Empirical Studies of the Chinese Banking Industry

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SUMMARY

This study trys to find the production behaviors of the Chinese banking industry. Two frameworks (fixed effects model and random effects model) generalized from Cobb-Douglas production function, stochastic frontier model and translog model are carried out for different purposes. Constant returns to scale is found for the whole industry, while smaller non-state-owned banks appear to have increasing returns to scale. The average technical inefficiency is found to be 46.5%, which is much higher than their international peers. State-owned banks are found to be more efficient than non-state-owned banks in production behavior.

INTRODUCTION

The Chinese banking industry has a history of more than 100 years, but a modernized socialism commercial banking system only took shape in the 1990s'.

Prior to 1990s', China's banking system changed dramatically along with the decentralization and market oriented reforms in economy which began from 1979. Some state-owned specialized banks were separated from the operations of the central bank[1]. For the first time, 1984 saw the People's Bank of China independently perform the central bank's function. The separation of the banking business was based on the belief that a more decentralized system would operate more efficiently. In late 1980s', both national and regional shareholding banks were founded[2]. The four state-owned banks have also taken the reform of commercialization. In the mid 1990s, a series of widely publicized financial reforms were implemented in China to improve bank performance. The most sweeping changes include:

1) Relaxation of binding credit plans following the 1993 anti-inflation campaign.

2) A shift to ratio management of loans, which gives more autonomy to state-owned banks to reallocate funds among provincial branch offices.

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1) The four state-owned specialized banks form the principal part of the Chinese banking system. They are Industrial & Commercial Bank of China, Agricultural Bank of China, Bank of China and China Construction Bank.

2) Bank of Communication, re-opened in 1987, is the first share-holding bank in China.

3) An adoption of a new Commercial Bank Law to improve managerial incentives and prudential financial regulation.

4) Establishment of policy banks to separate policy from commercial lending.

These reforms introduce more competition among banks and contribute significantly to a more efficient allocation of financial resource. Are Chinese banks ready for the competition from their international peers? With China entering WTO in December 2001, this problem becomes urgent. It is in great need to do research on the behavior of Chinese banks. Our research is based on the data of four state-owned specialized banks and some shareholding banks. All the methods used in this study can be found in advanced econometric literature. The estimations were carried out by Limdep (Greene, 1991).

Most studies on the banking industry have been done in the U.S., with less than a handful of papers focusing on banks outside the U.S.

Previous empirical research on returns to scale in banking has found increasing returns to scale only among relatively small banks, and decreasing returns to scale among larger banks (such as Clark (1988)). Benston, Hanweck and Humphrey (1992) contended that the increasing returns to scale are limited to small banks, but do not restrict the expansion of larger banks. They also found "an optimum or minimum cost size of bank office exists, is stable and occurs for institutions with from $10 million to $25 million in deposits". McAllister and McManus (1993) found strong evidence of increasing returns to scale for banks up to about $500 million in total assets and approximately constant returns for larger banks. Somewhat surprisingly, McKillop, Glass and Morikwa (1996), found increasing returns to scale for all sizes of Japanese banks.

As for technical inefficiency, Ferrier and Lovell (1990), using cost function, point out that, banks operate inefficiently with observed cost roughly 20–30% or more above their cost frontier. Smaller banks show greater inefficiencies. Berger, Hunter and Timme (1993) also found X-efficiencies account for 20% or more of cost in banking.

To our knowledge, no empirical studies have been done in the Chinese banking industry to examine the production behavior at industry and firm level. Park and Sehrt (1999), derived from a model of bank profit maximization, examined the performance of different Chinese financial institutions before and after the reforms in mid-1990s. Their results suggested that financial intermediation in China is far from efficient and financial reforms have not reversed a worsening trend. As they pointed out, these results did not necessarily mean the reforms were inefficient, but the sharply deteriorating performance of state-owned enterprises and the portfolio of older loans are overwhelming these effects.

In our study, production function is examined by the econometric analysis using panel data. The quantitative analysis will show the production behavior of Chinese banking firms.

The paper is organized as follows. Section 1 presents the background of the Chinese banking industry. Section 2 gives the econometric model. Two frameworks are generalized from Cobb-Douglas production function. They are fixed effects model and random effects model. Data description is given in Section 3. We first carry out estimation on balanced data and later on unbalanced data. The results from the unbalanced data are given in Appendix.

The result of the fixed & random effects models are given in Section 4 and constant returns to scale for the whole industry is found. We carry out Hausman test to test which one is more appropriate, and random effects model is found to be preferred. The fact that the null hypothesis cannot be rejected suggests that there is no correlation between the effects and the regressors, thus stochastic frontier production function is also suitable. In Section 5, technical inefficiency is calculated by stochastic frontier model. We followed the method of Battese and Coelli (1988).

In order to calculate the returns to scale not only for the whole industry but also for individual firms in a separate year, more flexible translog model is considered in Section 6. We also add *year* dummies to the standard translog model to examine the production change between years. Later, in Section 7, we employ the *nonstate* dummies to test if difference exists between the behavior of state-owned banks and non-state-owned commercial banks. Section 8 will give the conclusion of this paper.

1. Background of Chinese banking industry

China's banking system now comprises wide variety of banks:

1) The People's Bank of China (PBC), the central bank of China, has been independently performing the central bank's function since 1984.

2) Four state-owned specialized banks. They are the principal part of the Chinese banking system. The four specialized banks are:

Bank of China (BOC), organized in 1908, and served as China's Central Bank for 40 years. Since 1949, The Bank of China has primarily focused on deposits and loans of foreign exchange and international settlements.

Agricultural Bank of China (ABC), which was reestablished in 1979. Its main responsibilities are to receive deposits, extend loans to agricultural and rural industry.

China Construction Bank (CCB), reconstituted in 1979, manages government grants for fixed assets investment and extends loans to fixed assets investment.

Industrial and Commercial Bank of China (ICBC), separated from the central bank in 1984, is now the biggest specialized bank in China.

Each of these institutions is to provide service to a designated sector in the economy. Now the four specialized banks are allowed to engage in the service in all sectors. They are transformed into commercial banks that aim at profit-making while taking the risk themselves.

3) Policy banks

There are three policy banks in China now. They are the Development Bank, Import and Export Bank and Agricultural Development Bank. They will grant policy loans to selected projects in accordance with the state industrial policy. The separation of policy banks from specialized banks allows state-owned specialized banks become more commercially oriented.

4) Shareholding banks

Since 1987, many shareholding commercial banks, both nationwide and regional, have been established. Examples include:

Bank of Communications was opened in 1908, and reestablished in 1987. It is the first shareholding bank in China. Most of its shares are held by the local governments or state-owned enterprises. China Merchants Bank, founded in 1987, is the first shareholding bank whose shares are held by enterprises. Citic Industrial Bank, founded in 1987, is a subsidiary of China International Trust and Investment Corporation. Huaxia Bank, founded in 1992, is a nationwide shareholding bank. Mensheng bank, founded in 1996, is the first shareholding bank whose shares are held mainly by non-state-owned enterprises. Examples of regional banks include, Shenzhen Development Bank and Pudong Development Bank.

5) Branches or agencies of some foreign banks, whose service area is limited to certain area and scope.

We will inspect the descriptive statistics of the collected data for eight nationwide commercial banks through the years 1996 to 1999. These eight banks are: Industrial & Commercial Bank of China, Agricultural Bank of China, Bank of China, China Construction Bank, Bank of Communications, Citic Industrial Bank, Mensheng Bank and Huaxia Bank. We will call them bank 1, 2, 3, 4, 5, 6, 7, 8 respectively later in our article and figures. Since the first four are held wholly by the nation, we call them state-owned commercial banks. The rest four are shareholding banks, and we call them non-state-owned banks in this article.

