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Ownership reform, foreign competition, and efficiency of Chinese commercial banks: A non-parametric approach

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Research Paper No. 2008/38

Ownership Reform, Foreign Competition, and Efficiency of Chinese Commercial Banks

A Non-Parametric Approach

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and Genfu Feng³

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Abstract

Since China joined the WTO in 2001, the pressure for bank reforms has mounted as China ought to fully open up its financial market to foreign competition by 2006. Efficiency is key for domestic banks to survive in a liberalised environment, but it appears that the last hope for raising bank efficiency is through ownership reform. Whether ownership reform and foreign competition can solve China's banking problem remains to be tested. This paper aims to answer this question through using a non-parametric approach to analyse the efficiency changes of 15 large commercial banks during 1998-2005. We find that ownership reform and foreign competition have forced the Chinese commercial banks to improve performance, as their total factor productivity rose by 5.6 per cent per annum. This coincides with the recent bullish Chinese stock markets led by three listed state-owned commercial banks. Despite such encouraging results, we remain cautious about the future of the Chinese banks, as the good results may have been artificially created with massive government support and the fundamentals of the banks may be still weak.

Keywords: data envelopment analysis (DEA), efficiency, banking, China

JEL classification: C60, G14, G21, P34

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1 Introduction

State-owned commercial banks in China have been renowned for their low efficiency, mounting non-performing loans (NPLs) and loss making. China's bank reforms have lagged far behind reforms in the real economic sectors for two reasons. First, the banking industry has been overwhelmingly dominated by state ownership and enjoyed immense monopolistic power. Second, state commercial banks have enjoyed a significant leverage of soft budget constraint because they are frequently entrusted or coerced by local authorities to provide policy lending, or to help rescue insolvent state-owned industrial enterprises.

Aggressive banking reforms started from the late 1980s, initially to separate policy lending from commercial operations by establishing three state policy banks and then stripping off the NPLs from the largest state-owned commercial banks, including Bank of China (BOC), China Construction Bank (CCB), Industrial and Commercial Bank of China (ICBC), Agricultural Bank of China (ABC), or the Big Four hereafter, using four newly created state asset management companies. The latest reforms since China joined the World Trade Organisation (WTO) in December 2001 have been the result of both internal and external pressures. Internal pressure arises because of fierce competition from regional and private banking institutions, while external pressure comes from the free entry of foreign banks into the Chinese market.

But how have state commercial banks reacted to these new pressures for reform? Answering this question requires a comprehensive analysis of the change of efficiency and productivity of these banks in recent years. There are potentially many ways to evaluate bank efficiency. The two most frequently used methodologies are the stochastic production function approach and the data envelopment analysis, or DEA, approach. As the former requires a specific functional form, it may not be suitable for the data period when the banking industry in China had undergone dramatic changes. Hence, we use the latter approach which is not subject to such a problem. This paper is probably the first attempt in the literature to evaluate the technical efficiency of Chinese commercial banks using DEA to analyse the efficiency levels of these banks over the period 1998-2005, which covers both the pre-WTO and the first few years of the post-WTO era in China. In addition, a Malmquist index is calculated and decomposed to evaluate how Chinese commercial banks have improved their productivity through reform and adoption of new technologies in order to face up to the immense competition ahead of them by 2006, the last year when China had to fully open up its financial market to foreign banks.

This paper will focus on the efficiency issue in order to evaluate whether Chinese state commercial banks have reacted positively and successfully to the new reforms and challenges. It uses data from all national commercial banks, state and non-state owned, domestic and foreign-invested, over the period 1998-2005. It employs the data envelopment analysis (DEA) approach to measure the efficiency scores of banks and then conducts a Malmquist index analysis to study the evolution of productivity changes. The DEA results show that the Big Four are not necessarily less efficient than their joint equity counterparts. In fact, two state-owned banks, CCB and BOC,

continuously outperform their state-owned peers and most joint equity banks.¹ However, joint equity banks have a significant advantage over state-owned banks in terms of asset quality. The Malmquist index analysis indicates that the average productivity of all Chinese banks rose 5.6 per cent per annum over the data period. The productivity growth was almost equally explained by efficiency improvement and technological progress. Much of the productivity growth of the state-owned commercial banks was due to efficiency improvement and little due to technological progress. In contrast, much of the productivity growth of the joint-equity commercial banks was due to technological progress and little due to efficiency improvement. Such empirical results have interesting and important policy implications because they imply that government policies should be designed differently to improve the performance of different banks.

The rest of the paper is organised as follows. Section 2 summarises the reform and current structure of China's banking industry. Section 3 reviews the recent efficiency studies in the banking sector and introduces the DEA methodology. Section 4 evaluates the efficiency of 15 Chinese national commercial banks and provides a number of managerial implications by analysing the DEA results. The productivity change in Chinese national commercial banks is investigated in Section 5. Section 6 concludes with policy implications.

