SHARE	-0.2193	0.0711	-3.08	0.002***
POLICY	-0.0856	0.0855	-1.00	0.317
DLR	0.0163	0.0133	1.22	0.223
DLR^2	-0.0004	0.0005	-0.78	0.435
SIZE	0.0754	0.0500	1.51	0.132
WTO	-0.2104	0.0824	-2.55	0.011**
CRISIS	-0.0142	0.0730	-0.19	0.846
TIME	0.0134	0.0235	0.57	0.568
Constant	0.9465	0.0814	11.61	<0.001***
		R-square	0.3326	

Note: *** represents significance at the 1% level;
** represents significance at the 5% level.

Table 17. Factors of Scale Efficiency

Variables	Coefficient	Standard Error	t-ratio	P-value
DUR	0.0023	0.0019	1.15	0.249
SHARE	0.5285	0.0696	7.59	<0.001***
POLICY	0.2202	0.0838	2.63	0.009***
DLR	0.0512	0.0131	3.91	<0.001***
DLR^2	-0.0012	0.0005	-2.34	0.019**
SIZE	0.0440	0.0490	0.90	0.369
WTO	-0.3556	0.0807	-4.40	<0.001***
CRISIS	-0.1049	0.0715	-1.47	0.143
TIME	0.0622	0.0230	2.70	0.007***
Constant	0.1607	0.0798	2.01	0.044**
		R-square	0.7123	

Note: *** represents significance at the 1% level;
** represents significance at the 5% level.

Under the 1% level, the dummy variable, SHARE, has a significantly positive effect on overall technical and scale efficiencies, but has a significantly negative effect on pure technical efficiency. Other things being equal, the nationwide joint-equity commercial bank with a share-allocation system has a lower pure technical efficiency, but has higher overall technical and scale efficiencies than state-owned specialised banks in China. Moreover, under the 10% level, the dummy variable, SHARE, has a significantly positive effect on cost efficiency. It shows that the share-allocation policy could make banks' cost efficiency better than state-owned specialised banks.

Under the 1% level, the dummy variable, POLICY, has a significantly positive effect on scale efficiency. From the highest to the lowest, the scale efficiency rankings are: nationwide joint-equity commercial banks, policy-related banks, and state-owned specialised banks. Although nationwide joint-equity commercial banks

have a lower pure technical efficiency than the state-owned specialised banks, they have higher cost, overall technical, and scale efficiencies than the state-owned specialised banks.

Under the 1% level, the deposit-loan ratio has a significantly positive impact on cost, overall technical, and scale efficiency. Under the 5% level, the square of the deposit-loan ratio has a significantly negative impact on overall technical and scale efficiency. Therefore, a marginal increasing relation exists between the deposit-loan ratio and cost efficiency. The inverted U-shape relation exists between deposit-loan ratio and overall technical and scale efficiency.

Under the 1% level, the dummy variable of SIZE has significantly positive effects on cost and allocative efficiencies. Therefore, small-sized banks have significantly higher cost and allocative efficiencies than large-sized banks.

Under the 1% level, these twelve banks after WTO participation have significantly negative effects on cost, overall technical, and scale efficiencies. Moreover, they show the same effect on pure technical efficiency under the 5% level. Therefore, the cost, overall technical, pure technical, and scale efficiencies of these twelve banks in China are worse after WTO participation.

Under the 10% level, these twelve banks after the Asian financial crisis have a significantly negative effect on cost efficiency. Therefore, the cost efficiency of these twelve banks in China is worse after the Asian financial crisis.

Under the 1% level, the variable TIME has a significantly positive effect on overall technical and scale efficiencies. These twelve banks in China have significantly increasing overall technical and scale efficiencies from 1996 to 2003.