The variables presented here are: total assets, deposits, loans, labor and net profit. These are important and widely used variables in banking industry. Sum of the variable of each year from different banks giving the trend of the industry. Average of variable of each bank during the observed years shows the different character among the banks. Some useful ratios are also calculated to represent the change of the industry as well as the performance of each bank. These ratios are loan to deposits ratio, net profit to labor ratio and return to assets. Finally , we examine the relation between loan, labor and deposits to see if they have appropriate character to act as output and input factors.

(1) Total assets (Fig. 1)

The four state-owned banks are much bigger in size than the non-state-owned ones. Total assets in Chinese banking industry increased through the observed years.

(2) Deposits (Fig. 2)

The deposits in four state-owned banks are much more than those in non-state-owned ones. It increased from 1996 to 1999.

(3) Loans (Fig. 3)

Because most of the loan is funded by deposits, it shows a similar pattern to deposits.

(4) Labor (Fig. 4)

The number of employees fluctuated through the observed years. The stern economic environment made the banks take cautious actions in expanding their scales. The third bank (Bank of China) who has the corresponding scale has relatively small number of employees.

(5) Net profit (Fig. 5)

The net profit seems to decline through the years and situation improved a little in 1999. The second bank (the Agricultural Bank of China) do not have a sound financial situation. It has rather low average profit considering its scale.

