Three Empirical Essays on Efficiency and Productivity in Chinese Banking Industry

by

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ABSTRACT

This thesis is about measuring and interpreting banking efficiency in China. It consists of three empirical essays that use Data Envelopment Analysis (DEA) in three novel ways to measure inefficiency. The first essay measures cost inefficiency of the 14 nationwide banks over the period 1997-2006. A rational model of rent-seeking behaviour is used to explain part of the cost inefficiency. Cost inefficiency is decomposed into X-inefficiency and Rent-seeking inefficiency and the latter is interpreted as symptomatic of rational decision making by the Chinese bank manager. The efficiency estimates are obtained from a Simar and Wilson (2000a) proposed bootstrap method. A second stage regression model explains that the rate of decline of the inefficiencies is faster for the joint-stock commercial banks (JSCBs) than for the state-owned commercial banks (SOCBs). The second essay, estimates total factor productivity (TFP) growth for SOCBs, JSCBs and city commercial banks (CCBs) for the period 1997-2007. The method of estimation is the Malmquist bootstrap method. This study finds that TFP growth did not improve significantly in the run up to WTO. Technical innovation was dominated by the big banks and efficiency gains were dominated by the CCBs. The third essay uses a network DEA (NDEA) framework to analyse profit efficiency between three profit centres within the bank, namely consumer, corporate and Treasury banking. The internal efficiencies of the state wide banks are analysed for the period 2007-2009. The study demonstrates the value of the NDEA method in aiding the manager to identify areas of inefficiency within the internal flow of funds of the bank. The results show Treasury operations have the lowest efficiency. This is partly caused by restrictions on the loan-deposit ratio that forces the banks to hold lower yielding other earning assets through their Treasury operations.

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Chapter 1

Introduction and Motivation

"Nothing will ever be attempted if all possible objections must first be overcome."

Samuel Johnson

1.1 Introduction

Napoleon Bonaparte (1761-1821) once said 'Let China sleep. For when she awakes, she will shake the world'. The awakening of the Chinese dragon can be traced to the reform process initiated by Deng Xiao Ping in 1978. Yet while industrial China moved ahead in great leaps and bounds, for long its banking sector lagged behind in the reform process. Handicapped by bureaucratic management style and a large non-performing loan structure, the approach to banking reform has been cautious and piecemeal. In 2010 Chinese banking resembles a modern banking system with a harmonised regulatory framework that matches international standards in capital adequacy and risk management. The last of the big state-owned commercial banks (Agricultural Bank of China) was listed on the Shanghai and Hong Kong stock exchanges in July 2010. Whereas profit was a by-product of banking activity in the past, particularly for the state-owned banks (SOCBs) which had social and political objectives, in current times profit is the central objective of the banking unit.

This thesis examines some aspects of Chinese banking that sheds light on the process of evolution from the 1990s to the present. The central theme of this thesis is efficiency in Chinese banking. The technology used to measure efficiency is the *Data*

Envelopment Analysis familiarly known as DEA. The DEA is a linear programming method that maximises the ratio of weighted outputs to weighted inputs (or the dual minimises the ratio of weighted inputs to outputs). While the topic of bank efficiency has been well trodden both in China and in overseas research, this thesis develops and presents an innovative approach that has hitherto not been applied extensively to Chinese banking. This thesis consists of three empirical chapters. The following sections outline the main theme of each empirical chapter.

1.2 Cost Efficiency in Chinese Banks

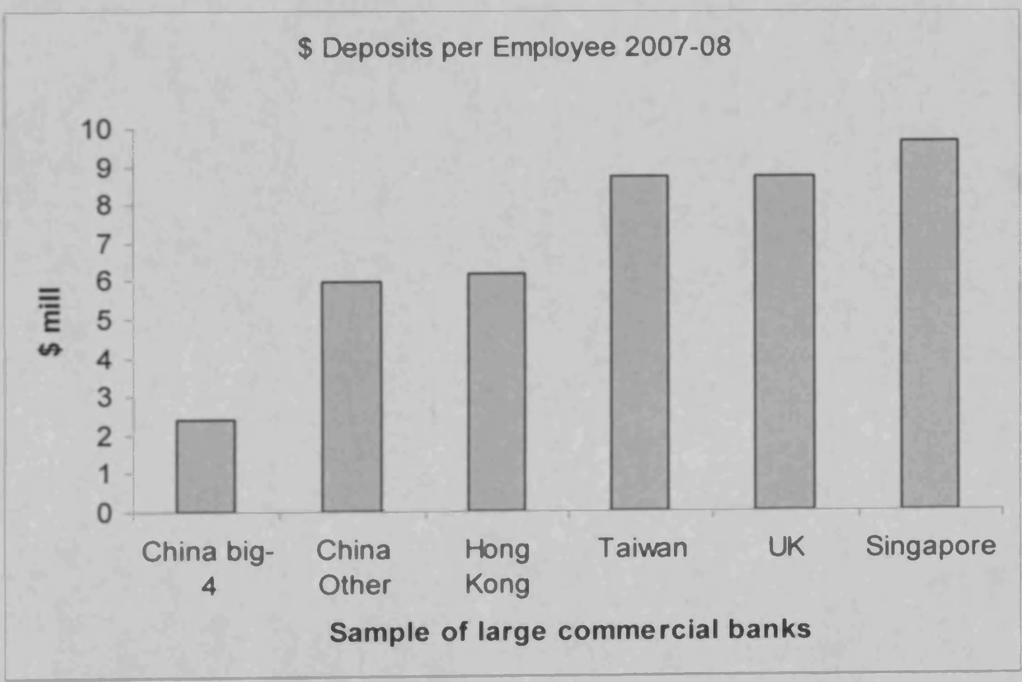
The first chapter uses non-parametric methods to examine cost efficiency in Chinese banks. Its contribution is twofold. First the method of estimation uses a bootstrapping technology provided by the seminal work of Simar and Wilson (1998) (2000a) (2000b) to produce measures of efficiency (or inefficiency) that allows for statistical inference[1]. Second it decomposes cost inefficiency into technical inefficiency and allocative inefficiency. Briefly technical inefficiency measures the excess use of inputs in producing a vector of outputs relative to the benchmark or alternative the under-production of the vector of outputs given a vector of inputs, relative to the benchmark. In much of the literature, technical efficiency (or inefficiency = 1 – efficiency) has been viewed as X-efficiency (or its inverse, X-inefficiency). This empirical chapter follows in this tradition and also interprets allocative inefficiency as indicative of rent-seeking. Bureaucratic rent-seeking behaviour is used to explain over-staffing in Chinese banks. Overstaffing has declined considerably since 1997 and is less of a problem in 2007-8. Crude measures of over-staffing can be obtained

[1] MATLAB and R codes of the algorithms are available on the respective websites of Simar and Wilson.

by comparing the deposits per employee of the Chinese banks with a sample of banks from other countries that can act as a benchmark.

Figure 1.1 below shows the common currency deposits per employee for China's big four banks and the rest (excluding city commercial banks) compared with a sample of banks from Hong Kong, Taiwan, UK and Singapore. By 2007 the $ equivalent of deposits in other Chinese commercial banks (joint-stock commercial banks plus Bank of Communications), matches Hong Kong and is in striking distance of levels associated with international benchmarks. However, the big-4 banks of China (Bank of China, Industrial and Commercial Bank of China, China Construction Bank and Agricultural Bank of China) have deposits per employee that is less than half of the levels of the other commercial banks in China.

Figure 1.1 Dollar deposits per employee - China, Hong Kong, Taiwan, Singapore and UK



Source: Fitch-Thompson *Bankscope*

A model of bureaucratic rent seeking would supplement the conventional utility function of the manager consistent with the shareholder from just profits to include staffing as an additional argument. Let π be profits, $\overline{w}$ be the given wage rate, p be the product price, and L represent staffing levels. The conventional optimisation for the firm is described by maximising the manager's utility function given by the implicit function;

$$\text{Max} \quad U = U(\pi) \qquad (1.1)$$

$$\text{Subject to} \quad \begin{aligned} &\pi = py - \overline{w}L \\ &y = f(L) \\ &f' > 0; f'' < 0 \end{aligned} \qquad (1.2)$$

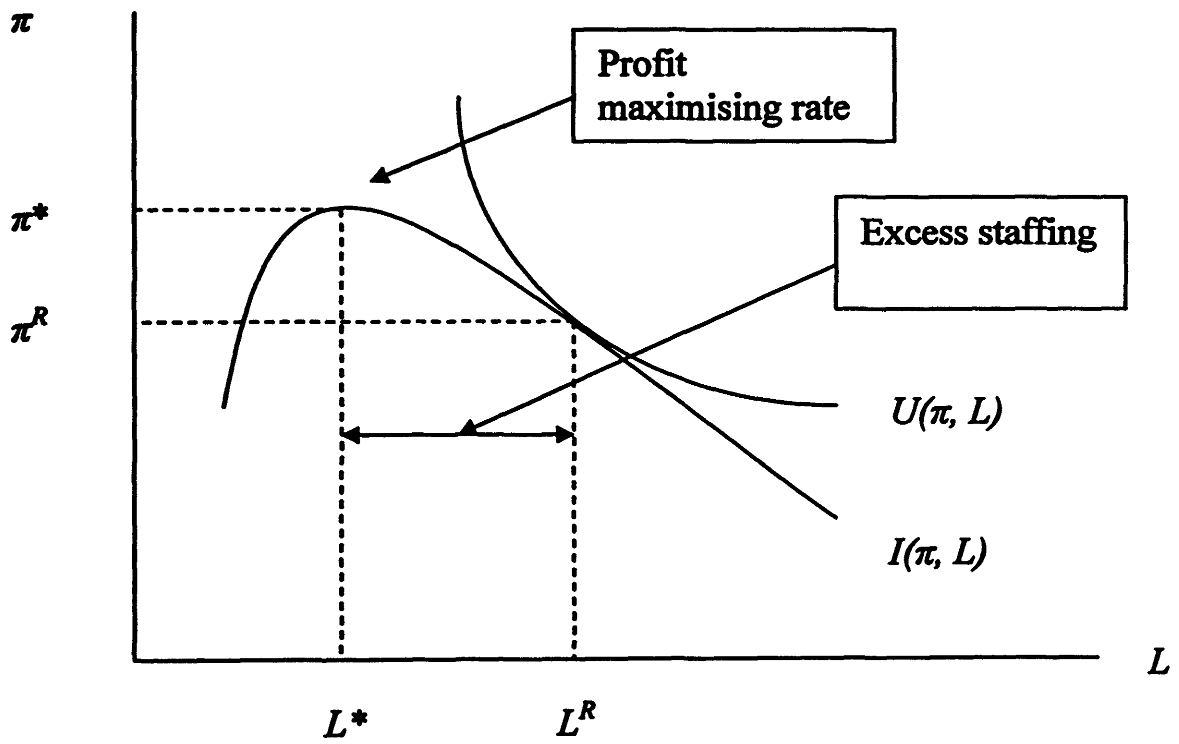
$$\begin{aligned} &\frac{d\pi}{dL} = pf' - \overline{w} = 0 \\ &L^* = L(\overline{w}, p; y) \\ &\frac{d^2\pi}{dL^2} = pf'' < 0 \end{aligned} \qquad (1.3)$$

Equation (1.3) describes the profit-labour input function which shows that there is a single maximum. The optimising conditions reveal the profit maximising input of staffing for a given level of output as described in figure 1.2. However, the bureaucratic manager may also have the objective of building up his managerial empire or be following political strictures to employ more staff. The utility function of the bureaucratic rent-seeking manager is given by;

$$U = U(\pi, L) \qquad (1.4)$$

Optimising 1.4 with respect to the constraints leads to excess staffing as shown by the tangency of the bureaucratic rent-seeking manager's utility function to the locus of profit and labour input in figure 1.2. The profit function describes the relationship between profit and the factor input. The maximum profit for a given level of output is shown at π^* and following Williamson (1963) the rent-seeking equilibrium is described by L^R. The excess staffing is given by $L^R - L^*$.

Figure 1.2 Excess staffing as a rational outcome



While it can be argued that bureaucratic rent-seeking behaviour and political imperatives led to excess staffing in the past, the dominance of the profit maximising framework in Chinese banks in recent years has led to the decline of rent-seeking inefficiency. The chapter on bank efficiency not only attempts to evaluate the relative differences between X-inefficiency and rent-seeking inefficiency between the SOCBs and the JSCBs, it also attempts to model the speed of decline of each over time.

While rent-seeking on the part of corrupt party officials and financing of publicly traded companies has been examined by Fan, Rui and Zhao (2006) and rent-seeking gains to individual membership of the Communist Party by Bishop and Liu (2006), to my knowledge the concept of rent-seeking as applied to over-staffing in regulated industries has not hitherto been examined previously.

1.3 Bank Productivity

The next piece of empirical work relates to the measurement and determination of productivity in Chinese banks. In this chapter (Chapter 6) I borrow concepts from the growth accounting literature in the form of total factor productivity (TFP) and growth convergence literature (beta-convergence). The contribution of this chapter is threefold. First it measures TFP of the Chinese banks for the SOCBs, the joint stock commercial banks (JSCBs) and the city commercial banks (CCBs) over the period 1998-2007 with a view to examining which of the types of banks have grown the fastest. Second, it uses the concept of conditional *β-convergence* to evaluate the dynamics of TFP controlling for bank specific factors. Third, it uses the Simar and Wilson bootstrapping technology to estimate TFP using a non-parametric framework and thereby providing the point estimates with a statistical inferential capability. The non-parametric method is an extension of the DEA approach to accommodate the change in efficiency between two periods which produces an index of growth for multiple outputs and inputs known as the *Malmquist index*[2].

[2] After the work of Malmquist (1953) and Caves, et al (1982).

The concept of total factor productivity growth and growth accounting developed from the work of Solow (1957). Solow discovered the one-third rule which states that a 1 per cent increase in capital per hour of labour brings a one-third increase in real GDP per hour of labour. This one-third I used to decompose the growth of real GDP per hour of labour into the increase in the capital per hour of labour and technological change to the growth of real GDP[3]. If the production function is of the form;

$$\begin{aligned} &Y = AF(K,L) \\ &F_K, F_L > 0 \\ &F_{KK}, F_{LL} < 0 \end{aligned} \qquad (1.5)$$

Where Y is real GDP, K is capital and L is labour time in hours and F_L, F_K and F_{LL}, F_{KK} define the conditions for marginal product of labour and capital respectively and diminishing marginal productivity of labour and capital. Defining, output per hour of labour time is $y = \frac{Y}{L}$ and capital per hour of labour is $k = \frac{K}{L}$, then;

$$y = af(k) \qquad (1.6)$$

Assuming a Cobb-Douglas technology;

$$\dot{y} = \dot{a} + \alpha\dot{k} \qquad (1.7)$$

The dots over the variables indicates proportional rate of growth. Alternatively, growth in GDP is given by;

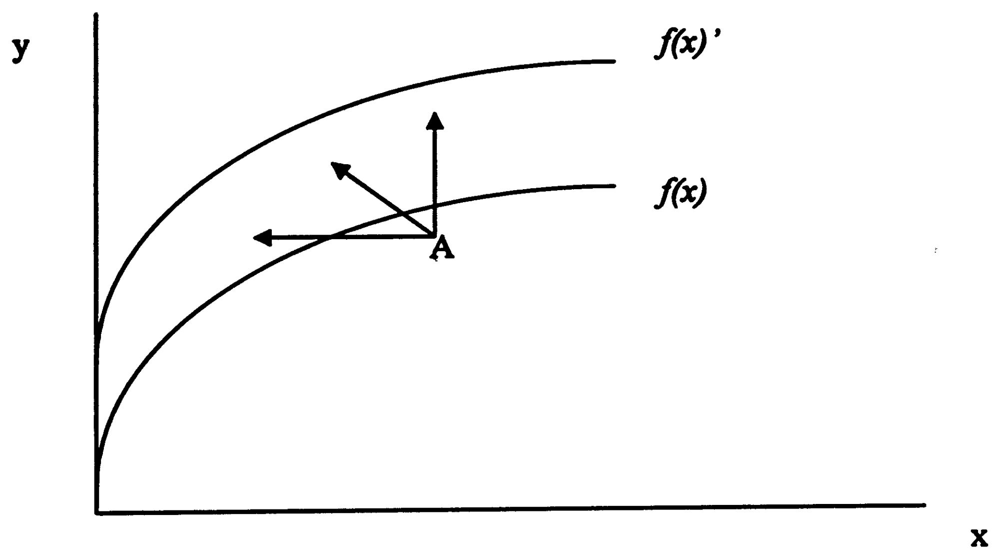
[3] For a textbook exposition see Parkin et al (2005) p.686

$$\dot{Y} = \dot{A} + \alpha\dot{K} + (1-\alpha)\dot{L} \qquad (1.8)$$

Equation 1.8 is the fundamental growth accounting statement which decomposes GDP growth into the growth in capital and the growth in labour and the residual $\dot{A}$ is the growth in total factor productivity.

In the context of multiple outputs and inputs the Malmquist index decomposes the growth in a firm or micro unit between two periods into the technological change and efficiency gain. Technological change represents growth in technical progress illustrated by a shift in the frontier of the production function and efficiency gain represents a movement towards the frontier on the part of an inefficient firm or micro unit. Figure 1.3 illustrates in the case of a one output and one input, where y is the output and x is the input; $y = f(x)$.

Figure 1.3 Technical progress and efficiency gain



The growth of an inefficient firm represented by the coordinates at A towards any point in the space defined by the arrows represents an increase in output growth that can be decomposed into technical progress given by a shift in the production function and a movement towards the frontier.

The research of Chapter 6 is to identify those banks that define the frontier in terms of being the benchmark and those banks that emulate best practice and make efficiency gains by shifting closer to the frontier. The findings of this chapter suggest that the SOCBs and some JSCBs have defined the frontier but it is the CCBs that have made the greatest strides in efficiency gains.

1.4 Bank Intermediate Outputs and Intermediate Inputs

The DEA technology relates to a single level situation where the efficiency of a unit is evaluated against comparable units at a given point in time. In their review of thirty years of DEA, Cook and Seiford (2009) describe a multistage model in which production passes through different levels. These can be thought of as one of three general models.

(1) A static framework where a finite set of sub technologies is connected to form a network which enables the analysis of the allocation of intermediate products.

(2) A dynamic network, where there is a sequence of production technologies separated in time. In this framework the outputs of one stage become the inputs of another stage.

(3) A technological adoption framework which allows for the production on different processors (machines). In this case inputs are allocated among the processors to allow for the adoption of a specific technology.

Chapter 7 examines a static parallel network that separates the bank into three profit centres, namely Consumer banking, Corporate banking and Treasury operations. Overall efficiency is given by the ratio of outputs to inputs (or the dual) but the network framework provides insight to the manager as to the internal efficiency of the profit centres relative to benchmark banks internal processes. The application of network DEA to banking is rare and application of this study is the first in applying the parallel network to Chinese banks[4].

1.5 Structure of the Thesis

The remaining chapters of the thesis outline the context, methodology and data used in the study. Chapter 2 details the development of the modern Chinese banking system concentrating on the reform period of the 1990s. Chapter 3 outlines the principle methodology used in each of the empirical chapters. This chapter sets out the technology of the DEA, Malmquist and Network frameworks and also reviews the literature and its application to Chinese banks. While this chapter outlines the methodology and the literature, there is some repetition in each of the empirical chapters as these were written with the principal aim of publication as scholarly papers. Chapter 4 describes the data and the assumptions used in deriving particular data used in the analysis. Chapter 5, 6 and 7 are three empirical studies. Chapter 5 decomposed cost inefficiency into technical and allocative inefficiency. Chapter 6 used the bootstrap technology to measure TFP growth of the banks and its components, technical innovation and efficiency catch-up. Chapter 7 applied a novel

[4] Matthews (2010) applies a serial network DEA to one year of Chinese banks data to evaluate the relative efficiency of risk management procedures as an intermediate process.

technology of network DEA to open up the "black box" from the conventional DEA estimates. Chapter 8 summarises and concludes.

1.6 Epilogue

After 10 years of experience in the Chinese banking industry, I felt I had a good worms-eye view of the workings of the system. My interest in developing a birds-eye view was stimulated by my study of the efficiency of Chinese banks as part of my dissertation when taking the MSc in International Economics, Banking and Finance at Cardiff University. At that time I was aware that there were many studies of Chinese banking that showed similar results. Measuring Chinese bank inefficiency had become a growth industry among Chinese Masters students and Chinese scholars. Over 180 papers have been published in China relating to bank efficiency. However, the measurement of bank inefficiency while being an important contribution does not explain the conception and evolution of this inefficiency. The existence of large scale inefficiency could only be explained by a political economy process. While the empirical chapters may not be the only explanation, they represent a beginning.

Chapter 2

The State of Chinese Banking

"Get the facts first, and then you can distort them as much as you want." *Mark Twain*

2.1 Introduction

The ancient Chinese sage Lao Tzu is supposed to have said, 'the journey of a thousand leagues begins with the first step'. A well-known Irish saying is 'If you want to get to Tipperary, I wouldn't start from here'. Both statements are appropriate to understanding the state of Chinese banking. Chinese banks have come a long way since the reforms of the last two decades of the 20th century, but it is also clear that in terms of global performance that they have much further to go. Similarly, the evolutionary journey of Chinese banks is made much more difficult because of the legacy of its history. Western banks have typically evolved from a 'free banking' tradition to a regulated one. In contrast, Chinese banks have come from the opposite direction, from a state-planned system to a regulated market-based system.

This chapter describes the state of the Chinese banking system. It traces its evolution from ancient tradition, through the socialist planning stage on to the current stage that resembles a modern banking system. The route taken will concentrate on the development of the modern Chinese banking system from the beginning of the reform period in 1979. The first part describes the evolution of the Chinese banks from ancient times to the revolutionary period. The next section describes the development of the banking system from the mono-banking system of the central planned economy to the current banking system. The third part outlines the main indicators of the

Chinese economy and the role of the banking system in its development. The fourth part examines the structure and performance of Chinese banks. The final part looks at very recent developments and the prognosis for the future of Chinese banks.

2.2 Chinese Banking from Ancient Times

Banking in China has an ancient and venerable tradition dating two thousand years. The use of paper money was pioneered in China and the earliest known credit institution appeared in the 5th century of the Tang dynasty (618-907) (Yang, 1952). The equivalent of promissory notes issued by the government, *feiqian* (flying money) redeemable at provincial treasuries existed and paper money, *jiaozi* (exchange medium), was in use in Sichuan province in the early part of the 11th century. A sophisticated system of banking that took in deposits, made loans, issued notes, and made long distance remittances of money developed during the Song dynasty (960-1279) (Tamagna, 1942). However, it was in the period of the Qing dynasty (1644-1911), with increased commercialisation of the economy did three distinct types of banks develop namely *piaohao*, *qianzhuang* and foreign banks (Cheng, 2003).

The *piaohao* (ticket store) was a cash remittance system that grew out internal transfers of credits by companies that had branches separated by geographical location. The difficulty in the secure transference of cash across geographical areas led to the development of an internal transfer of credit, which amounted to a cashable draft issued by one branch of a company on another branch. According to Cheng (2003), the Xiyuecheng Dye Company located in the Pingyao district of Shanxi province was the first to develop such a system. The large number of internal transactions led to a balancing netting system. The efficiency of the system led to many other merchants and traders either developing their own systems or began to use the *piaohao* as a means of remitting funds across the country. Eventually the *piaohao* began to remit government tax revenues, advanced payments to local authorities and raise foreign loans for provincial governments. By the late 19th century the *piaohao* had become a government financial agency in everything but name. By the end of the 19th century there were 32 *piaohaos* in business with 475 branches spanning all of China's eighteen provinces plus Manchuria, Mongolia, Xinjiang and frontier areas.

Independently of the *piaohao* system a large number of small domestic banks, *qianzhung*, developed during the 18th century. These were highly localised banks that conducted money exchange, issuance of cash notes, discounting and trading bills of exchange. These domestic banks were strongly suited to the small scale business of the local enterprises. Typically the loans were small scale and required no collateral and business hours were flexible providing what was often a '24 hour service'.

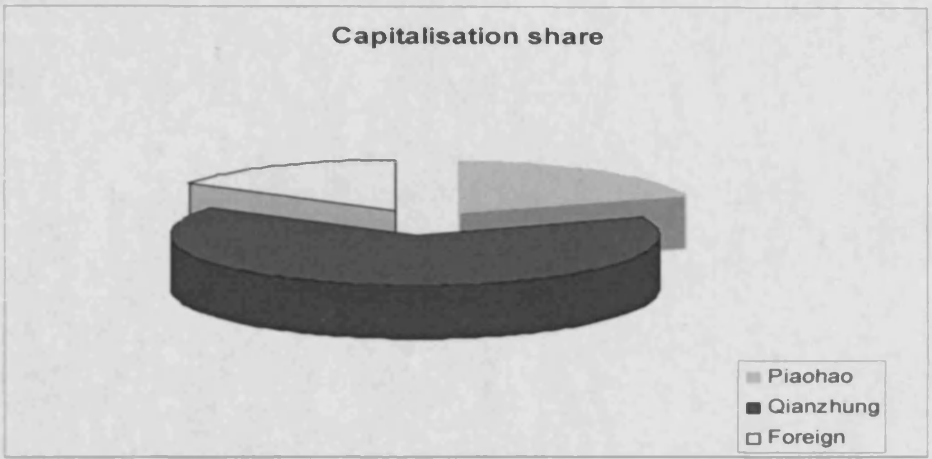
The two types of banking were specially separated and did not directly face a geographical competition. The two institutions frequently cooperated with *piaohao* depositing idle cash in *qianzhung*. In the early 1890s there were around 10 thousand *qianzhung* in China.

The third type of banking institution was the foreign merchant banks that followed their customers to the international trading areas of China. The first of these was an Indo-British bank called Oriental Bank, which set up a branch in Hong Kong in 1842 and an agency branch in Canton in 1854. A number of other Indo-British banks followed in rapid succession and in 1865 the Hong Kong and Shanghai Banking Corporation was established in Hong Kong. The late 19^{th} century saw banks from Germany, France, Japan and Russia establish in China. Because of the extra territorial rights granted to the foreign concessions, these banks were free of Chinese government regulations, which meant that not only had the banks as a group able to secure international currency business but they could also operate in China with no regulatory incumbency. The international borrowing of the Chinese government to meet reparations following the Sino-Japanese war of 1894 further enhanced the position of the foreign banks.

The division of the banking market between the three types of institution followed a keen segmentation. The foreign banks dominated international trade financing; the *piaohao* dominated the domestic remittance business and the *qianzhung* controlled domestic credit. The relative shares capital of the three banking types for 1894 is shown in Figure 2.1 below.

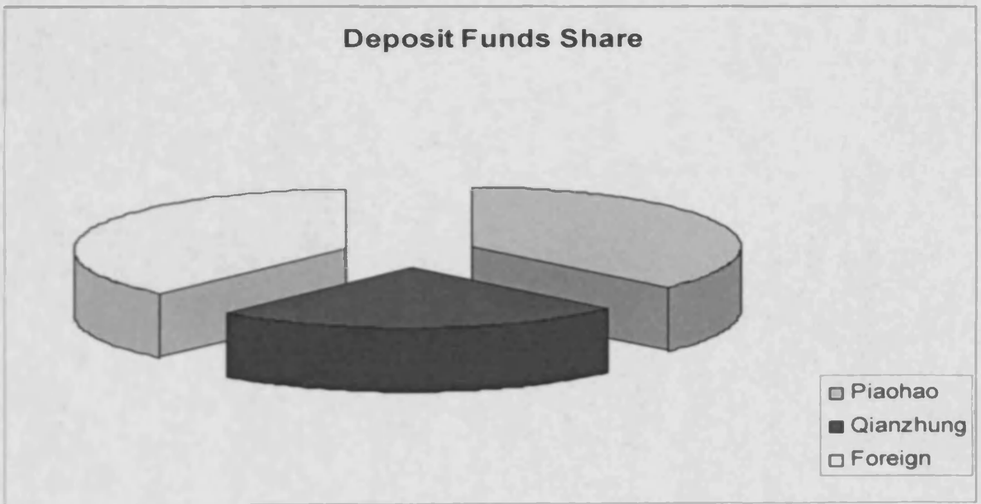
Out of a total capital of 220 million yuan, the *piaohao* had 19%, the *qianzhung* had 65% and the foreign banks had 16%. However, the share of deposit liabilities, which represented a total of 863 million yuan, was 32%, 35% and 32% respectively (Figure 2.2). The ratio of capital liabilities to deposit liabilities is an indicator of the constraints the *qianzhung* were working under. The ratio of capital to deposits for the *qianzhung* was 89% reflecting both high cost and high risk associated with small-scale banking. Whereas the *piaohao,* which had a nationwide network could exploit economies of scale and given the large amount of government business, a relatively lower risk profile, had a ratio of 18%. However, the relatively unregulated foreign banks had a ratio of 14%.

Figure 2.1



Source Peng (2003)

Figure 2.2



Source Peng (2003)

One of the reasons for the relative dominance of foreign banks in China was the regulation that covered domestic banks. The *piaohao* and *qianzhung* were organised a single proprietorships or partnerships with unlimited liability. Therefore business expansion was constrained by capital availability, whereas foreign banks did not face this regulation (typically joint-stock) but were able to compete nationwide on international trade business[5].

The first modern Chinese bank, the Imperial Bank of China (IBC) was set up in 1897, organised on a joint-stock basis. The IBC followed the customs and organising principles of the HSBC and hired foreign professionals into senior management. Its business was the financing of domestic industry and international trade. An additional privilege was the right to print its own currency bank notes in competition with the foreign banks. Ironically this turned out to be one of the reasons for its relative decline in reputation following the looting of its branches in Beijing and Tianjin during the Boxer rebellion and massive counterfeiting that led to a run on the bank in 1903. The loss of reputation of the IBC highlighted its relative financial weakness. Recognising the value of a stable domestic banking system, the Qing government set in motion a series of reforms to encourage the development of domestic banking. In 1903 the Daqing Bank was set up as a limited liability company with many of the functions of a central bank. It governed the financial business of the state treasury and unified the currency circulation with the monopoly issue of Qing currency banknotes.

The establishment of the Daqing Bank was a green light for the creation of a number of other banks both from government and private backing. In 1906 the Xincheng Bank was established in Shanghai; in 1907 the National Commercial Bank (Zhejiang Xingye Yinhang) was established in Hangzhou by the Zhejiang Railroad Company

5 The financing of domestic industry by the foreign banks was limited due to unfamiliarity with Chinese business customs, accounting procedures and laws relating to loan security. See Peng (2003) p.22.

and in 1908 the Ningbo Commercial and Savings Bank (Siming Yinhang) was set up. In 1908 the Bank of Communications was set up by the Ministry of Posts and Communications. By 1911 a total of seventeen domestic banks had been set up in China. Even during the turbulent years of the interwar period, Chinese banking business grew with a total of 266 new banks setting up in the years from 1912 to 1927.

2.3 From Socialist Planning to Market Based Banking

The mono-banking system of China began with the creation of the Peoples Republic of China in 1949[6]. All banks were nationalized culminating in the creation of the Peoples Bank of China (PBOC). Between 1949 and 1978 the PBOC operated as a commercial bank and as a central bank. The PBOC behaved less as a financial intermediary and more as an instrument of the centrally planned system. Some specialist banks existed but these were either agents for budgetary grants from the government or business branches of the PBOC. For example the Peoples Construction Bank of China, established in 1954, was the cashier of the capital construction finance department of the government ministry of finance and the Bank of China (BOC) was the international business arm of the PBOC.

Bank lending was administered according to a strict quota system. No adjustment or exchange between the various quotas was allowed. Lending was channeled to the state owned enterprises (SOE). The purpose of the mono banking system was to implement the financial targets of the central economic plan. Bank credits were

[6] An extensive review of the Chinese banking system can be found in Shirai (2002), and Allen, Qian and Qian (2005a) (2005b)

created as accounting units independently of deposits or other sources of funds, purely to fund net public spending. The fiscal-credit funds planning framework[7] is set out in equations (2.1) ~ (2.3) below.

$$R + \Delta L = G \quad (2.1)$$

$$\Delta L = \Delta D + \Delta C + \Delta B \quad (2.2)$$

$$\Delta C = I - W \quad (2.3)$$

Equation (2.1) says that planned state expenditure (G) is equal to state budgetary revenues (R) and the increase in bank credit (ΔL). Equation (2.2) sates that the increase in bank credit is financed from the increase deposits (ΔD), the increase currency in circulation (ΔC) and the increase in bank's own capital and other liabilities to domestic and international financial institutions (ΔB). Equation (2.3) states that the increase in currency is given by the difference between planned currency injections (I) and planned currency withdrawals (W). Nowhere in this system was bank credit constrained by reserve requirements or deposit financing. In reality bank credit played a junior role in financing state expenditures and it was only since the start of the reform period that it began to take on sizeable proportions. Between 1953 and 1978 the average annual contribution to state funding from bank credit was only 5.6%. In 1979 this jumped to 15.8%, in 1980 it was 22.4% and in 1991 it was 36%. Even after the start of the reform of the banking system in aggregate the state expenditure plans were increasingly supported by bank credit.

[7] Referred to as the *Zhonghe Caizheng Xindai Zijin Pingheng*. See Tam (1995)

In 1979 the monopolistic position of the Peoples Bank of China (PBOC) was removed with the establishment of three specialized banks in the early 1980s that took over its banking business. The Agricultural Bank of China (ABOC) took over the business of providing credits to the rural sector, The Bank of China (BOC) took over foreign currency transactions, and the China Construction Bank (CCB) took over financing the construction sector. The fourth specialized bank, the Industrial and Commercial Bank of China (ICBC) was set up in 1984 that eventually took over the commercial business of the PBOC in 1994.

The 1980s saw the setting up of other commercial banks, joint-stock banks, and state-owned investment banks. The Commercial Bank Law of 1995 ushered in a two-tier banking system. At the apex sits the PBOC and below it the commercial banks that are subject to prudential regulations and supervision by the PBOC. Policy banks were officially separated from commercial banks, although in reality because of a lack of a branch network, the commercial banks continued with policy lending (Chen et. al 2005). In reality commercial banks followed the direction of the PBOC in its quota lending (Perkins, 1994) and lending rates were kept below shadow prices (Perkins, 1988 1994). However, an element of profit retention was introduced into the banking system in 1981 with the sole purpose of developing business and rewarding employees in the form of bonuses. The Ministry of Finance ruled on what could constitute operating costs and an after tax profit retention rate was stated for the specialized banks[8]. Prior to the reform period the banks faced a highly centralized method of management with little discretion on personnel and business expansion.

[8] The practice of dictating the scope of operating costs and continuing to use commercial banks to prop up loss-making state and local industries gave bank managers ample room for 'rent-seeking' behaviour.

Some discretion was allowed in the reform period relating to business expansion and hiring but this discretion was tempered by the continued interference by state and local governments, which led to the continued support of local and state industries by bank credit. Preferential rates of interest for selected industries existed and in 1984 there were 47 kinds of preferential rates of interest to particular industries with the aim of encouraging capital accumulation. In an attempt to control the rapid growth of credit, the PBOC introduced credit ceilings and selective quotas for credit.

From 1996 onwards, foreign banks were allowed to open branches across China but their business was largely confined to the non-RMB market. As of the end of 2008, only 58 foreign bank branches (out of 116) and 27 locally incorporated foreign banks were licensed to engage in RMB business, of which only 7 foreign banks were approved to offer RMB retail business. Table 2.1 below shows the status of foreign banks in China.

Table 2.1 Status of Foreign Banks in China (as of end-2008)

Number of Banks	Foreign banks	Wholly foreign-funded banks	Joint-venture banks	Wholly foreign-funded finance company	Total
Head offices of locally incorporated banks		28	2	2	32
Branches and subsidiaries of locally incorporated banks		157	6		163
Foreign bank branches	116				116
Total	116	185	8	2	311

Source: CBRC annual report (2008)

Limited interest rate deregulation followed. In 2008, the Chinese banking system consisted of 5,634 legal entities, including 3 policy banks, 5 state-owned large commercial banks (big-5), 12 joint-stock commercial banks, 136 city commercial banks, 32 foreign banks and the rest was made of urban and rural credit cooperatives and other financial institutions.

Like many economies that have undeveloped financial and capital markets, the banking sector in China plays a pivotal role in financial intermediation. Table 2.2 below shows that the ratio of total bank deposits to GDP has increased from 99.1% in 1997 to 152% in 2008. The market is absolutely dominated by the five[9] state owned banks, although their share of the market has been decreasing steadily through gains made by the joint-stock banks.