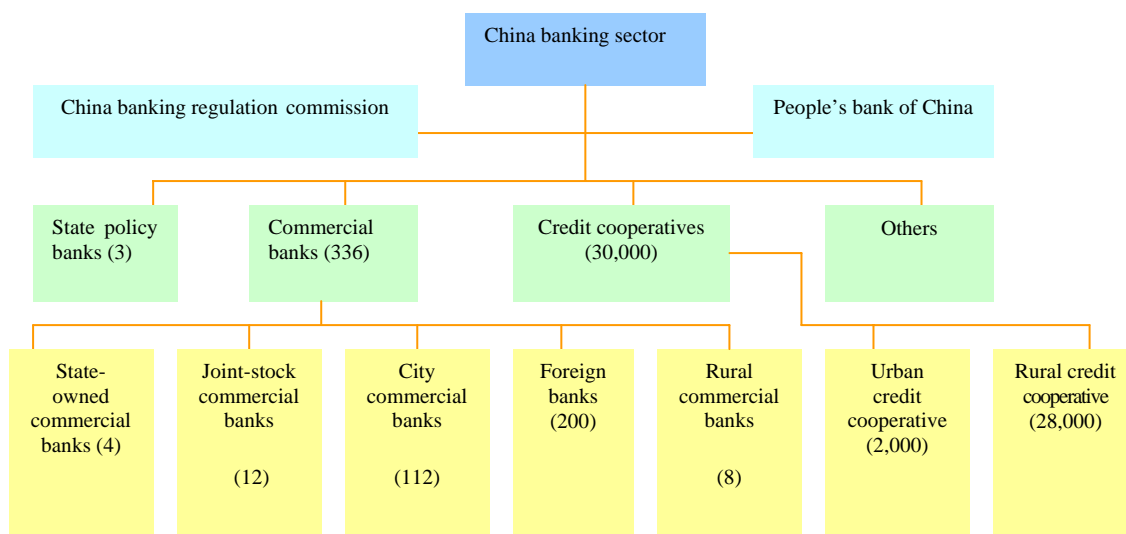
2 Reforms in China's banking industry

Before economic reforms, China had only one large bank, the People's Bank of China (PBC), which had absolute monopoly power in all banking activities. The reform of China's banking industry started in 1979. By 1992, four state-owned commercial banks and a number of joint equity banks were established. This led the PBC to focus on its role as central bank. In 1994, three policy banks were set up to take over policy banking activities, enabling the state-owned commercial banks to focus on commercial operations. The promulgation of the Central Bank Law and the Commercial Bank Law in 1995 and 1996 strengthened the authority of PBC and provided commercial banks a legal framework for operation. In 2003, the China Banking Regulatory Commission (CBRC), was established to take over the supervisory function from PBC. By 2004, apart from the Big Four, China had twelve national joint stock banks, 111 city commercial banks, three rural commercial banks, 35,544 rural credit cooperatives, and 204 foreign bank subsidiaries.² The structure of the Chinese banking sector at the end of 2005 is illustrated in Figure 1.

¹ Throughout this paper, only the abbreviations of the full names of banks will be used for simplicity of presentation. The full names of these abbreviations are provided in Appendix 1.

² In this paper, we only consider the big four state-owned commercial banks and the 11 national joint equity banks. The city commercial banks, rural commercial banks, rural credit cooperatives and foreign bank subsidiaries are not included because they are either too small, or do not have consistent data for analysis. The 15 national commercial banks included in this paper, however, accounted for more than 80 per cent of China's commercial lending activities and deposits.

Figure 1: China banking sector overview, 2005



According to the *Almanac of China's Finance and Banking* (2005), the market shares of four state-owned banks, or the Big Four, account for 60 per cent of total deposits and 57 per cent of total loans. However, the average ratio of non-performing loans of the Big Four was over 30 per cent in the 1990s. The mounting NPL implies that the Big Four are effectively insolvent and their continuing survival is supported by the state through a soft budget constraint. In order for Chinese commercial banks to compete and survive in a liberalised environment, further reforms were imperative. A critical element of ownership reform was to restructure the Big Four as well as other commercial banks to enable them to be listed in the stock exchanges, subjecting them to monitoring and control by shareholders rather than politicians.

One important condition for the state-owned commercial banks to be listed on the stock exchanges was a substantial reduction in the level of NPLs and a significant increase in working capital. This required huge state assistance to the Big Four. Starting from 1999, there have been three big waves of state support to strip off NPLs from the Big Four and inject new capital. The first wave was in 1999 when four state asset management companies were set up to accommodate 1.4 trillion RMB of NPLs, equivalent to almost 20 per cent of China's GDP in the same year. The second wave of support came in 2003 and 2004, when 475.6 billion RMB of NPLs was stripped off from CCB and BOC. In the meantime, the government provided US\$22.5 billion, taken from the country's huge foreign exchange reserves, to support these two banks. The final wave of support was in 2005, when 705 billion RMB of NPLs was stripped off from ICBC, with an additional capital injection of US\$15 billion and the issuance of US\$12.1 billion in subordinated debt (Garcia-Herrero et al. 2006).