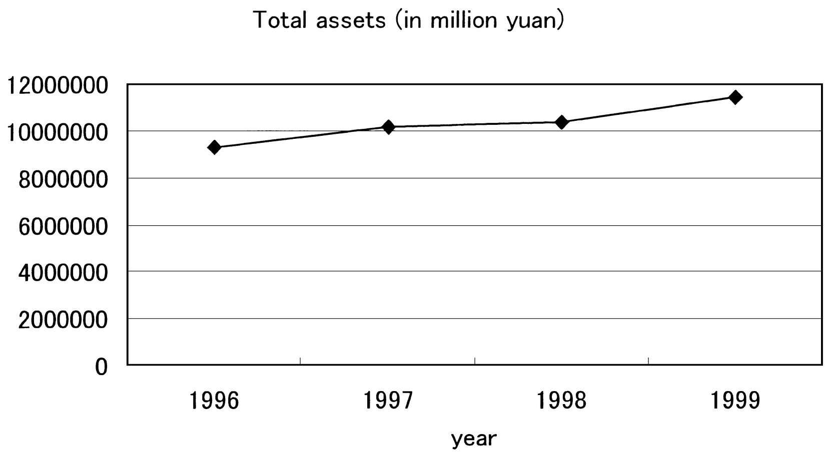

Fig. 1. Total assets for whole industry (8 banks) through year 1996–1999

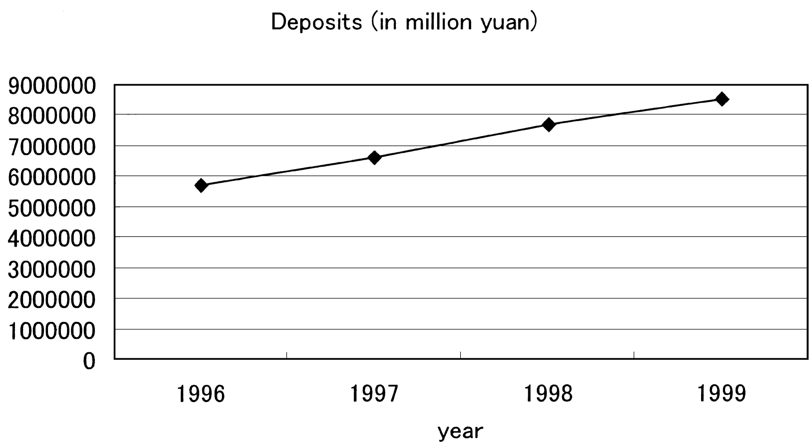

Fig. 2. Deposits for whole industry through year 1996–1999

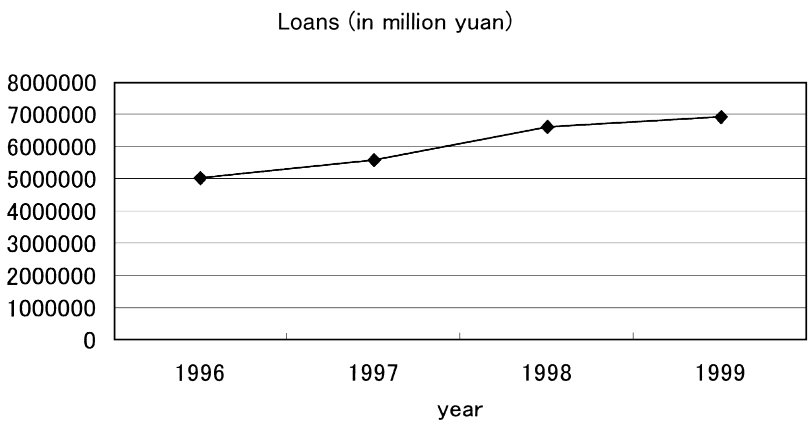

Fig. 3. Loans for whole industry through year 1996–1999

Fig. 4. Labor for whole industry through 1996 to 1999

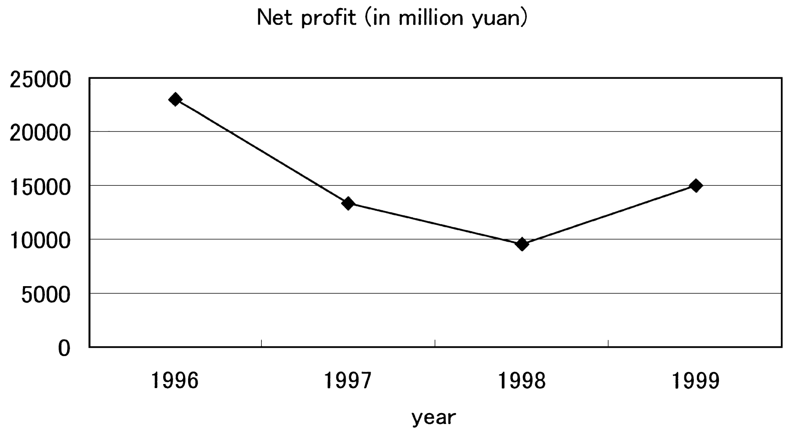

Fig. 5. Net profit for whole industry through 1996–1999

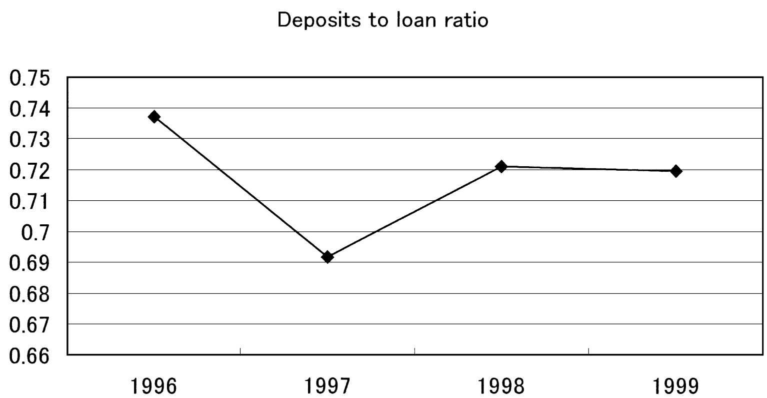

Fig. 6. Deposits to loan ratio for whole industry through year 1996–1999

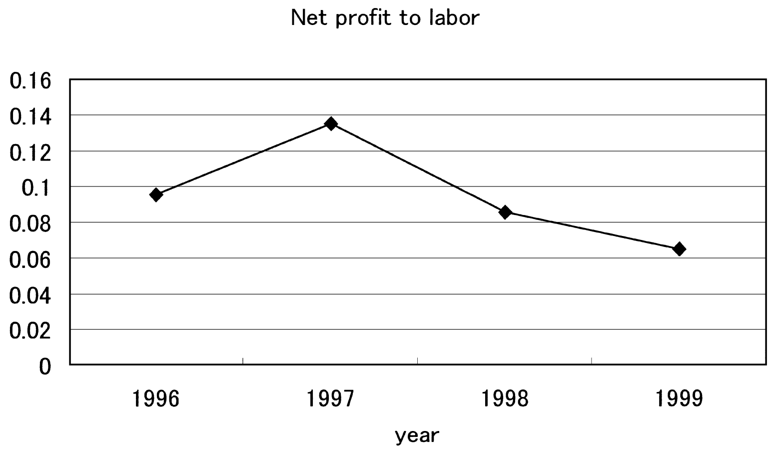

Fig. 7. Net profit to labor ratio whole industry through 1996–1999

Table 1–1 ROA (%) of each bank through 1996 to 1999

	1	2	3	4	5	6	7	8
1996	0.160	0.140	0.250	0.310	0.910	0.979	0.140	1.83
1997	0.075	0.034	0.180	0.044	0.630	1.090	2.106	1.32
1998	0.107	–0.045	0.095	0.057	0.300	1.062	0.970	0.99
1999	0.117	–0.016	0.111	0.225	0.343	0.483	0.838	0.83

(6) Deposits to loan ratio (Fig. 6)

The figure does not change so much through the years and state-owned banks (the first four) have a higher ratio than non-state-owned ones. It means that the proportion of asset that can earn profit is higher in state-owned banks. Thus state-owned banks may earn higher cash flows (interest rates), but they also take higher risks.

(7) Net profit to labor ratio (Fig. 7)

In the Chinese banking industry, shareholding banks count up to only a small proportion. Thus this ratio is very helpful to judge the performance of each bank.

We can see that the smaller, non-state-owned banks (bank 5, 6, 7, 8) have a higher ratio than the four biggest banks(bank 1, 2, 3, 4) held by the state.

(8) Return to assets (ROA) (Table 1–1)

This ratio is very useful in judging the behavior of a bank's ability to earn profit. This ratio is rather low compared to their international peers. Non-state-owned banks have a higher ratio than the state-owned ones as a whole.

(9) Relation between loan, labor and deposits (Figs. 8, 9)

Apparently, loan has a positive relation with labor and deposits. We did regression with loan to labor and loan to deposits, the R^2 are 0.82 and 0.98, respectively. This fact will be one of the reasons we choose loan as output, labor and deposits as input factors in our study.

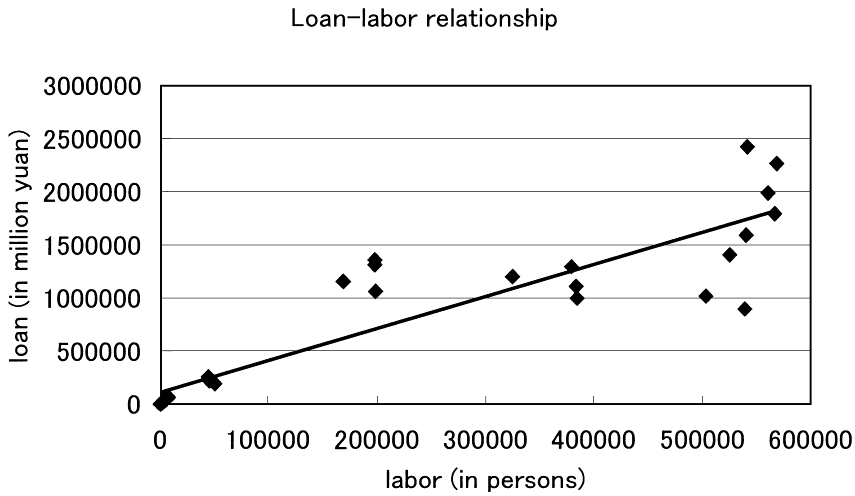

Fig. 8. Relation between loan and labor

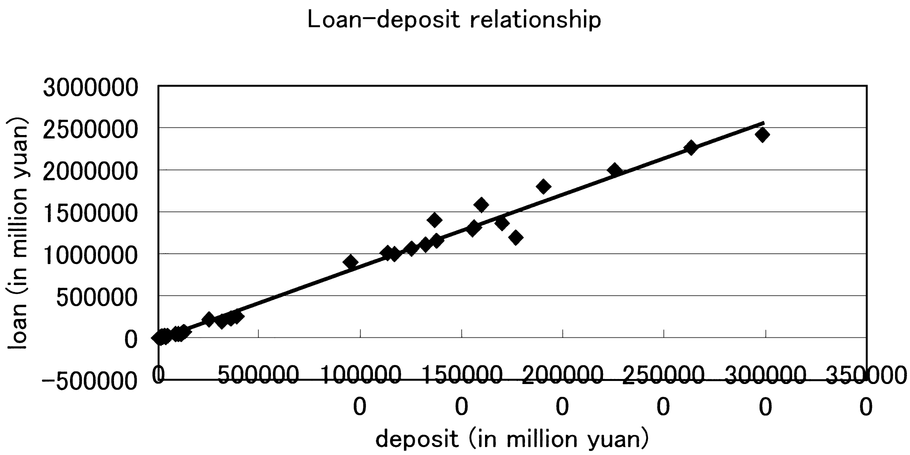

Fig. 9. Relation between loan and deposits

2. Theoretical model

In the present research, we focus on the production behavior of the Chinese banking industry during the period 1996 to 1999. The production behavior will be inspected by estimating the production function of the industry.

To apply the production function in studies of financial firms, it is imperative to look closely at what is meant by the term "production" and how it is related to financial firms.

The technical process of production, according to Frisch (1965), is a process of transformation. The transformation process for a financial firm involves the borrowing of funds from surplus spending units and lending those funds to deficit spending unit, i.e., financial intermediation.

Sealey and Lindley (1977) pointed out later,

> The production process of the financial firm from the firm's viewpoint, is a multistage production process involving intermediated outputs, where loanable funds, borrowed from depositors and serviced by the firm with the use of capital, labor, and material inputs, are used in the production of earning asset.... Eventually, the intermediate outputs culminate in the final economic output of the firm, i.e., earning assets. The output of the financial firm is, therefore, produced with capital, labor, material, and loanable fund inputs where loanable funds are "produced" through other production operations of the financial firm.

Thus production function is also suitable for financial firms. First we consider the Cobb-Douglas production function, the popular production function in production theory.

The general Cobb-Douglas production function can be expressed as

$$Y_{i,\,t} = AX1_{i,\,t}^{\beta_1}\,X2_{i,\,t}^{\beta_2}\,e^{\varepsilon_{i,\,t}} \quad \text{while } \beta_1, \beta_2 > 0 \tag{2.1}$$

$Y_{i,\,t}$ denotes the production of the i th firm (i = 1, 2, ... 8), for the t th time period (t = 1, 2, 3, 4). X1 and X2 are input factors, usually capital and labor. $\varepsilon_{i,\,t}$ is a random error, and $E(\varepsilon_{i,\,t}) = 0$, $\mathbf{var}(\varepsilon_{i,\,t}) = \sigma^2$.

Cobb-Douglas production function's characters are well known:

(1) β_1 is the elasticity of output to capital. It gives the percentage change of output to 1% change of capital, keeping the labor constant.

(2) β_2 is the elasticity of output to labor keeping capital constant.