Table 2.2 Chinese Banking Market

Variable	1997	2002	2004	2005	2006	2007	2008
Total Deposits [a] to GDP	99.1%	152%	158%	164%	164%	161%	152%
SOCB Employment (,000)	1,670.4	1,524.0	1,412.1	1,407.0	1,469.4	1,492.1	1483.3
SOCB Market share (% assets)	88%	71.4%	57%	56%	55%	53%	51%
ROAA SOCB*	0.17%	0.25%	0.61%	0.58%	0.77%	0.90%	1.11%
Cost-Income Ratio SOCB*	52.7%	61.9%	45.4%	46.4%	46.1%	42.8%	35.9%

Sources: IMF *International Financial Statistics*, Annual Accounts, *The Banker*, China Regulatory Banking Corporation website and Annual Reports, *Almanac of China's Finance and Banking*, National Bureau of Statistics of China, Author's calculation, a) all data include foreign currency deposits, * weighted average by asset share

Faced with the potential of increased competition from 2007 onwards, the big banks have begun the process of restructuring and reducing unit costs. Employment in the state-owned banks has declined from a peak number of 1,524 thousand in 2002, return

[9] Up until 2004, the CBRC classified the big-4 as the state owned banks which included Bank of China, Industrial and Commercial Bank of China, China Construction Bank and Agricultural Bank of China. From 2005-2006 the classification of state-owned bank was extended to include the Bank of Communications.

on average assets have shown some improvement (partly as a result of the removal of a proportion of non-performing loans (NPLs) from the balance sheet and its transference to asset management companies and partly through a greater flexibility in setting loan rate margins). Significantly, the major banks have worked to reduce costs as shown in the sharp reduction in the weighted average cost-income ratio.

Up until 1995, control of the banking system remained firmly under the government and its agencies[10]. Under state control, the banks in China served the socialist plan of directing credits to specific projects dictated by political preference rather than commercial imperative. Since 2001 foreign banks and financial institutions were allowed to take a stake in selected Chinese banks. While control of individual Chinese banks remain out of reach for the foreign institution[11], the pressure to reform management, consolidate balance sheets, improve risk management and reduce unit costs has increased with greater foreign exposure. As of end-2008, 4 large commercial banks, namely the ICBC, BOC, CCB and BoCom, introduced 9 foreign institutional investors; 24 small and medium-sized commercial banks formed partnership with 33 foreign institutional investors; and 3 rural cooperative financial institutions introduced 3 foreign institutional investors, altogether taking in foreign equity investment of USD32.78 billion. Table 2.3 shows the entry of overseas investors in 2003 ~ 2008, while table 2.4 lists the detailed extent of foreign ownership of individual banks.

Over the period of 2003 to 2008 the number of domestic banks that have had an injection of foreign capital has increased from 5 to 31. However, this figure has

[10] According to La Porta, et. al (2002), 99% of the 10 largest commercial banks were owned and under the control of the government in 1995.

[11] There is a cap of 25% on total equity held by foreigners and a maximum of 20% for any single investor, except in the case of joint-venture banks.

increased with IPOs and foreign investment increasing through 2008 to the present day.

Table 2.3 Entry of Overseas Investors (2003 – 2008)

Unit: Number of banks, USD100million

Items / Year	2003 Cumulative amount	2004 Current amount	2005 Current amount	2006 Current amount	2007 Current amount	2008 Current amount	2008 Cumulative amount
Number of banks with foreign capital	5	6	7	6	5	6	31
Total amount of investment	2.6	23.5	116.9	52.2	17.6	115.2	327.8
Total amount of capital raised in the listed overseas markets	-	-	113.9	299.0	42.2	0	455.1
Total amount	2.6	23.5	230.8	351.2	59.8	115.2	782.9

Source: *CBRC annual report 2008*

Table 2.4 Foreign Bank Ownership Stake

Chinese Bank	Foreign Bank (Stake %)	Announcement Date
Bank of Shanghai	HSBC (8%), International Finance Corporation (7%)	December 2001
Shanghai Pudong Development Bank	Citigroup (3.78%)	December 2003
Ping An Bank	HSBC (16.78%)	December 2003
Industrial Bank	Hang Seng Bank (12.78%)	April 2004
Bank of Communications	HSBC (18.60%)	June 2004
Jinan City Commercial Bank	Commonwealth Bank of Australia (11%)	September 2004
Xi'an City Commercial Bank	Bank of Nova Scotia (12.5%), International Finance Corporation (12.5%)	October 2004
Shenzhen Development Bank	Newbridge Capital (16.76%)	December 2004
Bank of Beijing	ING (16.07%), International Finance Corporation (4.04%)	March 2005
Hangzhou City Commercial Bank	Commonwealth Bank of Australia (19.90%), Asia Development Bank (4.90%)	April 2005
China Construction Bank	Bank of America (8.19%), Temasek (5.65%), Reca Investment Limited (0.34%)	June 2005
Nanchong City Commercial Bank	DEG (10%), SIDT (3.3%)	July 2005

ICBC	Goldman Sachs (4.9%), Dresdner Bank Luxembourg S.A.[12] (1.9%), American Express (0.4%)	August 2005
Bank of China	Royal Bank of Scotland (8.25%), Temasek Holdings (4.13%), UBS (1.33%), Asia Development Bank (0.20%), The Bank of Tokyo-Mitsubishi UFJ Ltd. (0.19%)	August 2005
Tianjin Bohai Bank	Standard Figureered (19.99%)	September 2005
Bank of Nanjing	BNP Paribas (12.61%)	September 2005
Hua Xia Bank	Deutsche Bank (9.90%), Sal Oppenheim Jr. (4.08%)	October 2005
Tianjin City Commercial Bank	Australia & New Zealand Banking Group Ltd (19.9%)	November 2005
Bank of Ningbo	Overseas-Chinese Banking Corp Ltd (10%)	January 2006
United Rural Bank of Hangzhou	Rabobank (10%), International Finance Corporation (5%)	July 2006
Shanghai Rural Commercial Bank	Australia & New Zealand Banking Group Ltd (19.9%)	July 2006
China CITIC Bank	BBVA (4.83%), Mizuho Corporate Bank (0.17%)	November 2006
Guangdong Development Bank	Citigroup (20%), IBM (4.74%)	November 2006
Chongqing City Commercial Bank	Dah Sing Bank (17%), Carlyle Group (7.99%)	December 2006
Dalian City Commercial Bank	Bank of Nova Scotia (20%), International Finance Corporation (5%)	January 2007
Qingdao City Commercial Bank	Intesa SanPaolo SpA (19.99%), Rothschild Merchant Banking (5%)	July 2007
Chengdu City Commercial Bank	Hong Leong Bank Bhd (19.99%)	October 2007
Bank of Yingkou Co Ltd	Bumiputra-Commerce Hldg Bhd (19.99%)	March 2008
Xiamen City Commercial Bank	Fubon Bank (Hong Kong) Ltd (19.99%)	April 2008
Bank of Jilin	Hana Bank (19.7%)	July 2008
Changshang Commercial Bank	BRED Banque Populaire (20%)	August 2008

Source: *Thomson One Banker, Company Website, Factiva*

2.4 Banking and the Economy

This section deals with role of banking in the economy. Like many developing economies where the capital markets are as yet undeveloped, the principal vessel for

[12] A wholly-owned subsidiary of Allianz Group

financial intermediation is the banking system. Table 2.5 below shows the total savings of the domestic sector and the flow of funds counterparts. In 2004, nearly half of domestic savings is household savings and almost all of this is held in the form of bank deposits. Private securities accounted for 20.9% of domestic savings and nearly 9% accounted for foreign investments including foreign currency deposits.

Table 2.5 Domestic Savings and Flow of Funds
(100 million Yuan, Flow of funds as % Savings in parenthesis)

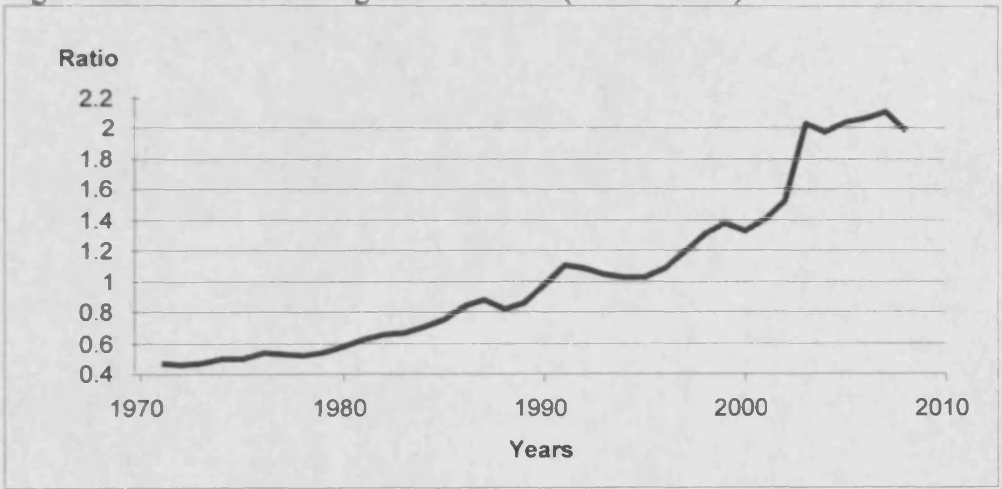
Item	2000	2004
Savings (Domestic Sector)	34194.44	74450.4
Domestic Currency	1197.16 (3.7%)	1722.3 (2.3%)
Domestic Deposits	16424.54 (48.0%)	33761.6 (45.3%)
Securities	6149.29 (18.0%)	15596.0 (20.9%)
Other Investments	4871.37 (14.2%)	1938.6 (2.6%)
Foreign Investments	3178.76 (9.3%)	4547.0 (6.1%)

Source: China Statistical Yearbook 2003, 2007 by National Bureau of Statistics China

Table 2.5 gives a snapshot of addition to financial assets from domestic savings. A more revealing picture is provided by Figure 2.3, which shows the ratio of aggregate banking assets to GDP from 1971 to 2008. The Figure shows that bank assets (credit) have been growing faster than GDP throughout this period but there was a shift in the trend rate of growth in the latter half of the 1980s. Despite the attempts by the PBOC to place constraints on lending, bank credit has grown rapidly and accelerated in 2002-3. The rapid increase in bank credit relative to GDP indicates the important role of the banking sector in the economic development of China.

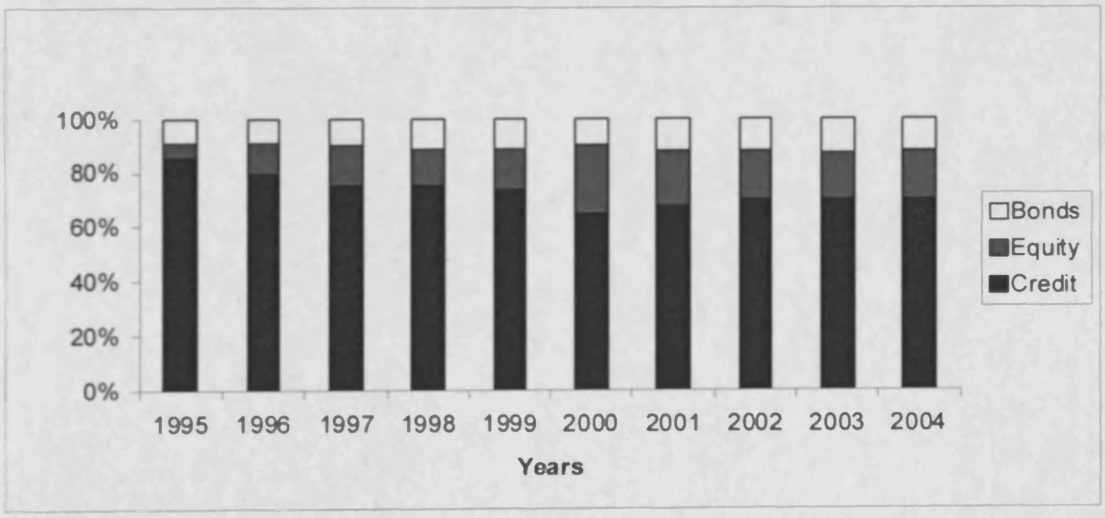
The growth of bank credit is reflected in the continued dominance of the banks as the main source of financing by the private and public sectors. Figure 2.4 shows the percentage break down of the sources of financing. 70% of external financing by the borrowing sectors was from the banks in 2004. While equity has increased in recent years as an alternative source of financing, the dominant source remains bank loans. In this respect China is unique in the economic region. Figure 2.5 shows the relative position of China compared with other economies in the region for 2004.

Figure 2.3 Ratio of Banking Assts to GDP (1971 – 2008)



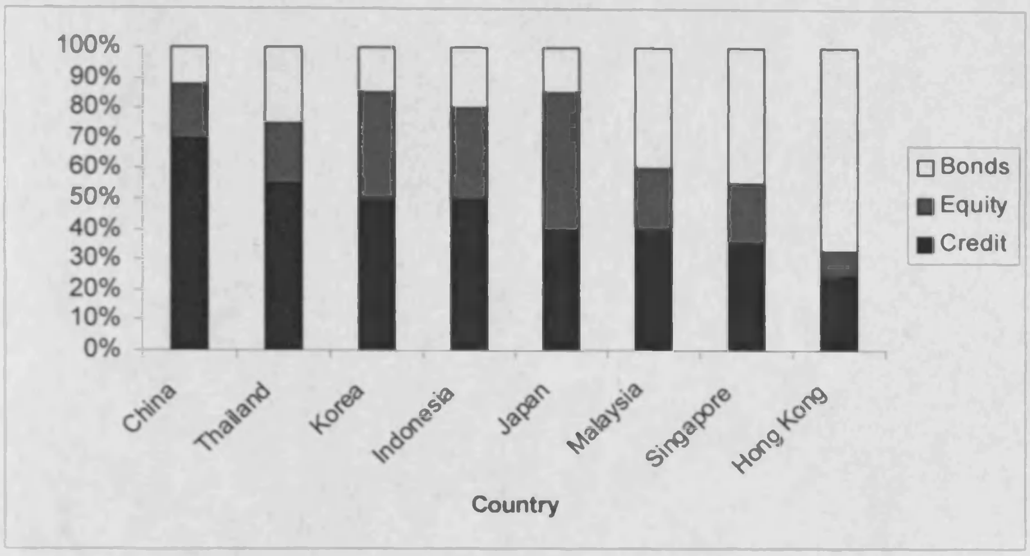
Source: China Abstract of Statistics (Various), IMF and CBRC

Figure 2.4 Source of Financing in China



Source: Asian Development Bank

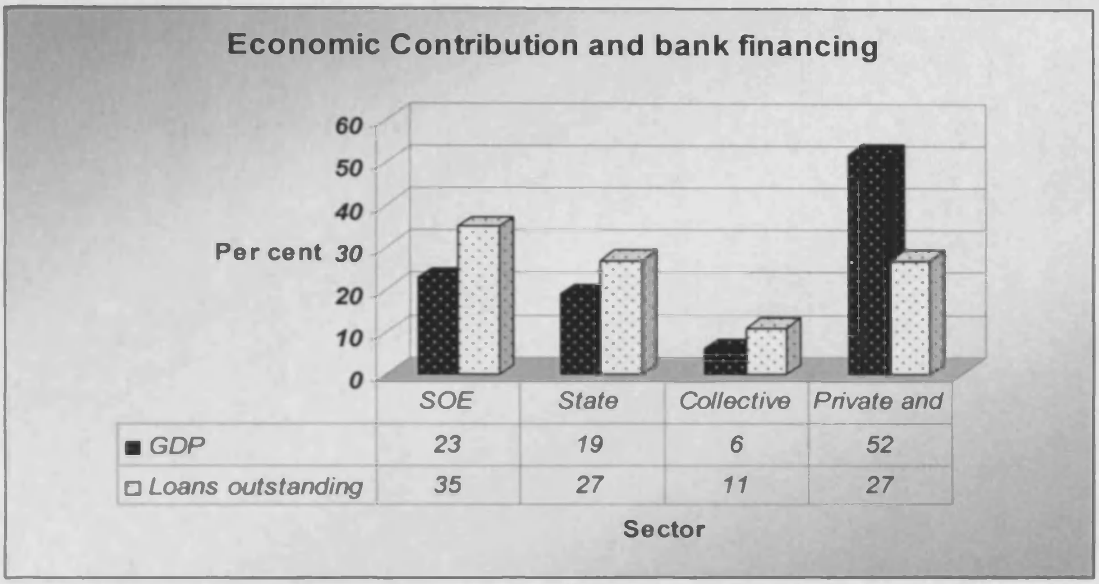
Figure 2.5 Inter-regional Domestic Financing



Source: Asian Development Bank

The use of the banks as a tool of socialist planning meant that the state-owned enterprise sector was the principal recipient of bank credit, even though they contributed less to GDP than other sectors. A recent study by McKinsey (2006) decomposed the contribution of the various sectors to GDP in China in 2003 into State Owned Enterprise, State dominated shareholding firms, Collective enterprises and Private and foreign enterprises. The analysis from McKinsey, shown in Figure 2.6, reveals that SOEs receive 35% of the loans yet contribute only 23% to GDP. Together with the state dominated shareholding enterprises, these two sectors contribute 42% of GDP but have 62% of outstanding bank credit, whereas the private and foreign sector contributes 53% of GDP but only command 27% of outstanding bank credit. The Mckinsey (2006) thesis is also supported by Allen, Qian and Qian (2005b), who also argue that the most successful part of the economy is the hybrid non-state sector, which is sparsely funded by the banking sector.

Figure 2.6 Economic Contribution and Bank Financing



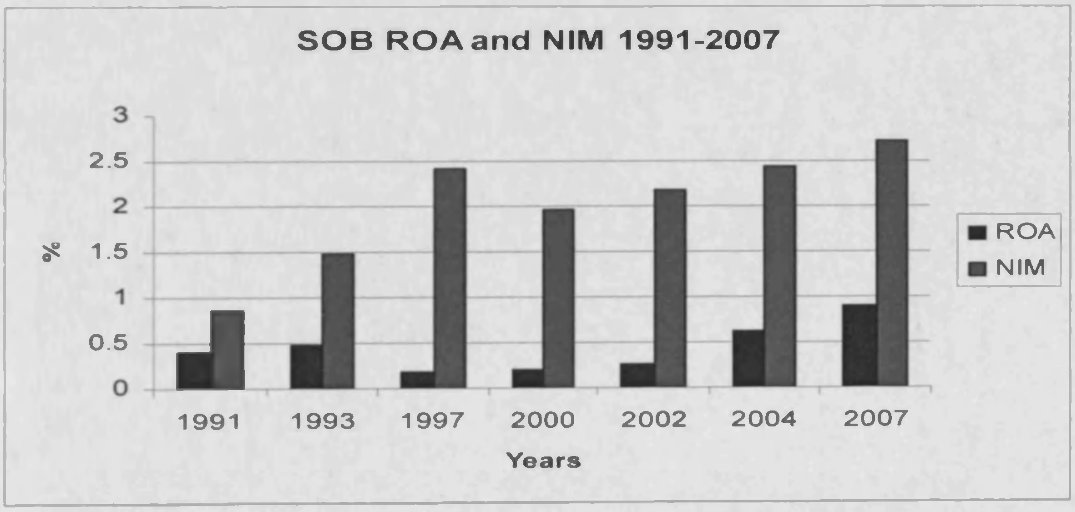
Source: Mckinsey & Co (2006)

2.5 Structure and Performance

The evolution of Chinese banking from state planning to a market system has been gradual in keeping with the step-by-step reform policy initiated by the government. Table 2.2 and Figure 2.3 show the evolution of liabilities and assets and provide an indicator of the strong role the banking sector plays in the Chinese economy. However, this evolution was carried out with only gradual reforms to lending policies and the pricing of loans. The reforms to the banking system followed on from the setting up of the three-tier system. After the urban cooperatives were transformed into commercial banks, some foreign banks were granted licenses to operate under certain restricted areas of business. Initially, foreign banks were allowed only to serve foreign businesses on foreign currency transactions. Licenses were extended to non-state owned commercial banks. There was a gradual movement of removing government intervention in credit allocation and some loosening of interest rate controls. Importantly, there was a convergence on a common system of accounting although international standards of accounting are not as yet uniformly adopted. Appendix 2-I gives an up to date chronological list of major financial reforms.

However, the deregulation of interest rates on commercial deposits and on negotiated loans began in a piecemeal way from the year 2000 and was originally confined to non-RMB business. The strict control of lending rates and credit, particularly to state-owned enterprises meant that net interest margins (NIM) were set artificially low and did not reflect the risk premium that would be normally expected in economies in similar stages of development as China. Figure 2.7 shows that return on average assets (ROA) and net interest revenue as a percentage of average assets (Net Interest Margin NIM) weighted by assets for the 5 SOCBs have been increasing over the period. While NIM and ROA have converged on Western bank levels from below, it can be argued that they continue to under price risk in an economy at the current stage in development. For example NIM in India is in excess of 3 percent for the same period (Shirai, 2002).

Figure 2.7 ROA and NIM of SOCBs (1991~2007)

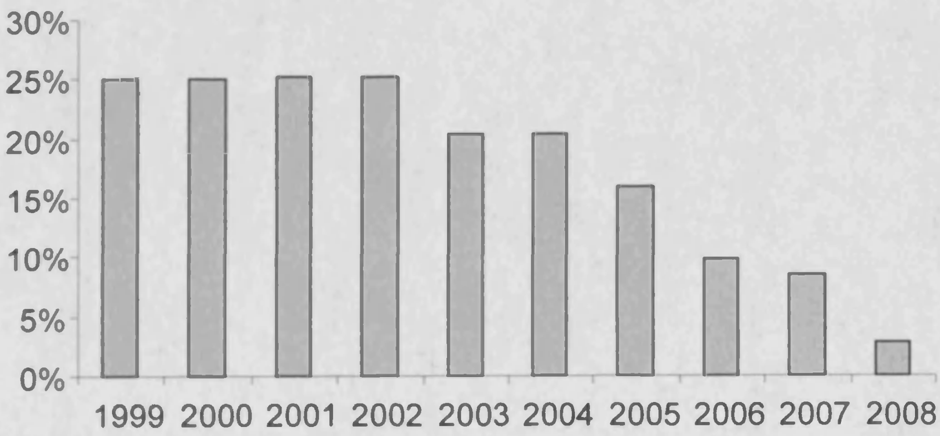


Source: Bankscope and author calculations

Net interest margins look respectable compared with developed economies like the UK but do not reflect the implicit risk premium that would be usually associated with economies in the stage of development China is in. It is arguable that the SOEs are unlikely to be allowed to fail because of the government implicit guarantee which under-rights their losses. This creates a strong problem of moral hazard where the SOE does not have to improve its performance and the SOCB doesn't have to demand a risk premium because of the implicit government guarantee.

The use of the state-owned banks to underpin credits to the state-owned enterprises has resulted in an uncomfortable increase in non-performing loans (NPLs). Accurate figures for NPLs in the distant past are unavailable; however official figures emerged from January 1998[13]. Figure 2.8 shows the percent ratio of NPLs to total loans provided by official sources.

Figure 2.8 NPL Ratio of SOCBs



Source: Pei and Shirai (2004) and CBRC

[13] Pei and Shirai (2004)

These estimates have been challenged by a number of studies. Shi Huaqiang (2003) estimated the NPL ratio of the SOCBs to 39% in 1999 and 29.2% in 2000. Moody's Investor Service estimated the NPLs of SOCBs to be between 35% and 70% in 1996. Recognition of the NPLs problem and the potential it has to destabilize the financial system, the government established four Asset Management Companies in 1999 to aid the disposal of the NPLs from the big-4 SOCBs[14]. Prior to this a capital injection of RMB 270 million was made in 1998 to the big-4. In 1999 the AMCs transferred RMB 1.4 trillion ($169 billion) from the big-5 onto its books[15]. However, NPLs continued to grow and in 2003-4 a further $45 billion of foreign reserves was injected to the BOC and CCB and $15 billion to ICBC in 2005. A credit boom in 2002-3 saw the assets of the banking sector grew rapidly which has had the effect of reducing the NPL ratio to 7.5% by mid 2006, but in turn has raised doubts about the path of future NPLs[16]. It is also the case that the JSCBs have had a lower NPL ratio, indicating either a better starting position or superior management[17].

Despite the movement in reforms and the encouragement of market based banking, the market structure is highly concentrated and dominated by the big 5 SOCBs. Table

[14] Each AMC was exclusively assigned to an individual bank. Cinda was associated with China Construction Bank, Great Wall with the Agricultural Bank of China, Oriental with the Bank of China, and Huarong with the Industrial and Commercial Bank of China.

[15] Most of the financing of the AMCs was through the issue of 10-year bonds but a sizeable portion is estimated to be cash financed by the PBOC (RMB 563 billion) , which has implications for monetary control. See Ma and Fung (2002).

[16] The furore following the Ernst and Young report that estimated China's NPLs to be $911 billion (40% of GDP) in 2006 is a good example.

[17] Estimates of the NPL ratio of the JSCBs in 1997 obtained by annual accounts, web sources and bankscope suggest that this was 3% in 1997 and 51% for the SOCBs. In 2006 CBRC estimates put the NPL ratio for the JSCBs at 3.1% and SOCBs at 9.5%.

2.6 shows the 5-bank concentration ratio and Herfindal-Hirschman index (HHI)[18] measure for selected years. There has been a modest decline in concentration in the very recent years but the dominance of the big 5 is still evident. This dominance is however being challenged by the growth of the joint-stock banks and latterly by the stronger city commercial banks (CCBs – see also Chapter 6). By the end of 2008 the JSCBs had increased their collective share to 14% of the bank asset market. Figure 2.9 shows banking sector market shares in 2008.

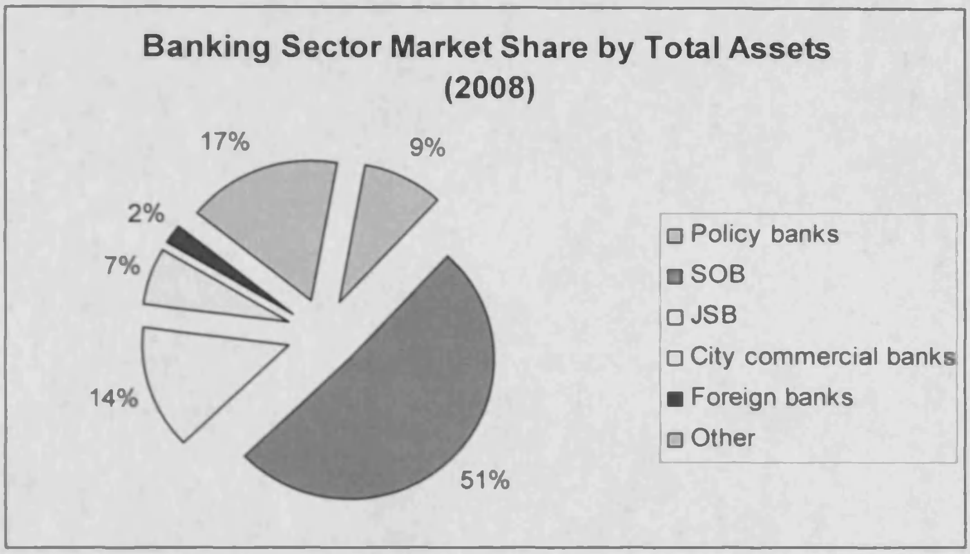
Table 2.6 Measures of Market Structure

Year	5-bank Concentration	HHI
1991	0.91	5420.8
1993	0.91	2268.7
1998	0.87	2027.2
2000	0.84	1904.2
2002	0.78	1720.0
2004	0.79	1596.0
2005	0.54	783.5
2006	0.53	649.7
2007	0.53	708.3
2008	0.51	660.3

Source: Demirgüç-Kunt and Levine (2001) and author calculations

[18] The U.S. Department of Justice considers a market with a result of less than 1,000 to be a competitive marketplace; a result of 1,000-1,800 to be a moderately concentrated marketplace; and a result of 1,800 or greater to be a highly concentrated marketplace. As a general rule, mergers that increase the HHI by more than 100 points in concentrated markets raise antitrust concerns.

Figure 2.9



Source: CBRC Annual Report 2008

2.6 Summary and Prognosis

This chapter has summarized the contextual framework in which the Chinese banks have operated. Banking in China has a venerable history but modern Chinese banking began in the late 19^{th} century in answer to the competition from foreign banks. Banking flourished even in the turbulent years of the 1920s and 30s covering the Japanese war and the civil war. The use of the banking system as an arm of socialist economic planning reduced the banks to an arm of the government service and bank managers as civil servants. For 30 years since the establishment of the Peoples Republic of China, the banking sector acted as the financial arm of the government.

The reforms of the 1979-88 period focused on the changing the administrative structure and operations of the banking system. A two-tiered banking system replaced the mono-banking system of the strong planning period. However, the system still remained corralled by the central economic plan. In 1985 the banks were given greater scope in raising and allocating capital. Further reforms followed in the period

1988-94, which also saw the development joint-stock banks that operated nationwide. The Central Bank Law of 1995 gave the PBOC greater autonomy. A process of deregulation followed (see Appendix 2-I) with the aim of improving the efficiency of the Chinese banking system and raising its profit capacity. According to Berger et al (2005) the tentative opening up of the banking market to foreign competition has had positive impacts on performance. The full opening up of the domestic banking market to foreign competition scheduled for end-2006 according to the WTO rules can be expected to add further competitive pressure on the Chinese banks. The theory of market contestability (Baumol, 1982) suggests that incumbent banks will restructure weak balance sheets, reduce costs, and improve efficiency in preparation from the threat of entry. Chinese banks should exhibit less inefficiency in 2005 than in 1997. The purpose of this study is to evaluate this process.

Appendix 2-I Significant events of major financial reforms

Year	Type	Details
1949	Major Banking Reforms	The Chinese socialist banking system was established following the system in the former Soviet Union
1978	Major Banking Reforms	The reform initiatives were undertaken by Deng Ziaoping
1979-1981	Foreign Entry	Foreign banks were allowed to open representative offices
1982-1992	Foreign Entry	Foreign banks were allowed to open operational branches in Special Economic Zones. Later, this geographical restriction was extended to most coastal cities. Early instances included Hong Kong banks operating in nearby Shenzhen.
Early 1980s	New bank Entry	Industrial and Commercial Bank of China (ICBC) was brought in the market in order to finance the industrial sector
1985	Scope of Business	The restrictions that limit each bank to its own designated sector (i.e. industrial commercial) were lifted and banks were allowed to expand their scope of business and to compete with each other in providing loans and deposit services
1986	New bank entry	Bank of Communications (BCOM) was re-established
1987	New bank entry	Schezhen Development Bank (SDB) and China Merchants Bank (CMB) were established.
1988	New bank entry	Guangdong Development Bank (GDB) was established
1991	New bank entry/IPOs	SDB started to list on Shenzhen stock exchange
1992	Restructuring	Guangdong Development Bank (GDB) was converted into a shareholding bank.
1994	Foreign Entry	The "Regulation Directives of Foreign Financial Institutions in People's Republic of China" were announced effective by the State Council, thus became the first regulation document regarding foreign financial institutions issued by the State Council of China. (This document was updated by "Revisions of 'Regulation Directives of Foreign Financial Institutions in People's Republic of China' by the State Council" that became effective on February 1, 2002 to honour the WTO agreement.
1994-1995	Foreign Entry	Foreign banks were permitted to operate in 23 cities
1995	Legislation	Passed the Commercial Bank Law, PBOC Law, which separated commercial banks from policy banks, thus establishing a three-tier banking system.
1995	Major Banking Reforms	The major state-owned banks were officially termed as "commercial banks" next to their respective names and were expected to operate on market principles and to maximize profit.
1995	Major Banking Reforms	The central government began to allow local governments to establish local banks.
1995	Privatization	Minsheng Bank was established as the first domestic private bank
1995	Prudence	Capital Adequacy Requirement was applied to all commercial bank
1995	Scope of Business/Prudence	Capital Adequacy Requirement was applied to all commercial banks. The government required all banks to divest themselves of investment banking affiliat4es and prohibited commercial banks from engaging in securities trading and underwriting, investment in nonblank financial enterprises and productive enterprises, investment tryst business under the Commercial Bank Law.
1996	Foreign Entry	Foreign banks were allowed to open branches al over

		China.
1996	New Bank Entry	China Misheng Banking Corporation (CMBC) was established
1996, Jan	Integration	The Interbank Markets were unified into a national market through a computer network system
1996, June	Interest Rates	Interest Rate was deregulated for Interbank Market—the Interbank Offered Rate was decided by the market conditions since then
1997, June	Interest Rates	InterBank Treasury Market was established, and at the same time, the repurchasing and trading interest rates of treasuries in the InterBank Market were allowed to float with market conditions.
1998	Interest Rates	The floating range within which financial institutions were allowed to set their lending interest rates were raised from 10% to 20%, while the floating range of lending interest rate of rural credit cooperatives were raised from 40% to 50%.
1998, March	Interest Rates	The 'rediscount rate and discount rate mechanism' was reformed to allow these rates to float.
1998, Sept	Interest Rates	The interest rates of financial bonds issued by policy-banks were allowed to float with market conditions.
1998	Liberalization	PBC removed the credit plan for both working capital loans and fixed investment loans, replacing it with an indicative non-binding target, which only serves as a reference for commercial banks.
1998	Prudence	The loan classification system was reformed by introducing an international accepted five-tier classification of loans. However, few banks really followed these norms.
1998	Prudence	State-owned banks introduced 'lifetime responsibility system' which penalized bank managers responsible for bad loans even after their retirement.
1998	Scope of Business/Diversification	Major State-owned commercial banks began to provide money-managing services, such as foreign exchange transactions and personal finance.
1999, Oct	Interest Rates	Interest rates were allowed to be negotiated for large deposits from insurance companies: bilateral negotiations were allowed between insurance companies and commercial banks for deposits with values more than RMB 30,000,000 and at least 5 years of deposit commitment.
1999, Sept	Interest Rates	Public bidding was invited for the interest rate on the treasury in the interbank treasure market for the first time.
1999	Interest Rates	Lending interest rate for sub-county financial institutions were allowed to float within the range of 30%, and meanwhile, the allowance of 30% floating range of lending interest rate for small businesses were also applied to all mid-scale enterprises.
1999	Less Local government Intervention	PBOC (central bank) restructured its branches to centralize credit allocation decisions from branch level to headquarters.
1999, November	Bank IPO	Shanghai Pudong Development Bank started to list on Shanghai Stock Exchange.
2000	Liberalization	PBC fully liberalized interest rates on foreign currency. loans and interest rats on foreign currency deposits for $3 million or more.
2000, May	Self-discipline	China Association of Banks, a national-level non-government organization was established to promote self-discipline and cooperation in the domestic banking sector, also the authority to determine the interest rates on deposits of less than $3 million.