5. Concluding Remarks

5.1 General Discussions and Conclusions

China's government started share-allocation reform of its banking industry in 1979. First, share-allocation reform in China does not equal to property rights reallocation. Second, the share-allocation reforms are managerial reforms, especially as the ownership is never transferred from state to the private sector. Third, the Third Plenary Session of the Fourteenth Central Committee of the Communist Party of China asserted "to define the property rights; to clarify the line between duty and authority; to separate government and enterprise; to manage in a scientific way." All state-owned enterprises in China have since been changing from the their improvement reform of a modern enterprise system to the new definition of share-allocation reforms.

The dataset contains twelve nationwide banks in China during the period of 1996 to 2003, with a comparison between stated-owned and share-allocation reformed banks. The major findings are as follows.

Nationwide joint-equity commercial banks are share-allocation reformed banks. The scale efficiency rankings from the highest to the lowest are: nationwide joint-equity commercial banks, policy-related banks, and state-owned specialised banks. Moreover, nationwide joint-equity commercial banks have a lower pure technical efficiency, but have a higher overall technical efficiency than state-owned specialised banks. Therefore, if China's government wants to improve the banks' cost, overall technical, and scale efficiencies, the best way is that banks' ownership is transferred from the specialised system to share-allocation system. However, share allocation reform is significantly adverse to pure technical efficiency. Share

allocation reform has no significant impact on allocative efficiencies.

A marginal increasing relation exists between the deposit-loan ratio and cost efficiency. Therefore, the higher the deposit-loan ratio is, the higher cost efficiency will be. Moreover, the inverted U-shape relation exists between the deposit-loan ratio and overall technical and scale efficiency. According to this relation, banks can raise the deposit-loan ratio to improve the overall technical and scale efficiencies, but the high level of deposit-loan ratio could lower these two efficiency scores.

The small-sized banks include China Export-Import Bank, China Minsheng Banking Corporation, CITIC Industrial Bank, Hua Xia Bank, and China Everbright Bank. Small-sized banks have higher cost and allocative efficiencies, implying that these banks operate efficiently at cost minimisation during the period of 1996 to 2003.

The cost, overall technical, pure technical, and scale efficiencies of these twelve banks in China after WTO participation in 2001 turned worse. Moreover, the cost efficiencies of these twelve banks in China also became worse after the 1997 Asian financial crisis.

5.2 Research Limitations

If China's government improves its statistical and relevant systems, we hope to get more economic information in the future and may study other Chinese financial institutions such as rural credit cooperatives. Furthermore, the number of samples can also be increased and environmental variables such as the number of bank branches, government shareholdings, and ATM numbers can also be made available for future research.

Finally, owing to the limitation of not being able to collect detailed information

from foreign banks, their discussion cannot be inputted on in this study. After China entered WTO in 2001, it promised to open its financial markets to all member states. Pressure from foreign banks will continue to increase after China's accession to WTO. The effects from foreign banks entering the China's market are also an interesting topic for further studies.

References

Afrait, S.N., 1972, 'Efficiency Estimation of Production Functions,' *International Economic Review*, Vol.13, No.3, pp.568-598.

Alibaba.com, 2005, 'China's Growth: Recent Trading Trends,' Downloaded from http://resources.alibaba.com/article/150/China_s_growth_recent_trading_trends.htm.

Aly, H.Y., R. Grabowski, C. Pasurka and N. Rangan, 1990, 'Technical, Scale, and Allocative Efficiencies in U.S. Banking: An Empirical Investigation,' *Review of Economics and Statistics*, Vol.72, No.2, pp.211-218.

Banker, R.D., A. Charnes and W.W. Cooper, 1984, 'Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis,' *Management Science*, Vol.30, No.9, pp.1078-1092.

Boels, J.N. (1966), 'Efficiency Squared – Efficiency Computation of Efficiency Indexes,' *Proceedings of the 39th Annual Meeting of the Western Farm Economics Association*, pp.137-142.

Beccalli, E., B. Casu and C. Girardone, 2003, 'Efficiency and Stock Performance in European Banking,' *NBER Working Papers*, 5879.