(3) $\beta_1 + \beta_2$ gives the returns to scale. If $\beta_1 + \beta_2=1$, then it is constant returns to scale. If $\beta_1 + \beta_2 < 1$, decreasing returns to scale; $\beta_1 + \beta_2 > 1$, increasing returns to scale.

We may transform it into natural log form as:

$$\begin{aligned}\mathbf{ln}Y_{i,\,t} &= \mathbf{ln}A + \beta_1\mathbf{ln}X1_{i,t} + \beta_2\mathbf{ln}X2_{i,\,t} + \varepsilon_{i,\,t}\\ &= \beta_0 + \beta_1\mathbf{ln}X1_{i,\,t} + \beta_2\mathbf{ln}X2_{i,\,t} + \varepsilon_{i,\,t}\end{aligned} \tag{2.2}$$

where $\beta_0 = \mathbf{ln}A$.

The classic procedure is to assume that the effects of omitted variables are independent of the regressors and are independently identically distributed. Thus, all observations are random variations of a representative firm. However, (2.2) has often been criticized for ignoring variables reflecting managerial and other technical differences among firms or time periods.

Ideally, such firm-and timed-effects variables, say, α_i and γ_t, should be explicitly introduced into (2.2). Thus, $\varepsilon_{i,\,t}$ can be written as:

$$\varepsilon_{i,\,t} = \alpha_i + \gamma_t + u_{i,\,t} \tag{2.3}$$

where $u_{i,\,t}$ is independent identically distributed error terms and are assumed that $E(u_{i,\,t}) = 0$,

$\mathbf{var}(u_{i,\ t}) = \sigma^2$. There are two basic frameworks used to generalize this model. The fixed effects model and the random effects model. Our panel data estimator allows "two-way" fixed and random effects models.

The fixed effects model for a two-way design is:

$$\mathbf{ln}Y_{i,\ t} = \beta_0 + \alpha_i + \gamma_t + \beta_1\mathbf{ln}X1_{i,\ t} + \beta_2\mathbf{ln}X2_{i,\ t} + u_{i,\ t} \tag{2.4}$$

We relax the assumption that firms are operating on the efficient frontier, and the technical inefficiency is measured by α_i and γ_t where α_i captures the inefficiency of the i th bank (individual effect) and γ_t shows inefficiency of the t th year (time effect).

When we treat α_i and γ_t as fixed, the model can be called a fixed effects model. If they are assumed to be random variables, the model is called a random effects model or an error component model. In a case of a random effects model, the model (2.2) can be rewritten as :

$$\begin{aligned}\mathbf{ln}Y_{i,\ t} &= \beta_0 + \beta_1\mathbf{ln}X1_{i,\ t} + \beta_2\mathbf{ln}X2_{i,\ t} + \varepsilon_{i,\ t} \\ &= \beta_0 + \beta_1\mathbf{ln}X1_{i,\ t} + \beta_2\mathbf{ln}X2_{i,\ t} + \alpha_i + \gamma_t + u_{i,\ t}\end{aligned} \tag{2.5}$$

where i = 1, ... 8 and t = 1, ... 4

In a random effects model, $\alpha_i(\gamma_t)$ is a individual (time) specific disturbance, which are random variables like $u_{i,\ t}$.

Which model is more appropriate for our investigation will be examined later by Hausman test.

3. Data description

In our study, we included the data of eight banks from the years 1996 to 2000 (Source: Newsroom of China Finance Yearbook). All these banks are nationwide banks. Some other nationwide banks are not considered in our study only because the data is not available.

Commercial banking is a very difficult service industry to measure output, technical change, or productivity growth. There is disagreement over which services banks produce and over how to measure them.

Virtually all observers would agree that bank liabilities have some characteristics of inputs because they provide the raw material of investable funds, and that bank assets have some characteristics of outputs as they are ultimate uses of funds that generate the bulk of the direct revenue banks earn.

Loans and other earning assets are considered to be bank outputs, capital, labor, material, deposits and other liabilities are inputs. These are due to Sealey and Lindley (1977).

Our output and inputs factors are defined as:

Y ----- loans, in million yuan

X1 ----- deposits, also in million yuan

X2 ----- labor, which is the number of employees both at the head office and branch offices

This is a little different from Sealey and Lindley (1977) who use loans and securities as outputs and deposits as input. The reason for this change is that, in Chinese banking industry loans make the majority of earning assets. We include the number of employees as another input from the fact that, to make high quality loan, banks need people to gather information and supervise the companies which borrowed the money. Our data also shows that the correlation coefficient between loan and deposits is 0.99, and that between loan and labor is 0.9. Thus our choice of input factors and output are reasonable.

The data is normalized by its mean value, thus the means' of the input factors are unity. We do so for the reason that later in Section 6 we will employ translog model, which is obtained by expanding $\ln Y$ in a second-order Taylor series about the point $\ln P = 0$, where P is a vector of input factors. Thus we can expand $\ln Y$ at the mean value of input factors.

4. Estimation results: fixed vs. random effects model

1. Result of fixed effects model

If we treat α_i and γ_t as fixed as in (2.4), this is a familiar dummy variable model. The least squares method yields consistent estimates of the regression coefficients.

Schmidt and Sickles (1984) describe how to obtain the consistent estimates of the technical inefficiency. The most efficient bank (year) is counted as the 100% efficient, and the efficiency (inefficiency) is measured by the distance from the inefficiency of the 100% efficient company (year).

Greene (1997) imposes the following restrictions to avoid perfect collinearity among the regressors:

$$\sum_i \alpha_i = \sum_t \gamma_t = 0 \tag{4.1}$$

The result of the estimation is included in Table 4-1 and Table 4-2. Table 4-1 shows the estimates of the regression coefficients (individual and time effects are not shown) and those divided by standard errors.

Table 4–1 Result of least squares

Variable	Estimated coefficient	Estimate/St.E.
Constant	–0.03056573	–0.166
Deposits (lnX1)	0.5794872480	3.522
Labor (lnX2)	0.3803974951	1.995

No. of observations = 32
Degrees of freedom = 18
R^2=0.998021 and $\overline{R}^2$ = 0.99659

The estimates of the coefficients of Deposits and Labor are positive, thus the assumption of monotonicity is satisfied. The coefficients of Deposits and Labor are significantly different from zero at the 5% level. The elasticity of loan to deposits is 0.58, and that to labor is 0.38.

Technical inefficiency is shown both by the individual effects and the time effects, which are

Table 4–2 Individual effects and time effects

Bank	α_i	t-ratio	Year	γ_t	t-ratio
1	0.11328	0.41682	1996	–0.04517	–0.88828
2	–0.04663	–0.14845	1997	–0.04691	–1.24828
3	0.26422	1.68285	1998	0.02691	0.68929
4	–0.03555	–0.14728	1999	0.06518	1.41823
5	–0.01510	–0.25757			
6	0.02362	–0.09025			
7	–0.31214	–0.79229			
8	0.00830	0.02633			

included in Table 4-2.

It should be noted that the inefficiency α_i and γ_t are non-positive. The larger the absolute value of the inefficiency is, the more inefficient the banks (years) are. However, some of the estimates of the inefficiency become positive because of the restriction (4.1).

The estimates of the individual effects are α_1 (the inefficiency of the first bank) through α_8 (the inefficiency of the eighth bank). Among the eight α_is, the estimated value of α_3 is 0.26422, which is assumed to be 100% efficient and the inefficiencies of other banks are measured by the distance $\alpha_i - \alpha_3$.

From Table 4-2, we know that the 3rd bank (Bank of China) is the most efficient, the 1st bank follows. The least efficient one is the 7th bank.