2000, September	Interest Rates	Interest rates for foreign exchange began its liberalisation process in China: firstly, lending interest rates of foreign exchange were allowed to float; and meanwhile, the deposit Interest rates of foreign exchange were allowed to float: and meanwhile the deposit interest rates of large foreign exchange deposits of more than £3,000,000 were allowed to be set by negotiation between depositors and banks.
2000, December	Bank IPO	China Minsheng Banking Corporation started to list on Shanghai Stock Exchange.
2001 , July	Scope of business	PBC issued a provisional regulation on commercial bank' intermediate business to promote business innovation, improve bank services and competitiveness, and reduce financial risks
2001	Prudence	Prudential regulations and accounting standards were tightened in the face of the increasing challenges from globalisation and China's accession to WTO
2002, February	Interest Rates	Both deposit rates and lending rates were decreased by PBOC.
2002, April	Bank IPO	China Merchants Bank started to list on Shanghai Stock Exchange.
2003, March	Major Banking Reforms	1st Meeting of the 10th National People's Congress approved the establishment of the CBRC
2003, April	Major Banking Reforms	CBRC was officially inaugurated in Beijing.
2003, May	Major Banking Reforms	CBRC adopted its banking reform strategy of "grasping both ends and facilitating development of the majority", prioritizing the reform of state owned banks and the RCCs on its work agenda. In the meantime, the reform of other institutions was scheduled and promoted together with the reform of the priority institutions.
2003, September	Bank IPO	Hua Xia Bank started to list on Shanghai Stock Exchange.
2003, December	Foreign Entry	Overseas financial institutions were allowed to participate in the reform and restructuring of local banking institutions on a commercial and voluntary basis.
2004, March	Major Banking Reforms	CBRC issued "the Guidelines on the Reform and Rules of Corporate Governance of Bank of China and China Construction Bank" to improve the corporate governance structure of state owned commercial banks by benchmarking against international best practices.
2004, June	Restructuring/New Bank Entry	Zheshang Bank was established from the reorganization of Zhejiang Commercial Bank following the CBRC's approval.
2004, October	Bank IPO	China Construction Bank started to list on Hong Kong Stock Exchange.
2004, October	Interest Rates	Both deposit rates and lending rates were increased by PBOC.
2004, December	Foreign Entry	Renminbi business operation of foreign-funded financial institutions was expanded to Kunming, Beijing, Xiamen, Xi'an and Shenyang.
2005, January	Foreign Entry (Hong Kong)	CBRC gave approval to the mainland branches of Hong Kong SAR banks to conduct insurance brokerage business.
2005, February	Major Banking Reforms	CBRC, together with PBOC and CSRC, jointly issued "the Rules on the Trial Establishment of Fund Management Companies by Commercial Banks", to set up rules for establishing pilot fund management companies by commercial banks. Mixed operation is the future trend.
2005, May-June	Major Securities Reforms	The non-tradable shares reform programme began on May 9 to end the split share structure, one of the major factors blamed for the country's sluggish stock market performances. Four companies were selected for the first

		round of the experiment, and 42 more were involved in the second phase launched on June 20.
2005, July	Major Exchange Rate Reforms	With approval from the State Council, China will implement a regulated, managed floating exchange rate system based on market supply and demand and in reference to a package of currencies.
2005, December	Foreign Entry	Renminbi business was opened to foreign-funded financial institutions in Shantou and Ningbo and also in Harbin, Changchun, Lanzhou, Yinchuan and Nanning, ahead of the WTO accession schedule.
2005, December	Restructuring	CBRC approved the merger between 6 urban commercial banks and 7 UCCs within the jurisdiction of Anhui into Huishang Bank, which was the first commercial bank in China at provincial level.
2005, December	New Bank Entry	CBRC approved the Tianjin-based Bohai Bank Co. Ltd to start its business.
2006	Reserve Ratio	The reserve ratio was increased three times in one year to solve liquidity.
2006, April	Interest Rates	Lending rates were increased by PBOC.
2006, April	Major Reforms	Domestic institutions and citizens were allowed to entrust commercial banks to make portfolio investments overseas.
2006, July	Bank IPO	Bank of China started to list on Shanghai Stock Exchange.
2006, August	Interest Rates	Both deposit rates and lending rates were increased by PBOC.
2006, September	Bank IPO	China Merchants Bank started to list on Hong Kong Stock Exchange.
2006, October	Bank IPO	ICBC started to list on Shanghai Stock Exchange and Hong Kong Stock Exchange on one day.
2006, November	Restructuring/Foreign Bank	Citigroup's consortium successfully closed the agreement to acquire an 85.6% stake in Guangdong Development Bank. Citigroup owns a 20% stake in GDB, as do China Life, State Grid, and CITIC Trust. IBM holds a 4.74% stake. Thus, Citigroup was the first foreign bank to have significant management influence at domestic bank.
2006, December	Foreign Entry	9 foreign banks received the CBRC's approval to convert their branches into local incorporations.
2006, December	New Bank Entry	China Postal Savings Bank was approved to open its business, and China Post Group, as the sole shareholder, of the new China Postal Savings Bank Co., Ltd.
2007, February	Bank IPO	Industrial Bank started to list on Shanghai Stock Exchange.
2007, February	Scope of Business	Chengdu Suburban Credit Cooperatives Union became the first authorized credit cooperative to engage in credit assets transfer business.
2007, March	New Bank Entry	Sichuan Yilong Huimin Village Bank, the first village bank in China, commenced its business.
2007, March	New Bank Entry	Sichuan Yilong Rural Lending Company, the first lending company in China, commenced its business.
2007, March	Interest Rates	Both deposit rates and lending rates were increased by PBOC.
2007, March	New Bank Entry	Baixin Rural Mutual Credit Cooperative in Yanjia Village of Lishu County, Jilin Province, commenced business as the first RMCC in China.
2007, March	Foreign Banks	CBRC approved four foreign banks, namely Citi Bank, HSBC, Standard Figureered Bank and Bank of East Asia to be locally incorporated. In such capacity, the four banks were permitted to engage in the RMB retail business.
2007, April	Bank IPO	China Citic Bank started to list on Shanghai Stock Exchange.
2007, May	Interest Rates	Both deposit rates and lending rates were increased by

		PBOC.
2007, May	Prudence	CBRC formally established the Reference Benchmark for Measuring Market Risk of Banking Institutions.
2007, May	Bank IPO	Bank of Communication started to list on Shanghai Stock Exchange.
2007, June	Foreign Entry	CBRC issued "the Notice on the Issues Relevant to the Engagement by Wholly Foreign-funded Banks and Joint-venture Banks in Bankcard Business", which signified the permission to wholly foreign-funded banks and joint venture banks to conduct bankcard business where they are subject to the same licensing criteria as the Chinese banks.
2007, July	Bank IPO	Bank of Ningbo started to list on Shenzhen Stock Exchange.
2007, July	Bank IPO	Bank of Nanjing started to list on Shanghai Stock Exchange.
2007, July	Interest Rates	Both deposit rates and lending rates were increased by PBOC.
2007, August	Interest Rates	Both deposit rates and lending rates were increased by PBOC.
2007, September	Bank IPO	Bank of Beijing started to list on Shanghai Stock Exchange.
2007, September	Interest Rates	Both deposit rates and lending rates were increased by PBOC.
2007, September	Bank IPO	China Construction Bank started to list on Shanghai Stock Exchange.
2007, December	Interest Rates	Both deposit rates and lending rates were increased by PBOC.

Source: *CBRC, PBOC, Factiva*

The information for this appendix was updated from Berger et. al (2005)

Chapter 3

Bank Efficiency

"There are only two qualities in the world: efficiency and inefficiency; and only two sorts of people: the efficient and the inefficient." *George Bernard Shaw*

3.1 Introduction

The term efficiency is commonly used in areas of engineering, physics, management, computing, accounting, economics and statistics. Dictionaries provide a very loose definition of the term (the ratio of the effective or useful output to the total input in any system), partly because of its strong contextual application. For the economist the term efficiency is a relationship between ends and means. Something is termed inefficient if the desired ends could be achieved with less means, or that the means employed could produce more of the ends desired[19]. This approach leads to the definition of efficiency in production as an allocation of resources such that no other allocation would permit more of one good to be produced without necessarily reducing another.

The economic concept of efficiency is operationalised with the use of a non-parametric methodology called *Data Envelope Analysis* (DEA). The technology of DEA is based on the seminal work of Farrell (1957) and elaborated later by Banker et al (1984) and Färe et al (1985). The purpose of this chapter is to outline the DEA methodology and its derivatives the Malmquist productivity measure and network DEA which is used in the following three empirical chapters in the examination of the

[19] Concise Encyclopaedia of Economics www.econlib.org-library

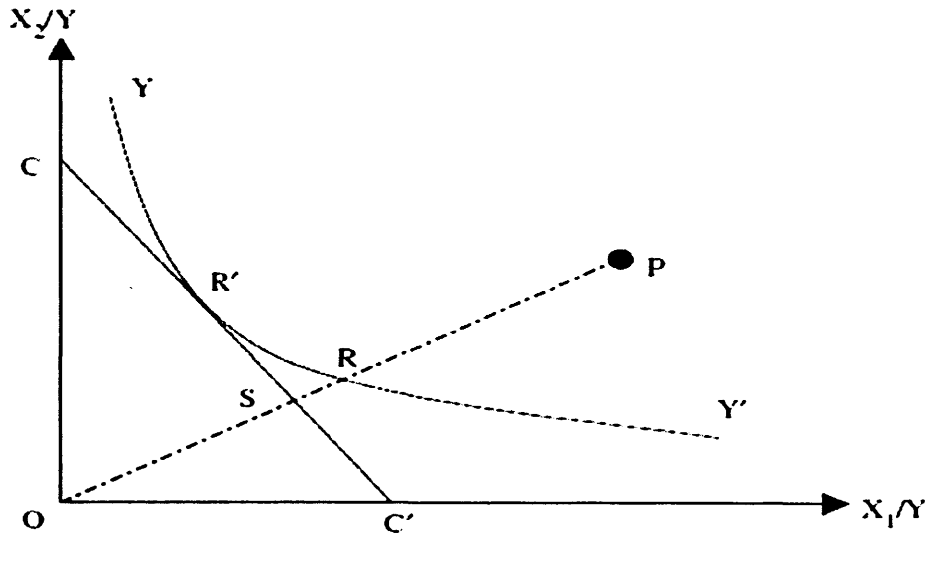
Chinese banking system. This chapter will also review the application to the banking literature in general and the main results for the Chinese banking sector in particular.

The next section sets out the theoretical concepts in a two-dimensional graphical framework. Section 3 outlines the mathematical problem in a multi-dimensional framework. Section 4 describes how the non-parametric approach can be used to examine the growth of productivity in the time dimension. Section 5 describes the principles of network DEA. Section 6 reviews the application of DEA in banking focusing on China in particular. Section 7 summarizes.

3.2 Efficiency: A two-dimensional description

Farrell (1957) developed the basis of standard efficiency methodology by decomposing overall efficiency (OE) of a production unit into two components: technical efficiency (TE) and allocative efficiency (AE). Farrell characterized the different ways in which a productive unit can be inefficient either by obtaining less than the maximum output available from a given set of inputs (technically inefficient) or by not purchasing the best package of inputs given their prices and marginal productivities (allocatively inefficient). The analysis of efficiency by Farrell (1957) can be explained in Figure 3.1:

Figure 3.1 Overall, Technical and Allocative Efficiency



Assuming constant returns to scale (CRS), the production set is fully described by the unit isoquant YY′ that captures the minimum combination of inputs per unit of output needed to produce a unit of output. In this framework, every combination of inputs along the unit isoquant is considered as technically efficient while any point above and to the right of it, such as point P, defines a technically inefficient producer since the input combination that is being used is more than enough to produce a unit of output. Hence, the distance RP along the ray OP measures the technical inefficiency of the producer located at point P. Geometrically, the technical inefficiency level associated to point P can be expressed by the ratio RP/OP, and therefore; the TE of the producer under analysis (1-RP/OP) would be given by the ratio OR/OP.

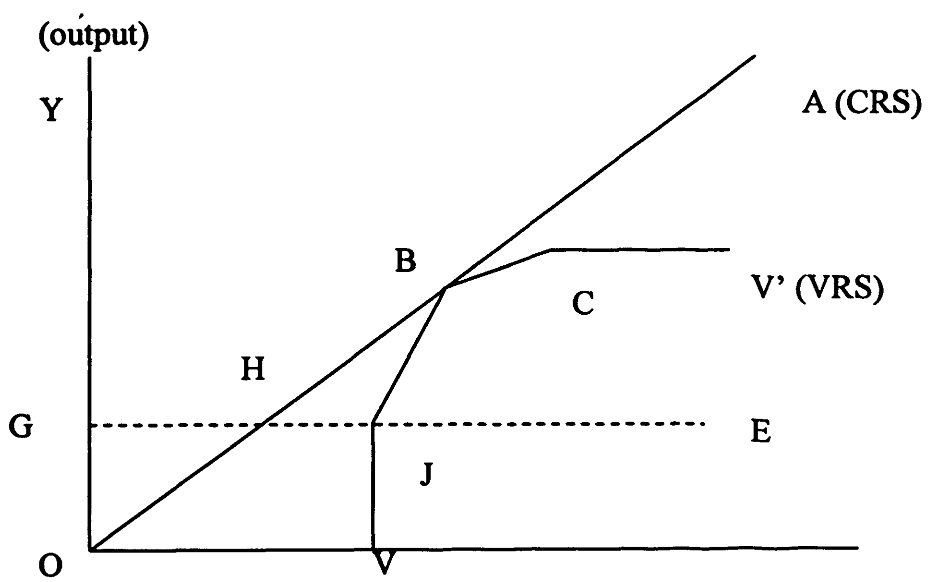
If information on factor input prices is known and a particular behavioral objective such as cost minimization is assumed in such a way that the input price ratio is reflected by the slope of the isocost-line CC', allocative inefficiency can also be derived from the unit isoquant plotted in Figure 3.1. In this case, the relevant distance is given by the line segment SR, which in relative terms would be the ratio SR/OR.

With respect to the least cost combination of inputs given by point R', the above ratio indicates the cost reduction that a producer would be able to reach if it moved from a technically but not allocatively efficient input point (R) to a both technically and allocatively efficient one (R'). Therefore, the AE at point P is given by the ratio OS/OR. Together with the concepts of technical efficiency and allocative efficiency, Farrell describes a measure of overall efficiency (OE), which is TE multiplied by AE, or:

$$OE = TE \times AE = (OR/OP) \times (OS/OR) = OS/OP$$

Figure 3.2 illustrates the further decomposition of technical efficiency into measures of pure technical efficiency (PTE) and scale efficiency (SE).

Figure 3.2 Pure technical and scale efficiency



Assuming a case of one input, *x* and one output, *y*, OA represents a constant returns to scale frontier. Therefore, the measure of technical efficiency (TE) of the firm is the ratio of GH/GE. For the variable returns to scale frontier, represented by VV', the measure of pure technical efficiency (PTE) can also be obtained as at point E, PTE equals to the ratio of GJ/GE. The measure of SE can be derived from the measures of TE and PTE. Hence, SE is the ratio of GH/GJ. That means SE equals TE divided by PTE. The value of SE is unity when operating under constant returns to scale. Values of less than unity reflect scale inefficiency.

The source of scale inefficiency can be attributed to either operating under increasing returns to scale or decreasing returns to scale. To examine this, another frontier allowing for non-increasing returns to scale is developed, presented by OBCV'. Decreasing returns to scale exists if SE is not equal to unity and PTE is equal to GH/GE.

There are two broad categories of methods for measuring efficiency. The first approach, called data envelopment analysis (DEA), involves solving linear programs in which an objective function envelopes the observed data and deriving efficiency scores by measuring how far an observation lies from the "envelope" or frontier. This approach is a nonparametric approach. The second is parametric approach which involves fitting structural models based on explicit behavioural assumptions, that is, estimating an economic function (cost or production functions) and deriving efficiency score from either the residuals or dummy variables. This is known as stochastic frontier analysis (SFA).

3.3 Efficiency: A multi-dimensional approach

DEA is a theoretically sound framework for performance analysis that offers many advantages over traditional methods such as performance ratios and regression analysis. Technically, it represents the set of nonparametric, linear programming techniques used to construct empirical production frontiers and evaluate the relative efficiency of production units. DEA is particularly effective in handling complex processes, where these Decision Making Units (DMUs), use multiple inputs to produce multiple outputs.

DEA identifies:

• The efficient frontier, or envelopment surface, consisting of the best practice units;

• Efficiency measures for each DMU that reflect its distance to the frontier;

• An efficient reference set, or peer group, which is a small subset of efficient units closest to the unit under evaluation, for each inefficient DMU;

• Efficient targets for each inefficient DMU (projections onto the frontier).

Other important results that can be obtained from DEA analyses include: returns to scale, technical inefficiencies and investigation of achievable targets for inefficient DMUs etc.

Further important characteristics are:

• DEA can handle multiple input and multiple output models;

• It doesn't require an assumption of a functional form relating inputs to outputs (as in regression approaches) (Banker et al, 1984; Al-Faraj et al., 1993; Burley, 1995);

• Inputs and outputs can have very different units without requiring an a priori weight (as in index number approaches);

• DMUs are directly compared against a peer or combination of peers;

The same characteristics that make DEA a powerful tool can also create problems. DEA also has the following limitations:

- DEA assumes data to be free of measurement error (Mester, 1996). When the integrity of data has been violated, DEA results cannot be interpreted with confidence.
- The efficiency of a DMU estimated by DEA is relative efficiency not absolute efficiency. In other words, it can tell you how well you are doing compared to your peers but not compared to a theoretical maximum.
- The estimating results are influenced by the homogenous levels of DMUs. The higher homogenous of DMUs, the more reliable results of DEA.
- Since DEA is a nonparametric technique, statistical hypothesis tests are difficult;

Sample size should be larger than the product of the number of inputs and outputs (Dyson et al., 1988) or at least three times larger than the sum of number of inputs and outputs (Stern et al., 1994).

The early development of using linear programming to examine efficiency measures was developed by Charnes, Cooper and Rhodes (1978) (CCR). The CCR model imposes three restrictions on the frontier technology: constant returns to scale, convexity of the set of feasible input-output combinations and strong disposability of inputs and outputs.

Assume that there are *n* DMUs to be evaluated. Each DMU consumes varying amounts of *m* different inputs to produce s different outputs. Specifically, DMU_j

consumes amount x_{ij} of input i and produces amount y_{rj} of output r. We assume that $x_{ij} \geq 0, y_{rj} \geq 0$ and further assume that each DMU has at least one positive input and one positive output value. One of the $j = 1, \ldots, n$ DMUs (DMU_0) is singled out for evaluation.

$$\max : h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \qquad (3.1)$$

$$\text{Subject to} \quad \begin{aligned} &\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1; j = 1,2,\ldots,n \\ &\frac{u_r}{\sum_{i=1}^{m} v_i x_{i0}} > \varepsilon; r = 1,\ldots.,s \\ &\frac{v_i}{\sum_{i=1}^{m} v_i x_{i0}} > \varepsilon; i = 1,\ldots..,m \end{aligned} \qquad (3.2)$$

Where ε is a non-Archimedean element smaller than any positive real number. DMU_0's maximum efficiency score will be $h_0^* \leq 1$ by virtue of the constraints.

The numerator in (3.1) represents a set of desired outputs and the denominator represents a collection of resources used to obtain these outputs. The optimal value h_0^* obtained from this ratio satisfies $0 \leq h_0^* \leq 1$ and can be interpreted as an efficiency rating in which $h_0^* = 1$ represents full efficiency and $h_0^* < 1$ means inefficiency is present. Furthermore, h_0^* i s invariant to the units of measure used for the input and output variables.

The formulation in (3.1) and (3.2) makes it easy to relate DEA to the one output to one input ratio measures of efficiency utilized in engineering and the natural sciences. Indeed, as shown in Charnes, Cooper, and Rhodes (1978), the model in (3.1) and (3.2) generalizes the usual single output to single input efficiency measures used in these disciplines in a way that accommodates the case of multiple outputs and multiple inputs.

The problem would be computationally intractable if addressed directly. However, the theory of fractional programming, developed by Charnes and Cooper (1962), makes it possible to replace the maximizing problem with an equivalent linear programming problem. The transformation can be represents in two versions, which are the input-oriented version and the output-oriented version. In what follows below is the description taken from Zhou (2003).

3.3.1 Input Orientated Version

$$\text{maximize: } \sum_{r=1}^{s} u_r y_{r0}$$

$$\text{subject to: } \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \qquad (3.3)$$

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$u_r, v_i \geq \varepsilon \geq 0$$

The formulation in (3.3) provides contact with economics. This is accomplished by interpreting (3.3) so that the objective is to maximize virtual output subject to unit virtual input while maintaining the condition that virtual output cannot exceed virtual input for any DMU. As noted in Charnes *et al.* (1985), this implies that the conditions for Pareto (or Pareto-Koopmans) optimality are fulfilled since further increases in this maximal value can be attained only if some of the input values x_{ij} are increased or if some of the output values y_{rj} are decreased.

For formulation (3.3) the LP dual problem is

$$\theta^* = \min \theta$$

$$\text{subject to: } \sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{i0} \qquad i = 1,\ldots,m; \qquad (3.5)$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{r0} \qquad r = 1,\ldots,s;$$

$$\lambda_j \ge 0 \qquad j = 1,\ldots,n$$

Model (3.5) is sometimes referred to as the "Farrell model", which is the one used in Farrell (1957). This model conforms to the assumption of strong disposability because it ignores the presence of non-zero slacks. The efficiency measured by this model is referred to as "weak efficiency".

It is to be noted that the LP dual problem of Model (3.3) also can be solved as:

$$\text{minimize: } \theta - \varepsilon\left(\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+\right)$$

$$\text{subject to: } \sum_{j=1}^{n} \lambda_j x_{ij} + S_i^- = \theta x_{i0} \qquad i = 1,\ldots,m; \qquad (3.4)$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - S_r^+ = y_{r0} \qquad r = 1,\ldots,s;$$

$$\lambda_j, S_i^-, S_r^+ \geq 0 \forall i, j, r$$

where the S_i^- and S_r^+ are slack variables used to convert the inequalities in (3.4) to equivalent questions. Here ε >0 is a non-Archimedean element and θ is unrestricted in sign.

Note that any admissible choice of λ_j provides an upper limit for the outputs and a lower limit for the inputs of DMU_0 and against these limits θ is tightened with $\lambda_j^*, s_i^{-*}, s_r^{+*} \geq 0$ representing optimizing choices associated with minimize $\theta = \theta^*$. The collection of such solutions then provides an upper bound, which envelops all of the observations, and hence, leads to the name Data Envelopment Analysis.

DEA Efficiency (the input-oriented version): The performance of DMU_0 is fully (100%) efficient if and only if (i) $\theta^* = 1$ and (ii) all slacks $s_i^{-*} = s_r^{+*} = 0$.

Weakly DEA Efficient (the input-oriented version): The performance of DMU_0 is weakly efficient if and only if both (i) $\theta^* = 1$ and (ii) $s_i^{-*} \neq 0$ and/or $s_r^{+*} \neq 0$ for some i and r in some alternate optima.

3.3.2 Output Orientated Version

$$\text{Minimize: } \frac{\sum_{i=1}^{m} v_i x_{10}}{\sum_{r=1}^{s} u_r y_{ro}}$$

$$\text{Subject to: } \frac{\sum_{i=1}^{m} v_i x_{ij}}{\sum_{r=1}^{s} u_r y_{rj}} \geq 1 \text{ for } j = 1, \ldots, n; \qquad (3.6)$$

$$u_r, v_i \geq \varepsilon > 0 \text{ for all } i \text{ and } r$$

where $\varepsilon > 0$ is the previously defined non-Archimedean element.

Again, the Charnes-Cooper (1962) transformation for linear fractional programming yields model (3.7) (multiplier model) below, with associated dual problem (3.8) (envelopment model), as in the following pair,

$$\text{Minimize: } q = \sum_{i=1}^{m} v_i x_{i0}$$

$$\text{Subject to: } \sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} \geq 0 \qquad (3.7)$$

$$\sum_{r=1}^{s} u_r y_{ro} = 1$$

$$u_r, v_i \geq \varepsilon, \forall r, i$$

$$\text{maximize: } \phi + \varepsilon\left(\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+\right)$$

$$\text{subject to: } \sum_{j=1}^{n} \lambda_j x_{ij} - x_{i0} + S_i^- = 0 \qquad (3.8)$$

$$\sum_{j=1}^{n}\lambda_j y_{rj} - \phi y_{r0} - S_r^+ = 0$$

$$\lambda_j \geq 0, i = 1,\ldots,m; r = 1,\ldots,s; j = 1,\ldots,n$$

Model (3.8) is calculated in a two-stage progress. First, we calculate ϕ^* by ignoring the slacks. Then, optimize the slacks ($\max\sum_{i=1}^{m}S_i^- + \sum_{r=1}^{s}S_r^+$) by fixing ϕ^*.

DMU$_0$ is efficient if and only if $\phi^* = 1$ and $s_i^{-*} = s_r^{+*} = 0$ for all i and r.

DMU$_0$ is weakly efficient if $\phi^* = 1$ and $s_i^{-*} \neq 0$ and (or) $s_r^{+*} \neq 0$ for some i and r in some alternate optima.

Table 3.1 presents the CCR Model in input- and output-oriented versions, each in the form of a pair of dual linear programs.

Table 3.1 CCR DEA Model

	Envelopment model	Multiplier model
Input-oriented	$\min\ \theta-\varepsilon(\sum_{i=1}^{m}S_i^-+\sum_{r=1}^{s}S_r^+)$ subject to: $\sum_{j=1}^{n}\lambda_j x_{ij}+S_i^-=\theta x_{i0}\quad i=1,...,m;$ $\sum_{j=1}^{n}\lambda_j y_{rj}-S_r^+=y_{r0}\quad r=1,...,s;$ $\lambda_j,S_i^-,S_r^+\geq 0\forall i,j,r$	$\max\ \sum_{r=1}^{s}u_r y_{r0}$ subject to: $\sum_{r=1}^{s}u_r y_{rj}-\sum_{i=1}^{m}v_i x_{ij}\leq 0$ $\sum_{i=1}^{m}v_i x_{i0}=1$ $u_r,v_i\geq\varepsilon\geq 0$
Output-oriented	$\max\phi+\varepsilon(\sum_{i=1}^{m}S_i^-+\sum_{r=1}^{s}S_r^+)$ subject to: $\sum_{j=1}^{n}\lambda_j x_{ij}-x_{i0}+S_i^-=0\quad i=1,...,m;$ $\sum_{j=1}^{n}\lambda_j y_{rj}-\phi y_{r0}-S_r^+=0\quad r=1,...,s;$ $\lambda_j\geq 0, j=1,...,n$	$\min q=\sum_{i=1}^{m}v_i x_{i0}$ subject to: $\sum_{i=1}^{m}v_i x_{ij}-\sum_{r=1}^{s}u_r y_{rj}\geq 0$ $\sum_{r=1}^{s}u_r y_{ro}=1$ $u_r,v_i\geq\varepsilon\geq 0$

3.3.3 Banker, Charnes, and Cooper Version

Another version of DEA being used commonly is the Banker, Charnes, and Cooper (BCC) (1984) model. The primary difference between this model and the CCR model is the treatment of returns to scale. The CCR version bases the evaluation on constant returns to scale. The BCC version is more flexible and allows variable returns to scale.

Minimize: $\theta-\varepsilon\left[\sum_{i=1}^{m}s_i^-+\sum_{r=1}^{s}s_r^+\right]$ (3.9)

Subject to: $\theta x_{i0}-\sum_{j=1}^{n}x_{ij}\lambda_j-s_i^-$

$$y_{r0} = \sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+$$
$$\sum \lambda_j = 1 \qquad (3.10)$$

$\lambda_j, s_i^-, s_r^+ \geq 0$ for $i = 1,2,....m$; $r = 1,2,....s$; $j = 1,2,....,n$

The difference between the CCR model and the BCC model is that the λ_j is now restricted to sum to one. This has the effect of removing the constraint in the CCR model that DMUs must be scale efficient. Consequently, the BCC model allows variable returns to scale and measures only technical efficiency for each DMU. That is, for a DMU to be considered as CCR efficient, it must be both scale and technical efficient. For a DMU to be considered BCC efficient, it only need be technically efficient.

The separate evaluation of returns to scale in the BCC model is more evident in the dual to (3.9 – 3.10) which can be written as follows.

$$\text{Maximize: } \sum_{r=1}^{s} u_r y_{r0} - u_0 \qquad (3.11)$$

$$\text{Subject to: } \begin{aligned} &\sum_{r=1}^{s} v_i x_{i0} = 1 \\ &-u_r \leq -\varepsilon \\ &-v_i \leq -\varepsilon \end{aligned} \qquad (3.12)$$

In this model, the u_0^* indicates the return to scale possibilities:

u_0^* <0 implies increasing returns to scale;

$u_0^*=0$ means local constant returns to scale;

$u_0^*>0$ shows decreasing returns to scale.

Note that the CCR model previously discussed simultaneously evaluates both technical and scale efficiency in the aggregate. The BCC model, however, separates the two types of inefficiencies in order to evaluate only technical inefficiencies in the envelopment model and scale inefficiencies in the dual to (3.11 – 3.12).

3.4 Productivity

The major drawback of the DEA approach is that the efficiency scores obtained from a particular sample at a particular time period are confined to that particular sample in that time period and cannot be compared with another sample in a different time period. This limitation means that improvements in efficiency and the measurement of productivity growth, as well as technical progress cannot be captured by DEA.

The idea of comparing the input of a decision making unit over two periods of time (period 1 and period 2) by which the input in period 1 could be decreased holding the same level of output in period 2 is the basis of the Malmquist Index[20]. Färe et al. (1994) developed a Malmquist productivity measures using the DEA approach based on constant returns to scale[21]. The Malmquist productivity index (*M*) enables

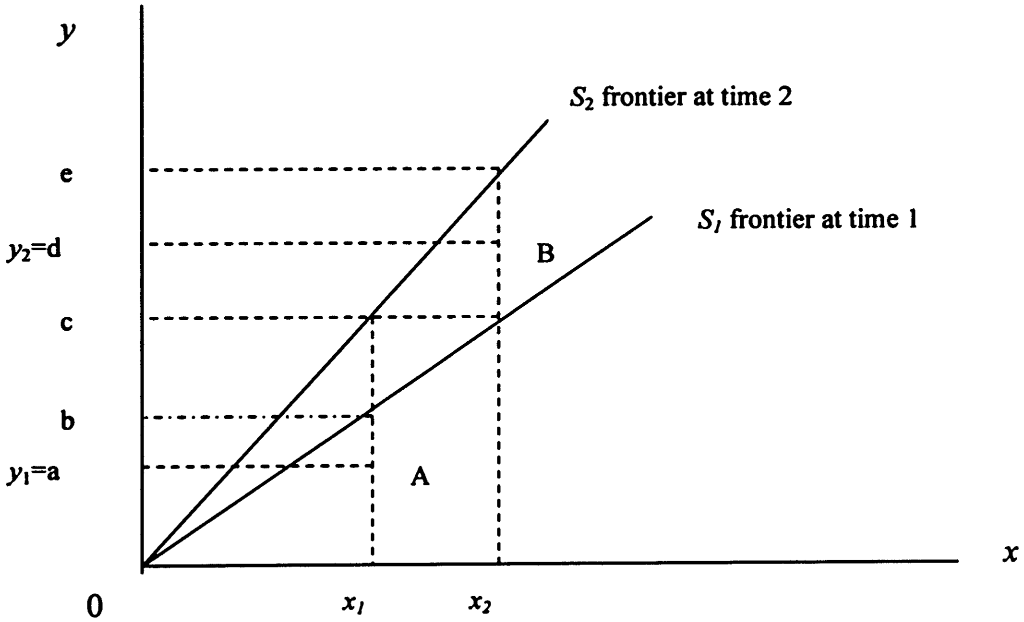
[20] Grosskopf (20 03) provides a brief history of the Malmquist productivity index and discusses the theoretical and empirical issues related to the index. For the decomposition of Malmquist productivity index, see Lovell (2003).

[21] Ray and Desli (1997) proposed the decomposition of the same Malmquist index using a variable returns to scale frontier as the benchmark, which may lead to different conclusions concerning the sources of productivity growth.

productivity growth to be decomposed into changes in efficiency (catch-up) and to changes in technology (innovation).

Calculation of the Malmquist productivity index can follow one of two approaches. Caves et al. (1982) and Zhou (2003) employ the technology in period 2 as the reference technology. Alternatively, the technology in period 1 (base period) can also be used as reference technology. This is the approach taken by Casu et al. (2004), Canhoto and Dermine (2003), Wheelock and Wilson (1999) and Färe et al. (1994). The difference in the reference technology used affects the magnitude in interpreting the index. When the reference technology is based on period 2, then M > 1 implies deterioration in productivity over the period under study. Alternatively, when the reference technology is based on period 1, then M > 1 implies an improvement in productivity. An illustration using the one input one output case is shown in Figure 3.3 below.

Figure3.3 Mamquist Measure



Points A and B represent observations in periods 1 and 2 respectively. The rays from the origin S_1 and S_2 represent frontiers of production for periods 1 and 2 respectively. Relative efficiency is measure in one of two ways. The relative efficiency of production at A compared to the frontier S_1 is $d_1(y_1,x_1)$ = 0a/0b. But compared with the period 2 frontier S_2 it is $d_2(y_1,x_1)$ = 0a/0c. The relative efficiency of production at B compared to the period 2 frontier S_2 is $d_2(y_2,x_2)$ = 0d/0e. Compared with the period 1 frontier S_1, the relative efficiency is $d_1(y_2,x_2)$ = 0d/0c. The Malmquist index (M) of total factor productivity change is the geometric mean of the two indices based on the technology for periods 1 and 2 respectively. In other words:

$$M = \left[\frac{d_1(y_1,x_1)}{d_2(y_2,x_2)} \frac{d_2(y_1,x_1)}{d_1(y_2,x_2)} \right]^{\frac{1}{2}} \qquad (3.13)$$

An equivalent way of writing (2) is:

$$M = \frac{d_1(y_1,x_1)}{d_2(y_2,x_2)} \left[\frac{d_2(y_2,x_2)}{d_1(y_2,x_2)} \frac{d_2(y_1,x_1)}{d_1(y_1,x_1)} \right]^{\frac{1}{2}} \qquad (3.14)$$

or $$M = ET \qquad (3.15)$$

where

M = the Malmquist productivity index

E = a change in efficiency over the period t and t+1 (the term outside the square bracket)

T = a measure of technical progress measured by shifts in the frontier from period 1 and 2 (the two ratios in the square bracket).

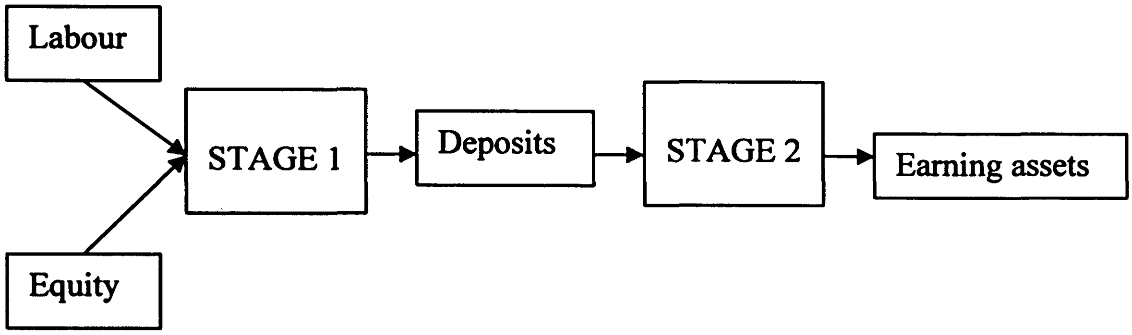
When the reference technology is based in period 2 as in (3.14), then $M < 1$ means that there has been a positive total factor productivity change between periods 1 and 2.

3.5 Network DEA

Earlier in this chapter I described the traditional DEA method as an approach for measuring the relative efficiency of DMUs that have multiple inputs and outputs. In the traditional DEA model, performance measurement is based on 'black box' process (Färe and Grosskopf, 2000). Inputs are transformed into outputs but the transformation process is implicit and unknown. Indeed the advantage of DEA is that it is structure-free. However, researchers impose some structure when applying DEA to specific problems. A common structure is the two-stage DEA[22]. The two-stage method has been applied to numerous cases. For example in the case of a bank, labour and equity capital can be used to generate deposits, which in turn is used to generate interest earning assets. The first stage is the input of labour and equity to create deposits. The deposits can be viewed as an intermediate output which is an intermediate input to produce interest bearing assets in the second stage of production. Recent expositions can be found in Chen and Zhu (2004), Kao and Hwang (2008) and Chen, Liang and Zhu (2009). Figure 3.4 demonstrates the process.