The purpose of state support was to make the initial public offerings, IPOs, of CCB, BOC and ICBC attractive to investors. In the meantime, the Big Four introduced a strict monitoring mechanism to control non-performing loans and reduced their workforce by 250,000 (*The Economist* 2006). The first bank of the Big Four to be listed was CCB,

whose IPO in Hong Kong in October 2005 raised US\$8 billion. It was followed by BOC, which was listed in Hong Kong and Shanghai in May 2006, raising US\$11.2 billion. The IPO of ICBC in October 2006 in Hong Kong and Shanghai raised US\$21.9 billion, setting a new world record, surpassing the IPO record set by Japan's NTT Mobile Communications Network Inc., which raised US\$18.4 billion in 1998 (Mitchell 2006). The extraordinary performance of the Chinese stock markets in 2006 and 2007 has produced many world-class companies in terms of market value. The Shanghai Stock Exchange Index increased six fold in two years, so did the Shenzhen Stock Exchange Index. As a result, the three listed state-owned commercial banks, ICBC, BOC and CCB, are now among the top ten largest banks in the world in terms of market value.

Although China's banking sector was opened to foreign banks in 1981, foreign participation was extremely restrictive until December 2001 when China joined the WTO. Since 2001, the restriction was gradually relaxed, allowing full access by 11 December 2006. According to CBRC (2006), the development of foreign banks in China has three features: radiating outwards from concentration in the Yangtze, Pearl and Bohai Rim economic circles; expanding rapidly, with market share increasing; and providing more than 100 kinds of business services in twelve business categories. The most active foreign bank in China is HSBC, which has significant investments in the CBC (US\$1.75 billion, or 19.9 per cent of the total equity) and some regional city commercial banks. The Royal Bank of Scotland has bought 4.37 per cent of the total share equity of BOC. Most other foreign investors, including the Asian Development Bank, International Financial Corporation, CitiBank, Hang Seng Bank, Newbridge Asia and Commonwealth Bank of Australia have focused their investments in the regional city commercial banks.

Ownership reform and foreign investments have provided significant impetus for the Chinese domestic commercial banks to improve their performance through restructuring, strict control and monitoring of lending activities and the reform of corporate governance. By 2006, foreign banks and their subsidiaries had no business or geographical restriction to serve Chinese customers. It is urgent for domestic commercial banks to improve efficiency to survive in a more competitive market.

3 Banking efficiency literature and DEA methodology

Since the 1990s, numerous studies have focused on measuring the efficiency of commercial banks. Berger and Humphrey (1997) document 130 studies on financial institutions' efficiency, using data from 21 countries, from various types of institutions including banks, bank branches, savings and loan institutions, credit unions and insurance companies. Richard et al. (2002) use a constrained multiplier, input-oriented, DEA model to evaluate the production efficiency of US commercial banks during 1984-98. They found a strong and consistent relationship between efficiency and independent measures of performance. Pastor (1999) proposes a new sequential DEA procedure for Spanish banks to break down the main indicator of banking risk-provision for loan losses into internal and external components. Girardone et al. (2004) investigate the main determinants of Italian banks' cost efficiency over the period 1993-96. They find that X-inefficiencies tend to decline over time for all bank sizes. The inclusion of risk and output quality variables in the cost function reduces the significance of the scale economy estimates.

The efficiency of banks in Taiwan and Hong Kong has also attracted strong academic interests. Chen and Yeh (2000) adopt the intermediation approach in the DEA model where deposits are treated as an input since a bank's main business is to borrow funds from depositors and then lend to others. The approach specifies three outputs: the provision of loan services; portfolio investment; and non-interest income and three inputs: bank staff; assets; and deposits. They also note that the increase in staff salaries and market competition may result in the difficulty in improving technical efficiency. Drake et al. (2003) use Hong Kong banking data to examine the macroeconomic and regulatory factors that influence bank efficiency. In the Tobit regression, external factors such as GDP and government expenditures are tested instead of firm characteristics.

Few studies have been found to address the efficiency issues of China's banking industry in the English language. Fu and Heffernan (2005) measure concentration, market share, X-efficiency and scale efficiency of Chinese banks to test both the market power and the efficient structure hypotheses. Their results show that during the first phase of reform, large state banks exercising market power as major loan providers were subsidised by the government. During the second phase of reform, state bank subsidies were cut, allowing the relatively more X-efficient joint stock banks to earn higher profits although they were less scale efficient. Chen et al. (2005) examine the cost, technical and allocative efficiency of 43 Chinese banks during 1993-2000. The results show that large state-owned banks and small banks are more efficient than medium sized banks. The financial deregulation in 1995 was found to have improved both technical and allocative efficiency. There is also evidence of continuous dominance of technical efficiency over allocative efficiency, implying that Chinese banks need to improve their ability to minimise cost through input combinations. Yao et al. (2006) employ a stochastic production frontier function to investigate the effects of ownership structure and hard budget constraint on technical efficiency of Chinese domestic banks. They find that non-state banks are 8 to 18 per cent more efficient than state banks and banks facing a harder budget tend to perform better than those heavily capitalised by the state or regional governments.