Our result that the 3rd bank is the most efficient one in Chinese banking industry, is consistent with the fact that Bank of China is the first and biggest bank in China to do business in international markets. This fact insures that Bank of China has a higher technical efficiency than the rest. It is evaluated to be the best bank in China by *The Europe Money*, which is the authorized journal in international financial circles during the IMF annual meeting Oct. 1996 (Lu and Zhao, 1998).

The time effects are captured by γ_1 (the inefficiency of 1996) through γ_4 (the inefficiency of year 1999). The largest value is the estimate of γ_4, which is 0.06518. Therefore, year 1999 is assumed to be 100% efficient, and the inefficiencies of other years are measured by the distance $\gamma_i - \gamma_4$.

From the table, we know that the efficiency increased (inefficiency decrease) a little as time went by from 1996 to 1999, though not significant. This shows that with reform in the Chinese banking industry and the pressure to enter WTO, the Chinese banks are getting, though slightly, more competitive. One of the major reforms was that from Jan. 1st 1998, the People's Bank of China released the loan limit on the state-owned banks (Lu and Zhao, 1998).

2. Fixed vs. random effects model

The result of random effects model is given in Table 4-3.

The coefficient of Deposits and Labor are both positive and significant, thus monotonicity of the function is satisfied. Elasticity of loan to deposits is 0.73 and that to labor is 0.3. The variances of α and γ are

Table 4–3 Result of the estimation of the random effects model

Variable	Estimated coefficient	Estimate/St.E.
Constant	–0.003037541313	–0.040
Deposits (lnX1)	0.7258247793	6.943
Labor (lnX2)	0.3028223299	3.641

$\sigma_\alpha^2 = 0.0230460$
$\sigma_\gamma^2 = 0.00230355$

respectively.

Hausman test, developed by Hausman (1978), is carried out. Judge et al. (1988) also describes this test in determining which specification, a fixed effects model or a random effects model, is appropriate. The Hausman statistic follows the Chi-square distribution asymptotically when the null hypothesis (Ho: no correlation between the effects and the regressors) is true. When we denote the estimated parameter vector of the fixed effects model as b_f, the variance-covariance vector as ν_f, GLS estimates vector as b_g, and its variance-covariance vector as ν_g, the Hausman statistic is:

$$H = (b_f - b_g)^T(\nu_\nu - \nu_g)^{-1}(b_f - b_g) \sim \chi_K^2 \quad (4.2)$$

where K is the dimension of the vectors. The Hausman statistic in our study becomes 2.39, whose P value is 0.302253. Therefore, the null hypothesis cannot be rejected at reasonable level of significance, and the random effects model can be used as an appropriate one. However, we believe that technical inefficiency must be affected by input factors, thus random effects models will not be used in the present research.

3. Returns to scale

Since returns to scale represent the percentage change in total bank output associated with a percentage change in bank inputs. Firms in an industry realize increasing returns scale if technology allows products rise more than 1% when input factors increase 1% synchronism. That is, increasing returns to scale exist if per-unit or average product cost declines as output rises.

To test if the increasing returns to scale exist in the Chinese banking industry, we make the following hypothesis testing:

Hypothesis: H_0: $\beta_1 + \beta_2 = 1.0$ vs $\beta_1 + \beta_2 > 1.0$

Using the fixed effects model, we calculate the t-value by

$$t = \frac{\widehat{\beta}_1 + \widehat{\beta}_2 - 1}{\sqrt{\widehat{\sigma}_1^2 + \widehat{\sigma}_2^2 + 2\mathrm{cov}(\widehat{\beta}_1, \widehat{\beta}_2)}} \quad (4.3)$$

where $\widehat{\beta}_1$ and $\widehat{\beta}_2$ are the coefficient estimated, $\widehat{\sigma}_1$, $\widehat{\sigma}_2$ are the corresponding standard errors.

cov$(\widehat{\beta}_1, \widehat{\beta}_2)$ is the covariance.

One tail test is carried out. The calculated t is –0.414166, with the P value of 0.17. The hypothesis that $\beta_1 + \beta_2 = 1.0$ cannot be rejected at 0.10 level. Thus constant returns to scale is observed in the Chinese banking industry. This result tells that at the present technology level, Chinese banking industry as a whole is in a suitable scale. The scale is not too small to make full use of its resources, and not too big to use its resources inefficiently.

5. Stochastic frontier model

Since the null hypothesis (H_0: no correlation between the effects and the regressors) in the Hausman test is not rejected, stochastic frontier model is considered to be appropriate for the database of our study, too. We did not use random effects models since we believed that input factors affects inefficiency. However, we include the analysis of stochastic frontier model because it is widely used in empirical studies.

Stochastic frontier production function, (also called composed error production function) introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and Van Den Broeck (1977) postulate that the error term $\varepsilon_{i,\,t}$ is made up of two independent components.

$$\varepsilon_{i,\,t} = \nu_{i,\,t} - u_i \tag{5.1}$$

so that, function (2.2) can be rewritten as:

$$\begin{aligned} \mathbf{ln}Y_{i,\,t} &= \beta_0 + \beta_1 \mathbf{ln}X1_{i,\,t} + \beta_2 \mathbf{ln}X2_{i,\,t} + \varepsilon_{i,\,t} \\ &= \beta_0 + \beta_1 \mathbf{ln}X1_{i,\,t} + \beta_2 \mathbf{ln}X2_{i,\,t} + \nu_{i,\,t} - u_i \\ &= g(\mathbf{x}_i, \mathrm{b}) + \nu_{i,\,t} - u_i \end{aligned} \tag{5.2}$$

where $\mathbf{x}_i$ is the input factors vector, and b is the coefficient vector. $\nu_{i,\,t}$ is assumed to be normally distributed and represents the usual statistical noise. $u_{i,\,t}$ is non-negative and represents technical inefficiency, that is, failure to produce maximal output, given the set of inputs used.

Note that u_i measures technical inefficiency in the sense that it measures the shortfall of output from its maximal possible value given by the stochastic frontier: $g(\mathbf{x}_i, \mathrm{b}) + \nu_{i,\,t}$. In this model, intercept u_i is a random variable that varies only over firms. Differences in u_is are intercepted as differing efficiency levels, with the level of efficiency for each firm assumed to be time invariant.

As noted by Pitt and Lee (1981) and Schmidt (1985), firms may discover, after a period of time, the extent of their inefficiency and adjust their input value accordingly. This is not assumed to be the case in this paper. Our application of the frontier model involves only four years of data on Chinese banks, so we believe that the time-invariant model is not unreasonable.

The major econometric problem lies in distinguishing efficiency differences from random errors that may temporarily give certain institutions relatively high or low products. Different approaches maintain a different set of assumptions about the probability distributions of the efficiency differences and random errors for the purpose of distinguishing between these two random variables. In our stochastic frontier model, we use EFA (econometric frontier approach), which generally assumes that inefficiencies follow an asymmetric half-normal distribution and that random errors follow a symmetric normal distribution, while both are orthogonal to the exogenous variables.

$$u_i = |\omega_i| \ and \ \omega_i \sim N[0, \sigma_u^2]$$
$$\nu_{i,\,t} \sim N[0, \sigma_v^2] \quad (5.3)$$

The stochastic frontier regression model is a classical linear regression model with a non-normal, asymmetric disturbance. It has been used variously in studies of production and cost. The components of the disturbance are assumed to be mutually independent. There are many variations on this which have appeared in the literature. In our study we use normal-half normal model (Greene, 1991). As specified above:

$$f(u_i) = (2/\pi)^{1/2}\,\mathbf{exp}[-1/2(u_i/\sigma_u)^2]$$
$$E[u_i] = \sigma_u\phi(0)/\Phi(0)=(2/\pi)^2\sigma_u$$
$$\mathbf{var}[u_i] = (2/\pi-1)\sigma_u^2 \quad (5.4)$$

$\phi(\cdot)$ is the probability density of normal distribution and $\Phi(\cdot)$ is the corresponding cumulative distribution.