[22] For this and other variants see Charnes et al (1993)

Figure 3.4 Network DEA Serial Process



Adopting the notation of Chen and Zhu (2004) and Kao and Hwang (2008), formally, there are *n* DMUs (j = 1,2,...n) which use *m* inputs in the first stage, $x_{i,j}(i=1,2.....m)$ and D outputs from the first stage, $z_{d,j}(d=1,2,....D)$. These D outputs then become the inputs to the second stage and are called intermediate measures. The outputs from the second stage are $y_{r,j}(r=1,2,....s)$. The efficiency scores of each stage based on the CCR model can be expressed as follows;

Stage 1 $$\theta_{j,1}=\frac{\sum_{d=1}^{D}w_d z_{d,j}}{\sum_{i=1}^{m}v_i x_{i,j}} \qquad (3.16)$$

Stage 2 $$\theta_{j,2}=\frac{\sum_{r=1}^{s}u_r y_{r,j}}{\sum_{d=1}^{D}\tilde{w}_d z_{d,j}} \qquad (3.17)$$

The efficiency score for two-stage process is expressed as;

$$\theta_j = \frac{\sum_{r=1}^{s} u_r y_{r,j}}{\sum_{i=1}^{m} v_i x_{i,j}} \qquad (3.18)$$

The input-oriented model for a given DMU$_0$ is given as;

$$\begin{aligned} &Max\theta_{0,1}, \theta_{0,2} = \frac{\sum_{r=1}^{s} u_r y_{r,j,0}}{\sum_{i=1}^{m} v_i x_{i,j,0}} \\ &s.t.......\theta_{j,1} \leq 1......\theta_{j,2} \leq 1, \forall j \qquad (3.19) \\ &w_d = \widetilde{w}_d, \forall d \end{aligned}$$

From (3.19) it is clear that the two-stage process defined as above has the property that;

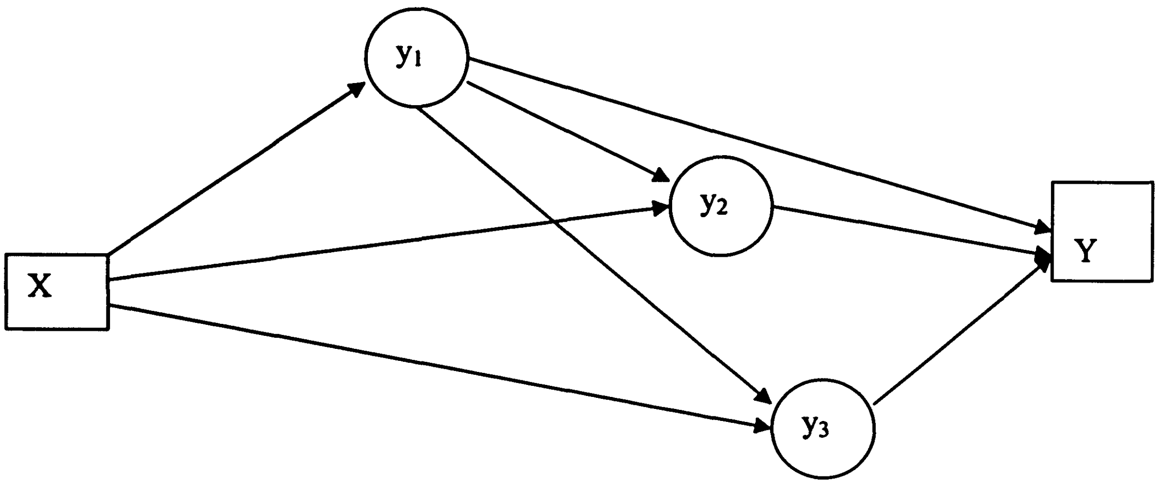
$$\theta_j = \theta_{j,1}\theta_{j,2} \qquad (3.20)$$

Howevr, the two-stage DEA model is only one of a family of DEA models that comes under the notion of a network DEA framework. Färe and Grosskopf (2000) (1996) develop a general formulation of the network DEA which attempts to provide deeper structure to the 'black box' transformation of the conventional DEA.

Hua and Bian (2008) illustrate the case of a general network model with several separate production nodes. Assume that each DMU consists of p sub-DMUs and each sub-DMU (S_t=1,2,...p) transforms inputs into outputs, producing R_t types of external outputs Y_t and O_t types of internal outputs Y_{it}. By consuming I_t types of external inputs

X_t and K_t types of internal inputs Y_{qt}. The internal inputs Y_{qt} are parts of outputs of other sub-DMUs, while internal outputs Y_{it} are parts of internal inputs of other sub-DMUs. Figure 3.5 illustrates.

Figure 3.5 Illustration of network Structure of a DMU



Denote $X_{t,j} = (x_{1,t,j}, x_{2,t,j}, ...x_{I,t,j}), (t = 1,2,.....p, j = 1,2,...n)$ the external input vector of the t[th] sub-DMU of the network DMUj. Let $Y_{q,t,j} = (y_{1,q,t,j}, y_{2,q,t,j}, ...y_{K,q,t,j})$ be the internal input vector of the t[th] sub-DMU, $Y_{t,j} = (y_{1,t,j}, y_{2,t,j}, ...y_{R_t,t,j})$ be the external output vector of the t[th] sub-DMU and $Y_{t,i,j} = (y_{1,t,i,j}, y_{2,t,i,j}, ...y_{O_t,t,i,j})$ be the internal output vector of the t[th] sub-DMU.

The external outputs $Y_{t,j}$ and the internal outputs $Y_{t,i,j}$ are produced from the inputs $X_{t,j}$ and $Y_{q,t,j}$. Following Hua and Bian (2008) aggregate efficiency is defined as;

$$e_{n,j} = \frac{\sum_{t=1}^{p} \mu_t Y_{t,j} + \sum_{t=1}^{p} v_t Y_{t,i,j}}{\sum_{t=1}^{p} \omega_t X_{t,j} + \sum_{t=1}^{p} u_t Y_{q,t,j}} \qquad (3.21)$$

Where μ_t and v_t are vectors of multipliers for outputs Y_t and $Y_{t,i}$ of S_t, respectively; ω_t, u_t are vectors of multipliers for external inputs X_t and internal inputs $Y_{q,t}$ of S_t. By the definition of the aggregate efficiency measure $e_{n,j}$ abov e, the performance measure for the t[th] sub-DMU of the network DMU$_j$ can be represented as;

$$e_{t,j} = \frac{\mu_t Y_{t,j} + v_t Y_{t,i,j}}{\omega_t X_{t,j} + u_t Y_{q,t,j}} \qquad (3.22)$$

A DMU is said to be efficient if its aggregate score is equal unity. It can be shown that the aggregate performance measure $e_{n,j}$ is a convex combination of all sub-DMU's performance measures $e_{t,j}(t = 1,3,....p)$.

[Proof]

$$e_{n,j} = \frac{\sum_{t=1}^{p} \mu_t Y_{t,j} + \sum_{t=1}^{p} v_t Y_{t,i,j}}{\sum_{t=1}^{p} \omega_t X_{t,j} + \sum_{t=1}^{p} u_t Y_{q,t,j}} = \frac{\mu_1 Y_{1,j} + \mu_2 Y_{2,j} + .. + \mu_p Y_{p,j} + v_1 Y_{1,i,j} + v_2 Y_{2,i,j} + .. + v_p Y_{p,i,j}}{M}$$

$$\Rightarrow = \frac{\mu_1 Y_{1,j} + v_1 Y_{1,i,j}}{M} + \frac{\mu_2 Y_{2,j} + v_2 Y_{2,i,j}}{M} + ... + \frac{\mu_p Y_{p,j} + v_p Y_{p,i,j}}{M}$$

$$\Rightarrow = \frac{\mu_1 Y_{1,j} + v_1 Y_{1,i,j}}{M}\left(\frac{\omega_1 X_{1,j} + u_1 Y_{q,1,j}}{\omega_1 X_{1,j} + u_1 Y_{q,1,j}}\right) + \frac{\mu_2 Y_{2,j} + v_2 Y_{2,i,j}}{M}\left(\frac{\omega_2 X_{2,j} + u_2 Y_{q,2j}}{\omega_2 X_{2,j} + u_2 Y_{q,2,j}}\right) + ...$$

$$+ \frac{\mu_p Y_{p,j} + v_p Y_{p,i,j}}{M}\left(\frac{\omega_p X_{p,j} + u_p Y_{q,p,j}}{\omega_p X_{p,j} + u_p Y_{q,p,j}}\right)$$

By the definition of the efficiency performance of the sub-DMU above;

$$\frac{\mu_1 Y_{1,j} + v_1 Y_{1,i,j}}{M}\left(\frac{\omega_1 X_{1,j} + u_1 Y_{q,1,j}}{\omega_1 X_{1,j} + u_1 Y_{q,1,j}}\right) + \frac{\mu_2 Y_{2,j} + v_2 Y_{2,i,j}}{M}\left(\frac{\omega_2 X_{2,j} + u_2 Y_{q,2j}}{\omega_2 X_{2,j} + u_2 Y_{q,2,j}}\right) + ...$$
$$+ \frac{\mu_p Y_{p,j} + v_p Y_{p,i,j}}{M}\left(\frac{\omega_p X_{p,j} + u_p Y_{q,p,j}}{\omega_p X_{p,j} + u_p Y_{q,p,j}}\right)$$
$$= \frac{\omega_1 X_{1,j} + u_1 Y_{q,1,j}}{M}(e_{1,j}) + \frac{\omega_2 X_{2,j} + u_2 Y_{q,2,j}}{M}(e_{2,j}) + ... \frac{\omega_p X_{p,j} + u_p Y_{q,p,j}}{M}(e_{p,j})$$
$$= \beta_1 e_{1,j} + \beta_2 e_{2,j} + ... + \beta_p e_{p,j}$$

Since $\sum_{t=1}^{p} \beta_t = 1$

Then $e_{n,j} = \sum_{t=1}^{p} \beta_t e_{t,j}$

[End proof]

This implies that the final efficiency score of the network DMU will *be an arithmetic weighted average of the sub-DMUs*. The objective is to maximise the aggregate efficiency measure of a DMU0 ($e_{n,0}$). Following Charnes and Cooper (1962) the non-linear programming problem becomes:

$$Max.e_{n,0} = \sum_{t=1}^{p} \mu_t Y_{t,0} + \sum_{t=1}^{p} v_t Y_{t,i,0}$$
$$s.t.$$
$$\sum_{t=1}^{p} \omega_t X_{t,0} + \sum_{t=1}^{p} u_t Y_{q,t,0} = 1 \qquad (3.23)$$
$$\sum_{t=1}^{p} \mu_t Y_{t,j} + \sum_{t=1}^{p} v_t Y_{t,i,j} - \sum_{t=1}^{p} \omega_t X_{t,j} - \sum_{t=1}^{p} u_t Y_{q,t,j} \le 0, j = 1,2,....n$$
$$\mu_t Y_{t,j} + v_t Y_{t,i,j} - \omega_t X_{t,j} - u_t Y_{q,t,j} \le 0, t = 1,2,...p; j = 1,2,...n$$

Solving (3.23) yields the score and all the input and output weights $[\mu_t, v_t, \omega_t, u_t]$. By using the estimates weights, the efficiency scores of the sub-DMUs of the network DMU can be calculated.

3.6 DEA in Banking

Most published studies on bank efficiency have focused on the developed economies[23]. However, some studies of developing and Far Eastern economies have emerged in recent years – they are examined in studies such as those by Rezvanian and Mehdian (2002), Hardy and di Patti (2001), Karim (2001), Hashim (2001), Edwards (1999), Laevan (1999), Katib and Matthews (1999), Chu and Lim (1998), Bhattacharyya et al (1997) and Fukuyama (1995). But the number of the studies related to this region is small in comparison. Berger and Humphrey (1997) survey 130 studies that have employed frontier analysis in 21 countries. Of these studies, only 8 were of the developing and Asian countries (including 2 in Japan). Studies on US financial institutions were the most common, accounting for 66 out of 116 single country studies.

A number of studies of Chinese banking efficiency have been published in Chinese scholarly journals[24] but to date there have been only a few studies that are available to non-Chinese readers[25]. There is no record on DEA application in China in the most comprehensive bibliography edited by Gabriel Tavares (2002). However, the DEA

[23] Drake and Hall (2003), Cavallo and Rossi (2002), Elyasiani and Rezvanian (2002), Maudos et al (2002), Drake (2001), Altunbas and Molyneux (1996) and Molyneux and Forbes (1993)
[24] For exa mple Qing and Ou, (2001); Xu, Junmin, and Zhensheng, (2001); Wei and Wang, (2000); Xue and Yang, (1998) and Zhao (2000) have used non-parametric methods to examine banking efficiency.
[25] A recent exception is a study using non-parametric methods by Chen et. al. (2005) and parametric methods by Fu and Heffernan (2005)

approach has been applied extensively in China. The earliest literature about application of DEA is relevant to the investigation of efficiency in the Chinese industrial sector (Wei Quan Ling, 1988), furthermore its application expanded to other fields.

The applications of DEA to Chinese banking mainly focus on the evaluation of efficiency, the relationship between efficiency, market power, market structure and profitability. With the innovation of the Chinese financial sector and the increasing competition in the banking system, the study of banking efficiency is put into perspective.

Wei Yi and Wang Li (2000) evaluated the technical efficiency for a sample of 12 banks including four state-owned and eight other commercial banks in 1997. Taking the number of full time employees, physical capital and loanable fund as inputs and selecting interest income and non-interest income as outputs, they reported an average technical efficiency 77.19%. In contrast with the other studies outsides China, they discovered the bank's size is negatively related to technical efficiency. Big banks suffer mainly from pure technical inefficiency, while small banks' inefficiency mainly comes from scale inefficiency. With respect to scale efficiency, big technical inefficiency banks represent decreasing return to scale, while small technical inefficiency banks embody increasing return to scale.

Zhao Xu (2000) used 15 banks as a sample to study the relationship between market structure and performance in Chinese banking by using a direct measure of DEA efficiency on the basis of analysis of traditional collusion hypothesis (structure re-behaviour-performance paradigm) versus efficient structure hypothesis. Selecting the number of full time employees, the deposit interest rate, and the depreciated value on physical equipment as inputs, and deposit, loan and profit as outputs, they discovered that efficiency is the main determinant of bank profitability, but that market concentration and market share is negatively correlated with efficiency.

The most recent study of bank efficiency in China (Chen et al, 2005) looked at efficiency pre- and post-deregulation examining the relative efficiency of the stat-owned banks, national joint-stock banks and the regional city commercial banks. The conclusions of the study that the deregulation programme provided a burst of efficiency gains that petered out in later years. In common with Zhao (2000), the paper finds that the SOBs are more efficient than other banks and argues that the decline in efficiency in recent years was due to domestic and international factors including the Asian financial crisis and the growth in NPLs[26].

The use of the Malmquist method of evaluating productivity performance of banks has also been a growth area of academic enquiry. Berg et al (1992) examined Norwegian banks 1980-89 and found productivity regress prior to deregulation and strong productivity gains due to catch-up after deregulation. The Malmquist decomposition was used by Wheelock and Wilson (1999) to examine bank productivity in the USA for the period 1984-93. They report a general drop in average productivity caused by failure to catch-up with outward shifts of the production

[26] There are a number of reasons why these arguments are not convincing. The main one being that the NPLs are included in the loans used as an output and would therefore show an increase in output of perhaps dubious value. The period when NPLs were divested from the SOBs to the Asset Management companies would affect the efficiency of the SOBs for the two periods when the transfers occurred. However, in the main the SOBs are the benchmark banks and the reduction of the loan book would make the other banks look better by moving them closer to the efficiency frontier.

frontier. Alam (2001) found that the deregulation period resulted in a productivity surge in the first half of the 1980s followed by a productivity regress in the second half for large US banks. These results were confirmed by Mukherjee et al (2001) who also uses panel estimation to explain productivity growth in terms of bank size, product-mix and capitalisation.

Other studies of bank productivity using the Malmquist method have been Drake (2001) for the UK, Grifell-Tatjéand Lovell (1997) for Spain, Canhoto and Dermine (2003) for Portugal, Noulas (1997) for Greece and Isik and Hassan (2003) for Turkey. A pan-European study was conducted by Casu et al (2004) who compare parametric with the Malmquist method. There finding is that productivity growth in European banking has been largely brought about by technological change rather than efficiency improvement. Outside Europe, Worthington (1999) finds that Australian Credit Unions exhibited strong technological progress after deregulation and Neal (2004) found that productivity improvements were mostly shifts in the frontier with the majority of banks having negative catch-up over 1995-99.

The productivity of Chinese banking has also been the subject of numerous studies by Chinese scholars. Chen (2002), Zhang and Wu (2005) and Tang and Wang (2006) use the Malmquist method to examine the productivity trend of Chinese banks over the 1994-1999, 1999-2003 and 1997-2003 periods respectively. Their basic findings were that the large state-owned banks exhibited lower average growth compared with the joint stock banks. In general average productivity growth was dominated by catch-up rather technical innovation but that there had been a marked improvement in Total

Factor Productivity (TFP) in the latter years[27]. In contrast Ni and Wan (2006) found strong productivity improvement led by technical improvement rather than catch-up, whereas Sun and Fang (2007) pose the question, whether foreign banks have stimulated an improvement in Chinese bank productive efficiency? Sun and Fang (2007) find that average TFP improved during the period 2001-2004 consistent with the hypothesis that the threat of entry has had significant efficiency effects on incumbent banks. Appendix 3-I provides a brief tabulated summary of studies of bank productivity using the Malmquist method.

In contrast to the application of DEA and Malmquist in studies of banking efficiency and productivity, very little has been produced using network DEA. While some applications have emerged in the academic literature[28], the only known study in banking is an unpublished paper by Avkiran and Fukuyma (undated).

3.7 Summary

This chapter has outlined the methodology of the non-parametric approach to measuring relative efficiency. As its blue print the chapter has outlined the framework set out in the CCR and BCC models and developed further by Zhou (2003). One of the problems of the DEA approach is that it is a relative measure that is not time transferable. This chapter explains the use of the Malmquist index as a measure of productivity that can be used to examine growth in efficiency over time, which also decomposes the growth into shifts in the frontier and movements towards the frontier.

[27] See also Hou (2006) which uses a two-stage panel estimation to explain productivity but inappropriately uses operating expenses as an explanatory variable when it is also an input in the construction of the M index.

[28] Prieto and Zofio (2007) on OECD countries; Lewis and Sexton (2004) on major league baseball; and Löthgreen and Tambour (1999) on pharmacies.

The application of non-parametric methods for evaluating bank efficiency in China is a growing industry in academic circles. Compared to the findings obtained from other countries' DEA application in banking system with that in China, the disagreement exists on the importance of scale effects on efficiency as well as the relationship between efficiency, market structure and profitability. It is not the purpose of the research to replicate these results but to add to the literature by using DEA to provide an alternative decomposition of technical efficiency in the form of rational efficiency or rent-seeking. It will address the non-stochastic problem associated with DEA by using a bootstrap method so that statistical inference is potentially possible.

Finally I have outlined the framework of network DEA which is a relatively recent innovation in the DEA literature. Chapter 5, 6 and 7 will apply these methodologies in analyzing the efficiency and productivity of Chinese banks.

Appendix 3-I Summary of Studies on bank productivity

Study	Country	Period	Inputs	Outputs	Results
Berg et al (1992)	Norway	1980-89	Labour hours, operational expenses deflated by materials price index	Short-term loans, long-term loans, deposits and loan losses treated as negative output	Low TFP growth but strong catch-up following deregulation. Big banks had stronger productivity growth than smaller banks.
Wheelock and Wilson (1999)	USA	1984-93	Labour, physical capital, purchased funds	Four categories of loans, demand deposits	Decline average productivity over the period. The benchmark banks improved technical productivity through technical innovation but average efficiency declined.
Alam (2001)	USA	1980-89	Two categories of deposits, other purchased funds, capital, labour, equity.	Securities, three categories of loans.	Lag in effect between regulatory reform and growth in productivity. Improvements in productivity obtained from technical innovation rather than efficiency gains.
Mukherjee et al (2001)	USA	1984-90	Labour, physical capital, equity, two categories of deposits.	Three categories of loans, investments, non-interest income	Productivity growth of large banks was generally positive in this period but productivity growth fluctuated with respect to size.
Drake (2001)	UK	1984-95	Physical capital, labour, (deposits)	Loans, Other investments, Non-interest income, (deposits)	Uses both intermediation and production methods. Productivity growth driven by technical progress. Slower TFP under the intermediation approach.
Grifell-Tatjé and Lovell (1997)	Spain	1986-93	Labour, non-labour operating expenses	Loans, Savings deposits, demand deposits (all deflated by CPI)	Savings bank productivity driven by technical progress and catch-up. Commercial bank productivity declined in latter half of period.
Canhoto and Dermine (2003)	Portugal	1990-95	Labour, physical capital	Loans, deposits, securities, interbank assets/liabilities	Strong technological progress following deregulation. Catch-up weakened as benchmark banks grew strongly.
Noulas (1977)	Greece	1991-92	Labour, physical capital, deposits	Liquid assets, loans, investments	State owned banks experienced faster TFP than private banks. Catch-up was faster in private banks. State-owned banks experienced stronger technical progress
Isik and	Turkey	1981-90	Labour,	Short-term	Productivity loss 1982-86.

Hassan (2003)			physical capital, deposits	loans, long-term loans, other earning assets, non-interest income	Productivity growth 1987-90. Strong catch-up in 1987-90 following deregulation but low technical progress.
Casu et al (2004)	Europe	1994-00	Wage bill/Assets, deposits, physical capital	Loans, other earning assets, non-interest income.	Productivity growth supported by technological progress rather than efficiency gains, except in the UK where catch-up was stronger.
Worthington (1999)	Australia	1993-97	Labour, physical capital, non-deposit liabilities	Demand deposits, time deposits, three categories of loans, other investments	Technological regress but high variability within credit unions. Technical progress occurred after deregulation. Efficiency gains due to technical efficiency rather than scale efficiency.

Chinese Studies of Bank Productivity

Study	Period	Inputs	Outputs	Results
Chen (2002)	1994-99	Physical assets, operating expenses	Deposits, loans, profit	Technological regress but strong catch-up drives TFP. JSCB exhibited higher TFP variation
Ni and Wan (2006)	1998-02	Labour, physical assets, branches, op expenses	Deposits, loans, op revenue	Positive TFP. Joint stock banks more productive than SOB. Productivity growth driven by technical progress.
Tan and Wang (2006)	1997-03	Labour, physical assets, deposits	Profit, gross income	TFP growth negative until final year, driven by technological regress. Efficiency improvements
Hou (2006)	1996-02	Deposits, physical assets, op. expenses	Interest earnings, non-interest earnings	Declining trend in technical efficiency. TFP driven by technological progress
Zhang and Wu (2005)	1999-03	Labour, non-deposit funds	Deposits, Profits	TFP driven by efficiency catch-up. SOCBs driven by technical progress
Xu and Zhong (2005)	2001-02	Capital, net fixed assets, total expenses	Deposits, loans, profit before tax	Adopted bootstrapping method to re-examine the efficiency results. Capital, fixed assets and deposits have significant impact on bank efficiency, while fixed assets, loans and profits have no significant impact.
Zou (2008)	1996-05	Deposits, net fixed assets, Op. expenses	Investments, loans	TFP driven by technical progress. Listed banks are more efficient than non-listed. The latter is better than SOB. Ownership is the key factor. Bank size is positive correlated to technical progress and efficiency catch-up.
Yan (2008)	1995-04	Op. expenses, deposits, number of staff	Loans, profits	Banking market concentration is declining, which caused bank efficiency improvement. Competition level is positively correlated with efficiency,
Sun and Fang (2007)	1996-04	Interest expenses, other expenses, operating expenses, total assets	Interest earnings, other earnings, profit before tax	From 1996 till 2001, TFP was less than 1. Foreign banks entry ha no significant impact on Chinese banking efficiency improvement. 2001-04, TFP, TE is positive greater than 1. As China joined WTO, foreign entry has limited impact on Chinese banking.
Pang (2006)	2000-04	Deposits, net fixed assets	Loans, investments	TFP improved, driven by technical progress. Size matters.

Zhu (2006)	2000-04	Labour, net fixed assets, deposits	Operating income, net income	The average TE is 0.87. SOB less productive than JSCB. TFP decreased caused by technical regress.
Tan and Wang (2006)	1997-03	Labour, next fixed assets, deposits	Income, profits	Declining trend in efficiency. TFP driven by frontier shift.
Hou and Wang (2006)	1996-02	Deposits, net fixed assets, operating expenses	Interest earnings, non-interest earnings	TFP is not driven by technical progress.
Ni and Wan (2006)	1998-02	Net fixed assets, number of outlets, labour, operating expenses	Gross income, deposits, loans	Efficiency improved, driven by technical progress. Ownership matters.
Zhang and Wu (2005)	1999-03	Net fixed assets, labour, loanable funds	Deposits, profits	TFP improved. For SOB, driven by AE, whilst technical progress contributed to TFP increase in JSCB.

Chapter 4

Banking Data

"Errors using inadequate data are much less than those using no data at all."
Charles Babbage

4.1 Introduction

The purpose of this chapter is to describe the data used for analysis in the following three chapters. Additionally this chapter will provide some descriptive statistics of the key variables used in the analysis. These variables are the key items of the bank's balance sheet and income accounts. Finally, the chapter will present the data sets used in each of the empirical chapters to follow.

Clearly the method of data collecting and the veracity of the sources are vital in determining the success of research. There are three methods of collecting data. These are first, primary data obtained from questionnaire-based information and surveys. Second, data obtained from documented or published sources. Third, data obtained from experimental exercises. The data used in this research comes from the reported balance sheet and income statements of individual banks.

The next section will describe the sample of banks used throughout the thesis and the principal sources. The following sections will examine the key variables used in the empirical chapters and I will outline the methods and assumptions used to fill the gaps in missing or unrecorded data. The final section comments on the distribution of the data on factor prices and the methodology of estimation used to soften the potential bias that may be associated with mis-measurement of important banking data.

4.2 Sample Size and Sources of Data

The three empirical studies employ annual data from 1997 to 2009 for the five state-owned commercial banks (SOCB or big-5), nine joint-stock commercial banks (JSCB)[29] and 47 city commercial banks (CCB). Chapter 5 uses the big-4 state owned banks and 10 joint-stock banks for the period 1997–2006 including the Bank of Communications which was re-designated as a SOCB. Chapter 6 extends the data to include 2007 and aggregates the SOCBs to include Bank of Communications and also combines the national based banks with the city commercial banks (CCBs). The final empirical chapter utilises the data of the SOCBs and JSCBs for the period 2007-2009 but examines the internal working of the financial flows between the Consumer, Corporate and Treasury sections of the bank. The full sample consisted of a balanced set of data for the national banks and an unbalanced set of data for the CCBs. In total, the sample consisted of 370 bank year observations.

As of the year-end of 2007, there were totally 5 SOCBs and 12 JSCBs and 124 CCBs in Chinese banking system. The collected data sample size accounts for 100%, 75% and 38% of SOCBs, JSCBs and CCBs respectively. The main source of data was Fitch/Bankscope, individual annual reports of banks, the *Almanac of China's Finance and Banking* (various issues) and governor/chairman's speeches from web sources. The sampled banks are listed below in Table 4.1.

[29] The China Regulatory Banking Commission (CBRC) had designated the big-4 banks, BOC, ICBC, CCB and ABOC as the state-owned banking sector. Since 2006, the SOCB sector included the Bank of Communications.

Table 4.1 List of banks and sample period

No Abbreviation

Table 4.1 List of banks and sample period

No	Abbreviation	Full name	Sample Period
State-owned Commercial Banks (SOCB)			
1	ICBC	Industrial and Commercial Bank of China Ltd.	1997-2009
2	CCB	China Construction Bank Corp.	1997-2009
3	ABC	Agricultural Bank of China	1997-2009
4	BOC	Bank of China Ltd.	1997-2009
5	BoCom	Bank of Communications Co. Ltd.	1997-2009
Joint Stock Commercial Banks (JSCB)			
6	CMB	China Merchants Bank Co.Ltd.	1997-2009
7	CMBC	China Minsheng Banking Corp. Ltd.	1997-2009
8	CITIC	China CITIC Bank Co.Ltd.	1997-2009
9	SPDB	Shanghai Pudong Development Bank Co.Ltd.	1997-2009
10	CIB	China Industrial Bank Co. Ltd	1997-2009
11	CEB	China Everbright Bank Co.Ltd.	1997-2009
12	HUAXIA	Hua Xia Bank Co.Ltd.	1997-2009
13	GDB	Guangdong Development Bank Co.Ltd.	1997-2009
14	SDB	Shenzhen Development Bank Co.Ltd.	1997-2009
City Commercial Banks (CCB)			
15	BEIJING	Bank of Beijing	1997-2007
16	SHANGHAI	Bank of Shanghai	1997-2007
17	Ping An	Ping An Bank/Shenzhen Commercial Bank	1997-2007
18	TIANJIN	Tianjin City Commercial Bank/Bank of Tianjin	1997-2007
19	NANJING	Nanjing City Commercial Bank/Bank of Nanjing	1999-2007
20	DONGUAN	Dongguan City Commercial Bank	1999-2007
21	WUXI	Wuxi City Commercial Bank	1999-2005
22	CHONQING	Chongqing Commercial Bank	1999-2007
23	XIAMEN	Xiamen International Bank	1999-2007
24	NINGBO	Ningbo Commercial Bank /Bank of Ningbo	2000-2007
25	XIAN	Xi'an City Commercial Bank	2000-2006
26	WUHAN	Wuhan Urban(City) Commercial Bank/HanKou Bank	2001-2007
27	QINGDAO	Qingdao City Commercial Bank	2001-2007
28	JINAN	Jinan City Commercial Bank	2001-2007
29	DALIAN	Dalian City Commercial Bank/Bank of Dalian	2000-2007
30	HANGZHOU	Bank of Hangzhou Co Ltd/Hangzhou City Commercial Bank	2000-2007
31	CHANGSA	Changsha City Commercial Bank Co Ltd.	2002-2007
33	SHIJIAZHUANG	Shijiazhuang City Commercial Bank	2003-2005
34	SHAOXING	Shaoxing City Commercial Bank	2003-2007
35	JINGZHOU	Jingzhou City Commercial Bank	2006-2007
36	LAIWU	Laishang Bank Co Ltd/Laiwu City Commercial Bank Co Ltd	2004-2007
37	JIUJIANG	Jiujiang City Commercial Bank	2004-2006
38	PANZHIHUA	Panzhihua City Commercial Bank	2004-2005
39	DONGYING	Dongying City Commercial Bank	2004-2006
40	ZHENGZHOU	Commercial Bank of Zhengzhou	2005-2006
41	WEIFANG	Weifang City Commercial Bank	2005-2006
43	LINYI	Linyi City Commercial Bank Co.Ltd	2003-2007
44	XINXIANG	Xinxiang City Commercial Bank	2005-2007
45	LIUZHOU	Liuzhou City Commercial Bank	2005-2007
46	HUZHOU	Huzhou City Commercial Bank	2005-2007
47	KARAMAY	Karamay City Commercial Bank	2005-2006

48	HUANGSHI	Huangshi City Commercial Bank	2006-2007
49	XUCHANG	Xuchang City Commercial Bank	2006-2007
50	JINING	Jining City Commercial Bank	2006-2007
51	CHENGDE	Chengde City Commercial Bank	2005-2007
52	HENGYANG	Hengyang City Commercial Bank	2006-2007
53	GANZHOU	Ganzhou City Commercial Bank	2006-2007
54	GUILIN	Guilin City Commercial Bank	2006-2007
55	MIANYANG	Mianyang City Commercial Bank	2006-2007
56	JIAOZUO	Jiaozuo City Commercial Bank Co Ltd	2006-2007
57	DEYANG	Deyang City Commercial Bank	2006-2007
58	MINTAI	Zhejiang Mintai Commercial Bank	2006-2007
59	CHOUZHOU	Zhejiang Chouzhou Commercial Bank	2006-2007
60	ZHANJIANG	Zhanjiang City Commercial Bank Co ltd	2006-2007
61	JIAXING	Jiaxing City Commercial Bank Co Ltd	2006-2007
62	TAILONG	Zhejiang Tailong Commercial Bank Co Ltd	2006-2007
63	WEIHAI	Weihai City Commercial Bank Co Ltd	2006-2007

Source: *Bankscope and individual websites*

4.3 Input and Output Selection

The correct definition of the inputs and outputs for banks is not straightforward and controversy remains in the literature, giving rise to alternative approaches. Most banking studies have tended to adopt either the "intermediation" or the "production" approach. The *intermediation* approach developed by Sealey and Lindley (1977) recognises the main function of the bank is to conduct financial intermediation. Under the *intermediation* approach, bank assets measure outputs and liabilities measure inputs. The popularity of the intermediation method in large part is to do with the availability of balance sheet data of banks. In contrast, the *production* approach recognises that the bank provides intermediation services and payment services to depositors. The outputs are loans, savings and account activity as measured by the number of transactions processed. It is common to group these transactions according to the type, complexity or function, which helps the interpretation of the results obtained. The inputs considered are physical inputs such as capital (fixed assets) and labour. Interest costs and revenue are excluded from this approach since only physical inputs are needed to perform transactions or provide other types of services[30].

It can also be argued that deposits are both inputs and outputs depending on its use in intermediation services or payments services[31] and suggests a weighting mechanism similar to the divisia approach of Barnett et al (1984). Demand deposits are used by customers to pay bills, standing orders, direct and debits by electronic transfer. The transactions incurred through the demand deposit account can be viewed as valid output of the bank under the production approach. Whereas time deposits in the thinking of Pesek and Saving (1967) represents largely a store of value function that reduces the 'moneyness' or medium of exchange function. To separate the total of borrowed funds of a bank into demand and time accounts would require information about the term maturity of deposits. This information is not easily available for banks in China and in any case up until very recently deposit interest rates were regulated and did not reflect market fundamentals.

In addition to the conventional output vector of banks, non-performing loans (NPLs) can be thought of as an undesirable output in the same way as pollution can be thought of as a necessary but undesirable output of a manufacturing firm. NPLs are by-product of the creation of loans. Bank managers have an expectation of default which is covered by provisions and capital adequacy. When defaults rise above the level of capital and other non-deposit liabilities, the bank is technically insolvent. Implicit guarantees and expected recapitalisation of the Chinese banks by the Chinese government enabled the banking system to continue to exist while technically

[30] Freixas and Rochet (1997) propose a third approach that recognises the specific activities of banks such as risk management and information processing.

[31] See for example Goldschmidt (1980)

insolvent. In the following two empirical chapters the research models NPLs as an undesirable output.

In this research, I adopt a variant of the production approach to examine the Chinese bank efficiency, and a hybrid between the intermediation and production approaches. The variant of the production approach uses net interest income and non-interest income as measures of output as a proxy measures for the number of transactions produced by the bank[32]. The variant production approach is used in the analysis of productivity in chapter 6. The hybrid intermediation-production approach is used in Chapter 5 and uses labour, fixed assets and deposits as inputs. For outputs I use loans, other earning assets and non-interest income and also performing loans as output to allow for NPLs as a negative output. In chapter 6 the hybrid intermediation-production approach uses overhead costs as a proxy measure for labour as a factor input. In addition the variant of the production approach is used as one of the models and NPLs are treated as an undesirable output. In Chapter 7 I use the profit efficiency model of DEA. The input set is interest expenses and operational expenses of each profit centre while the output is net interest income and net fee revenue of each profit centre.

Table 4.2 and 4.3 provide the mix of input and output and the summary statistics of the input and output date for 1997, 2006 and 2007 as a snapshot indicator of the scale of the variables used.

[32] The two income flows are closer in spirit to the neo classical production function which uses flow measures of output produced by stocks of factor inputs.