Charnes, A., W.W. Cooper and E. Rhodes, 1978, 'Measuring the Efficiency of Decision Making Units,' *European Journal of Operational Research*, Vol.2, No.2, pp.429-444.

Chen, X.G., M. Skully and K. Brown, 2005, 'Banking Efficiency in China: Application of DEA to Pre- and Post-Deregulation Eras: 1993-2000,' *China Economic Review*, Vol.16, No.3, pp.229-245.

Coelli, T.J., D.S.P. Rao and G.E. Battese, 1998, *An Introduction to Efficiency and Productivity Analysis*, Boston: Kluwer Academic Publishers.

Farrell, M.J., 1957, 'The Measurement of Productive Efficiency,' *Journal of Royal Statistical Society*, Vol.120, No.3, pp.253-281.

Hardy, D.C. and E.B. Patti, 2001, 'Bank Reform and Bank Efficiency in Pakistan,' *International Monetary Fund Working Paper*, pp.138-173.

Hu, J.L, Y. Li and Y.H. Chiu, 2004, 'Ownership and Non-performing Loans: Evidence from Taiwan's Banks,' *Developing Economies*, Vol.42, No.3, pp.405-420.

Jemric, I. and B. Vujcic, 2002, 'Efficiency of Banks in Croatia: A DEA Approach,' *Comparative Economic Studies*, Vol.44, No.2, pp.169-193.

Li, Y., J.L. Hu and Y.H. Chiu, 2004, 'Ownership and Production Efficiency: Evidence from Taiwan's Banks,' *Service Industries Journal*, Vol.24, No.4, pp.129-148.

Maudos, J., J.M. Pastor and F. Perez, 2002, 'Cost and Profit Efficiency in European Banks,' *Journal of International Financial Markets, Institutions and Money*, Vol.12, No.1, pp.33-58.

Mercan, M., A. Reisman, R. Yolalan and A.B. Emel, 2003, 'The Effect Scale and Mode of Ownership on the Financial Performance of Turkish Banking Sector: Results of a DEA-based Analysis,' *Socio-Economics Planning Sciences*, Vol.37, No.3, pp.185-202.

Mester, L.J., 1995, 'A Study of Bank Efficiency Taking into Account Risk-preferences,' *Journal of Banking and Finance*, Vol.20, No.6, pp.1025-1045.

Pi, L. and S.G. Timme, 1992, 'Corporate Control and Bank Efficiency,' *Journal of Banking and Finance*, Vol.17, No.2-3, pp.515-530.

Sathye, M., 2003, 'Efficiency of Banks in a Developing Economy: The Case of India,' *European Journal of Operational Research*, Vol.148, No.3, pp.662-671.

Seiford, L.M. (1996), 'Data Envelopment Analysis: The Evaluation of the State of the Art (1978-1995),' *Journal of Productivity Analysis*, Vol.7, No.2-3, pp.99-138.

Seiford, L.M. and R.M. Thrall, 1990, 'Recent Developments in DEA: the Mathematical Approach to Frontier Analysis,' *Journal of Econometrics*, Vol.46, No.1-2, pp.7-38.

Sturm, J.E. and B. Williams, 2003, 'Foreign Bank Entry, Deregulation and Bank Efficiency: Lessons from the Australian Experience,' *Journal of Banking and Finance*, Vol.28, No.7, pp.1775-1799.

Tian, G., 2000, 'Property Rights and the Nature of Chinese Collective Enterprises,' *Journal of Comparative Economics*, Vol.28, No.2, pp.247–268.

Wang, W.K., H.C. Huang and M.C. Lai, 2005, 'Measuring the Relative Efficiency of Commercial Banks: A Comparative Study on Different Ownership Modes in China,' *Journal of American Academy of Business*, Vol.7, No.2, pp.219-223.

Zellner, A., 1962, 'An Efficient Method of Estimating Seemingly Unrelated Regression Equations and Tests for Aggregation Bias,' *Journal of the American Statistical Association*, Vol.57, No. 298, pp.348–368.