Technical efficiency is measuring how well inputs are converted into outputs during a specific production process. It is stated as 'the ratio of weighted sum of outputs to weighted sum of inputs'. DEA was originally developed for efficiency measurement in an input-output setting based on the concept of Pareto optimum (Charnes et al. 1978). What is produced is an 'efficiency frontier' made up of those DMUs (decision making units) that are efficient relative to the other units under evaluation. The frontier consists of the 'best' units in the evaluation set and represents a linear combination of empirically derived maximum output per given input. Each DMU is assigned an efficiency rating based on its position relative to the frontier. The efficient units, those making best use of resources, are rated as being 100 per cent efficient whilst the inefficient ones obtain lower scores.

This paper uses a production boundary based linear programming model which is referred to as the envelopment model. Mathematical proof of equivalence of efficiency rating to Pareto Efficiency concept can be found in Thanassoulis (2001). The technical input efficiency of DMU k (decision making unit k , or bank k in our case) is a solution to the following problem:

$$\text{Min } E_k - \varepsilon \left[\sum_{i=1}^p s_i^- + \sum_{j=1}^q s_j^+ \right] \quad (1)$$

$$\text{Subject to } \sum_{k=1}^n \lambda_k x_{ik} = E_k x_{ik} - S_i^-, \quad \text{and} \quad \sum_{k=1}^n \lambda_k y_{jk} = S_j^+ + y_{jk}$$

$$\lambda_k \geq 0, \quad k=1, \dots, n, \quad j=1, 2, \dots, q, \quad i=1, 2, \dots, p$$

x_{ik} and y_{jk} denote the level of the i th input and j th output observed at DMU k . Any feasible set of λ values in model 1 identifies a point within the production possibility set which can be constructed from DMU k ($k = 1, 2, \dots, n$). S^- is defined as the input excesses and S^+ the output excesses. ε is a non-archimedean infinitesimal. DMU k is technically efficient if and only if $E_k^* = 1$, $S_i^- = 0$ and $S_j^+ = 0$. The envelopment model is a straightforward linear programming and λ values provide information about efficient peers in the reference sets.

In this paper, we will measure three types of efficiency scores: constant return to scale (CRS); variable return to scale (VRS); and scale efficiency. The CRS efficiency score draws from the assumption of constant returns to scale and represents technical efficiency which measures inefficiencies due to the input/output configuration as well as the size of operation. The VRS efficiency score is based on the assumption of variable return to scale and represents pure technical efficiency. Scale efficiency can be calculated by dividing pure technical efficiency into technical efficiency. To assess the input efficiency under VRS, we can still use model 1 but only include the so-called convexity constraint $\sum_{k=1}^n \lambda_k = 1$. In the following section, we first use a CRS input-oriented envelopment model to assess the technical efficiency of Chinese national commercial banks and then construct an output-oriented Malmquist index to examine the productivity growth in China's banking industry.

4 Efficiency analysis of Chinese commercial banks

4.1 Efficiency scores and ranks

Interest income and non-interest income have been widely recognised as outputs of commercial banks. However, there is a debate about whether deposits should be treated as an input or output. We do not agree that banks use deposits to produce loans. Deposits are intermediate substance which helps banks achieve interest income and non-interest income through banking services. The input is not the deposit itself but the resources that are used to generate the deposit, e.g., the interest expenses and labour cost. As such, the inputs should contain interest expenses and non-interest expenses such as salary cost. During the process of transferring deposits to loans, banks will inevitably incur some impaired loans. Banking in this sense is a sort of risk business. Impaired loans are a cost that banks have to bear and can be dealt with as a resource to gain interest yields from gross loans. The ratio of impaired loans, or non-performing loans, to gross loans is included in this study as the third input variable, taking the asset quality into account. Obviously, given the output levels, the lower the ratio, the higher the efficiency of the banks.

Table 1: Input and output variables of Chinese commercial banks: 2005 (billion RMB)

Bank	(1) Interest income	(2) Interest expense	(3) = (1)/(2)	(4) Non-interest income	(5) Non-interest expense	(6) = (4)/(5)	(7) NPLs/ gross loans %
ICBC	224.5	86.6	2.59	13.2	57.9	0.23	4.5
ABC	128.4	61.4	2.09	8.6	53.2	0.16	23.5
CCB	173.6	57.1	3.04	11.7	49.4	0.24	3.9
BOC	167.9	66.9	2.51	21.3	49.3	0.43	9.6
CBC	49.7	18.1	2.75	7.8	14.7	0.53	2.4
CMB	26.0	9.3	2.80	1.2	7.1	0.17	2.5
CITIC	22.0	9.6	2.29	0.7	5.9	0.12	5.6
CEB*	16.1	8.1	1.99	0.5	5.0	0.10	5.0
PDB	22.3	8.7	2.56	0.6	5.5	0.11	2.2
CMSB	23.6	11.0	2.15	0.5	5.9	0.08	1.4
GDB*	13.2	7.8	1.69	0.6	4.7	0.13	12.5
FIB	17.2	7.9	2.18	0.3	3.8	0.08	2.2
HXB	13.3	6.0	2.22	0.3	3.4	0.09	3.0
BOS	8.2	3.1	2.65	0.6	2.1	0.29	2.5
SDB	9.1	3.8	2.39	0.4	2.5	0.16	10.6
Average	61.0	24.4	2.50	4.6	18.0	0.25	6.1

Sources: Bankscope.