Table 4.2 Input and output set

Input		**Output**	
Variable	**Description**	**Variable**	**Description**
LAB	Number of employees	**LOANS**	Stock of loans
		PLOAN	Performing loans (loans less NPLs)
FA	Fixed assets	**NPLs**	Non-Performing loans (bad output)
		OEA	Stock of other earning assets
DEP	Total deposits	**NII**	Net interest income
		FEE	Net fee income
OHD	Overheads	**DEP**	Total deposits
PL	**Price of labour:** Personnel costs/LAB		
PK	**Price of capital:** Other operational expenses/FA		
PF	**Price of fund**: Interest payments/DEP		

Table 4.3 Input and Output Variables for 1997, 2000, 2004 and 2007 (million RMB) per bank group

Year		Bank Group	FA	LAB	DEP	LOANS	NII	OEA	FEE	NPL	PLOAN	OHDS
1997	Mean	SOCB	33778	288059	1596856	1148219	34338	521323	2172	588223	559996	22368
		JSCB	1193	3515	52368	31079	2544	29423	135	3764	27314	998
		CCB	499		39563	17721		21617	43	2074	15646	962
	Std. Dev.	SOCB	19207	186360	814482	632539	24965	316913	2940	364005	323600	9031
		JSCB	612	1620	32216	18454	1489	20135	120	3205	16195	615
		CCB	190		5517	4190		1106	33	841	5030	341
	Min.	SOCB	3422	45447	392001	233746	7548	193925	191	40835	192911	10817
		JSCB	356	1186	15939	6255	563	9198	8	101	6154	225
		CCB	365		35661	14758		20835	20	1480	12089	721
	Max.	SOCB	54398	528540	2422305	1987200	65144	1021901	7351	1032549	954651	33277
		JSCB	2166	5729	105366	59301	5030	67182	318	10185	54090	2009
		CCB	633		43464	20683		22399	66	2669	19203	1203
2000	Mean	SOCB	52979	308150	2267541	1421227	45519	923743	2964	453942	967285	27512
		JSCB	2698	6428	116867	69143	2746	58408	89	10499	58643	1670
			431		25171	12847		12073	15	1754	11093	355
	Std. Dev.	SOCB	27834	192900	1225061	735353	22755	566117	3580	309776	480935	12480
		JSCB	1136	3216	55813	29071	1134	29801	73	8053	24040	721
		CCB	233		27400	12764		13645	12	1275	11732	299
	Min.	SOCB	5125	47121	379994	329668	10920	262809	452	60166	269502	6820
		JSCB	3393	9636	148407	81554	3382	77030	248	23148	71785	847
		CCB	85		5930	3407		2096	0	383	2193	107
	Max.	SOCB	72615	509572	3572262	2402477	73160	1697294	9219	830999	1571478	38631
		JSCB	901	2124	53414	36585	1163	26376	22	1532	28338	2645
		CCB	731		88065	41017		44617	33	4333	37850	944

Year		Bank Group	FA	LAB	DEP	LOANS	NII	OEA	FEE	NPL	PLOAN	OHDS
2004	Mean	SOCB	63192	292686	3448298	2094270	78482	1402844	6205	327340	1766930	42250
		JSCB	4282	10190	350848	244739	8282	141265	325	13743	230997	4152
		CCB	507		36244	20788		17867	31	1167	19621	412
	Std. Dev.	SOCB	24747	177589	1520617	903086	37688	593405	2694	351565	667420	14927
		JSCB	1227	3901	112010	74337	3242	39319	229	11818	76847	1602
		CCB	430		52398	27158		26316	32	1206	26275	466
	Min.	SOCB	19919	54408	1036623	629557	19300	455302	1626	18550	611007	15677
		JSCB	2607	6382	148715	121355	4793	77448	157	3778	108657	1307
		CCB	30		2422	1404		787	-1	46	1343	24
	Max.	SOCB	79302	489425	5256157	3040627	117743	1965356	8557	728544	2312083	50385
		JSCB	6366	17829	540212	363119	14149	208128	889	41471	353662	6757
		CCB	1631		205746	105390		106131	135	4615	102478	2220
2007	Mean	SOCB	67524	286712	5237027	2859403	144435	2812504	24609	230295	2629108	73944
		JSCB	5068	14876	683500	428102	19556	347084	1874	9590	418512	8227
		CCB	354		36359	20246		20143	40	414	19461	374
	Std. Dev.	SOCB	23399	146000	2144809	1066789	69128	1271540	10711	331013	977922	30136
		JSCB	2223	6025	294569	156797	8072	148344	1826	4137	157601	3775
		CCB	521		62949	31257		37634	71	878	32692	509
	Min.	SOCB	32199	68083	1894385	1085724	54144	968331	7095	22694	1063030	21518
		JSCB	1995	8573	258339	215790	9606	129323	451	4583	203315	1853
		CCB	12		2972	613		1390	0	4	609	25
	Max.	SOCB	91094	447519	7774462	3838922	224465	4459941	34384	817973	3702086	93400
		JSCB	8444	28971	1212697	654661	33902	629934	6439	18749	644267	14653
		CCB	2788		311615	153324		190882	307	4373	150084	2524

Source: *Bankscope and individual bank websites*

4.4 Efforts to Reduce Non-performing Loans

A major issue of the output data is the quality of total loans. The loan data on a bank's balance sheet provide no clue as to its quality in terms of risk characteristics or distance to default. With Chinese banks, this is a particularly important issue as estimates of non-performing loans have at time put the number at nearly 50% of GDP[33]. Failing to account for the existence of NPLs could bias the efficiency scores as SOCBs have the largest share of loan stocks but also have the highest proportion of NPLs. Normally there are two approaches to mitigate the impact by NPLs: either use the performing loans by netting out NPLs from the total loans or treat NPLs as an undesirable output. Both methods have been used in a number of studies.

Park and Weber (2006) consider loans less non-performing loans (NPLs) as well as deposits as a valid output of the bank in their study of bank productivity in Korea, where NPLs are viewed as an undesirable output. Hua and Bian (2008) demonstrate the treatment of undesirable outputs in a network Data Envelope Analysis framework. However, one of the problems for the researcher is estimating the size and distribution of NPLs for the sample period. Disclosure of NPLs according to international norms was not made a regulatory requirement in China until 1999. Researchers such as Ma and Fung (2002), Rodman (2005) and Huang (2002) and many others have made estimates of the size of the NPLs but typically these are for the sector as a whole or for state owned banks as an aggregate. In this chapter I have collected NPL data from a mixture of official sources, web and newspaper sources, confidential sources and estimates based on reasonable assumptions. Below are the stages showing Chinese banks' efforts to reduce NPLs.

[33] See Ma and Fung (2002) and Rodman (2005)

There are two methods to recognize NPLs: accounting methods vs. problem recognition methods. The former approach categorized loans into 4-categories based on delinquency days, named "pass", "overdue less than 2 years", "overdue more than 2 years" and "legacy loss loan". The last three categories were NPLs. In 1998, a new 5-catagory method was introduced by Peoples Bank of China (PBOC) to Chinese banking, which focused on the repayment capacity of borrowers and problem early recognition. These are "Pass", "Special Mention", "Substandard", "Doubtful" and "Loss". The latter three are recognized as NPLs. From 2004 onwards, only 5-category NPLs have been reported.

Stage 1: Prior to 1993, no NPLs were reported as almost 100% bank lending was to State Owned Enterprise (SOEs) based on the central planning allocation.

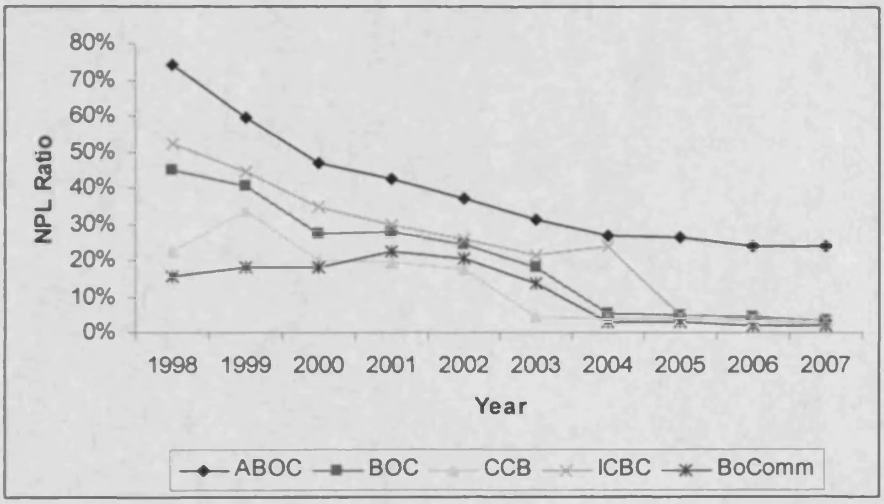
Stage 2: from 1994 to 1998. During this transit period from central planning system to market economy, many SOEs lost their market share and experienced financial difficulties, therefore defaulted the due obligations. At the same time, banking reform started and SOCBs operated more independently guided under the Commercial Bank Law. Banks started to look at the NPL recognition and reporting. In 1998 almost all SOCBs set up NPL resolution departments to manage the NPLs. In 1998 the NPL ratio of SOCBs was about 45% by accounting approach (author's calculation).

Stage 3: from 1999 to 2000, the first wave of NPL transfer to asset management companies (AMCs). To sort out the huge amount of legacy NPLs on the book of SOCBs, the State set up four asset management companies to take the NPLs from the big-4 SOCBs. Totally RMB1,300 billion NPLs were removed from the banks' balance sheets in 1999 and 2000. The NPL ratio therefore decreased to 28% in 2000 (author's calculation).

Stage 4: from 2001 to 2006, the second wave of NPL transfer from SOCBs for overseas Initial Public Offering (IPO) purpose. In 2005, CCB became the first SOCB listed in HK stock exchange. Following CCB's step, BOC and ICBC listed in HKSE in 2006. Before IPO, all these three banks had transferred and written off large amount of NPLs to AMCs/ State Treasury to meet the international standards. In 2004, BOC disposed NPLs of RMB254 billion and reduced the NPL ratio to 5.12% from 16.28% in the previous year. Another SOCB CCB reduced NPL ratio from 15.17% in 2002 to 3.92% in 2004. The biggest bank in China ICBC switched totalling RMB176 billion loss loans together with RMB70 billion of non-credit risky assets to State Treasury for government bonds at the book value in year of 2005. The last listed SOCB ABOC was supported by State Treasury to sell RMB816 billion NPLs at the book value in 2007.

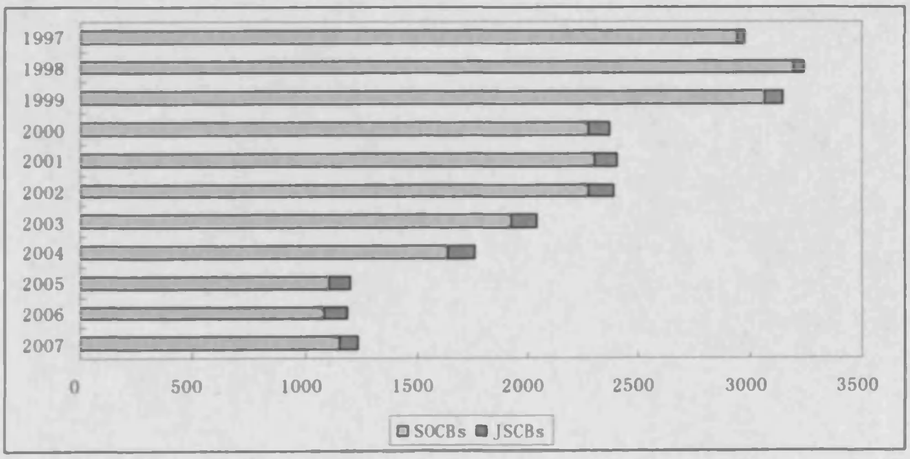
The Figure 4.1 below shows the NPL ratio from 1998 to 2007 for the SOCBs. The NPL ratios of the SOCBs have declined rapidly during this period due to a mixture of circumstances. There has indeed been some recovery of NPLs (and write-offs), but mostly the NPL ratio has fallen because of the operations of AMC and the rapid growth of the loan book over this period (see Rodman 2005). However, the China Bank Regulatory Commission (CBRC) has set targets for the NPL ratio and the absolute levels of NPLs. Figure 4.2 below shows the evolution of NPLs in total for the SOCBs and JSCBs over the sample period.

Figure 4.1 NPL ratio of state owned commercial banks 1997-2007



Source: author's calculation

Figure 4.2 NPL (RMB billion) SOCBs and JSCBs 1997 – 2007



Source: author's calculation

4.5 Assumptions for Missing Data

A further problem for the researchers into Chinese banks is that consistent data that meets international norms is available only in recent years. As mentioned above, NPL data are not available in late 90's for SOCB, while personnel costs are only disclosed by the SOCB ABOC in recent years. To fill in the missing data, a number of working assumptions are made as discussed below.

4.5.1 NPLs

For year 1997, NPLs of the big-4 SOCB were not available. Therefore the same NPL ratio in 1998 was applied to estimate the NPLs in 1997. In 1999 and 2000, totally 1294 billion NPLs were transferred to AMCs, with breakdown as below:

Table 4.4 Transference of NPLs from SOCBs to AMCs in 1999 and 2000

BOC	RMB267,400 million
CCB	RMB273,000 million
ICBC	RMB407,700 million
ABOC	RMB345,800 million
Total	RMB1293,900 million

The above information was used to derive the NPLs in 1998 by adding NPLs amount back to the available NPL figures in 2000 for respective banks. For NPLs of year 1999, totally RMB350,000 million NPLs were transferred out from banks' balance sheets, accounting for 27% of total NPLs being transferred. Therefore, 27% was adopted to estimate the NPLs taken away from big-4 in 1999. The estimated NPLs for each big-4 are the NPLs in 1998 plus the NPLs having been transferred.

A few other banks did not publish NPLs for some years, the average NPL ratio of the previous and following year is used to fill in the gap or use the next available year's ratio. These banks are:

- CITIC: No NPLs in 1999 and 2000, therefore the average NPL ratio of 1998 and 2001 is used.
- GDB: Missing NPLs in 1997, 98 and 1999, applied NPL ratio in 2000 to estimate.
- BoCom: no data in 1997, 99 and 2000. Used the ratio of 1998 as the ratio for 1997 and used the average ratio of 1998 an 2001 as the ratio to derive NPLs for 1999 and 2000.

4.5.2 Estimation of Personnel cost

As mentioned above, personnel costs were unavailable in some years for some banks and not available at all for ABOC up until 2007. In most cases the ratio of personnel costs to operational expenses in the nearest year were used as an estimate. In the case of ABOC the first estimate was obtained by assuming that the non-personnel costs as a percentage of operational costs, was similar to BOC which had a similar fixed assets profile. The figures were then readjusted to conform to the results of a survey of salaries in banks carried out in 2002/3 shown below in Table 4.5.

Table 4.5 Survey of Chinese Bank Salaries

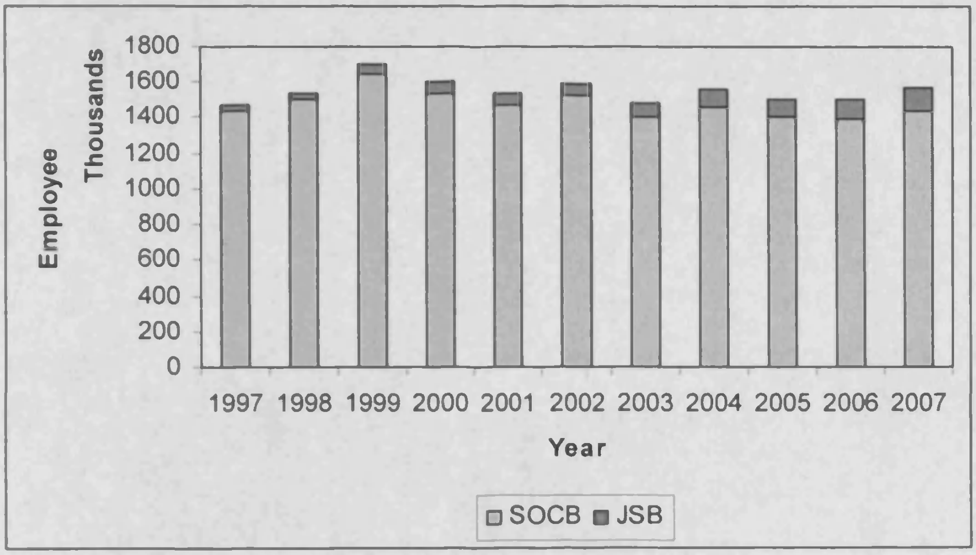
Bank	**Staff**	**Aver. Wages (Yuan) /year**
BOC	140450	35091
ICBC	375781	37005
ABOC	489425	32845
BOC	220999	42969
CCB	310391	45814
BoCom	54408	43393
Citic	11598	79031
CEB	8906	52191
CMBC	6382	55036
SPDB	8817	56800
Huaxia	7007	73860
CMB	17829	93040
GDB	11714	42148
IBC	8050	66357
SDB	6999	45600
Hengfeng	1365	40904

Source: Chinese Banker, 'Competitive Evaluation of Chinese Banks' 2003

4.6 Labour

Although the SOCBs have been losing their market share due to fierce competition from the JSCBs, the big-5 are still the market giants in terms of assets as discussed in the chapter 2. Being state-owned banks, the big-5 have social responsibility to keep a large number of staff. Below Figure 4.3 shows the employee allocation in the SOCBs and JSCBs. It is clear that SOCBs have more than 90% of the total employees. An effort to reduce the total employee by SOCBs has been made in the sample period: the allocation ratio dropped to 91% in 2007 from 98% in 1997. The Figure 4.4 shows more of the reduction of staff number of SOCBs.

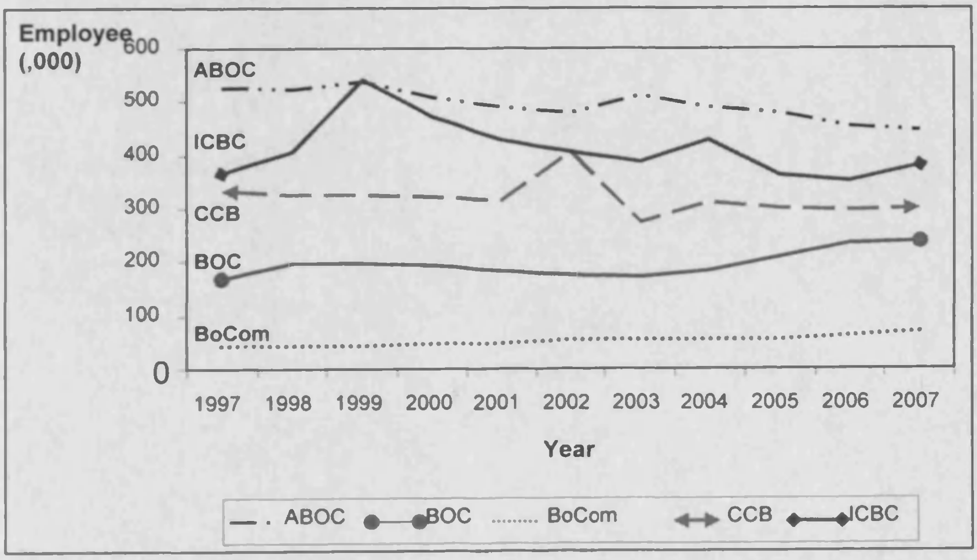
Figure 4.3 Comparison of employee number in SOCBs and JSCBs



Source: Bankscope and china Banking Almanac

Among the big-5, only BOC and BoCom continued with recruitment in the sample period although at a slow pace, while the other three banks continue the efforts to reduce the staff number. As a result, the total employee numbers of ABOC, CCB and ICBC dropped by 17%, 26% and 30% respectively in 2007 from the peak.

Figure 4.4 Total employee number of big-5 1997 - 2007

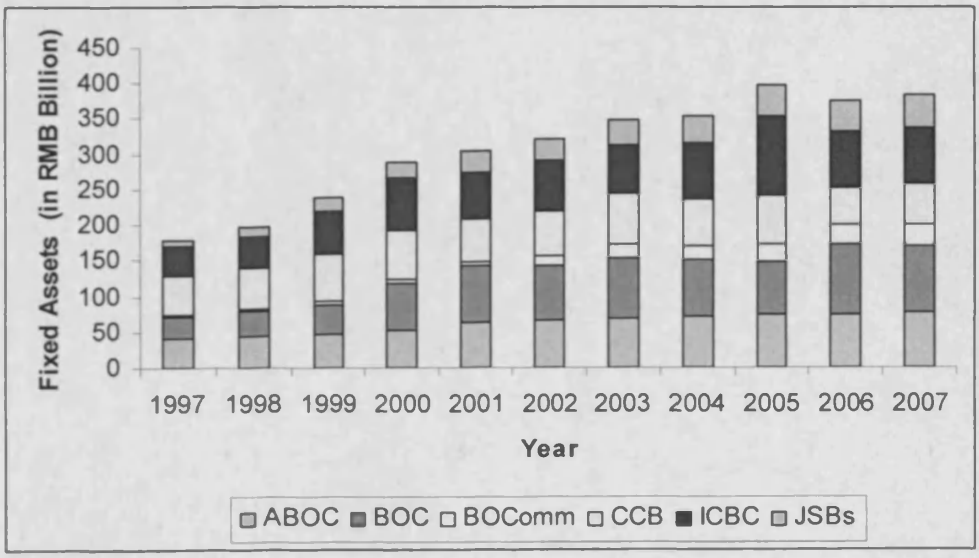


Source: Bankscope and China Banking Almanac

4.7 Fixed Assets

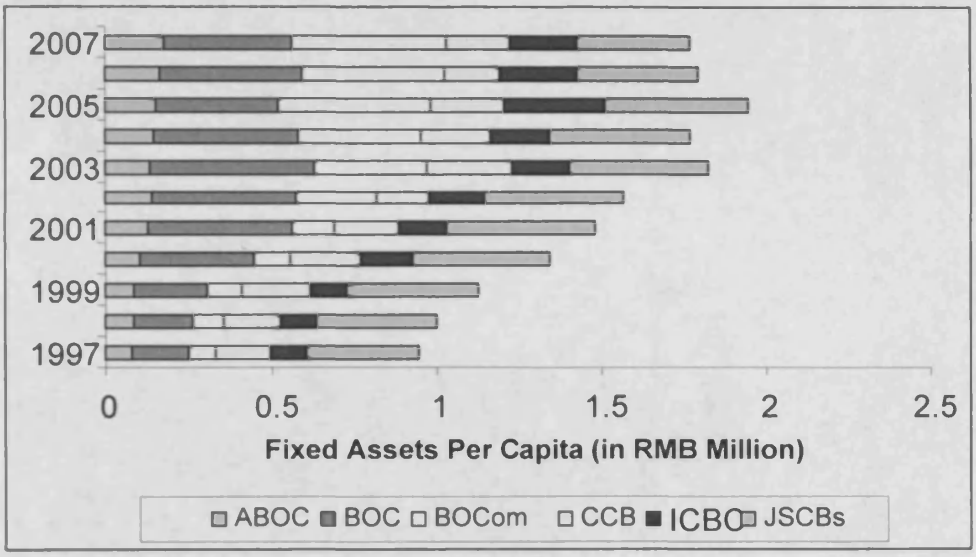
During the sample period, both SOCBs and JSCBs have seen the monetary value of fixed assets nearly double. This may in part be due to the increased expenditure on branch expansion and technical renovation on computer system and new office buildings. However, it is contradictory to the efforts to reduce employee and "get fit". The Figure 4.5 and 4.6 discloses the growth of fixed assets and the fixed assets per capita for SOCBs and JSCBs. It is clearly that the JSCB on average has the higher fixed assets per heads but SOCBs are catching up year by year. Especially in recent years, BOC and BoCom even exceeds the JSCBs. Considering that JSCBs are the late comers in the market. Therefore they should not have the legacy of technology problems. JSCBs can be treated as benchmark. In this regard, SOCBs, especially ICBC, ABOC and CCB have long way to go to continuing solve the problem of over-staffing. Chapter 5 discusses more of this.

Figure 4.5 Growth of fixed assets of SOCBs and JSCBs 1997 ~ 2007



Source: Bankscope

Figure 4.6 Fixed assets per capita of SOCBs and JSCBs 1997 ~ 2007

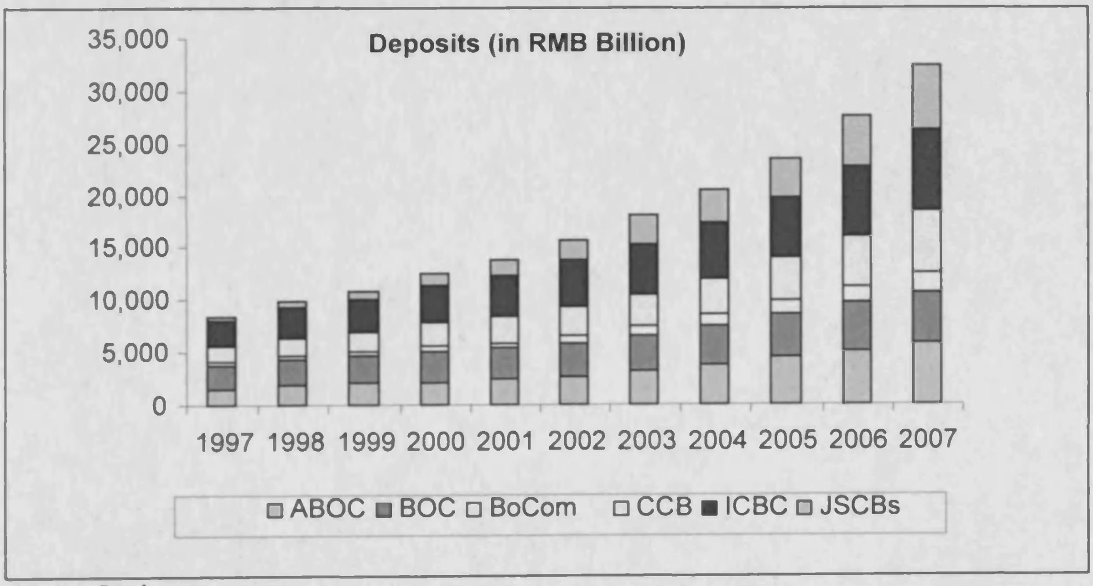


Source: Bankscope

4.8 Deposits and Loans

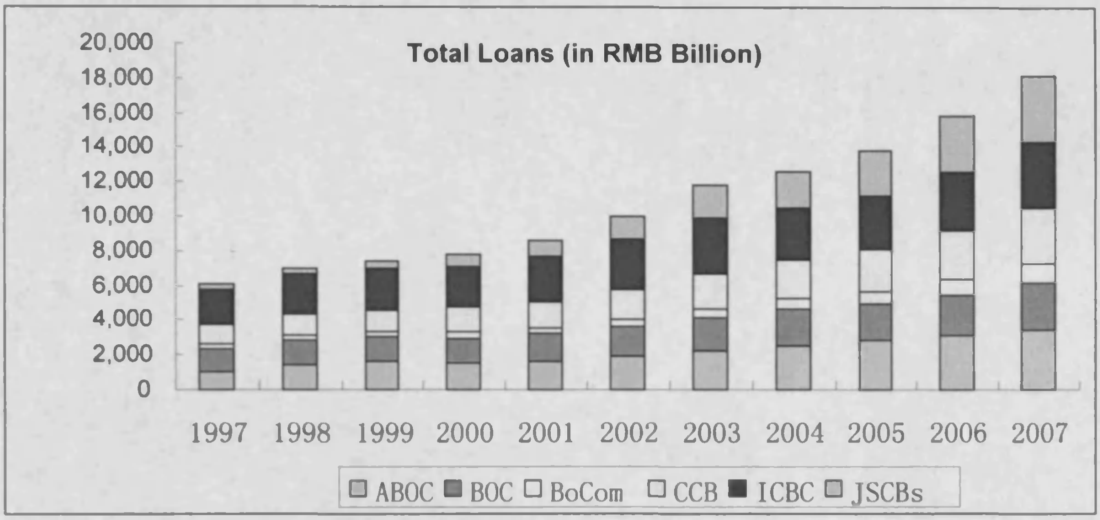
The CBRC stipulates a strict maximum of loan to deposit ratio of 75%. There is little interbank activity in volume terms and no possibility of overseas borrowing. The implication is that the trends in deposits and loans match each other. Figure 4.7 shows the general trend in deposits and Figure 4.8 shows the trend in loans.

Figure 4.7 Total deposits of SOCBs and JSCBs 1997 ~ 2007



Source: Bankscope

Figure 4.8 Total loans of SOCBs and JSCBs 1997 ~ 2007

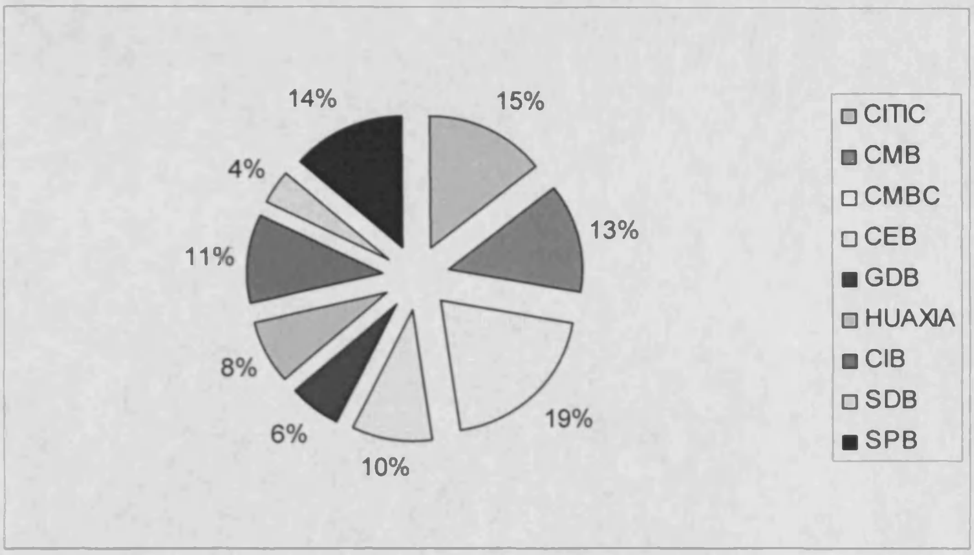


Source: Bankscope

It is clear from the data that the SOCBs dominate both sides of the balance sheet. Deposit growth in the sample is an indication of the rapid growth in the Chinese economy and particular that of household asset holdings. The limited savings outlets for households in China (bank deposits, the stock market and property being the main outlets) means that deposits grow faster than the economy with the increase in the average propensity to save in income. Deposits increased by 282% for aggregation of JSCBs and SOCBs (2007 to 1997). The growth of the JSCBs is faster than SOCBs. SOCBs average growth is 228% vs. JSCBs 1205% starting from a low base. CMB is the fastest growing bank in terms of deposit – 52 times larger than its 1997 level.

In the case of JSCBs, no one bank dominates the JSCBs market share. The leading JSCB is China Mingsheng Bank, only by 4 per cent to the 2nd best. Figure 4.9 gives a share breakdown of deposits in the JSCB sector.

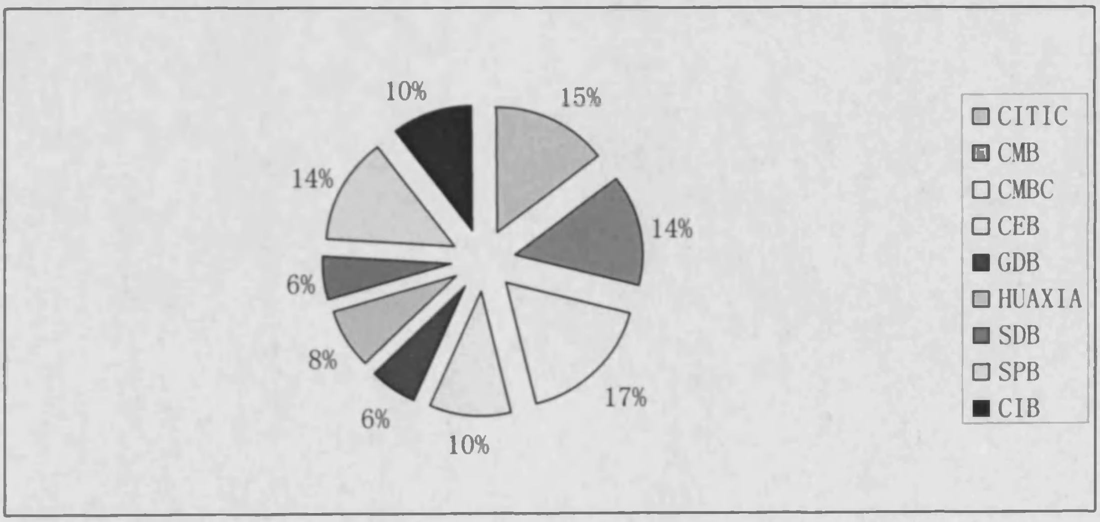
Figure 4.9 Deposit breakdown of JSCBs in 2007



Source: Bankscope

A similar breakdown for loans shows that no particular bank in JSCB sector dominates, which suggests a strongly competitive environment for loans and deposits within the JSCB sector.

Figure 4.10 Loan breakdown of JSCBs in 2007

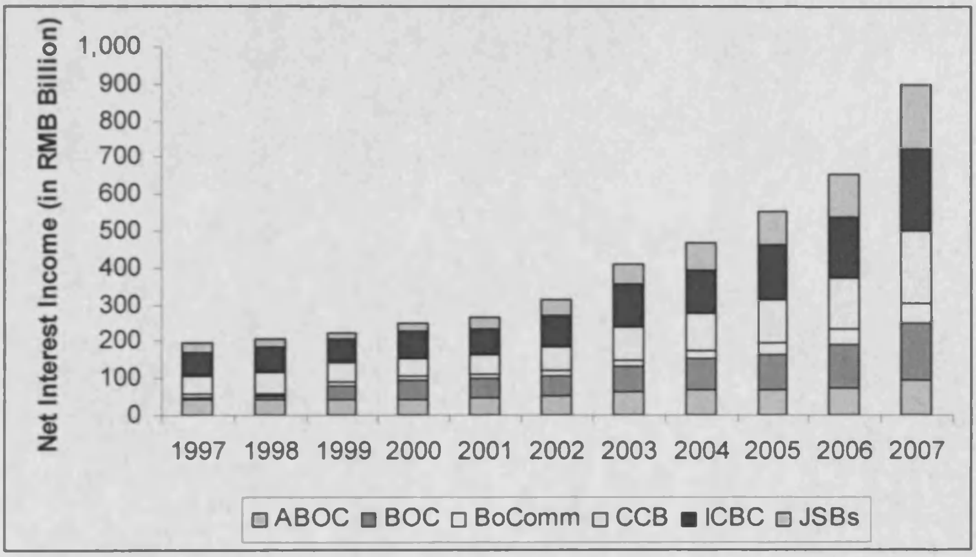


Source: Bankscope

4.9 Interest and Non-interest Income Flows

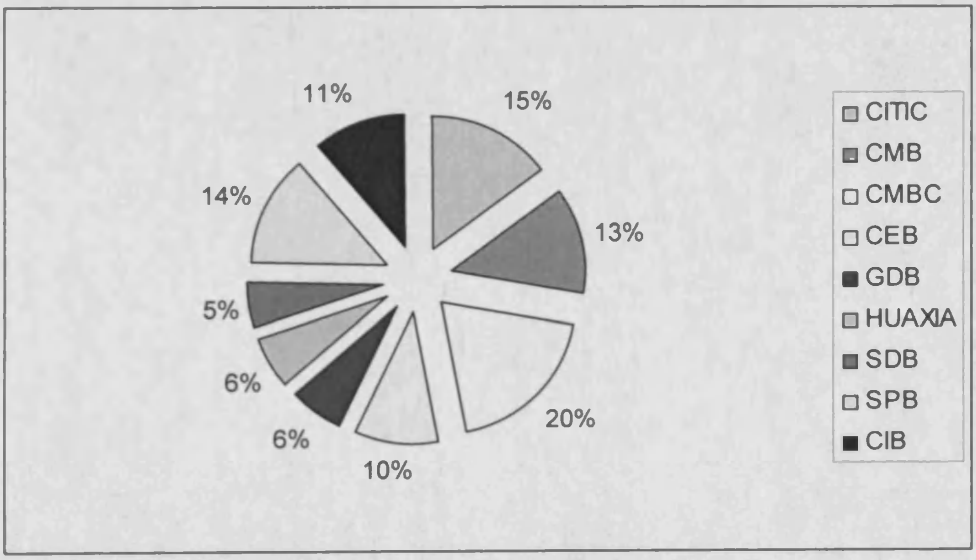
Net interest income has grown at the same pace of the growth in loans over 11 years of the sample. While the loan market is still dominated by the SOCBs, the decline in market share by the state owned sector is indicative of the aggressive growth of the JSCBs. Once again the share of net interest earnings in the JSCB sector mirrors that of the loan market as seen in Figure 4.12.

Figure 4.11 Net interest income 1997-2007



Source: Bankscope

Figure 4.12 Net interest income share among JSCBs in 2007



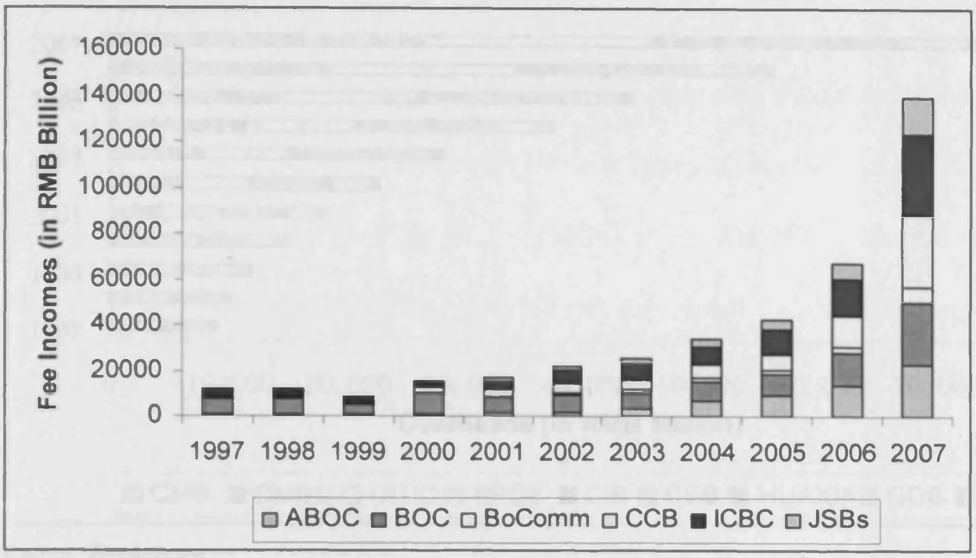
Source: Bankscope

Non-interest fees and other off-balance sheet income have been a relatively recent development in Chinese banks. In the past, services are almost free charge to customers. Given that interest spreads were regulated by the central bank (PBOC), free consumer banking was effectively a subsidy to the household sector paid for by the government. However, the reforms in recent years have led banks to move towards market rates and fees based on direct costs. In this aspect the SOCBs are in better position than JSCBs from the position owning large national branch network. Many JSCBs only have branch networking in major developed cities. For competition, JSCBs attempt to offer free services to customers but has been banned by CBRC as "unfair competition".