The result of estimation is shown in Table 5-1.

Table 5–1

Variable	Estimated coefficient	Estimate/St.E.
Constant	0.4533676229	0.00
Deposits (lnX1)	0.7064566945	5.0447
Labor (lnX2)	0.3101133457	1.871

No. of observations = 32
Degrees of freedom = 29
R^2 = 0.996025 and $\overline{R}^2$ = 0.99575

The estimated coefficients are all positive and significant. Elasticity of loan to deposits is 0.7, that to labor is 0.3. The result is consistent with the random effects model.

We also calculate the inefficiency for each bank during the four years using Battese and Coelli [1988] estimator for firm-specific component.

The result is given below in Table 5-2:

The value of inefficiency in Chinese banking are from 29% to 65.3%. This value measures the technical inefficiency, that is the failure to produce maximal output given the set of inputs used. The higher the value is, the more inefficient the bank is. The average value is 46.5%. This fact shows that the Chinese banking industry is less efficient than their international peers whose average inefficiency is from 20% to 30% (Berger, Hunter, Timme, 1993). The 3rd bank is again found to be

Table 5–2 Inefficiency of each bank

Bank	Inefficiency (%)
1	42.9
2	50.9
3	29.0
4	54.2
5	47.9
6	45.0
7	65.3
8	36.8

the most efficient among all the banks, whose inefficiency is only 29%. This fact is consistent with the result we got by fixed effects model.

One-tail hypothesis testing (4.3) is also carried out to test if increasing returns to scale exist. The calculated t is 0.107, with the P-value of 0.46. The null hypothesis cannot be rejected, thus constant returns to scale is found.

6. Translog model

The translog (transcendental logarithmic) function is most frequently used in empirical work. This function is obtained by expanding lnY in a second-order Taylor series about the point lnP = 0, where P is a vector of input factors. Our data is normalized by the means, thus the means of transformed data are unity. So we can expand lnY at the means of input factors.

Cobb-Douglas function is a special form of a translog function. Translog model is much more flexible than Cobb-Douglas model. For instance, it doesn't have the strong assumption of constant elasticity of substitutions. And we can calculate the returns to scale for each individual bank for each year by using this model.

The standard translog production function can be written as (Greene, 1997):

$$\ln Y_{i,t} = \beta_0 + \beta_1 \ln X1_{i,t} + \beta_2 \ln X2_{i,t} + \beta_3 \cdot 1/2 \cdot (\ln X1_{i,t})^2 + \beta_4 \cdot 1/2 \cdot (\ln X2_{i,t})^2 + \beta_5 \ln(X1_{i,t}) \cdot \ln(X2_{i,t}) + u_{i,t} \quad (6.1)$$

$$i = 1, \dots 8$$

$$t = 1, 2, 3, 4$$

where Y is output, $X1$, $X2$ are input factors, as defined above. $u_{i,t}$ is independent identically distributed errors. It is assumed that $E(u_{i,t}) = 0$ and $E(u^2_{i,t}) = \sigma^2$.

We have incorporated time dummies into the standard translog model (6.1) to capture inefficiency during the sampling period. We do not consider individual effects for the reason that we have only 32 observations and the number of regressors increased in this model. Later in Section 7, we will include "*nonstate*" dummy to capture differences in inefficiency between state-owned and non-state-owned banks. Thus, the model can be written as follows.

$$\ln Y_{i,\,t} = \beta_0 + \beta_1 \ln X1_{i,\,t} + \beta_2 \ln X2_{i,\,t} + \beta_3 \cdot 1/2 \cdot (\ln X1_{i,\,t})^2 + \beta_4 \cdot 1/2 \cdot (\ln X2_{i,\,t})^2 + \beta_5 \ln(X1_{i,\,t}) \cdot \ln(X2_{i,\,t}) + \beta_6 Y_{1997} + \beta_7 Y_{1998} + \beta_8 Y_{1999} + u_{i,\,t} \qquad i = 1, \ldots 8 \quad t = 1, 2, 3, 4 \tag{6.2}$$

Table 6-1 gives the result of translog model:

Table 6–1

Variable	Estimated coefficient	Estimate/St.E.
Constant	0.03952	0.5920
Deposits (lnX1)	0.8576	7.713
Labor (lnX2)	0.1610	2.090
½Deposits^2	–0.1381	–0.373
½Labor^2	–0.1507	–0.734
Deposits × Labor	0.1385	0.6197
Y_{1997}	–0.06387	–0.822
Y_{1998}	–0.02086	–0.262
Y_{1999}	–0.006210	–0.077

No. of observations = 32
Degrees of freedom = 23
R^2 = 0.996481 and $\overline{R}^2$ = 0.99526

Monotonicity is satisfied at the Taylor expansion point (means of the transformed data), because the estimated coefficient of Deposits and Labor are all positive. Elasticity of loan to deposits is 0.856, and 0.16 to labor. Production behavior (technical inefficiency) does not change through year 1996 to 1999 because the coefficient of *year dummies* are not significantly different from zero.

Returns to scale are calculated for the whole industry as well as for individual bank for each year.

Let us denote the output elasticity with respect to $X1$, $X2$ as e_1 and e_2 respectively. The returns to scale, denoted by e, can be written as:

$$\begin{aligned} e &= e_1 + e_2 \\ &= \beta_1 + \beta_2 + (\beta_3 + \beta_5) \cdot \mathbf{ln}(X1) + (\beta_4 + \beta_5) \cdot \mathbf{ln}(X2) \end{aligned} \tag{6.3}$$

Our data have been normalized by the mean value, at the mean point $\ln X1 = 0$, $\ln X2 = 0$, therefore the returns to scale for the whole industry is

$$e = e_1 + e_2 = \beta_1 + \beta_2 \tag{6.4}$$

One-tail hypothesis testing (4.3) is carried out to test if increasing returns to scale for the whole industry exist. The calculated t is 0.3134, with the P-value of 0.38. The null hypothesis cannot be rejected, thus constant returns for the whole industry is found.

Table 6-2 includes the estimated returns to scale for each bank from year 1996 to 1999 by the method given by (6.3).

Table 6–2

	1	2	3	4	5	6	7	8
1996	1.00693	1.00729	1.01962	1.01152	1.03585	1.06605	1.09487	1.08095
1997	1.00713	1.0082	1.02167	1.01159	1.03727	1.06322	1.08461	1.07544
1998	1.00701	1.00774	1.01976	1.01179	1.03756	1.06188	1.08024	1.0721
1999	1.00766	1.00746	1.01979	1.01372	1.03715	1.06045	1.07655	1.06854

Although we do not perform hypothesis testing, we may guess that the state-owned banks (the first four) have constant returns to scale, while the non-state-owned banks (the last four) enjoys the increasing returns to scale during the observed years. Considering that state-owned banks in China are much bigger than the non-state-owned ones, the results we got are consistent with the findings by other researchers that overall increasing returns to scale appear to exist at low levels of output with constant returns to scale at large output levels (McAllister and McManus, 1993).

The evidence that smaller non-state-owned banks have an increasing returns to scale implies that these banks may produce less than the optimal output relative to the larger, state-owned banks. The non-state-owned banks are likely to face the necessity of increasing the scale of their operations to remain competitive, while state-owned banks have already had reached at considerable scale.

7. Test on behavior differences between state-owned banks and non-state-owned banks

Our observations consist of eight banks, four of which are wholly state-owned banks, the rest four are non-state-owned (stock corporation) banks.