Table 1 describes the input and output levels of the 15 largest Chinese national commercial banks in 2005. The data for efficiency analysis consists of all 15 banks over 1998-2005. The data is extracted from Bankscope. The first column lists the banks' abbreviated name, the full names are given in Appendix, followed by columns containing information about interest incomes, interest expenses, non-interest incomes, non-interest expenses and the ratio of NPLs to gross loans for each bank. Only the Big Four achieve interest incomes greater than 100 billion RMB. In terms of interest incomes, the biggest state bank is ICBC while the biggest joint equity bank is CBC. The interest income gap between them is 174.5 billion RMB. However, when interest expenses are considered, the Big Four do not seem to perform much better than joint equity banks. CCB has the highest ratio at 3.04 of interest incomes to interest expenses and the runner up is CMB with a ratio of 2.80. With respect to the ratio of non-interest incomes to non-interest expenses, state owned banks outperform joint equity banks. Three of the Big Four, BOC, CCB and ICBC, have a ratio greater than 0.2, and only two of the joint equity banks, CBC and BOS, have a ratio above 0.2. Because different indicators provide mixed information, it is important to use a 'compound' single index to fully evaluate bank performance. The best candidate for the compound single index is efficiency scores.

Table 2 presents the estimated CRS input-oriented efficiency scores for the 15 commercial banks in 1998-2005. The software is DEA Excel Solver developed by Joe Zhu (2003). The average efficiency score of Chinese state-owned commercial banks over the data period is 0.85. It demonstrates that many banks are producing close to the frontier, which is led by BOC and CCB. In other words, the efficiency levels of the

sample banks are very close to each other. There are two possible explanations for the results. First, the data include only the national banks which have similar characteristics in terms of inputs and outputs. Second, in the data period, the banking system was highly competitive as inefficient banks have to emulate efficient banks quickly in order to avoid being taken over or forced out of business. For whatever explanation, the relatively high level of average efficiency scores implies that Chinese banks were trying to improve their competitiveness prior to and after WTO accession. This is reflected by the small but obvious improvement in the average efficiency scores over the data period. The industrial average efficiency scores rose from 0.78 in 1999 to 0.91 by 2005.

Three banks, CCB, BOC and CBC, are identified as the most technically efficient as their average efficiency scores are equal or close to unity. Of the Big Four, CCB, BOC and ICBC are among the most efficient banks but ABC is the second most inefficient in the sample. This explains why the government has allowed the former three to be listed on the stock markets but kept ABC in its present form. The finding that CCB, BOC and ICBC are among the most efficient commercial banks in China contradicts a common perception and the results of some previous studies. The relative understatement of the state-owned commercial banks in China by some other studies may have been due to their modelling method. If deposit is included as an input, the stock of deposits in the Big Four is much bigger than those in the joint equity banks, leading to a low efficiency rating of the Big Four. However, the expenses of maintaining the deposits by the Big Four are low. If deposit is excluded from the model as has been done in this paper, the efficiency rating of the Big Four is improved.

Table 2: Efficiency scores and ranking of Chinese commercial banks: 1998-2005

Bank	1998	1999	2000	2001	2002	2003	2004	2005	Average	Rank
ICBC	1.00	0.98	0.92	0.83	0.84	0.91	0.98	1.00	0.93	3
ABC	0.74	0.68	0.67	0.68	0.75	0.77	0.77	0.73	0.72	14
CCB	0.95	0.87	0.79	0.84	0.99	0.99	1.00	1.00	0.93	4
BOC	1.00	0.78	1.00	1.00	0.91	1.00	1.00	1.00	0.96	1
CBC	0.61	0.78	0.82	0.80	0.87	0.93	1.00	0.98	0.85	10
CMB	0.84	0.81	0.80	0.87	0.97	0.99	1.00	0.99	0.91	5
CITIC	1.00	0.57	0.81	0.79	0.85	0.87	0.91	0.91	0.84	11
CEB	1.00	0.75	0.78	0.71	0.77	0.82	0.81	0.79	0.81	13
PDB	0.76	0.78	0.78	0.79	0.96	0.99	1.00	0.99	0.88	9
CMB	0.81	0.85	0.85	0.89	0.85	0.97	1.00	0.97	0.90	6
GDB	0.59	0.61	0.64	0.68	0.67	0.64	0.64	0.66	0.64	15
FIB	0.79	0.87	0.86	0.88	0.93	0.83	0.96	0.97	0.89	7
HXB	0.82	0.81	0.92	0.86	0.87	0.92	0.92	0.93	0.88	8
BOS	0.93	0.84	1.00	0.93	1.00	0.89	0.99	0.92	0.94	2
SDB	1.00	0.74	0.86	0.82	0.84	0.78	0.84	0.82	0.84	12
Average	0.86	0.78	0.83	0.82	0.87	0.89	0.92	0.91	0.85	

Sources: Data are taken from Bankscope.