Unlike the developed economies, fee incomes are not related to on-balance sheet activities. For example, only 3.2% and 4.3% fee income of the China Construction Bank CCB was directly from guarantee and loan commitment in 2007 and 2006. The sharp increase in fee income in 2007 was largely due to the booming stock market where the banks performed as sales agents for mutual fund companies. Agent fee incomes accounted for 50% of total fee income for CCB in 2007.

By 2007 non-interest income had grown to an average of 17 percent of total income, compared with 3-4% at the beginning of the sample.

Figure 4.13 Non-interest Income 1997-2007

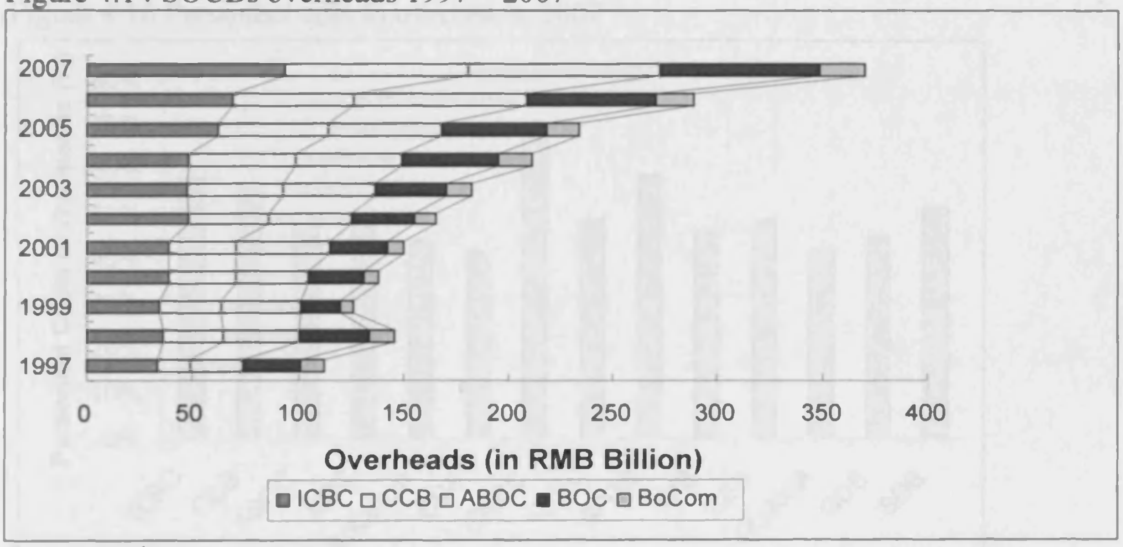


Source: Bankscope

4.10 Overheads

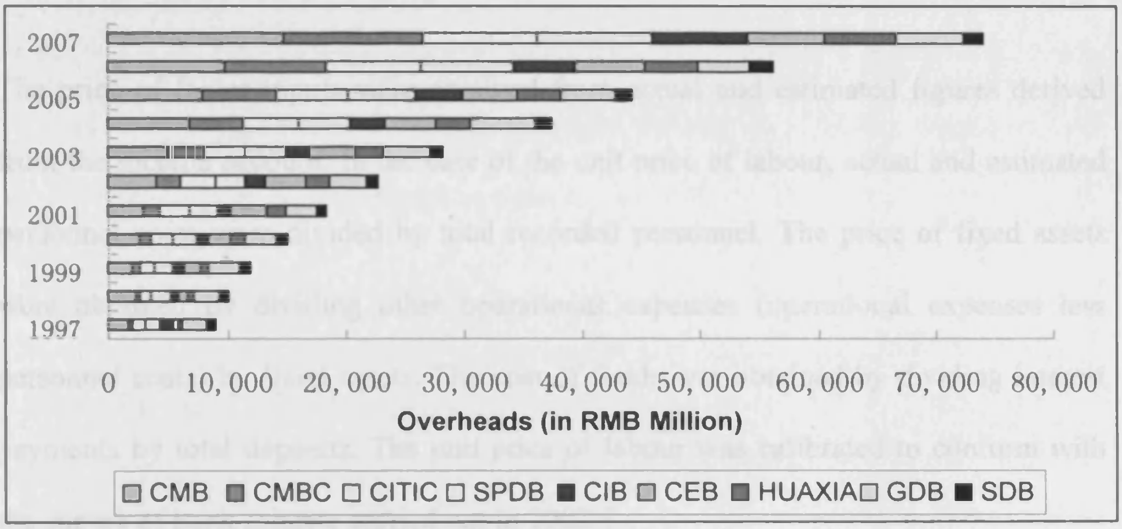
Overheads or operational costs are associated with the business volume, personnel costs and the financing of fixed assets. SOCBs' overheads all grew fast. China Construction Bank has the biggest increase in overhead: 455% (2007 to 1997).

Figure 4.14 SOCBs overheads 1997 ~ 2007



Source: Bankscope

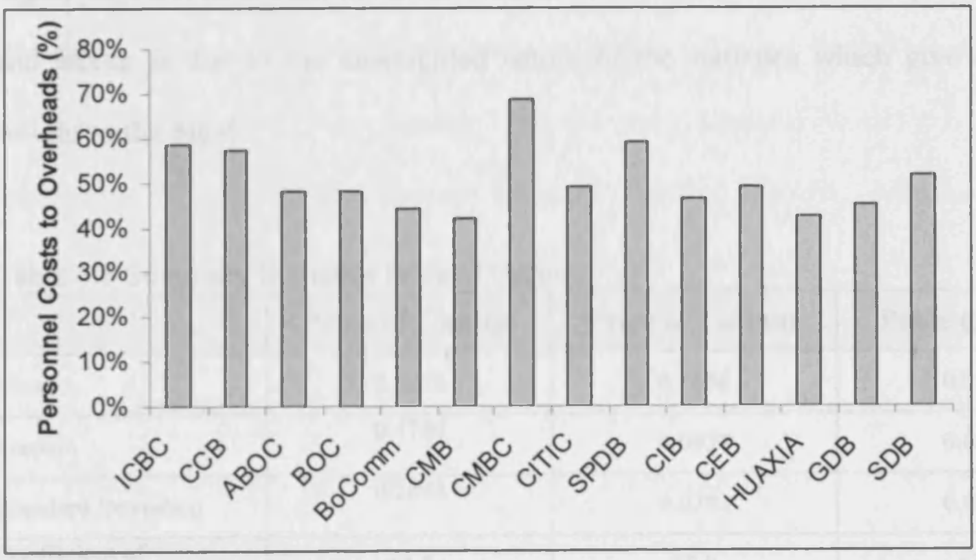
Figure 4.15 JSCBs overheads 1997 ~ 2007



Source: Bankscope

If looking closer at the overheads it can be seen that about 50% of overheads are personnel costs (see Figure 4.16). The fast growth of overheads is driven by the increasing labor costs. The unit price for a Chinese banker is more and more expensive, which adds further impetus for the correction of rent-seeking inefficiency in the form of allocative inefficiency

Figure 4.16 Personnel cost to overheads, 2007



Source: Bankscope and individual bank websites

4.11 Price of Factor Inputs

The price of factor inputs were obtained from actual and estimated figures derived from the income account. In the case of the unit price of labour, actual and estimated personnel costs were divided by total recorded personnel. The price of fixed assets were obtained by dividing other operational expenses (operational expenses less personnel costs) by fixed assets. The cost of funds was obtained by dividing interest payments by total deposits. The unit price of labour was calibrated to conform with the survey of bank salaries carried out in 2002/3.

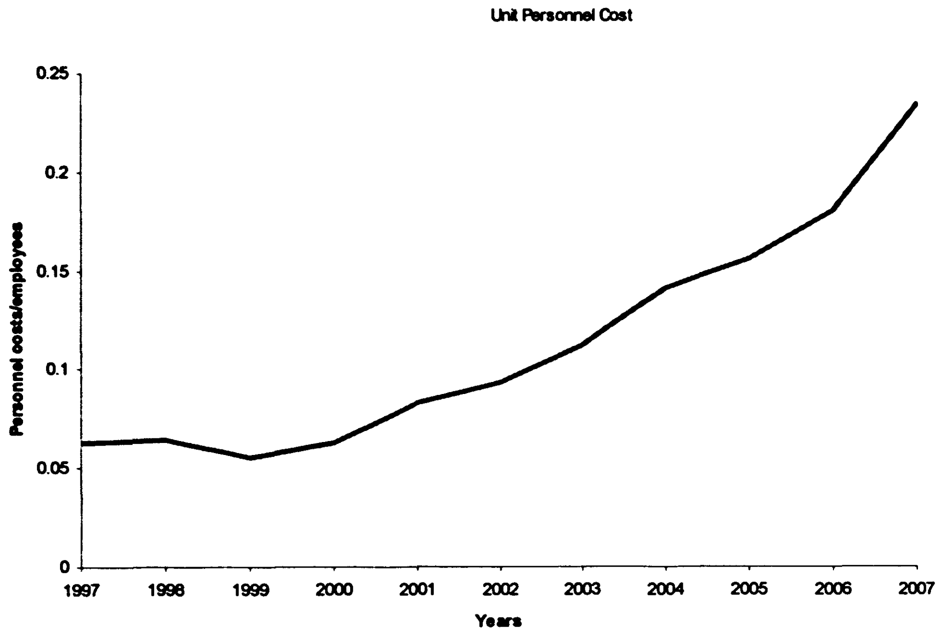
Table 4.6 shows the summary statistics of price of factor inputs and relative dispersion. The relative dispersion suggests that the unweighted distribution of factor prices is similar across all three prices. As expected the mean and median indicate left skewness for the price of capital maintenance and price of labour (positive skewness), but what is surprising is that the cost of funds also exhibits the same pattern. The likely cause of this is that some banks offer longer term maturities of deposits with higher deposits rates than the median banks. The left skewness in the price of capital and labour is due to the unweighted nature of the statistics which give equivalent weight to the big-4.

Table 4.6 Summary Statistics Price of Factors

	Price of Capital	Price of Labour	Price of Funds
Mean	0.5478	0.1136	0.0239
Median	0.4764	0.0927	0.0190
Standard Deviation	0.2893	0.0783	0.0129
Coefficient of Variation %	52.8	68.9	53.9
Skewness	2.23	1.28	2.58

The rising cost of personnel in banking mentioned above is shown in Figure 4.17. The Figure shows the dramatic rise in banker's pay over this period which has grown at an annual rate in excess of 14 per cent per year.

Figure 4.17 Unit Personnel Cost in Banking 1997-2007



Source: Author calculations

4.12 Summary

This chapter has described the main data used in the following three chapters. Most of the data was obtained from secondary sources and principally from Fitch/Thompson Bankscope. Supplementary sources were the Chinese Banking Almanac (various issues) and the CBRC website. Additional data for the City Commercial banks was obtained from their individual websites. Data on NPLs were obtained from a variety of official and unofficial sources supplementing Bankscope. Where data was missing or unavailable reasonable working assumptions were employed to fill the gaps.

Chapter 7 uses the basic consolidated balance sheet and income statement data which can be obtained from the conventional sources. However, the network DEA requires a description of the internal flow of funds of each bank. Data for this was obtained from individual bank annual reports. Where data on internal flows were incomplete this was obtained through simulation. Chapter 7 explains the details fully.

Chapter 5

Rent Seeking Versus X-Efficiency: An Interpretation of Inefficiency in Chinese Banking

"Microeconomic theory focuses on allocative efficiency to the exclusion of other types of efficiencies that, are in fact, are much more signigficant." *Harvey Leibenstein*

5.1 Introduction

The principal aim of this chapter is to address the question, how efficient is Chinese bank management[34]? The way this will be done is by evaluating the relative efficiency of Chinese banks over the period 1997 to 2006. Vickers (1993) argues that there is a direct link between the efficiency of an institution and managerial performance and explains differing degrees of inefficiency which constitute what Leibenstein (1966) calls X-effciency theory. In the Vickers (1993), firm-owner – firm-manager model, manager compensation is related to performance which in turn is a function of managerial effort, ability and luck. While the distributions of ability and luck may be known, the distribution of effort is not[35]. Hence it is possible to argue that average overall efficiency of the firm is related to managerial effort.

In a recent study of the success of privatizations in the former Soviet Union, Barberis et al (1996) survey 452 Russian retail privatizations between 1992 and1993 and pose the question, what explains the success of privatization – incentives or training

[34] An earlier version of this chapter was published in the China Finance Review and covered the year 1997 ~ 2003. Matthews et al (2007).

[35] Psychologists typically assume that IQ is normally distributed and it is acceptable to assume that luck is also normally distributed with a mean of zero.

(human capital)? In the same way, the question which is posed in this chapter is what can improve Chinese bank management performance, incentives or training? A safe answer is of course both, but which is more important? In this chapter bank efficiency is treated as a proxy for bank management efficiency. This chapter presents the results in trying to measure and Figure the evolution of relative efficiency in Chinese banks. In evaluating the path of inefficiency/efficiency, it will aim to decompose cost inefficiency into allocative inefficiency and X-inefficiency in the sense of Leibenstein. The main hypothesis is that relative inefficiency should decline as we get closer to the date when the banking market opens to foreign competition in China. This is known as the efficiency convergence hypothesis. The secondary hypotheses are in two parts. The first part is that cost inefficiency can be decomposed into X-inefficiency and allocative inefficiency. It will be argued that allocative inefficiency is symptomatic of rent-seeking behaviour and is therefore the outcome of rational optimizing managers. If it is found rent-seeking inefficiency is larger than X-inefficiency then it may be concluded that incentives are more important than training. However, if X-inefficiency is larger than rent-seeking inefficiency, then it may be argued that training is more important than incentives.

In theory, the Chinese banking market has been open to foreign competition since the end of 2006. The strategy of allowing a larger stake holding in the Chinese banking system by foreign banks as a means of improving efficiency has a good academic pedigree. The link between privatization and efficiency improvement in former government owned enterprises is now very much an established finding (Megginson and Netter, 2001). The link between privatization of banking and efficiency improvement is an emerging research area (see Megginson, 2005 for a survey).

Given the recent listing of the major state owned banks and the tacit acceptance of larger stakes by foreign banks in the smaller commercial banks, it is not surprising that bank efficiency in China has become a popular subject of research in recent years. A number of studies of Chinese banking efficiency have been published in Chinese scholarly journals[36] but to date there have been only a few studies that are available to non-Chinese readers[37].

While the gradualist economic reform policies of Deng Xiao Ping have transformed management practice and corporate efficiency in the manufacturing sector, it can be argued that the mindset of the corporatist thinking in management continues in much of the state owned enterprises (SOEs) in China, including its banks.

Cost inefficiency relative to 'best practice' is usually blamed on bad management and poor motivation. As already mentioned in terms of Leibenstein (1966) this efficiency gap is termed 'X-inefficiency'. However, in the context of an economy that has only recently begun to open its banking sector, this chapter argues that a significant cause of bank inefficiency is 'rent seeking' behavior, rather than X-inefficiency.

This research has three objectives. First it aims to decompose the measure of Cost inefficiency in Chinese banks into Technical inefficiency (sometimes viewed as X-inefficiency), and Rent-seeking inefficiency. This chapter argues that while the

[36] For example Qing and Ou, (2001); Xu, Junmin, and Zhensheng, (2001); Wei and Wang, (2000); Xue and Yang, (1998) and Zhao (2000) have used non-parametric methods while Liu and Song (2004), Zhang, Gu and Di (2005), Sun (2005) and Qian (2003) have used parametric methods.

[37] Recent exceptions are studies using non-parametric methods by Chen et. al. (2005) and parametric methods by Fu and Heffernan (2005). Other recent studies in English are, Lin and Zhang (2008), Berger et. al. (2008) and Fu and Heffernen (2008).

underutilization of factors is consistent with the notion of X-inefficiency, the wrong factor-mix is indicative of 'rent-seeking'. The decomposition of cost inefficiency into X-inefficiency (technical inefficiency) and rent-seeking inefficiency allows us to examine their evolution over the sample period. Second, this chapter aims to provide an inferential capability to the point-estimates of inefficiency through the use of bootstrapping methods. Third, the bootstrap estimates of inefficiency are used to test various hypotheses regarding the levels and trends in X-inefficiency and rent-seeking inefficiency. The threat of entry of foreign banks into the Chinese market should lead to improved management, which should result in improved technical efficiency and lower cost-inefficiency as incumbent banks attempt to cut costs and consolidate their balance sheets.

This chapter is organized on the following lines. The next section briefly describes the methodology of the non-parametric method of estimating bank efficiency[38] and the application of bootstrapping technology. Section 3 reviews the literature and discusses the concept of X-inefficiency and the implications for its measurement in the context of banking. Section 4 and 5 discusses the data and the results. Section 6 concludes.

5.2 Background and Methodology

Up until 1995, control of the banking system remained firmly under the government and its agencies[39]. Under state control, the banks in China served the socialist plan of directing credits to specific projects dictated by political preference rather than commercial imperative. Since 2001 foreign banks and financial institutions were

[38] A detailed examination is in Chapter 3

[39] According to La Porta, et. al (2002), 99% of the 10 largest commercial banks were owned and under the control of the government in 1995.

allowed to take a stake in selected Chinese banks. While control of individual Chinese banks remain out of reach for the foreign institution[40], the pressure to reform management, consolidate balance sheets, improve risk management and reduce unit costs has increased with greater foreign exposure. The theory of market contestability (Baumol, 1982) suggests that incumbent banks will restructure weak balance sheets, reduce costs, and improve efficiency in preparation for the threat of entry. Chinese banks should exhibit less inefficiency, whichever way measured, in 2006 than in 1997.

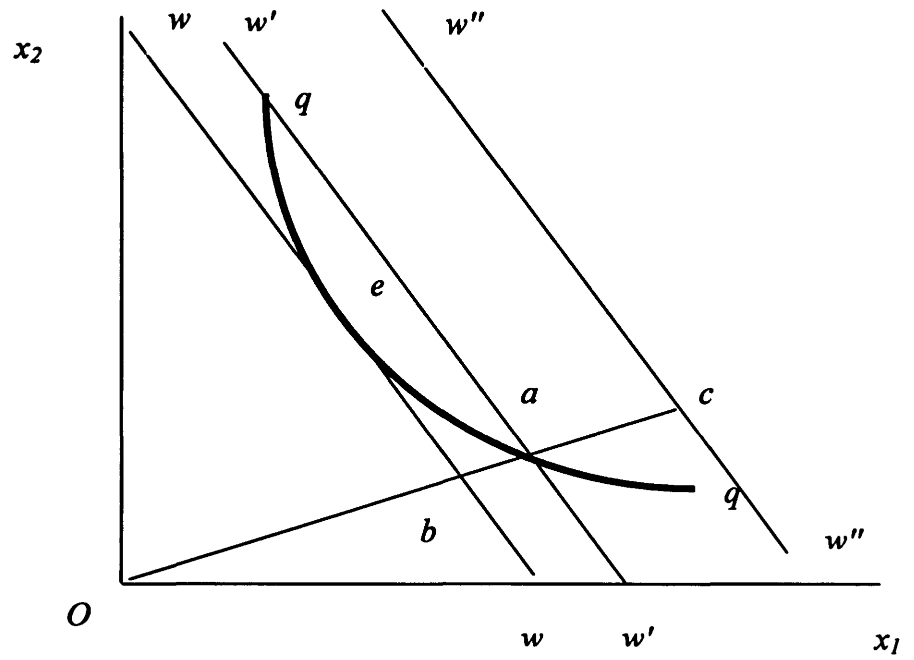
The basis of the non-parametric method of Data Envelope Analysis (DEA) is the extension by Charnes et al. (1978) (CCR)[41] of the single input-output model of Farrell (1957) to a multiple input-output generalisation. Technical efficiency (TE) is measured as the ratio of projected output (on the efficient frontier) to actual input used. There are a number of papers that describe the methodology of DEA as applied to banking[42], and therefore will not be elaborated here. Chapter 3 provides an overview of the basic methodology. A two-input single-output illustration will aid the understanding of the decomposition of cost inefficiency into its technical (X-inefficiency) and rent-seeking components.

Figure 5.1 shows an isoquant *qq* producing a given output with factor inputs x_1 and x_2 and isocost *ww*, which traces the ratio of factor prices. The efficient cost minimising position is shown at *e* where *ww* is tangential to *qq*. However, employing a factor

[40] There is a cap of 25% on total equity held by foreigners and a maximum of 20% for any single foreign investor, except in the case of joint-venture banks.
[41] Charnes et al. (1978) popularised the DEA method. According to Tavares (2002) who produces a bibliography of DEA (1978-2001), there are 3203 DEA authors whose studies cover a wide range of fields. Banxia.com also compiles DEA chapters from 1978 to the present.
[42] The most recent being Drake (2004)

combination shown by point *c*, which is to the right of the isoquant *qq* indicates that the firm is technically inefficient. Efficiency is decomposed into technical efficiency (TE) and allocative efficiency (AE).

Figure 5.1 Technical Efficiency and Allocative Efficiency



Technical efficiency is measured by the ratio *Oa/Oc* (Technical inefficiency is given by *ac/Oc*). The cost to the firm is shown by *w''w''* which is parallel to *ww* and passes through point *c*. Cost efficiency (CE) is measured by *Ob/Oc* and *Ob/Oa* gives AE[43].

DEA constructs a non-parametric frontier of the best practices amongst the decision-making units (DMUs). An efficiency score for each DMU is measured in relation to this frontier. DEA is relatively insensitive to model specification (input or

[43] It can be seen from this decomposition that under the assumption of constant returns to scale that AE = CE/TE.

output orientation) and functional form[44], however the results are sensitive to the choice of inputs and outputs. The weakness of the DEA approach is that it assumes data are free from measurement errors. Furthermore, since efficiency is measured in a relative way, its analysis is confined to the sample used. This means that an efficient DMU found in the analysis cannot be compared in a straightforward way with other DMUs outside of the sample.

One of the criticisms levelled at the DEA approach is that it produces estimates of efficiency that are not open to statistical inference. In other words if a DMU has a score of 0.95, in what statistical sense is it 5% inefficient relative to the benchmark? Without the capability for statistical inference, non-parametric methods would be weak alternatives to parametric methods of estimating efficiency. However, uncertainties also exist in the estimation of efficiency using DEA. The most obvious uncertainty is what comes from measurement error. Measurement error in the context of data on Chinese banks is particularly marked. There are three potential sources of error: firstly differences between local bank's accounting procedures and those of international bodies; secondly differences between local bank's accounting conventions and thirdly, researcher assumptions relating to the generation of missing observations. Other uncertainties arise from the estimation of the efficiency frontier; changes to the inputs and/or outputs can cause large differences in the resulting scores. Furthermore there may be errors in the sampling variation caused by the difficulty in obtaining a sufficiently large and consistent sampling frame.

[44] Hab abou (2002) and Avkiran (1999) provide a relatively thorough discussion of the merits and limits of the DEA.

The bootstrap procedure for non-parametric frontier models is set out in Simar and Wilson (1998, 2000a, 2000b). The efficiency scores calculated with the original data are used to construct pseudo data. The bootstrap procedure is based on the idea that there exists a Data Generating Process (DGP), which can be determined by Monte Carlo simulation. By using the estimated distribution of the DGP to generate a large number of random samples, a set of pseudo estimates of the efficiency scores $\hat{\theta}_i$ are obtained. However this 'naive' bootstrap yields inconsistent estimates (Simar and Wilson, 2000a). The author followed the homogeneous bootstrap procedure that produces consistent values of $\hat{\theta}_i$ from a kernel density estimate as given in Simar and Wilson (2000b). Following the Simar-Wilson method, 1000 bootstrap values of the individual DMU for all types of efficiency scores are generated in each year[45]. The appendix 5-I to this chapter provides a description of the algorithm.

5.3 X-Efficiency and Literature Review

Most studies of banking efficiency have focussed on the developed economies[46]. While there have been some studies of other Far Eastern economies[47], the number is small in comparison. Indeed, from Berger and Humphrey's (1997) survey of 130 studies of frontier analysis in 21 countries, only 8 were about developing and Asian countries (including 2 in Japan). Studies on US financial institutions were the most common, accounting for 66 out of 116 single country studies.

[45] Recent bootstrapping applications to DEA have been conducted by Löthgren and Tambour (1999); in the case of banking efficiency by Casu and Molyneux (2003); and in the case of Chinese rural credit cooperatives, Dong and Featherstone (2004).
[46] See for example Drake and Hall (2003), Cavallo and Rossi (2002), Elyasiani and Rezvanian (2002), Maudos et al. (2002), Drake (2001) Altunbas and Molyneux (1996) and Molyneux and Forbes (1993)
[47] See Rezvanian and Mehdian (2002), Hardy and di Patti (2001), Karim (2001), Laevan (1999), Katib and Matthews (1999), Chu and Lim (1998), Bhattacharyya et al. (1997) and Fukuyama (1995)

A number of efficiency studies of Chinese banks have emerged in recent years, using both DEA and stochastic frontier analysis[48]. The consensus of finding from the DEA studies is threefold. First, because of the continued banking reform programme technical inefficiency has been declining over time. Second, average bank efficiency is lower in the state owned banks (BIG-4s) than in the joint stock banks. Third, the gap between the two has been narrowing in recent years.

Studies of bank efficiency have used the terms technical efficiency and X-efficiency interchangeably as if they were the same thing. While similar in concept they are not necessarily the same. The concept of technical efficiency derives its basis in the neo-classical theory of the firm and assumes profit maximising behaviour. A firm or a bank may be technically inefficient for technical reasons such as low training or low human capital levels of managers and workers, or the use of inferior or out-of-date technology. The diffusion of new technology is not instantaneous and some firms or banks may lag behind others in the acquisition and utilisation of new technology. With further training and updating of capital, the firm or bank can expect to move towards the efficient frontier described by the isoquant in Figure 5.1. X-inefficiency is not caused by the variability of skills or the time variability of technology diffusion but by the use and organisation of such skills and technology.

Berger, Hunter and Timme (1993) argue that X-inefficiency constitutes 20% or more of bank costs. Poor motivation and weak pressure resulting in under utilization of factors of production, is part of what Leibenstein (1975) describes as 'organisational

[48] In addition to the studies cited in chapter 3, other studies by Chinese scholars that have used non-parametric techniques include Xu, Junmin and Zhensheng (2001), Zhang and Li (2001), Fang et. al. (2004). Studies using parametric methods include Zhang, Gu and Di (2005), Chen C and Song W (2004), Liu and Liu (2004), Sun (2005), Qian (2003), Chi, Sun and Lu (2005), Yao, Feng and Jiang (2004)

entropy'. X-inefficiency arises as a result of low pressure for performance. Some institutions would be protected by government regulation that would reduce the external pressure of competition. But even with a higher degree of pressure from the environment, firms may have organisational deficiencies so that management signals and incentives are lost in the hierarchy of the organisation.

An alternative interpretation of X-inefficiency is 'rent seeking' in the sense of Buchanan (1980) and Tullock (1967, 1980). Rent seeking in its basic form is the appropriation of surplus in the process of production or exchange without any real contribution to the process of either. Where there are government regulations on enterprise, barriers to entry and other anti-competitive rules, officials have the opportunity to extract rents through the mechanism of bribery and corruption. Therefore the term rent seeking has been generally associated with extortion, bribery and corruption. It is certainly the case that corruption is seen to be endemic in the financial sector in China. Recent high profile cases are Wang Xue Bing, former Governor of Construction Bank of China, jailed for 12 years – bribes of RMB1.2 million and Vice-Chairman of BOC under a suspended death sentence for embezzling RMB14.5 million.

However, a hidden but much more pervasive type of rent seeking is the extraction of larger budgets for bureaucracies and what results in the non-pecuniary rewards to workers in government owned enterprises[49]. The prestige of the senior bureaucrats is enhanced if the size of the workforce is expanded to be larger than necessary to

[49] See Tullock (196 7) or McKenzie and Tulloch (1975) Chapter 17.

meet production targets. Similarly, offices are more grandiose, holidays are longer, and benefits are greater and so on.

Bogetoft and Hougaard (2003) suggest that the existence of X-inefficiency in production is the outcome of a rational decision making process that represents on-the-job compensation to managers. Whereas X-inefficiency is viewed by Leibenstein (1966, 1978) as non-maximising behaviour, Stigler (1976) argues that its existence is symptomatic of firms maximising their individual utility functions. Given a production function, a given set of inputs and factor prices, the bureaucrat minimises costs subject to a Williamson (1963) type utility function that includes in its arguments the level of output and a subset of factor inputs[50].

For purposes of presentation, assume that the bank produces a single earnings asset (A). In reality this will consist of a combination of commercial loans, mortgages, government bonds, short-term bills, etc. Assume that this earning asset is produced by the inputs, deposits (D), labour (L) and fixed capital assets $(\overline{K})$[51].

$$A = D^{\alpha}\left(L^{\beta}\overline{K}^{1-\beta}\right)^{1-\alpha} \qquad (1)$$

The price of inputs are, the cost of deposits (r), the cost of labour (w) and the cost of fixed assets (ρ). The bank manager/bureaucrat has a utility function that includes an

[50] In the case of Williamson (1963) the utility function of the manager includes reported profit and expenditure on staff.

[51] This uses the assumption of the intermediation approach that recognises that the outputs are the interest earning assets while deposits and borrowed funds are included with capital labour as inputs. See Sealey and Lindley (1977).

output objective and as well as an employment objective given by rent-seeking preferences.

$$U = U(A, L) = \ln A + \ln L \qquad (2)$$

The objective of the manager/bureaucrat is to minimise costs subject to his utility.

$$\text{Min} \quad \rho\overline{K} + wL + rD - \lambda\left(\alpha \ln D + (1-\alpha)\beta \ln L + (1-\alpha)(1-\beta)\ln \overline{K} + \ln L - \overline{U}\right) \qquad (3)$$

The first order conditions are:

$$\begin{aligned} \frac{\partial \lambda}{\partial D} &= r - \frac{\lambda\alpha}{D} = 0 \\ \frac{\partial \lambda}{\partial L} &= w - \frac{\lambda[(1-\alpha)\beta + 1]}{L} = 0 \\ \frac{\partial \lambda}{\partial \lambda} &= \alpha \ln D + (1 + (1-\alpha)\beta)\ln L + ((1-\alpha)(1-\beta))\ln \overline{K} - \overline{U} = 0 \end{aligned} \qquad (4)$$

The FOC show that an allocative inefficiency is created that result in higher factor inputs of labour above that implied by the optimal factor mix. If the optimal labour input in a non-rent seeking environment is denoted as L^*, and the rent-seeking labour input is denoted as L_R. Then it can be shown that:

$$\left(\frac{L_R}{L^*}\right) = \left(\frac{(1-\alpha)\beta + 1}{(1-\alpha)\beta}\right)^{\frac{\alpha}{\alpha + \beta(1-\alpha)}} > 1 \qquad (5)$$

In Figure 5.1, point *e* defines the optimal factor mix given the observed factor prices, but point '*a*' while allocatively inefficient is the optimal position for the rent-seeking manager. A bank can organise its input factors to be on its production frontier but by using the wrong factor mix. Rent seeking in monopolistic public utilities involves over-staffing, 'elaborate offices and a lot of trips to important conferences' or 'expensive subsidised restaurants' (McKenzie and Tullock, 1975). The wrong factor mix in the case of the Chinese banking sector can be interpreted as excess staffing[52]. The management of the banks may reduce technical inefficiency (X-inefficiency as it has been sometimes interpreted) by moving the cost frontier from *w''w''* to *w'w'*, but would still remain cost inefficient as shown by the gap *ab*/*Oa*. The gap between the minimum cost optimal factor mix and the technically efficient minimum cost associated with the efficient production frontier with the sub-optimal factor mix (or allocative inefficiency) can be interpreted as the inefficiency associated with 'rent seeking'[53].

5.4 Data and Results

This study employs annual data (1997-2006) for 14 banks; the four state-owned banks (Big-4), and ten joint-stock commercial banks (JSCB including Bank of Communications which was latterly designated as a SOCB). Data for one of the joint-stock banks was unavailable for 2004 - 2006 (China Everbright); and in those years 13 banks data was used. The total sample consisted of 137 bank year observations. The main source of the data was Fitch/Bankscope, individual annual reports of banks and the *Almanac of China's Finance and Banking* (various issues). See also Chapter 4. The choice of banks was based on the fact that they face a common market and compete nationwide.

[52] In the case of pre-reform China, the bureaucratic bank manager would have been instructed to employ a quota of graduates from the central bank sponsored universities, and schools as well as retirees from the Peoples Army Officer Corps.

[53] Cra in and Zardkoohi (1980) suggest that X-inefficiency and rent seeking co-exist and that changes to X-inefficiency are offset by equal changes in rent seeking, so that there is a trade-off between one type of inefficiency against another.

In this study, three sets of outputs are considered. First, use three inputs and three outputs selected under the intermediation approach for the estimation of technical efficiency. Inputs are the number of employees (*LAB*), fixed assets (*FA*) and total deposits (*DEP*). Outputs are total loans (*LOANS*), other earning assets (*OEA*), and net interest income (*NII*).

Second, consider the quality of the loan portfolio by stripping out non-performing loans (NPLs) from the stock of loans for each bank (*PLOAN*). In both cases, the vector of inputs is the same as in the first case. The argument for adjusting loans for NPLs is to mitigate the effect of the large loan portfolios held by the big SOCBs on the efficiency calculation. The unadjusted loan portfolio would bias the efficiency score upwards for the SOCBs which have the largest share of loans but also the highest proportion of NPLs.

The inputs for the construction of cost-efficiency additionally require the factor prices of the relevant inputs above. The price of labour (*PL*) is obtained as the ratio of personnel expenses to employees. The price of fixed capital (*PK*) is obtained as operating expenses less personnel expenses divided by fixed assets (less depreciation). The price of funds (*PF*) is obtained from the ratio of interest paid to total funds.

The availability of uniform and comparable data on Chinese banking is a very recent development. Researchers have typically made a number of working assumptions to fill the gaps in data (see chapter 4). In general, balance sheet data is available although the data revisions alter the figures from year to year and up until recently the accounting standards of Chinese banks differed from international standards (Ng and Turton 2001). The number of employees are available for the big four state owned banks but not for all of the joint-stock banks over all years. Similarly, the availability of personnel expenses varies across banks. In the years that personnel expenses were not available, the ratio of personnel expenses to total operating expenses in the most recent year to the missing was applied (see also chapter 4). In the years where the number of employees was not available, the ratio of labour to fixed assets in the most recent year available was applied[54]. Where there were no personnel expenses available, survey data were used to construct personnel costs[55].

Table 5.1 presents the summary statistics of the input and output data for 1997 and 2006 as a snapshot indicator of the scale of the variables used. The high standard deviation is an indication of the dominance of the 4 state owned banks. The table shows how fast earnings assets have grown over this period. The total stock of loans has grown on average by 173% but subtracting for NPLs the growth has been faster by 362%. Other earning assets have grown by 405% in part reflecting the activities of the asset management companies that swapped tranches of the NPLs of the BIG-4s for bonds in 1999 and 2001. The most remarkable growth is in non-interest earnings which have grown by 503% reflecting an increasing source of profit for banks that have traditional depended on the banking book for the generation of income.

[54] Fu and Heffernan (2005) assume that the employee growth matches the growth of total assets and they use the average wage paid by state-owned and other types of financial institutions to estimate labour cost.

[55] This was only in the case of the Agricultural Bank of China. One year (2003) data was available from an independent survey. The Bank of China was used as the benchmark the relative wage for ABOC for the other years. See chapter 4.

5.5 Empirical Results

Table 5.2 illustrates the results of the bootstrap method for 1997 and 2006 in the case of Technical Efficiency (X-efficiency) for both the NPL-unadjusted and NPL-adjusted loan portfolio of the banks. The appendix 5-II shows the pure DEA results for cost efficiency, and Technical efficiency (X-efficiency) compared with the bias adjusted bootstrap values and the confidence intervals at the conventional 95% level.