State-owned banks have a longer history, higher management expertise, as well as more assets. What's more, non-state-owned banks have limited service field under the present finance laws and regulations in China. We believe that these facts affect the production behavior of the two different types of banks in China

A dummy variable "*nonstate*" is included in the function (6.2) to test if the behavior changes between the two types of banks. The value of the dummy variable is zero for state-owned banks, while it is unity for non-state-owned banks.

$$\ln Y_{i,\,t} = \beta_0 + \beta_1 \ln X1_{i,\,t} + \beta_2 \ln X2_{i,\,t} + \beta_3 \cdot 1/2 \cdot (\ln X1_{i,\,t})^2 + \beta_4 \cdot 1/2 \cdot (\ln X2_{i,\,t})^2 + \beta_5 \ln(X1_{i,\,t}) \cdot \ln(X2_{i,\,t}) + \beta_6 Y_{1997} + \beta_7 Y_{1998} + \beta_8 Y_{1999} + \beta_9 Nonstate + u_{i,\,t} \quad (7.1)$$

$$i = 1, \ldots 8$$
$$t = 1, 2, 3, 4$$

In the test of whether different behavior exists or not, the null hypothesis is that β_9 is zero, while the alternative hypothesis is that β_9 is not zero. Keeping other things equal, if β_9 is positive, the non-state-owned banks appear to have a higher output than the state-owned bank. The fact β_9 is negative suggests that non-state-owned banks appear to be less efficient that the state-owned banks.

The result is given in Table 7-1.

Table 7–1

Variable	Estimated coefficient	Estimate/St.E.
Constant	0.1521	1.619
Deposits (lnX1)	0.7729	6.459
Labor (lnX2)	0.09320	1.097
½Deposits^2	–0.2519	–0.4960
½Labor^2	–0.2463	–0.2457
Deposits × Labor	0.2219	0.2703
Y_{1997}	–0.06565	–0.875
Y_{1998}	–0.01419	–0.184
Y_{1999}	–0.007423	–0.094
nonstate	–0.3147	–1.646

No. of observations = 32
Degrees of freedom = 22
R^2 = 0.996867 and $\overline{R}^2$ = 0.99558

Estimated β_9 (the coefficient of *nonstate*) is –0.3147, which means that the state-owned banks are more efficient. This might due to the following reasons.

1) State-owned banks in China have a longer history, this ensures them to have more experience and higher management expertise.

2) Through the years, state-owned banks have already had a bigger and higher quality database of their customers than the non-state-owned banks.

3) The fact that they have more and wider spread branches and network, made them to attract more customers and know more about their customers.

4) The stated-owned banks have closer relationship with local clients and government officials and enjoy more beneficial policy. It will be hard for new comers to replace long-standing relationships and obtain market share.

8. Conclusion

This study trys to clarify the production behaviors of Chinese banking industry by econometric analyses using panel data. Our data include eight banks (four of which are state-owned banks and the rest are non-state-owned banks) from year 1996 to year 1999. Loan is chosen as output, deposits and number of employees are input factors in our production function.

Two-way fixed & random effects model, based on Cobb-Douglas production function, are estimated first in succession. We calculate the inefficiency of each firm and year based on fixed effects model, by assuming the most efficient bank (year) is 100% efficient. Bank of China is found to be the most efficient one among the eight banks. We also find that technical efficiency increases slightly through the observed years.

Hausmen test is also conducted and random effects model is not rejected. To test if increasing returns to scale exist, we carry out one tail hypothesis H_0: $\beta_1 + \beta_2 = 1.0$ vs. H_1: $\beta_1 + \beta_2 > 1.0$, and constant returns to scale is found in Chinese banking industry. This fact implies that the Chinese industry as a whole is in a suitable scale.

The fact that random effects model can't be rejected suggests that stochastic frontier model is also a suitable model for our data, and inefficiency is calculated for each bank following the estimation by Battest and Coelli (1988). The average inefficient rate is 46.5%, which is much higher than their international peers. Bank of China is again found to be the most efficient one, which has the inefficient rate of 29%. Again we find that constant returns to scale is also observed in the Chinese banking industry.

Dropping the strong assumption in Cobb-Douglas production function, estimation of translog model is carried out. In this model, returns to scale is calculated for each bank in each year. It is interesting to find that the state-owned banks seem to have constant returns to scale, while the non-state-owned banks enjoy increasing returns to scale. The whole industry still appears to have constant returns to scale.

Later, we included *nonstate* dummy in translog model to test if the production behavior is different between state-owned banks and non-state-owned banks. State-owned banks are found to be more efficient than the non-state-owned banks in China. This result is not surprising if we consider the longer history of the state-own banks and closer relationship with both the clients and government officials and beneficial policy to them.

It is interesting to have found that state-owned banks have advantage over the non-state-owned banks in production behavior, but not as profitable as the latter (see section 1). One of the main reasons is that the state-owned banks have to take some 'responsibility' to lend money to state-owned enterprises. The deteriorating performances of state-owned enterprises make the 'output' of the banks less profitable. How these influences change the banks' production behavior in China remains to be an interesting topic for the future researching.

Though the fact that technical efficiency is slightly increasing during the observed years is inspiring, the Chinese banking industry is far from efficient. Central government should continue to move China to a more commercial banking system. As for the state-owned banks, the policy lending, distorted pricing, poor managerial incentives can undermine financial performance of state-owned banks. Only when more autonomy is given to state-owned banks, state banks can be both productive and profitable. The small but rapidly growing shareholding banks are mostly commercial in their orientation. Government should encourage the development of the non-state- owned banks, and remove the restrictions over them. Thus Chinese banking as a whole will improve their efficiency and can face their international peers with confidence. The pressure to enter into WTO will fasten the reform of banking system and change the whole landscape of Chinese banking finally.

We would like to thank Professor Fukuda Atsuo and Professor Tanaka Yasushi for their helpful discussions with us, and their comments on an earlier version.

The conclusions reflect the view of the authors only.

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APPENDIX: Unbalanced model with missing observations

We also did the estimations by using unbalanced data with missing observations rejected. The unbalanced data consists of 5 years' data for the eight banks from 1995 to 1999. However bank 7, Mensheng Bank, was founded only in 1996, and the number of the employees are not available for bank 5, 6, 8. We reject the 4 missing observations and did the same estimation as above by Limdep.

1. Fixed vs. random effects model

The result for the fixed effects model is given in Table A1-1 and Table A1-2. Table A1.1 shows the estimates of the regression coefficients and those divided by standard errors.

Table A1–1 Result of the estimation of the fixed effects model

Variable	Estimated coefficient	Estimate/St.E.
Constant	–0.09910382836	–0.650
Deposits (lnX1)	0.6454412213	4.560
Labor (lnX2)	0.2835935479	1.741

No. of observations = 36
Degrees of freedom = 21
R^2 = 0.998064 and $\overline{R}^2$ = 0.99677

The estimates of coefficients of Deposits and Labor are both positive and significantly different from zero. Elasticity of loan to deposits is 0.65 and that to labor is 0.28.

Technical inefficiency is shown both by the individual effects and the time effects, which are included in Table A1-2:

Table A1–2 Individual effects and time effects

Bank	α_i	t-ratio	Year	γ_t	t-ratio
1	0.20752	0.89360	1995	–0.07047	–1.13389
2	0.05230	0.19669	1996	–0.07384	–1.69272
3	0.28262	2.16796	1997	–0.01646	–0.37839
4	0.06265	0.31151	1998	0.06594	1.49442
5	–0.01780	–0.31040	1999	0.18966	0.99952
6	–0.11387	–0.43303			
7	–0.48816	–1.22996			
8	–0.13653	–0.42450			

Again, the 3rd bank, Bank of China, whose coefficient has the positive sign and the biggest absolute value, is found to be the most efficient one. The result also indicates that the state-owned banks (the first four) are more efficient than non-state-owned banks (the last four), because the coefficient of the state-owned banks are all positive, while the private ones have a negatives sign.