The most inefficient joint equity bank is GDB, justifying why the government has been negotiating with Citigroup and Société Générale to buy 85 per cent of GDB's share capital. China has been reluctant to allow any foreign bank to have a controlling stake in any Chinese bank. However, there are exceptional cases if foreign participation can fundamentally transform the performance of a local bank and provide valuable experiences for the reforms of others by introducing the best foreign managerial practices and corporate governance. One such exceptional case was the San Francisco-based capital fund Newbridge that was allowed to become the largest and controlling shareholder of SDB through the procurement of 17.8 per cent stake worth US\$145 million from its four government shareholders in May 2004 (Dong 2005).

4.2 Slacks and targets

As for input-efficiency, an efficiency score equal to one means that efficient banks lie on the boundary and their input levels cannot be radically reduced for a given output level. DEA results not only help managers to identify best practice in the sector, but also point to the direction and magnitude that inefficient banks can improve. In 2005, for example, CEB had an efficiency score of 0.79, which means that the maximum radial contraction (0.21) is possible to the input level without reducing its output. According to the DEA model, the input and output slacks must be taken into account. As a result, the target for efficiency improvement will be the sum of radial reduction and the existing slack. Take CEB as an example, the target ratio of NPLs/gross loans will be $(0.05 \times 0.79) - 0.028 = 0.011$.

After knowing the targets of efficiency improvement, inefficient banks need to find out the most feasible way to catch up. It is crucial that the process of efficiency improvement should be made in a short time period. The efficiency theory suggests that it is always good to learn from the efficient peers with the same or similar input-output mix. The reference set offers inefficient banks a feasible means to emulate their efficient peers by learning from their practice.

Taking CEB in 2005 as an example, CMB and PDB are identified as its efficient peers in the reference set as their corresponding $\lambda = 0.296$ and $\lambda = 0.498$ are the only positive values at the optimal solution to the envelopment model. Compared with CEB, PDB has less non-interest expenses and a lower NPL/gross loan ratio but more interest and non-interest incomes. Although PDB has 3 per cent more interest expenses than CEB, the former earns 17.5 per cent more interest incomes than the latter. If we scale down PDB and CMB by 0.498 and 0.296 respectively, the combination of scaled down input levels of PDB and CMB offers the same interest income as CEB could deliver but it uses only 87 per cent of the inputs used by CEB. This underlies the Pareto-efficiency rating of CEB at 0.87. PDB and CMB are thus regarded as the efficient benchmarks for CEB in 2005. It requires high managerial skills within inefficient banks to study their efficient peers' practices and set up targets in relation to the combination of input and output levels of their efficient benchmarks.

Among state banks, CCB and BOC are most frequently referenced. Another efficient state bank, ICBC, has never been referenced. In this sense, CCB and BOC should be regarded as the efficient benchmarks for the inefficient state bank ABC. The empirical results provide a strong theoretical backing for the government's decision on the order of priority of restructuring CCB, BOC and ICBC of the Big Four. PDB and BOS are often quoted in the reference sets of joint equity banks although their average efficiency

scores are not the highest among joint equity banks. One possible explanation for their frequent appearance in the reference sets is that their operating practices and environment match more closely with the less efficient joint equity banks than the other more efficient counterparts.

4.3 Scale type and scale efficiency

In theory, an efficient bank must produce at constant returns to scale. At an IRS, increasing return to scale, production point the firm raising its input levels by a small percentage will lead to an expansion of its output by a higher percentage. At a DRS, decreasing return to scale, production point a small expansion of output requires a larger percentage increase in inputs. Obviously, when IRS holds a bank should increase its scale size. Similarly, when DRS holds a bank should reduce its operation. The ideal scale size is where CRS holds.

It is striking to note that inefficient state banks in most years exhibit DRS while inefficient joint equity banks show IRS. The empirical results provide valuable information for policy makers to justify their capital injection initiatives and business expansion regulations. It is interesting to deduce that the reason why non-state ownership in joint equity banks has not brought about superior performance over their state-owned and bigger counterparts is clearly due to the lack of scale economies. To improve the overall performance of the Chinese banking industry will require not only ownership reform but also a consolidation of operation to exploit the economies of scale in the non-state sector.