Table 5.1 Output-Input Variables 1997 - 2006 (million RMB)

Variable	Description	Mean 1997	SD 1997	Mean 2006	SD 2006
LOANS RMB mill	Total stock of loans	430033	657201	1174038	1213224
OEA RMB mill	Investments	205103	301626	1037659	1203155
NII RMB mill	Net Fees and Commissions	862	1922	5200	6141
LOANSQ RMB mill	Loans less NPLs	246365	320844	1139258	1124600
LAB	Total Employed	105138	175233	125953	164260
DEP RMB mill	Total stock of Deposits	604013	891353	2167172	2258284
FA RMB mill	Fixed assets	12831	19398	32562	38745
PL	Unit price of labour	.0631	.0380	.1663	.0811
PF	Unit price of funds	.0502	.0202	.0172	.0025
PK	Unit price of fixed assets	.6528	.5282	.6478	.2242

Sources: Fitch/Bankscope, Almanac of China's Finance and Banking (various) and author calculations from web sources.

Table 5.2 shows the median[56] of the pure bootstrap estimates, the bootstrap bias-adjusted values and the confidence intervals of the pure bootstrap results. Simar and Wilson (2000a, 2000b) show that the bootstrap estimates are biased but a bias correction will introduce extra noise that may result in a mean-square error (MSE)

[56] The median estimate provides a more robust measure of the score when the distributions are skewed as in DEA.

greater than the MSE of the bias-unadjusted bootstrap values. In the limit the bias corrected MSE will be three times that of the uncorrected estimate and Simar and Wilson caution against the bias correction unless the ratio $\left(\frac{\frac{1}{3}B^2}{\hat{\sigma}^2}\right)$ is greater than unity. Where B is the bias correction and $\hat{\sigma}^2$ is the sample variance of the uncorrected bootstrap values. This condition was satisfied 78-84% of the time for each year in the sample. Although the bias-corrected estimates are reported, the non universal satisfaction of the bias correction condition means that the median estimates must be treated with caution.

Table 5.2 Bootstrap Estimates of Technical efficiency (Bias corrected, median estimates) 1997 & 2006 CRS

Bank	Output	1997				2006			
		Pure Boot TE	Bias Adjusted	Confidence intervals 95% -pure boot		Pure Boot TE	Bias Adjusted	Confidence intervals 95% - pure boot	
ABOC	Unadjusted	.9286	.8487*	.8971	.9976	1.0091	.9152*	.9572	1.678
	Adjusted	.4836	.3054*	.4183	.6124	.9482	.7475*	.8952	1.186
BOC	Unadjusted	1.519	.6555	.3619	9.2055	1.3029	.7602*	1.0192	2.7772
	Adjusted	1.4811	.6647	.2369	5.7010	1.3114	.7573*	1.0283	2.3151
CCB	Unadjusted	1.6778	.5959*	1.2848	2.3951	.9999	.9194*	.9695	1.0723
	Adjusted	1.5431	.5635*	1.083	2.4132	1.0112	.8938*	.9742	1.1175
ICBC	Unadjusted	1.0241	.9202*	.9663	1.9762	1.1463	.6562*	.9494	2.1750
	Adjusted	.5462	.2762*	.4348	.8265	1.1633	.6411*	.9555	2.331
BoCom	Unadjusted	1.7939	.5570*	1.4080	2.4404	1.4504	.6600*	1.1548	2.0092
	Adjusted	1.6506	.6050*	1.2892	2.2381	1.3978	.6278*	1.1331	1.8989
CITIC	Unadjusted	1.5565	.6379*	1.1937	2.0459	1.4158	.6766*	1.1723	1.914
	Adjusted	1.3964	.7182*	1.1345	1.8470	1.4083	.6295*	1.1670	1.8631
CMB	Unadjusted	1.5789	.6279*	1.2867	2.1975	1.3855	.6990*	1.1908	1.6847
	Adjusted	1.5613	.6431*	1.2238	2.2317	1.3806	.6814*	1.1856	1.6763
CMBCL	Unadjusted	1.9288	.5150*	1.5810	2.6368	1.1009	.8136*	.9937	1.3612
	Adjusted	1.7305	.5863*	1.1903	2.5958	1.0988	.7630*	.9839	1.3716
EVERBRT	Unadjusted	1.0345	.7732*	.9402	1.2845	-	-	-	-
	Adjusted	.8768	.4507*	.6921	1.2044	-	-	-	-
GDB	Unadjusted	1.6470	.6030*	1.2551	2.1861	1.3251	.6625*	1.0678	1.7580
	Adjusted	1.4875	.6751*	1.1845	1.9952	1.2821	.6262*	1.0639	1.6831
HUAXIA	Unadjusted	3.3857	.2944*	2.0423	5.3428	1.6716	.5809*	1.2880	2.0847
	Adjusted	3.4962	.2855*	2.2137	5.3695	1.6464	.5576*	1.3208	2.0790
IBCL	Unadjusted	1.2858	.7795*	.7931	4.867	1.1351	.5808*	.8422	3.1528
	Adjusted	.5601	.2714*	.4360	.8632	1.1194	.8552*	.8764	2.4531
SDB	Unadjusted	1.0533	.9107*	1.0038	1.2363	1.2583	.7768*	1.1027	1.6326
	Adjusted	.9119	.3332*	.6608	1.3266	1.1938	.7464*	1.0349	1.5603
SPB	Unadjusted	2.0651	.9107*	1.5949	2.8071	1.5465	.6232*	1.2231	2.1256
	Adjusted	15.918	.0595*	3.815	47.25	1.4914	.5769*	1.1965	2.0215

** significantly different from biars corrected at the 95% level of confidence*

Table 5.3 presents the results of bias corrected bootstrap estimation of X-inefficiency and rent-seeking inefficiency for the Constant Returns to Scale (CRS) assumption. For reasons of brevity four years for both types of output are shown in the table.

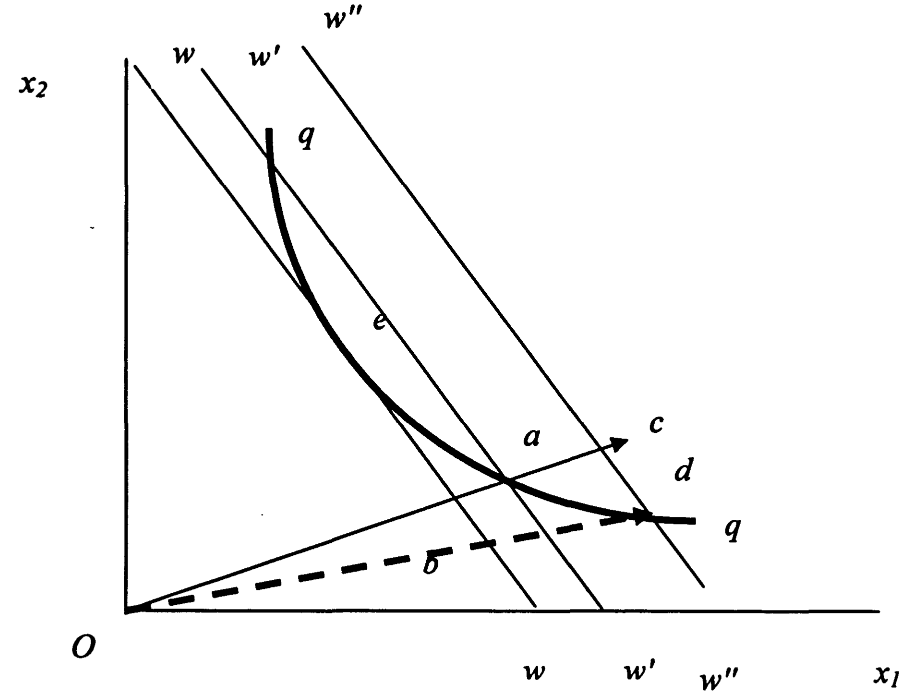
Table 5.3 Bootstrap Estimates of Inefficiency (Bias corrected, median estimates) 1997-2006 (%) CRS

Bank	Output	1997		2000		2003		2006	
		X-ineff	Rent	X-ineff	Rent	X-ineff	Rent	X-ineff	Rent
ABOC	Unadjusted	14.5	50.5	27.6	36.6	4.7	54.3	8.5	47.5
	Adjusted	69.5	27.8	54.8	21.1	28.5	38.9	25.3	37.2
BOC	Unadjusted	34.5	25.6	33.9	0.0	43.9	0.0	24.0	8.6
	Adjusted	33.5	55.1	31.9	0	44.1	0	24.3	10.4
CCB	Unadjusted	7.9	52.9	42.7	25.3	16.0	37.0	34.7	13.2
	Adjusted	72.4	23.8	42.0	24.8	15.5	35.3	35.9	13.7
ICBC	Unadjusted	22.1	30.2	36.2	25.1	19.4	23.9	12.6	26.8
	Adjusted	72.9	23.7	48.7	17.8	11.4	36.2	14.4	27.0
BoCom	Unadjusted	40.1	15.7	46.3	0	17.1	38.7	8.5	42.4
	Adjusted	43.7	50.0	45.9	0	19.2	37.2	10.6	40.7
CITIC	Unadjusted	44.3	6.7	39.3	23.8	36.6	10.6	34.0	8.3
	Adjusted	39.5	49.3	38.0	22.8	38.1	11.2	37.2	6.2
CMB	Unadjusted	36.2	17.6	25.4	34.6	52.1	0	32.3	3.1
	Adjusted	28.1	64.1	24.0	26.5	52.1	0	37.1	0
CMBC	Unadjusted	37.2	17.1	22.1	26.5	25.2	13.1	30.0	0
	Adjusted	35.7	51.0	18.2	28.7	25.7	11.2	31.9	0
EVERBRT	Unadjusted	48.5	2.9	41.5	16.0	35.1	6.1	-	-
	Adjusted	41.4	51.5	38.8	17.9	32.5	21.5	-	-
GDB	Unadjusted	22.7	37.9	29.5	34.6	15.3	33.6	18.6	22.0
	Adjusted	54.9	38.5	35.9	28.3	16.1	48.0	23.7	19.4
HUAXIA	Unadjusted	39.7	15.4	23.6	36.0	31.0	20.0	33.7	11.8
	Adjusted	32.5	59.1	30.4	19.7	28.1	22.3	37.4	10.0
IBCL	Unadjusted	70.6	0	26.6	34.4	32.4	18.1	41.9	0
	Adjusted	71.4	0	22.9	33.2	28.9	21.3	44.2	0
SDB	Unadjusted	8.9	56.3	23.1	41.3	18.1	29.2	22.3	18.1
	Adjusted	66.7	26.3	31.7	32.8	21.4	28.4	25.4	18.5
SPB	Unadjusted	51.3	0	33.9	31.6	40.9	0.9	37.8	0
	Adjusted	94.4	0	33.3	30.5	44.7	0	42.0	17.0

The adjustment of loans for NPLs has had a significant effect in worsening the X-inefficiency score of a number of banks but in particular the SOCBs (excluding Bank of China). This should not be a surprise as the SOCBs have a larger concentration of NPLs than the JSCBs over the sample. However by 2006 the NPL ratio for all the banks declined significantly so that the difference between the two measures produces minimal difference between the two measures of X-inefficiency.

Three questions can be asked about the bootstrap estimates as a whole and three hypotheses can be tested. First, is there a significant difference between the level of X- and rent-seeking inefficiency between the BIG-4s and JSCBs and what differences do the NPL adjustment to loans make? According to Crane and Zardkoohi (1980) in a rent seeking society, firms are motivated to be X-efficient so that they can generate rent seeking investment in order to influence government so as to meet their profit needs. X-inefficiency is therefore not a free good. Greater X-inefficiency means less of another type of inefficiency. Hence there is a trade-off between the two types of inefficiency. If there is a strong preference for rent-seeking, X-inefficiency should be lower relative to Rent-seeking inefficiency. Figure 5.2 illustrates this trade-off. At point [c] the bank manager is X-inefficient and is rent-seeking by utilising the wrong factor mix. But for the same cost, the bank manager can use more of factor x_1 by moving to point [d]. By remaining at point [c] the manager is not maximising his/her utility by extending the scale of rent-seeking as shown by the dashed line at point [d]. The manager has an incentive to minimise X-inefficiency so as to maximise rent-seeking. In reality X-inefficiency may be inherited because of existing staff contracts and type of personnel.

Figure 5.2 Trade off between X-efficiency and Rent Seeking



So the second question is, is there evidence that inefficiency is being reduced over time? The impending opening up the banking market under WTO rules would suggest that all banks would be 'upping their game' by improving relative cost efficiency, which implies that relative X-inefficiency and rent-seeking inefficiency should decline over the period. Third, if there is evidence of inefficiency reduction, is there a difference between the speed of reduction of X-inefficiency and Rent-Seeking inefficiency?[57] These questions are examined in turn.

Table 5.4 below examines the difference in group means of inefficiency using a non-parametric (Mann-Whitney) test. The first two rows of Table 5.4 show that mean estimate of X-inefficiency and rent-seeking inefficiency don't come from the same population and that contrary to the prediction of the rational inefficiency hypothesis,

[57] The BIG-4s have in the past been used by the state to employ graduates from the central bank sponsored universities and to place retiring officers from the Peoples Liberation Army. Consequently, rent-seeking inefficiency should decline at a slower rate than X-inefficiency

rent-seeking inefficiency is not greater than X-inefficiency on either measure of output. The first two rows of Table 5.4 show the means of X-inefficiency and rent-seeking inefficiency for all the banks with the two different measures of output.

Table 5.4 Mean inefficiency, Unadjusted loans and NPL adjusted loans

Measure	X-inefficiency	Rent-seeking Inefficiency	Z Value
Unadjusted	34.0%	18.5%	4.59***
NPL - Adjusted	28.1%	18.8%	7.35***
Unadjusted BIG-4	28.9%	19.4%	
Unadjusted JSCB	36.1%	18.2%	
Z value	1.33	0.74	
Adjusted BIG-4	16.1%	23.8%	
Adjusted JSCB	32.9%	16.8%	
Z value	4.74***	2.19**	

**** significant at the 1%, ** significant at the 5%*

There is a clear statistical difference between the mean level of X-inefficiency and rent-seeking inefficiency over the full sample period. Average rent-seeking inefficiency is lower than X-inefficiency for all banks. Stronger differences emerge when the sample is split between BIG-4s and JSCBs. The next four rows show the mean inefficiency breakdown separated by BIG-4 and JSCB for the two different measures of output. There is no statistical difference in the mean levels of X-inefficiency and rent-seeking inefficiency of the BIG-4s and the JSCBs when loans are unadjusted. However, stripping out NPLs from loans produces clear differences. Rent-seeking inefficiency is significantly higher in the BIG-4s than JSCBs. So evidence of rational inefficiency is more prevalent in the BIG-4s once the loan portfolio is adjusted for quality.

The second and third questions are addressed by modelling the dynamics of both type of inefficiency. Pooling the data, we use SURE estimation to model the rate of convergence of X-inefficiency (XI) and rent-seeking inefficiency (RI). The dependant variable is respectively the change in X-inefficiency (**ΔXI**) and rent-seeking inefficiency (**ΔRI**). The speed of convergence is captured by the negative coefficient on the lagged values of **XI** and **RI** respectively. The larger the absolute value of the negative coefficient, the faster the rate of convergence.

I use lagged values of bank-specific variables as controls. A one-year lag is specified as a means of eliminating potential endogeneity in the determining variables. The lagged bank cost-income ratio (COST_1), which is operational cost to total revenue, is an indicator of management competence; the higher the cost-income ratio, the higher the level of inefficiency. The lag of the natural logarithm of total assets is used as a proxy for the size of the bank (SIZE_1). The lag of fee income (FEE_1) as a percent of total revenue is an indicator of management flexibility in diversifying the output of the bank and higher values would be expected to be associated with lower levels of inefficiency. The variable FOR indicates the share of foreign ownership of the bank and may be associated with lower levels of inefficiency. Interaction terms for different speeds of adjustment between the big 4 BIG-4s and the joint-stock banks are captured by B4*XI_1 and B4*RI_1. The Non-performing loans ratio (NPL) indicates past management failures and would be associated with higher levels of inefficiency. Table 5.5 presents some selected results.

The first thing to note about the results of Table 5.5 is that the coefficient on the lagged measures of inefficiency are negative and statistically significant indicating a significant decline in both types of inefficiency over time. The negative effect of the lag in rent-seeking inefficiency on the level of X-inefficiency highlights the trade-off between the two types of inefficiency. The lagged operational cost-income ratio explains rent-seeking inefficiency rather than X-inefficiency indicating the focus of costs towards factor hoarding.

Table 5.5 All banks, 1997-2006, SURE estimation, SE values in parenthesis

	Unadjusted		Adjusted	
Dep Variable	**ΔXI**	**ΔRI**	**ΔXI**	**ΔRI**
Intercept	.6624*** (.146)	.2484** (.124)	.6075*** (.141)	-.0077 (.0400614)
Ln(SIZE_1)	-.0293*** (.010)	-.0260*** (.010)	-.0261*** (.009)	-
FEE_1	-.0215*** (.007)	0.0114* (.006)	-.0195*** (.005)	-
COST_1	-	0.0025*** (.001)	-	0.0012* (.001)
FOR	-	0.0041*** (.002)	-	-
NPL	-	.0012*** (.001)	-	-
RI_1	-.1363** (.066)	-.7403*** (.071)	-.2908*** (.071)	-.3111*** (.060)
XI_1	-.7335*** (.074)		-.6373*** (.088)	-
B4*XI_1	.2044*** (.007)	-	-	-
B4*RI_1	-	0.4051*** (.109)	-	-
R^2	0.4118	0.5031	0.3496	0.1888

**** significant at the 1%, ** significant at the 5%, *significant at the 10%.*

Looking at the NPL unadjusted results first it can be seen that an interaction term for the BIG-4s show that the speed of decline in both types of inefficiency was faster in the case of the JSCBs than the BIG-4s. However, the rate of decline in X-inefficiency was faster than the rate of decline of rent-seeking in the BIG-4s. In this respect, the results of this chapter differ strongly from the findings of Chen *et al* (2005) who find no trend improvement in bank efficiency[58].

[58] C hen et. al (2005) uses a wider data frame of banks, including regional joint-stock banks and international trust and investment companies. It can be argued that the use of DMUs that do not compete in the same geographical market or product is a violation of the homogeneity requirement of DEA.

Once loans are adjusted for NPLs the speed of decline slows and there is no statistical difference in the speed of decline of inefficiency between the two types of banks. However, the speed of decline of rent inefficiency is slower than the decline in X-inefficiency. This is explained by the extraordinary increase in the balance sheets of the Chinese banks that has resulted in the reduction in X-inefficiency for the non-benchmark banks. However, the social problems associated with dealing with inherited over-staffing and over-branching is likely to produce a slower speed of adjustment of rent-seeking inefficiency particularly in the case of the state-owned banks.

5.6 Conclusion

This chapter has used non-parametric methods to conduct an analysis of inefficiency in a sample of Chinese banks. The estimates of bank inefficiency were buttressed with bootstrapping techniques to enable statistical inference. In general, the estimates from bootstrapping support the view that relative efficiency has improved. We have partitioned cost inefficiency into X-inefficiency and rent-seeking inefficiency in the spirit of the rational inefficiency model. Inefficiency in Chinese banking is made up of both X-inefficiency and rent-seeking inefficiency. Adjusting for the quality of the loan portfolio, this chapter shows that bureaucratic rent-seeking is more prevalent in the state-owned banking sector than in the JSCBs.

Bureaucratic rent seeking is a rational response to a particular set of incentives based on protectionist policy. It would be no surprise to learn that over the years of protected growth, as the banks were vessels for the channelling of unprofitable loans to state-owned enterprises, the banking sector was forced to develop rent seeking strategies and acted as employment sponges for the educated youth in China. While the dismantling of protection and the listing of the state-owned banks and the plans to list joint stock banks will alter the incentive structure for managers, the trend reduction in rent-seeking inefficiency will be balanced by social and political constraints – particularly those faced by the BIG-4s.

I find that once loans are adjusted for NPLs, the speed of decline of rent-seeking inefficiency is slower than that of X-inefficiency. This suggests that banks have inherited rent-seeking strategies that are more difficult to reduce than X-inefficiency. The finding that X-inefficiency is being reduced faster than rent-seeking inefficiency is an indicator that Chinese bank managers are doing the best they can in improving efficiency given the constraints.

However, I must still interpret the results with caution. The improvement in efficiency is in terms of the benchmark banks, which are themselves 'best-practice' Chinese banks. The real benchmarks should be foreign banks competing on an equal footing or foreign banks operating in their home countries under similar conditions of development and risk. However, the argument of this chapter is that there have been significant improvements in bank efficiency. The main message of this chapter is that while Chinese banks may not be in the best shape they could be to meet the challenges of post 2007, they are in better shape than they have ever been.

But what off the question posed about the relative merits of training versus incentives? It can be seen that from Table 5.4 rent-seeking inefficiency is mostly less than X-inefficiency[59] (except for the case when NPL is adjusted for the BIG-4s). It is also seen from Table 5.5 that rent-seeking inefficiency is being reduced at about the same rate for the JSCBs but at a slower rate for the BIG-4s. If the argument that training can be targeted at reducing X-inefficiency is accepted and rent seeking being symptomatic of rational behaviour would respond to incentives, the weighting of resources to improve Chinese bank management should be skewed towards training rather than incentives.

[59] This supports the conjecture of Leibenstein (1966) that X-inefficiency is larger than Allocative inefficiency

Appendix 5-I Bootstrap Algorithm

The bootstrap algorithm is summarised in the following steps. The algorithm is run on MATLAB and the codes are available from the authors on request.

Step 1. Compute the original DEA efficiency scores using the linear programming model (equation 1) and let $\hat{\delta}_i = 1/\hat{\theta}_i$;

Step 2. Since radial distances are used, we will refer to the polar coordinate of the input vector of each DMU x defined by its modulus $\omega = \omega(x) = \sqrt{x'x}$ and its angle $\eta = \eta(x) \in \left[0, \frac{\pi}{2}\right]^{K-1}$ where for j=1,..., K-1, $\eta_i = \arctan(x_{j+1}/x_1)$ if $x_1 > 0$ and $\eta_i = \frac{\pi}{2}$ if $x_1 = 0$. Then translate the data into polar coordinates: $(y_i, \eta_i, \hat{\delta}_i)$, $i = 1, . . . , K$. And form the augmented matrix $\widetilde{L}$ by: $L = \lfloor y_i \quad \eta_i \quad \hat{\delta}_i \rfloor$, $L_R = \lfloor y_i \quad \eta_i \quad 2-\hat{\delta}_i \rfloor$, $\widetilde{L} = \begin{bmatrix} L \\ L_R \end{bmatrix}$

Step 3. Compute the estimated covariance matrices $\hat{\Sigma}_1$, $\hat{\Sigma}_2$ of L and L_R by

$$\hat{\Sigma}_1 = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \qquad \hat{\Sigma}_1 = \begin{bmatrix} S_{11} & -S_{12} \\ -S_{21} & S_{22} \end{bmatrix}$$

where S_{11} is $(M+N-1)\times(M+N-1)$, $S_{12} = S'_{21}$ is $(M+N-1)\times 1$ and S_{22} is scalar, and compute the lower triangular matrices L_1 and L_2 such that $\hat{\Sigma}_1 = L_1 L'_1$ and $\hat{\Sigma}_2 = L_2 L'_2$ via the Cholesky decomposition.

Step 4. Choose an appropriate bandwidth h as described in Simar and Wilson (2000b) using the information in $\widetilde{L}$, $\hat{\Sigma}_1$, $\hat{\Sigma}_2$.

Step 5. Draw K rows randomly, with replacement from the augmented matrix $\widetilde{L}$ and denote the result by the $K \times (M+N)$ matrix $\widetilde{L}^*$; compute $\bar{z}^*$, the $K \times 1$ row vector containing the means of each column of $\widetilde{L}^*$.

Step 6. Use a random number generator to generate a $K \times (M+N)$ matrix ε of i.i.d. standard normal pseudo-random variates; let $\varepsilon_{i.}$ denote the *i*th row of this matrix. Then compute the $K \times (M+N)$ matrix ε^{*} with the *i*th row $\varepsilon_{i.}^{*}$ given by $\varepsilon_{i.}^{*} = \varepsilon_{i.} L_j'$ so that $\varepsilon_{i.}^{*} \sim N_{M+N}(0, \hat{\Sigma}_j)$ where j=1 if the *i*th row of $\widetilde{L}^{*}$ was drawn from rows 1, . . . , K of $\widetilde{L}$, or j=2 if the *i*th row of $\widetilde{L}^{*}$ was drawn from rows $(K+1)$, . . . , $2K$ of $\widetilde{L}$.

Step 7. Compute the $K \times (M+N)$ matrix $\Gamma = (1+h^2)^{-1/2}(M\widetilde{L}^{*} + h\varepsilon^{*}) + i_K \otimes \bar{z}^{*}$ where $M = I_K - (1/K) i_K i_K'$ is the usual $K \times K$ ce ntring matrix with I_K denoting an identity matrix of order K, i_K an $K \times 1$ vector of ones, and $\otimes$ denotes the Kronecker product.

Step 8. Partition Γ so that $\Gamma = [\gamma_{i1} \quad \gamma_{i2} \quad \gamma_{i3}]$, where $\gamma_{i1} \in R_{+}^{M}$, $\gamma_{i2} \in [0, \pi/2]^{K-1}$ and $\gamma_{i3} \in (-\infty, +\infty)$ for $i = 1, \ldots, K$. Define the $K \times (M+N)$ matrix of bootstrap pseudo-data L^{*} such that the i the row z_i^{*} of L^{*} is given by

$$z_i^{*} = \begin{cases} (\gamma_{i1} \quad \gamma_{i2} \quad \gamma_{i3}) & \gamma_{i3} \geq 1 \\ (\gamma_{i1} \quad \gamma_{i2} \quad 2-\gamma_{i3}) & otherwise \end{cases}$$

Step 9. Translate the polar coordinates in L^{*} to Cartesian coordinates. This yields the bootstrap sample $\{(x_i^{*}, y_i^{*})\}_{i=1}^{K}$.

Step 10. For the given point (*x*, *y*), compute $\hat{\theta}^{*}(x,y)$ b y solving the DEA program taking $\{(x_i^{*}, y_i^{*})\}_{i=1}^{K}$ as the benchmarks and compute the bias-corrected efficiency scores $\widetilde{\theta}(x,y) = \hat{\theta}^{2} / \hat{\theta}^{*}$

Step 11. Repeat Steps 5~11, obtain another group of bias-corrected efficiency scores, reducing the input vector of each DMU x into $\widetilde{\theta}x$. Compute the cost efficiency scores using equation(2) from the reduced inputs and outputs.

Step 12. Similar to Step 11, obtain rent-seeking-efficiency scores (the difference between cost-efficiency score and technical (x)-efficiency score)

Step 13. Repeat Steps 5~12 *B* (=1000) times to obtain a set of bootstrap estimates $\{\widetilde{\theta}_b(x,y)\}_{b=1}^{B}$ and cost efficiency scores and x-efficiency scores.

Appendix 5-II Bootstrapped Estimations of Efficiencies (1,000 bootstrap, Biars corrected) * indicates significant bias at the 5% level of significance

Year	Bank	X-Efficiency - NPL unadjusted				Cost Efficiency - NPL unadjusted			
		Pure DEA	Boot Median	L-B	U-B	Pure DEA	Boot Median	L-B	U-B
1997	ABOC	0.89 *	0.85	0.77	0.89	0.79 *	0.35	0.00	0.49
1997	BOC	1.00	0.66	0.09	1.98	0.95 *	0.39	0.00	0.52
1997	BoCom	1.00 *	0.60	0.40	0.79	0.92 *	0.44	0.00	0.54
1997	CCB	0.97 *	0.92	0.36	0.97	0.89 *	0.37	0.00	0.55
1997	CITIC	1.00 *	0.56	0.40	0.72	1.00 *	0.48	0.00	0.61
1997	CMB	1.00 *	0.64	0.47	0.85	0.99 *	0.47	0.00	0.59
1997	CMBC	1.00 *	0.63	0.42	0.77	1.00 *	0.46	0.00	0.58
1997	CEB	1.00 *	0.52	0.38	0.63	1.00 *	0.46	0.00	0.58
1997	GDB	0.89 *	0.77	0.62	0.85	0.83 *	0.39	0.00	0.48
1997	HUAXIA	1.00 *	0.60	0.44	0.78	1.00 *	0.45	0.00	0.59
1997	CIB	1.00 *	0.29	0.18	0.50	1.00 *	0.29	0.00	0.49
1997	ICBC	1.00	0.78	0.01	1.21	1.00 *	0.46	0.00	0.63
1997	SDB	0.98 *	0.91	0.76	0.95	0.84 *	0.34	0.00	0.47
1997	SPDB	1.00 *	0.49	0.35	0.64	1.00 *	0.47	0.00	0.62
1998	ABOC	0.98 *	0.90	0.44	0.98	0.85 *	0.44	0.48	0.41
1998	BOC	1.00	0.63	0.12	1.73	1.00 *	0.61	0.08	0.91
1998	BoCom	1.00 *	0.62	0.41	0.77	0.95 *	0.45	0.09	0.58
1998	CCB	0.96 *	0.90	0.56	0.95	0.83 *	0.42	0.09	0.56
1998	CITIC	1.00 *	0.54	0.40	0.70	1.00 *	0.51	0.10	0.67
1998	CMB	0.79 *	0.55	0.43	0.66	0.73 *	0.35	0.07	0.45
1998	CMBC	1.00 *	0.63	0.49	0.78	1.00 *	0.51	0.10	0.66
1998	CEB	1.00 *	0.49	0.36	0.63	1.00 *	0.47	0.09	0.61
1998	GDB	0.97 *	0.76	0.58	0.88	0.88 *	0.47	0.08	0.61
1998	HUAXIA	1.00 *	0.59	0.45	0.75	1.00 *	0.51	0.11	0.66
1998	CIB	0.88 *	0.64	0.52	0.75	0.73 *	0.36	0.07	0.47
1998	ICBC	1.00	0.74	0.20	1.11	1.00 *	0.52	0.11	0.68
1998	SDB	1.00 *	0.93	0.85	0.97	0.89 *	0.46	0.09	0.60
1998	SPDB	1.00 *	0.60	0.45	0.73	1.00 *	0.54	0.10	0.68
1999	ABOC	0.85 *	0.74	0.41	0.83	0.72 *	0.36	0.16	0.46
1999	BOC	1.00	0.59	0.15	1.15	1.00 *	0.59	0.14	0.95
1999	BoCom	1.00 *	0.53	0.38	0.72	1.00 *	0.50	0.22	0.64
1999	CCB	0.74 *	0.58	0.32	0.68	0.63 *	0.33	0.13	0.41
1999	CITIC	0.94 *	0.49	0.35	0.69	0.79 *	0.37	0.16	0.48
1999	CMB	0.76 *	0.55	0.43	0.67	0.65 *	0.29	0.12	0.38
1999	CMBC	1.00 *	0.71	0.51	0.85	0.97 *	0.51	0.16	0.72
1999	CEB	1.00 *	0.44	0.31	0.62	0.89 *	0.41	0.18	0.53
1999	GDB	0.95 *	0.78	0.55	0.91	0.80 *	0.47	0.12	0.76
1999	HUAXIA	0.89 *	0.57	0.42	0.74	0.79 *	0.37	0.16	0.48
1999	CIB	0.81 *	0.58	0.46	0.70	0.64 *	0.27	0.12	0.36
1999	ICBC	0.88	0.76	0.37	0.92	0.84 *	0.42	0.18	0.54
1999	SDB	0.89 *	0.77	0.68	0.85	0.65 *	0.30	0.13	0.39
1999	SPDB	0.99 *	0.57	0.42	0.77	0.70 *	0.34	0.13	0.43
2000	ABOC	0.84 *	0.72	0.48	0.82	0.67 *	0.35	0.19	0.48
2000	BOC	1.00	0.66	0.15	1.35	1.00	0.65	0.13	1.24
2000	BoCom	1.00 *	0.54	0.40	0.73	1.00 *	0.52	0.28	0.72
2000	CCB	0.72 *	0.57	0.51	0.65	0.61 *	0.32	0.16	0.44
2000	CITIC	1.00 *	0.61	0.47	0.75	0.71 *	0.37	0.18	0.50
2000	CMB	0.91 *	0.75	0.62	0.83	0.75 *	0.39	0.20	0.53
2000	CMBC	0.99 *	0.78	0.63	0.89	0.92 *	0.51	0.17	0.70

Year	Bank	X-Efficiency - NPL unadjusted				Cost Efficiency - NPL unadjusted			
		Pure DEA	Boot Median	L-B	U-B	Pure DEA	Boot Median	L-B	U-B
2000	CEB	1.00 *	0.58	0.47	0.71	0.82 *	0.43	0.18	0.56
2000	GDB	0.83 *	0.71	0.64	0.77	0.68 *	0.36	0.18	0.49
2000	HUAXIA	1.00 *	0.76	0.60	0.88	0.78 *	0.41	0.20	0.55
2000	CIB	0.91 *	0.73	0.62	0.81	0.75 *	0.39	0.17	0.51
2000	ICBC	0.78 *	0.64	0.37	0.74	0.73 *	0.38	0.20	0.52
2000	SDB	0.92 *	0.77	0.70	0.84	0.68 *	0.36	0.17	0.48
2000	SPDB	1.00 *	0.66	0.50	0.81	0.66 *	0.35	0.17	0.46
2001	ABOC	0.80 *	0.70	0.63	0.78	0.60 *	0.33	0.19	0.45
2001	BOC	1.00	0.67	0.19	1.14	1.00 *	0.65	0.19	0.92
2001	BoCom	1.00 *	0.56	0.45	0.80	1.00 *	0.55	0.35	0.79
2001	CCB	0.72 *	0.56	0.44	0.64	0.63 *	0.35	0.21	0.49
2001	CITIC	0.98 *	0.62	0.50	0.77	0.75 *	0.41	0.25	0.56
2001	CMB	1.00 *	0.65	0.55	0.78	0.96 *	0.52	0.28	0.66
2001	CMBC	1.00 *	0.81	0.69	0.90	0.95 *	0.53	0.23	0.71
2001	CEB	1.00 *	0.60	0.49	0.75	0.82 *	0.45	0.27	0.60
2001	GDB	0.91 *	0.79	0.72	0.85	0.79 *	0.43	0.25	0.60
2001	HUAXIA	1.00 *	0.64	0.53	0.79	0.98 *	0.52	0.24	0.67
2001	CIB	1.00 *	0.79	0.64	0.89	0.95 *	0.51	0.28	0.68
2001	ICBC	0.78 *	0.62	0.28	0.77	0.76 *	0.41	0.23	0.58
2001	SDB	1.00 *	0.78	0.67	0.90	0.89 *	0.48	0.27	0.63
2001	SPDB	1.00 *	0.65	0.53	0.82	0.85 *	0.46	0.24	0.59
2002	ABOC	0.93 *	0.86	0.57	0.92	0.70 *	0.38	0.19	0.48
2002	BOC	1.00	0.59	0.19	1.04	1.00	0.59	0.17	1.03
2002	BoCom	0.88 *	0.77	0.68	0.84	0.78 *	0.43	0.19	0.58
2002	CCB	0.81 *	0.74	0.67	0.79	0.70 *	0.39	0.17	0.54
2002	CITIC	0.94 *	0.58	0.43	0.75	0.93 *	0.49	0.25	0.62
2002	CMB	1.00 *	0.46	0.38	0.60	1.00 *	0.45	0.29	0.58
2002	CMBC	1.00 *	0.70	0.61	0.83	1.00 *	0.54	0.26	0.71
2002	CEB	1.00 *	0.61	0.47	0.79	0.98 *	0.51	0.29	0.63
2002	GDB	0.80 *	0.72	0.63	0.77	0.76 *	0.41	0.20	0.52
2002	HUAXIA	1.00 *	0.62	0.50	0.81	0.99 *	0.49	0.24	0.64
2002	CIB	1.00 *	0.63	0.51	0.79	1.00 *	0.48	0.29	0.61
2002	ICBC	1.00	0.83	0.44	1.31	0.97 *	0.53	0.23	0.72
2002	SDB	1.00 *	0.74	0.57	0.88	1.00 *	0.53	0.29	0.66
2002	SPDB	1.00 *	0.56	0.43	0.72	1.00 *	0.53	0.31	0.67
2003	ABOC	1.00	0.95	0.64	1.12	0.70 *	0.40	0.18	0.51
2003	BOC	1.00 *	0.56	0.18	0.94	1.00 *	0.55	0.18	0.93
2003	BoCom	0.91 *	0.83	0.71	0.88	0.75 *	0.44	0.18	0.60
2003	CCB	0.90 *	0.84	0.51	0.88	0.79 *	0.46	0.18	0.65
2003	CITIC	0.99 *	0.63	0.49	0.82	0.92 *	0.52	0.26	0.65
2003	CMB	1.00 *	0.48	0.38	0.65	1.00 *	0.47	0.27	0.63
2003	CMBC	1.00 *	0.75	0.63	0.87	1.00 *	0.62	0.29	0.79
2003	CEB	1.00 *	0.65	0.49	0.83	1.00 *	0.57	0.30	0.72
2003	GDB	0.94 *	0.85	0.73	0.92	0.84 *	0.51	0.23	0.66
2003	HUAXIA	0.96 *	0.69	0.55	0.87	0.89 *	0.49	0.26	0.61
2003	CIB	0.96 *	0.68	0.55	0.83	0.92 *	0.49	0.26	0.62
2003	ICBC	1.00	0.81	0.31	1.25	0.95 *	0.55	0.23	0.76
2003	SDB	0.97 *	0.82	0.65	0.93	0.90 *	0.51	0.26	0.65
2003	SPDB	1.00 *	0.59	0.44	0.80	1.00 *	0.56	0.30	0.71
2004	ABOC	1.00	1.32	0.57	1.06	0.78 *	0.48	0.19	0.66
2004	BOC	1.00 *	0.55	0.17	0.96	1.00 *	0.55	0.17	0.90