Generally speaking, the result shows an increase in technical efficiency increase through the observed 5 years.

The result of random effects model is given in Table A1-3:

Table A1–3 Result of the estimation of the random effects model

Variable	Estimated coefficient	Estimate/St.E.
Constant	–0.00943282588	–0.228
Deposits (lnX1)	0.8126844725	12.807
Labor (lnX2)	0.2386150173	4.915

The coefficient of Deposits and Labor are both positive and significant, thus the assumption monotonicity is satisfied. Elasticity of loan to deposits is 0.82 and that to labor is 0.24. The variances of α and γ are

$$\sigma_\alpha^2 = 0.00740687$$
$$\sigma_\gamma^2 = 0.71461 \times 10^{-5}$$

respectively.

Hausman statistic is 3.6 with the P-value of which is 0.164999. Therefore the null hypothesis (no correlation between the effects and the regressors) is not rejected. The random is not rejected at reasonable significant levels.

One tail hypothesis testing, H_0: $\beta_1 + \beta_2 = 1.0$ vs. H_1: $\beta_1 + \beta_2 > 1.0$, is also carried out. Using the same method as in (4.3), the calculated t is –1.432, with P-value of 0.164. Hence, constant returns to scale is observed in the Chinese banking industry. This result is consistent with what we got from balance data.

2. Stochastic frontier model

Hausman test suggests that stochastic frontier model is also considered to an appropriate model.

The result of the estimation of stochastic frontier model is given below in Table A1-4:

Table A1–4

Variable	Estimated coefficient	Estimate/St.E.
Constant	0.06222936554	1.212
Deposits (lnX1)	0.8293979775	11.179
Labor (lnX2)	0.2217761186	3.538

No. of observations = 36
Degrees of freedom = 33
$R^2 = 0.996116$ and $\overline{R^2} = 0.99588$

The coefficients of Deposits and Labor are both positive and significant, thus the assumption of monotonicity is satisfied. Elasticity of loan to deposits is 0.83 and that to labor is 0.22.

Time invariant inefficiency is also calculated by computing Battest and Coelli estimator. Table A1-5 gives the result.

It is surprised to have found that the Chinese banking industry is quite efficient by using the pair of output and inputs we have chosen. The worst inefficiency rate is 17.2% from the production frontier (the 7th bank) and the whole industry enjoys an average inefficiency of 8.5%. But the result doesn't consider the quality of the loan but the quantity of the loan. One reason for it may be that state-owned banks take some 'responsibility' to make policy loan, which they are lack of incentive to

Table A1–5 Inefficiency of each bank

Bank	Inefficiency (%)
1	6.2
2	8.1
3	2.9
4	10.8
5	7.8
6	9.3
7	17.2
8	3.1

investigate in the project and supervise the project. This fact makes them seem to be more ‘productive’ and have a lower average cost since they lack incentives to investigate in the project and supervise the project. And our unbalanced data includes the data of state-owned banks in 1995, when the market oriented reform in banking was not carried out in China.

One tail hypothesis that H_0: $\beta_1 + \beta_2 = 1.0$ vs. H_1: $\beta_1 + \beta_2 > 1.0$ is also carried out. The calculated t value is 2.8736, with the P-value of 0.01, thus the null hypothesis is rejected at 0.01 level. Increasing returns to scale are inspected. The result is not consistent with the ones we got from the balanced data. This might due to two reasons, one is our unbalanced data only includes the data of four state-owned banks in 1995, but not that of non-state-owned banks, which may not tell the truth of the whole industry. The other is that stochastic frontier model has a very strong assumption over how the disturbance and the inefficiency are distributed, which is not true for our data.

3. Translog model

The standard translog model with year dummies gives the result as follows:

Table A1–6 Result of estimation of translog model with period dummies

Variable	Estimated coefficient	Estimate/St.E.
Constant	0.0630	0.751
Deposits (lnX1)	0.880	10.306
Labor (lnX2)	0.142	2.36
½Deposits^2	–0.177	–0.688
½Labor^2	–0.172	–1.241
Deposits × Labor	0.167	0.898
Y_{1996}	–0.0209	–0.221
Y_{1997}	–0.0868	–0.881
Y_{1998}	–0.0441	–0.440
Y_{1999}	–0.0287	–0.284

No. of observations = 36
Degrees of freedom = 26
R^2 = 0.996661 and $\overline{R}^2$ = 0.99551

The coefficient of Deposits and Labor are both positive and significant thus the assumption montonicity is satisfied. Elasticity of loan to deposits is 0.88 and that to 0.14. Production behavior (technical efficiency) does not change through the observed years since the coefficient of year dummies are not significant from zero.

To test if the whole industry shows increasing returns to scale, one tail hypothesis testing that H_0: $\beta_1 + \beta_2 = 1.0$ vs. H_1: $\beta_1 + \beta_2 > 1.0$ is carried out. The calculated t value is 0.401085, with the P-value of 0.35, thus the null hypothesis can't be rejected at 0.10 level. Constant returns to scale is found, which is consistent with the results we got by balanced data. translog model is flexible enough for our data.

For each firm, the returns to scale for each year are given in Table A1-7:

Table A1–7

	1	2	3	4	5	6	7	8
1995	1.0132	1.02017	1.0204	1.02113	NA.	NA.	NA.	NA.
1996	1.01107	1.01783	1.01936	1.0173	1.03797	1.06058	1.09985	1.08174
1997	1.00951	1.01644	1.01914	1.01614	1.03719	1.05812	1.0849	1.07512
1998	1.00797	1.01451	1.01731	1.01465	1.03659	1.05647	1.08053	1.07107
1999	1.00699	1.01294	1.01651	1.01408	1.04065	1.0548	1.07135	1.06739

The result indicates that the state-owned banks (the first four) seem to have a constant returns to scale, and the private banks (the last four) enjoy the increasing returns to scale.

4. State owned banks vs. non-state-owned banks

We employ the dummy variable "*nonstate*" in the translog model in A1.3, to test if the behavior changes between two types of banks.

The result is given in Table A1-8:

Table A1–8

Variable	Estimate	Estimate/St.E.
Constant	0.113	1.296
Deposits (lnX1)	0.800	8.289
Labor (lnX2)	0.088	1.309
½Deposits^2	–0.251	–0.988
½Labor^2	–0.235	–1.679
Deposits × Labor	0.218	1.189
Y_{1996}	0.017	0.177
Y_{1997}	–0.049	–0.494
Y_{1998}	0.0023	0.022
Y_{1999}	0.023	0.227
nonstate	–0.274	–1.613

No. of observations = 36
Degrees of freedom = 25
R^2 = 0.996976 and $\bar{R}^2$ = 0.99577

The coefficient of *nonstate* in our estimation is –0.274, which means that the state-owned banks are more efficient, which is consistent with the result in Section 7.

中国における銀行業の実証分析

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本研究は中華人民共和国における銀行業の生産活動を分析したものである．対象となった銀行は国立銀行を含む国有銀行および民間銀行を合わせた８行であり，1996年から1999年の４年間のパネルデータが収集され，コブ＝ダグラス生産関数，フロンティア生産関数およびトランスログ生産関数が推定された．コブ＝ダグラス関数は検定により不適と判断され，またフロンティア関数は極めて強い仮定を設けなければ推定できないという問題があるため，これらの推定結果は参考として掲載した．中心となったのはトランスログ・モデルで，非効率をダミー変数で捉えるタイプと非効率を確率変数として扱うモデルの２種類を推定した．これらのモデルにより技術的非効率が計測され，その結果国有銀行の方がより効率的であることが判明した．さらに規模の経済性も検証され，産業全体では規模に関して収益不変となったが，規模の小さい民間銀行で収益増大が観察された．