By controlling for the scale effect, joint equity banks become relatively more efficient than their state-owned counterparts. In particular, CMB, HXB and BOS improve their efficiency and ranking dramatically, implying that joint equity banks should be encouraged to expand their branch networks in order to improve their competitiveness and overall efficiency of the entire banking industry in China. Scale inefficiency is the biggest source of the overall technical inefficiency of joint equity banks.³

4.4 Correlation between firm size, efficiency ranking and profitability ranking

It is interesting to investigate the relationship between efficiency and profitability rankings of commercial banks. Studies such as Berger and Mester (1997) find that firm size is a possible factor that influences efficiency and profitability of commercial banks. The profitability in this study is measured as the ratio of pre-tax profit over total assets.

The results show that there is no evidence of any strong correlation between the rankings of efficiency scores, profitability and firm size, implying that firm size is not an important factor for efficiency and profitability. Because profitability is measured as the ratio of pre-tax profit over total assets, it effectively measures the accumulated historical performance of banks, instead of their current operating performance. In this sense, a DEA efficiency score is a better measurement of firm performance than profitability.

³ The detailed decomposed results relating to the economies of scale are not reported here to save space but are available on request.

There is also no evidence that joint equity banks outperform state owned banks. CCB and BOC enjoy high rankings based on both efficiency and profitability indices. Similar results are obtained in other years. Our finding is in accordance with the conclusions reached in recent research by Bonin et al. (2005) but contradicts some other studies that are based on a different research methodology (Yao et al. 2006). With respect to the impact of ownership, privatisation or a joint equity arrangement is not sufficient condition to increase a bank's efficiency as state-owned banks are not appreciably less efficient than private or joint equity banks in as far as our sample is concerned. However, it is found that efficient commercial banks, whether they are state-owned or of joint equity, happened to be those that have been listed in the stock markets recently while the inefficient banks have not been allowed to be listed.

5 Malmquist index

The Malmquist index has been frequently used to measure productivity changes in various industries. The advantage of the Malmquist index as opposed to other alternative measurements is that productivity change can be decomposed into efficiency improvement and technological progress. The first empirical study relating to the Malmquist index in a DEA context is Färe et al. (1989). The Malmquist index captures productivity change in terms of quantities without reference to input prices or output values. As the Malmquist index is always computed maintaining a constant returns to scale assumption, its value is the same whether it is computed in an input or output orientation (Thanassoulis 2001). Hence, the output orientation efficiency scores are used to conduct the Malmquist index to fit the interpretation of productivity change.⁴

Calculation of the Malmquist index and its decomposition can be done on an annual basis for individual banks or for a given data period. To save space, the detailed calculations on an annual or periodic basis are not presented here. Table 3 only presents the geometric average annual growth rates of total factor productivity (TFP), measured by the Malmquist index in column 2, and the geometric average annual growth rates of technical efficiency, in column 3, and the geometric average annual growth rates of technological progress.

Except for CITIC, CEB and SDB, all the banks achieved significant TFP growth over the data period. The star performer is CCB, which becomes a benchmark for other state banks. Over the data period, CCB achieves an average annual growth of more than 15 per cent in TFP. Among the joint equity banks, CBC, CMB and PDB outperform their peers. They achieve an annual productivity growth of 7.5 per cent or more. In contrast, CITIC, CEB and SDB experience serious deterioration in their productivity, with a negative growth rate of nearly 4 per cent per annum.

⁴ The specification of Malmquist index can be found in Thanassoulis (2001).

Table 3: Decomposition of productivity, geometric average annual growth, 1998-2005

Banks	Malmquist index (%)	Efficiency growth (%)	Technical change (%)
ICBC	4.20	1.83	2.33
ABC	7.10	5.96	1.07
CCB	15.70	15.51	0.15
BOC	10.50	10.50	0.00
CBC	11.20	11.12	0.07
CMB	5.50	3.78	1.65
CITIC	-4.10	-5.54	1.52
CEB	-5.10	-7.89	3.03
PDB	7.60	3.10	4.37
CMSB	8.60	5.20	3.23
GDB	0.30	-4.63	5.17
FIB	4.60	0.49	4.09
HXB	2.60	-3.46	6.28
BOS	0.40	-3.55	4.09
SDB	-3.20	-4.41	1.27
Mean	5.60	2.88	2.64

Notes: Malmquist index indicates geometric average annual growth of total factor productivity decomposed into efficiency growth and technological change, i.e., Malmquist index = efficiency growth * technical change.

Sources: Data are from Bankscope.

On average, Chinese national commercial banks achieved remarkable growth in TFP. The average growth is 5.6 per cent per annum pulling 15 banks together over the entire data period. The average growth rate after China's accession to the WTO in 2001 was more than ten per cent per year, much higher than the average growth prior to the WTO accession. This implies that WTO accession has been a powerful impetus for reforms in China to improve bank efficiency.

The Malmquist index can be decomposed into efficiency changes and technological progress, or frontier shift. As shown in column 3 of Table 3, the average industrial technical efficiency change is 2.88 per cent per annum, which accounts for more than half the TFP growth. CCB and BOC are the best performers in terms of efficiency growth, as both achieve double-digit annual growth in the data period. The contribution of technological progress to TFP is presented in the last column in Table 3. The average annual growth is 2.64 per cent for all the banks over the whole data period. It is striking to find that all the banks achieve positive technological growth, and the best performers are not the Big Four state-owned banks but the joint equity banks, such as HXB, BOS, PDB and CEB.

The decomposition results in Table 3 have important policy implications. First, the Chinese banking industry has become considerably more competitive in recent years, especially after the WTO accession, although state-owned banks still enjoy some encapsulated market power, as well as government protection and financial support. Second, the growth of TFP is almost equally explained by its two components:

efficiency improvement and technological progress. Third, large state-owned banks make more progress in improving their technical efficiency than their joint equity counterparts, but the latter achieve more technological progress than the former. One possible explanation for the significant improvement in TFP growth, especially for CCB and BOC, are due to their efforts to retrench employment, to implement a stricter monitoring and control mechanism on lending and to improve management and corporate governance.

6 Conclusion

This paper uses the latest banking data to assess the efficiency of Chinese national commercial banks. It is the first attempt to use the resource approach to identify inputs and outputs in the banking context with reference to asset quality. One key finding is that Chinese national commercial banks do not have substantial differences in technical efficiencies as the average scores of efficiency are high and the aggregate gaps in technical efficiency are low at only 15 per cent. Another important finding is that the TFP of the sample banks rose significantly by 5.6 per cent per annum over the data period. These empirical results show clear evidence that Chinese national commercial banks have reacted positively and aggressively to ownership reform and foreign competition.

Three large state-owned banks, CCB, BOC and ICBC dominate the market as they have high technical efficiency and profitability, explaining why their IPOs in 2005 and 2006 were so heavily demanded by investors. Despite the improvement in efficiency, productivity and the success of transformation into shareholding companies, it has to be pointed out that the results of bank reform in China in the last few years may have been artificially created, or at least supported, by the government. On the other hand, the empirical results in this paper provide some useful additional insights into the Chinese commercial banking industry. They contradict a perceived conception that Chinese state-owned banks cannot withstand the onslaught of foreign banks entering into China after WTO accession. The successful IPOs of CCB, BOC and ICBC indicate that the government has achieved its first goal of ownership reform with foreign competition after WTO accession, which is to transfer the Big Four from state-owned banks into shareholding companies. Anecdotal evidence and observation over the past two years show that Chinese commercial banks have made significant progress in improving their efficiency and corporate governance. Apart from reducing the number of employees, the Big Four have improved their lending strategies and tried to steer away from intervention by local governments. Some commercial banks have tried to form strategic alliances with foreign commercial banks by allowing their investments in an effort to learn from their advanced managerial and organisational experiences.

This paper shows some strong and unambiguous results that CCB and BOC have emerged to be China's best performing commercial banks, even better than many of the joint-equity banks. Although it is too early to predict whether the Big Four will compete successfully with foreign banks and establish themselves as world class commercial financial institutions, the fact that the Chinese commercial banks in general and the CCB, BOC and ICBC in particular, have achieved admirable productivity growth implies that the most recent banking reforms in China have produced some encouraging results.

The empirical results in this paper also indicate that the Big Four, except for ABC, were able to improve TFP mainly through improving technical efficiency, instead of technological progress. In contrast, the joint equity banks have improved their productivity mainly through technological progress rather than efficiency improvement. In addition, they appear to have suffered from the lack of scale economies because they do not have a large network of branches as do their larger state-owned counterparts. In other words, joint equity banks have not been able to exploit their ownership advantage over the Big Four because they are not big enough. Joint equity banks were initially established by regional governments with the clear objective of serving the local market. Although they have expanded their services throughout the country, they are still locally controlled and do not have the ability to become truly national, let alone international, through exploiting the economies of scale and scope. Future bank reforms in China may go in the following directions. First, the Big Four should change their ownership structure to become truly large commercial banks with minimum intervention from central and regional governments. Bank directors should be appointed based on professional qualifications and managerial ability instead of party seniority. Second, the same reforms in the state sector should also be applied in the joint equity sector, but merger and acquisition should be encouraged to enable them to exploit the economies of scale and scope.

Appendix

Names and abbreviations of national commercial banks in China

Abbreviations	Full names of banks
ICBC	Industry and Commercial Bank of China
ABC	Agricultural Bank of China
CCB	China Construction Bank
BOC	Bank of China
CBC	China Bank of Communications
CMB	China Merchant Bank
CITIC	China Investments and Trust Bank
CEB	China Everbright Bank
PDB	Pudong Development Bank
CMSB	China Mingsheng Bank
GDB	Guangdong Development Bank
FIB	Fujian Investment Bank
HXB	Huaxia Bank
BOS	Bank of Shanghai
SDB	Shenzhen Development Bank

Notes: All banks listed in this table are national commercial banks, meaning that they can provide banking services throughout the country without any geographical restriction. The state-owned commercial banks are the Big Four, ICBC, ABC, CCB and BOC. The others are joint equity banks. These 15 banks account for over 80 per cent of China's total commercial lending activities and deposits.

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