Year	Bank	X-Efficiency - NPL unadjusted					Cost Efficiency - NPL unadjusted				
		Pure DEA		Boot Median	L-B	U-B	Pure DEA		Boot Median	L-B	U-B
2004	BoCom	0.99	*	0.94	0.84	0.98	0.85	*	0.48	0.19	0.68
2004	CCB	1.00	*	0.83	0.42	0.99	0.91	*	0.53	0.19	0.76
2004	CITIC	1.00	*	0.65	0.48	0.86	0.91	*	0.49	0.26	0.61
2004	CMB	1.00	*	0.46	0.32	0.68	1.00	*	0.45	0.30	0.65
2004	CMBC	1.00	*	0.79	0.66	0.89	1.00	*	0.64	0.27	0.85
2004	GDB	0.99	*	0.89	0.74	0.97	0.87	*	0.55	0.24	0.72
2004	HUAXIA	1.00	*	0.71	0.54	0.90	0.89	*	0.47	0.24	0.59
2004	CIB	1.00	*	0.59	0.47	0.73	1.00	*	0.53	0.29	0.67
2004	ICBC	0.87	*	0.82	0.77	0.85	0.75	*	0.47	0.18	0.63
2004	SDB	0.99	*	0.95	0.85	0.98	0.82	*	0.44	0.21	0.58
2004	SPDB	1.00	*	0.57	0.40	0.80	1.00	*	0.51	0.31	0.67
2005	ABOC	0.97	*	0.85	0.80	0.75	0.71	*	0.46	0.29	0.53
2005	BOC	1.00	*	0.68	0.27	0.98	1.00	*	0.61	0.27	0.72
2005	BoCom	0.98	*	0.93	0.87	0.96	0.82	*	0.48	0.30	0.56
2005	CCB	1.00	*	0.77	0.46	0.97	0.91	*	0.55	0.31	0.64
2005	CITIC	1.00	*	0.78	0.56	0.94	0.88	*	0.48	0.36	0.58
2005	CMB	1.00	*	0.55	0.39	0.75	1.00	*	0.54	0.38	0.70
2005	CMBC	1.00	*	0.67	0.55	0.79	1.00	*	0.66	0.46	0.78
2005	GDB	0.78	*	0.64	0.53	0.74	0.70	*	0.45	0.33	0.52
2005	HUAXIA	0.98	*	0.73	0.53	0.91	0.92	*	0.50	0.36	0.62
2005	CIB	1.00	*	0.53	0.43	0.68	1.00	*	0.53	0.40	0.68
2005	ICBC	0.93		0.90	0.44	0.94	0.78	*	0.47	0.26	0.54
2005	SDB	1.00	*	0.87	0.69	0.97	0.90	*	0.51	0.30	0.62
2005	SPDB	1.00	*	0.63	0.44	0.85	0.97	*	0.53	0.38	0.66
2006	ABOC	0.96	*	0.92	0.61	0.95	0.66	*	0.42	0.25	0.50
2006	BOC	1.00	*	0.76	0.27	0.99	1.00	*	0.64	0.26	0.78
2006	BoCom	0.96	*	0.92	0.85	0.95	0.80	*	0.49	0.30	0.58
2006	CCB	0.91	*	0.66	0.32	0.88	0.79	*	0.52	0.28	0.64
2006	CITIC	1.00	*	0.66	0.48	0.86	0.92	*	0.56	0.39	0.69
2006	CMB	1.00	*	0.68	0.50	0.85	1.00	*	0.63	0.44	0.76
2006	CMBC	1.00	*	0.70	0.57	0.83	1.00	*	0.68	0.42	0.82
2006	GDB	0.96	*	0.81	0.66	0.92	0.89	*	0.59	0.37	0.70
2006	HUAXIA	0.96	*	0.66	0.50	0.85	0.92	*	0.54	0.38	0.66
2006	CIB	1.00	*	0.58	0.45	0.74	1.00	*	0.58	0.41	0.73
2006	ICBC	1.00		0.87	0.27	1.21	0.95	*	0.58	0.26	0.70
2006	SDB	1.00	*	0.78	0.60	0.92	0.98	*	0.59	0.27	0.73
2006	SPDB	1.00	*	0.62	0.45	0.81	1.00	*	0.60	0.43	0.75

Year	Bank	X-Efficiency - NPL adjusted				Cost Efficiency - NPL adjusted			
		Pure DEA	Boot Median	L-B	U-B	Pure DEA	Boot Median	L-B	U-B
1997	ABOC	0.38 *	0.31	0.24	0.35	0.35 *	0.02	0.01	0.11
1997	BOC	1.00	0.66	0.16	3.63	0.80 *	0.11	0.04	0.26
1997	BoCom	0.93 *	0.56	0.36	0.78	0.80 *	0.05	0.01	0.23
1997	CCB	0.39 *	0.28	0.18	0.35	0.37 *	0.03	0.01	0.12
1997	CITIC	1.00 *	0.61	0.44	0.78	1.00 *	0.09	0.03	0.33
1997	CMB	1.00 *	0.72	0.54	0.88	0.99 *	0.06	0.02	0.29
1997	CMBC	1.00 *	0.64	0.45	0.81	0.98 *	0.12	0.04	0.32
1997	CEB	1.00 *	0.59	0.37	0.83	0.79 *	0.05	0.01	0.23
1997	GDB	0.63 *	0.45	0.31	0.56	0.57 *	0.05	0.02	0.19
1997	HUAXIA	1.00 *	0.68	0.49	0.85	0.99 *	0.06	0.02	0.30
1997	CIB	1.00 *	0.29	0.19	0.45	1.00 *	0.26	0.11	0.40
1997	ICBC	0.39 *	0.27	0.17	0.35	0.38 *	0.02	0.01	0.11
1997	SDB	0.55 *	0.33	0.23	0.46	0.48 *	0.06	0.02	0.16
1997	SPDB	1.00 *	0.06	0.02	0.30	1.00 *	0.06	0.02	0.30
1998	ABOC	0.39 *	0.29	0.25	0.34	0.35 *	0.18	0.09	0.23
1998	BOC	1.00	0.63	0.18	1.69	1.00 *	0.62	0.17	0.92
1998	BoCom	1.00 *	0.61	0.42	0.79	0.92 *	0.45	0.28	0.58
1998	CCB	0.65 *	0.54	0.44	0.62	0.58 *	0.30	0.18	0.39
1998	CITIC	1.00 *	0.55	0.42	0.70	1.00 *	0.52	0.21	0.67
1998	CMB	0.79 *	0.56	0.48	0.66	0.73 *	0.36	0.18	0.46
1998	CMBC	1.00 *	0.63	0.46	0.77	1.00 *	0.54	0.30	0.67
1998	CEB	1.00 *	0.49	0.35	0.63	1.00 *	0.48	0.28	0.62
1998	GDB	0.92 *	0.69	0.54	0.81	0.86 *	0.46	0.23	0.57
1998	HUAXIA	1.00 *	0.60	0.46	0.74	1.00 *	0.52	0.27	0.66
1998	CIB	0.87 *	0.62	0.53	0.74	0.71 *	0.37	0.20	0.47
1998	ICBC	0.65 *	0.53	0.33	0.62	0.61 *	0.31	0.19	0.40
1998	SDB	0.91 *	0.74	0.59	0.87	0.81 *	0.44	0.25	0.56
1998	SPDB	1.00 *	0.55	0.39	0.74	1.00 *	0.54	0.33	0.71
1999	ABOC	0.50 *	0.39	0.33	0.46	0.43 *	0.23	0.11	0.29
1999	BOC	1.00	0.61	0.16	1.48	1.00 *	0.61	0.16	0.99
1999	BoCom	1.00 *	0.50	0.37	0.69	1.00 *	0.50	0.30	0.68
1999	CCB	0.67 *	0.51	0.31	0.61	0.57 *	0.30	0.14	0.38
1999	CITIC	1.00 *	0.55	0.41	0.73	0.79 *	0.39	0.20	0.49
1999	CMB	0.76 *	0.54	0.45	0.65	0.65 *	0.33	0.16	0.41
1999	CMBC	1.00 *	0.67	0.52	0.81	1.00 *	0.56	0.22	0.73
1999	CEB	1.00 *	0.45	0.33	0.62	0.89 *	0.42	0.20	0.52
1999	GDB	1.00 *	0.83	0.67	0.94	0.89 *	0.53	0.16	0.82
1999	HUAXIA	1.00 *	0.66	0.50	0.82	0.83 *	0.42	0.23	0.53
1999	CIB	0.81 *	0.57	0.47	0.70	0.64 *	0.31	0.16	0.39
1999	ICBC	0.68 *	0.51	0.27	0.62	0.66 *	0.34	0.17	0.43
1999	SDB	0.83 *	0.64	0.53	0.75	0.65 *	0.33	0.17	0.41
1999	SPDB	1.00 *	0.53	0.39	0.70	0.76 *	0.39	0.21	0.49
2000	ABOC	0.56 *	0.45	0.44	0.42	0.45 *	0.24	0.15	0.33
2000	BOC	1.00 *	0.68	0.09	0.73	1.00	0.67	0.09	1.32
2000	BoCom	1.00 *	0.54	0.40	0.75	1.00 *	0.53	0.35	0.75
2000	CCB	0.73 *	0.58	0.44	0.66	0.61 *	0.33	0.21	0.45
2000	CITIC	1.00 *	0.62	0.46	0.77	0.73 *	0.39	0.25	0.54
2000	CMB	1.00 *	0.76	0.57	0.89	0.90 *	0.48	0.31	0.66

Year	Bank	X-Efficiency - NPL adjusted					Cost Efficiency - NPL adjusted				
		Pure DEA		Boot Median	L-B	U-B	Pure DEA		Boot Median	L-B	U-B
2000	CMBC	1.00	*	0.82	0.67	0.91	0.92	*	0.53	0.24	0.72
2000	CEB	1.00	*	0.61	0.50	0.71	0.82	*	0.43	0.22	0.59
2000	GDB	0.77	*	0.64	0.55	0.71	0.66	*	0.36	0.22	0.49
2000	HUAXIA	1.00	*	0.70	0.51	0.85	0.93	*	0.49	0.31	0.67
2000	CIB	0.94	*	0.77	0.62	0.87	0.82	*	0.43	0.26	0.58
2000	ICBC	0.66	*	0.51	0.34	0.60	0.62	*	0.33	0.20	0.45
2000	SDB	0.85	*	0.68	0.60	0.76	0.67	*	0.35	0.22	0.48
2000	SPDB	1.00	*	0.67	0.49	0.81	0.68	*	0.36	0.23	0.49
2001	ABOC	0.59	*	0.03	0.44	0.55	0.44	*	0.04	0.16	0.33
2001	BOC	1.00		0.33	0.22	1.20	1.00	*	0.20	0.22	0.95
2001	BoCom	1.00	*	0.08	0.47	0.78	1.00	*	0.09	0.41	0.77
2001	CCB	0.74	*	0.05	0.46	0.68	0.65	*	0.06	0.25	0.49
2001	CITIC	1.00	*	0.08	0.48	0.80	0.80	*	0.06	0.31	0.58
2001	CMB	1.00	*	0.06	0.49	0.76	1.00	*	0.07	0.40	0.72
2001	CMBC	1.00	*	0.05	0.69	0.89	0.96	*	0.10	0.32	0.73
2001	CEB	1.00	*	0.07	0.48	0.75	0.83	*	0.07	0.33	0.60
2001	GDB	0.90	*	0.04	0.65	0.83	0.84	*	0.09	0.30	0.63
2001	HUAXIA	1.00	*	0.06	0.52	0.77	0.98	*	0.08	0.33	0.67
2001	CIB	1.00	*	0.09	0.51	0.85	1.00	*	0.09	0.39	0.75
2001	ICBC	0.72	*	0.20	0.26	0.69	0.70	*	0.07	0.25	0.52
2001	SDB	0.98	*	0.07	0.59	0.88	0.92	*	0.07	0.36	0.65
2001	SPDB	1.00	*	0.07	0.49	0.78	0.88	*	0.06	0.34	0.62
2002	ABOC	0.70	*	0.61	0.53	0.67	0.51	*	0.27	0.16	0.35
2002	BOC	1.00		0.59	0.19	1.13	1.00		0.57	0.17	1.02
2002	BoCom	0.86	*	0.73	0.64	0.80	0.74	*	0.40	0.21	0.59
2002	CCB	0.84	*	0.75	0.51	0.81	0.70	*	0.37	0.20	0.55
2002	CITIC	1.00	*	0.49	0.34	0.73	1.00	*	0.49	0.33	0.66
2002	CMB	1.00	*	0.45	0.37	0.59	1.00	*	0.45	0.34	0.59
2002	CMBC	1.00	*	0.71	0.59	0.83	1.00	*	0.53	0.31	0.71
2002	CEB	0.92	*	0.58	0.47	0.77	0.81	*	0.40	0.20	0.52
2002	GDB	0.53	*	0.46	0.39	0.52	0.38		0.17	0.06	0.41
2002	HUAXIA	1.00	*	0.62	0.50	0.80	0.99	*	0.48	0.25	0.63
2002	CIB	1.00	*	0.61	0.45	0.79	0.99	*	0.46	0.34	0.58
2002	ICBC	0.98		0.82	0.38	1.58	0.83	*	0.44	0.23	0.68
2002	SDB	0.95	*	0.65	0.46	0.83	0.89	*	0.43	0.30	0.57
2002	SPDB	1.00	*	0.52	0.37	0.71	1.00	*	0.49	0.34	0.63
2003	ABOC	0.79	*	0.72	0.66	0.76	0.54	*	0.33	0.23	0.43
2003	BOC	1.00	*	0.56	0.29	0.96	1.00	*	0.56	0.29	0.96
2003	BoCom	0.90	*	0.81	0.72	0.87	0.74	*	0.43	0.28	0.59
2003	CCB	0.91	*	0.84	0.46	0.90	0.78	*	0.46	0.30	0.65
2003	CITIC	0.98	*	0.62	0.45	0.82	0.92	*	0.50	0.38	0.63
2003	CMB	1.00	*	0.48	0.38	0.64	1.00	*	0.48	0.37	0.64
2003	CMBC	1.00	*	0.74	0.60	0.86	1.00	*	0.63	0.45	0.80
2003	CEB	0.94	*	0.68	0.55	0.86	0.88	*	0.46	0.32	0.61
2003	GDB	0.88	*	0.84	0.77	0.88	0.64	*	0.35	0.18	0.58
2003	HUAXIA	0.99	*	0.72	0.54	0.89	0.89	*	0.49	0.37	0.61
2003	CIB	0.99	*	0.71	0.54	0.88	0.95	*	0.49	0.37	0.62
2003	ICBC	1.00		0.89	0.46	1.35	0.89	*	0.52	0.34	0.74
2003	SDB	0.95	*	0.79	0.59	0.91	0.88	*	0.49	0.36	0.62
2003	SPDB	1.00	*	0.55	0.39	0.78	1.00	*	0.54	0.38	0.70

Year	Bank	X-Efficiency - NPL adjusted					Cost Efficiency - NPL adjusted				
		Pure DEA		Boot Median	L-B	U-B	Pure DEA		Boot Median	L-B	U-B
2004	ABOC	0.91	*	0.84	0.65	0.89	0.74	*	0.45	0.24	0.65
2004	BOC	1.00	*	0.60	0.28	0.99	1.00	*	0.60	0.28	0.89
2004	BoCom	0.99	*	0.94	0.84	0.98	0.85	*	0.50	0.30	0.68
2004	CCB	1.00		0.84	0.49	1.01	0.91	*	0.55	0.32	0.75
2004	CITIC	1.00	*	0.66	0.49	0.88	0.91	*	0.50	0.36	0.61
2004	CMB	1.00	*	0.47	0.33	0.71	1.00	*	0.47	0.33	0.68
2004	CMBC	1.00	*	0.79	0.64	0.88	1.00	*	0.68	0.41	0.85
2004	GDB	0.93	*	0.85	0.75	0.91	0.80	*	0.52	0.31	0.67
2004	HUAXIA	0.99	*	0.72	0.56	0.89	0.89	*	0.48	0.35	0.60
2004	CIB	1.00	*	0.59	0.46	0.72	1.00	*	0.55	0.40	0.67
2004	ICBC	0.86	*	0.79	0.74	0.83	0.74	*	0.48	0.29	0.63
2004	SDB	0.94	*	0.88	0.79	0.93	0.80	*	0.45	0.30	0.58
2004	SPDB	1.00	*	0.59	0.41	0.83	1.00	*	0.53	0.38	0.69
2005	ABOC	0.91	*	0.84	0.60	0.90	0.71	*	0.46	0.42	0.49
2005	BOC	1.00		0.71	0.37	1.00	1.00	*	0.63	0.60	0.70
2005	BoCom	0.98	*	0.94	0.87	0.97	0.82	*	0.50	0.46	0.55
2005	CCB	1.00	*	0.83	0.47	0.99	0.91	*	0.56	0.52	0.61
2005	CITIC	1.00	*	0.80	0.57	0.96	0.86	*	0.48	0.45	0.62
2005	CMB	1.00	*	0.56	0.38	0.76	1.00	*	0.55	0.51	0.78
2005	CMBC	1.00	*	0.68	0.57	0.80	1.00	*	0.67	0.60	0.70
2005	GDB	0.77	*	0.61	0.49	0.73	0.69	*	0.45	0.40	0.49
2005	HUAXIA	0.97	*	0.73	0.53	0.92	0.91	*	0.50	0.47	0.68
2005	CIB	1.00	*	0.53	0.43	0.70	1.00	*	0.53	0.51	0.62
2005	ICBC	0.93		0.89	0.57	0.96	0.78	*	0.48	0.45	0.53
2005	SDB	0.91	*	0.78	0.63	0.87	0.82	*	0.49	0.45	0.61
2005	SPDB	1.00	*	0.64	0.45	0.87	0.96	*	0.53	0.49	0.73
2006	ABOC	0.80	*	0.75	0.68	0.79	0.61	*	0.38	0.24	0.46
2006	BOC	1.00		0.76	0.38	1.01	1.00	*	0.64	0.37	0.77
2006	BoCom	0.96	*	0.89	0.79	0.95	0.80	*	0.48	0.35	0.57
2006	CCB	0.91	*	0.64	0.31	0.89	0.79	*	0.51	0.31	0.63
2006	CITIC	1.00	*	0.63	0.46	0.83	0.92	*	0.55	0.42	0.69
2006	CMB	1.00	*	0.63	0.48	0.81	1.00	*	0.61	0.46	0.76
2006	CMBC	1.00	*	0.68	0.55	0.83	1.00	*	0.67	0.47	0.82
2006	GDB	0.94	*	0.76	0.60	0.89	0.86	*	0.56	0.40	0.67
2006	HUAXIA	0.95	*	0.63	0.48	0.81	0.92	*	0.52	0.40	0.66
2006	CIB	1.00	*	0.56	0.45	0.71	1.00	*	0.56	0.44	0.72
2006	ICBC	1.00		0.86	0.38	1.19	0.95	*	0.57	0.36	0.68
2006	SDB	0.98	*	0.75	0.56	0.90	0.92	*	0.55	0.28	0.69
2006	SPDB	0.76	*	0.58	0.45	0.71	0.69	*	0.40	0.31	0.49

L-B and U-B mean lower and upper bounds defined by the 95% confidence interval

Chapter 6

Productivity in Chinese Banks: An Exercise in Measurement[60]

" Life is the art of drawing sufficient conclusions from insufficient premises." *Samuel Butler*

6.1 Introduction

Banking sector reform in China has been a gradual and on-going process since 1978. A further stage of reform was announced in 1993 with the objective of creating an efficient commercial banking sector. Following the conditions of the WTO, the Chinese banking market has been open to foreign competition since the end of 2006. Chinese banks have been encouraged to allow foreign banks and investors to take minority shareholding positions. The listing of four of the big five banks on the international exchange during 2006-7 is supposed to usher in, not only foreign capital but also foreign managerial expertise to improve bank management, performance and productivity. Given the acceptance of larger stakes by foreign banks in the smaller commercial banks (to a specified limit of 25% share); it is no surprise that Chinese bank productivity has become a popular topic of research in recent years.

There have been a number of studies of Chinese banking productivity that have been published in Chinese scholarly journals, but to date only a few studies are available to non-Chinese readers[61]. The gradualist reforms of the banking sector and the potential

[60] A earlier version of this chapter has been accepted for publication in the *China Economic Review*. A conceptual version with a shorter data span and only the national banks was published in *The Chinese Economy* (2009).

[61] A recent exception is a study using non-parametric methods by Matthews et al (2009) and parametric methods by Khumbhaker and Wang (2007)

of foreign competition would be expected to improve efficiency and productivity in the banking sector. Evidence of improved performance has begun to emerge.

This chapter is an empirical exercise in measurement and convergence. Its principal aim is to measure the productivity of the commercial banks in China for the period 1997-2007. Three issues are addressed in this paper, namely measurement, modeling strategy, and convergence. First, the measurement of output (and input) of banks is not a simple matter. Numerous studies of bank productivity by Chinese scholars employ a bewildering mix of inputs and outputs. I therefore consider several alternative measures of output as a means of obtaining robust results.

Second, I use the Malmquist index of total factor productivity (TFP) as a means of translating inputs and outputs into a measure of productivity growth. The Malmquist index has the advantage of being able to decompose productivity growth into technological change, which captures a shift in the production frontier from efficiency improvement, which captures the movement towards the frontier. One of the problems associated with this approach is that it is constructed within the framework of Data Envelope Analysis (DEA), which is a non-parametric linear programming method that applies observed input and output data to create a 'best practice' frontier. The main drawback of the DEA approach is that it assumes the inputs and outputs are measured without error and therefore do not permit statistical evaluation. This paper provides an inferential capability to the point-estimates of productivity through the use of non-parametric bootstrapping methods.

Third, I use the concepts of conditional *beta-convergence* from the growth convergence literature (Barro and Salai-i-Martin, 1991, 1992) to examine the properties of convergence of TFP. This paper poses the following questions. What has been the total factor productivity (TFP) growth of Chinese banks over the period 1997 – 2007? What have been the driving factors in TFP growth? Has there been a significant improvement in TFP growth in the second half of the period consistent with an increase in the pace of reform prior to the opening up of the banking market according to the WTO treaty? What is the effect on the measurement of TFP if non-performing loans are treated as 'bad' outputs? Finally, is there evidence of the convergence of TFP to peer group clusters?

The contribution of this chapter is to extend the analysis of Matthews et al (2009) to obtain a more robust statement of bank productivity growth by expanding the data set to include city commercial banks; to model non-performing loans in a consistent manner as a separate but undesirable output; to extend the range of models considered; and to extend the data by a further year. This paper uses 1570 bank-year observations to 492 bank-year observations in the previous study. The results confirm the main findings of Matthews et al (2009) that the productivity of state-owned banks was neutral over this period and that technical progress was offset by negative catch-up (lead banks widening the gap with laggard banks). The value-added of this paper is to show that the productivity of city commercial banks outstripped the national commercial banks and to identify the main driver of TFP growth of the CCBs as 'catch-up' based on cost saving efficiencies. This paper identifies the benchmark banks in each bank category and analyses the factors that determine conditional convergence of productivity and its decomposition. The results of this paper confirm the findings of Ferri (2009) that city commercial banks have improved their performance and pose a challenge to the national commercial banks.

The chapter is organized on the following lines. The next section outlines the background to the Chinese banking system. Section 3 discusses the methodology and literature relating to the Malmquist method of estimating bank productivity. Section 4 presents the banking data. Section 5 discusses the results and section 6 concludes.

6.2 Chinese Banking

In 2007, the Chinese banking system consisted of 8,877 institutions, including 3 policy banks, 5 large state-owned commercial banks (SOCB), 12 joint-stock commercial banks (JSCB), 124 city commercial banks (CCB), 29 locally incorporated foreign bank subsidiaries and the rest made up of urban and rural credit cooperatives and other financial institutions[62].

Like many economies that have undeveloped financial and capital markets, the banking sector in China plays a pivotal role in financial intermediation. Table 6.1 below shows that the ratio of total bank assets to GDP has increased from 125% in 1997 to 213% in 2007. The market is absolutely dominated by the five state owned banks, although their share of the market has been decreasing steadily through competition from the other commercial banks (JSCBs and CCBs).

[62] CBRC Annual Report 2007

Table 6.1 The Chinese banking Market

Variable	1997	2000	2007
Total Assets to GDP	125.6%	147.1%	213.4%
SOCB employment (,000)	1,670.4	1,540.8	1,492.1
Market share SOCB (% assets)	88.0%	71.4%	53.2%
NPL ratio SOCB	49.8%	30.8%	8.1%
ROAA SOCB*	0.2%	0.2%	0.9%
NIM SOCB*	2.4%	2.0%	2.7 %
Cost-Income Ratio SOCB*	52.7%	55.8%	42.8%

Sources: IMF *International Financial Statistics*, Individual Bank Annual Accounts, China Regulatory Banking Corporation Annual Report, *Almanac of China's Finance and Banking*, Fitch-Bankscope data base, National Bureau of Statistics of China, * weighted average by asset share. SOCBs are Agricultural Bank of China, Bank of China, China Construction Bank, Industrial and Commercial Bank of China and Bank of Communications.

Net-interest margins (NIM) and return on average assets (ROAA) of the SOCBs are respectable by western standards but are well below levels that would be consistent with economies in the same stage of development (as for example India where NIM would be in the region of 3.5%). Part of the reason is that interest rates were heavily controlled during this period and the remaining reason is the large amount of non-performing loans on the books of the commercial banks. The non-performing loans (NPL) ratio of the SOCBs has been falling from around 50%[63] in 1997 to around 8% in 2007.

With the encouragement of the regulatory authorities, Chinese banks have in recent years, had to restructure their balance sheet, develop modern risk management

[63] Estimate based on 1998 values. The 1998 values were obtained by adding back the Asset Management Company operations in 1999 back to the reported figures. This is the basic assumption used by Rodman (2005). An overestimate is likely to be small as Huang (2002) suggests that the mid-2002 official NPL ratio at 23% is underestimated by 12%.

methods, improve capitalization, diversify earnings, reduce costs and improve corporate governance and disclosure[64].

Up until 1995, control of the banking system remained firmly under the government and its agencies[65]. Under state control, the banks in China served the socialist plan of directing credits to specific projects dictated by political preference rather than commercial imperative. Since 2001 foreign banks and financial institutions were allowed to take a stake in selected Chinese banks. While control of individual Chinese banks remain out of reach for the foreign institution[66], the pressure to reform management, consolidate balance sheets, improve risk management and reduce unit costs has increased with greater foreign exposure. Table 2.4 in chapter 2 shows the extent of foreign strategic investment in individual Chinese banks.

The theory of market contestability (Baumol, 1982) suggests that incumbent banks will restructure weak balance sheets, reduce costs, and improve efficiency in preparation for the threat of entry. In their annual report on foreign banks in China, Pricewaterhouse-Coopers[67] refer to the China Bank Regulatory Commission (CBRC) report on the opening up of the banking sector. The CBRC divided the pace of reform and innovation into three stages; 1980-1993, 1993-2002 and 2003-2006. In the third stage, more of the domestic banking business was opened up to external competition. Foreign banks were allowed to expand RMB business from the four major cities of Shanghai, Shenzhen, Tianjin and Dalian which existed at the time of accession to the

[64] CBRC Annual Report 2006 http://www.cbrc.gov.cn/english/home/jsp/index.jsp
[65] According to La Porta, et. al (2002), 99% of the 10 largest commercial banks were owned and under the control of the government in 1995.
[66] There is a cap of 25% on total equity held by foreigners and a maximum of 20% for any single investor, except in the case of joint-venture banks.
[67] Pricewaterhouse Coopers (2007)

WTO, to the rest of the country. RMB business activity was extended from foreign enterprises and individuals to cover domestic firms and residents. Quantitative restrictions on foreign banks RMB liabilities were lifted and capital requirements were brought into equality with domestic banks. Various restrictions on branch development were removed and branches were particularly encouraged in the under-banked geographical regions outside the east coast. The upshot of these and a number of other reforms is that Chinese banks should exhibit less inefficiency, and strong productivity improvements in this period, with marked improvements in the latter years as competition with foreign banks intensify.

6.3 Methodology and Literature

Data Envelope Analysis (DEA) can be used to evaluate the efficiency of a firm by comparing it with a 'best practice' or output efficient firm. An output efficient firm is one that cannot increase its output unless it also increases one or more of its input, whereas an output inefficient firm is one that can increase its output without increasing its inputs. An output efficient firm would have a score of 100% as being located on the output efficient frontier whereas an output inefficient firm would be inside the frontier and have a score of less than 100%. Similarly an input efficient firm is one that cannot reduce its inputs without reducing its output whereas an input inefficient firm can.

The major drawback of the DEA approach is that the efficiency scores obtained from a particular sample are confined to that particular sample and cannot be compared with another sample in a different time period. This limitation does not allow the measurement of productivity growth, which allows for improvement in efficiency as well as technical progress.

The idea of comparing the input of a decision making unit over two periods of time (period 1 and period 2) by which the input in period 1 could be decreased holding the same level of output in period 2 is the basis of the Malmquist Index[68]. Färe et al. (1994) developed a Malmquist productivity measure using the DEA approach based on constant returns to scale. The Malmquist productivity index (M) enables productivity growth to be decomposed into changes in efficiency (catch-up) and to changes in technology (innovation)[69].

Briefly, for a vector of inputs $\{x\}$ and vector of outputs $\{y\}$, for each time period $\{t\}$ the production set $\{S_t\}$ describes all feasible input-output pairs at a given time such that;

$$y_t = \max\{\hat{y}_t : (x_t, y_t) \in S_t\} \qquad (6.1)$$

However, observed output at any point of time $\{\hat{y}_t\}$ may not correspond to the maximum potential output for given input $\{x_t\}$ .The appropriate method of accounting for the discrepancy between actual and potential maximum output (technical inefficiency) is the output distance function of Shephard (1970) defined as;

$$d_t(y_t, x_t) = \inf\{\theta : (y_t/\theta, x_t) \in S_t\} \qquad (6.2)$$

[68] Grosskopf (2003) provides a brief history of the Malmquist productivity index and discusses the theoretical and empirical issues related to the index. For the decomposition of Malmquist productivity index, see Lovell (2003).

[69] A further decomposition can be conducted by separating the change in efficiency into the change in pure efficiency x change in scale efficiency. The change in efficiency is constructed under CRS while the change in pure efficiency and scale efficiency is constructed under VRS.

To construct the Malmquist productivity index we need to specify the distance function for two adjacent time periods. So for period {t+1} the distance function is defined as;

$$d_{t+1}(y_{t+1}, x_{t+1}) = \inf\{\theta : (y_{t+1}/\theta, x_{t+1}) \in S_{t+1}\} \qquad (6.3)$$

The Malmquist index (*M*) of total factor productivity change is the geometric mean of the two output distance function ratios based on the technology for period's t+1 and t respectively. In other words:

$$M = \left[\frac{d_{t+1}(y_{t+1}, x_{t+1})}{d_{t+1}(y_t, x_t)} \frac{d_t(y_{t+1}, x_{t+1})}{d_t(y_t, x_t)}\right]^{\frac{1}{2}} \qquad (6.4)$$

In their study of productivity growth in industrialised countries, Färe et al (1994) decompose (6.4) for changes in efficiency (catch up) and changes in frontier technology (innovation). This can be seen by expressing (6.4) as:

$$M = \frac{d_{t+1}(y_{t+1}, x_{t+1})}{d_t(y_t, x_t)}\left[\frac{d_t(y_{t+1}, x_{t+1})}{d_{t+1}(y_{t+1}, x_{t+1})} \frac{d_t(y_t, x_t)}{d_{t+1}(y_t, x_t)}\right]^{\frac{1}{2}} \qquad (6.5)$$

or $$M = E_{t+1}T_{t+1}$$

where

M = the Malmquist productivity index

E_{t+1} = a change in relative efficiency over the period t and t+1 (catch-up)

T_{t+1} = a measure of technical progress measured by shifts in the frontier from period t to t+1

When $M > 1$ it means that there has been a positive total factor productivity change between period t and t+1. When M < 1 it means that there has been a negative total factor productivity change.

The use of the Malmquist method of evaluating productivity performance of banks has been a growth area of academic enquiry. Berg et al (1992) examined Norwegian banks over the period 1980-89 and found productivity regress prior to deregulation and strong productivity gains due to catch-up after deregulation. The Malmquist decomposition was used by Wheelock and Wilson (1999) to examine bank productivity in the USA for the period 1984-93. They reported a general drop in average productivity caused by failure to catch-up with outward shifts of the production frontier. Alam (2001) found that the deregulation period resulted in a productivity surge in the first half of the 1980s followed by a productivity regress in the second half for large US banks. These results were confirmed by Mukherjee et al (2001) who also used panel estimation to explain productivity growth in terms of bank size, product-mix and capitalisation.

Other studies of bank productivity using the Malmquist method have been Drake (2001) for the UK, Grifell-Tatjéand Lovell (1997) for Spain, Canhoto and Dermine (2003) for Portugal, Noulas (1997) for Greece, Fukuyama (1995) for Japan, and Isik and Hassan (2003) for Turkey. A pan-European study was conducted by Casu et al (2004) who compared parametric with the Malmquist method. Their finding is that productivity growth in European banking was been largely brought about by technological change rather than efficiency improvement. Outside Europe, Worthington (1999) found that Australian Credit Unions exhibited strong technological progress after deregulation and Neal (2004) found that productivity improvements were mostly shifts in the frontier with the majority of banks having negative catch-up over 1995-99.

The productivity of Chinese banking has also been the subject of numerous studies by Chinese scholars. Chen (2002), Zhang and Wu (2005) and Tang and Wang (2006) use the Malmquist method to examine the productivity trend of Chinese banks over the 1994-1999, 1999-2003 and 1997-2003 periods respectively. Their basic findings were that the large state-owned banks exhibited lower average growth compared with the joint stock banks. In general average productivity growth was dominated by catch-up rather technical innovation but that there had been in a marked improvement in TFP in the latter years[70]. In contrast Ni and Wan (2006) found strong productivity improvement led by technical improvement rather than catch-up. Sun and Fang (2007) pose the question, whether foreign banks have stimulated an improvement in Chinese bank productive efficiency? They find that average TFP growth improved during the period 2001-2004 consistent with the hypothesis that the threat of entry has had significant efficiency effects on incumbent banks.

However, these studies are limited by two important issues. First, the results are conditional on the inputs and outputs employed. There is no consensus as to the appropriate measures of inputs and outputs used in the construction of Chinese bank productivity. On the input side, operational expenses or labour (where available), fixed assets and sometimes deposits in varying combinations are used most

[70] See also Hou (2006) which uses a two-stage panel estimation to explain productivity but inappropriately uses operating expenses as an explanatory variable when it is also an input in the construction of the M index.

frequently. However, on the output side, the studies can be grouped into three variants. Some studies use asset stocks (loans and other earning assets) whereas others use income flows (interest earnings, non-interest earnings, net income, profits). A third group takes an eclectic approach mixing assets with liabilities (deposits and loans) and stocks with flows (loans and profits) and even others mixing (assets, liabilities and income flows).

Second, the lack of statistical inferential capability makes it difficult to evaluate the sensitivity of the estimates obtained relative to sample variation. In other words, the deterministic estimates of the Malmquist index cannot assign confidence levels to the measures of growth. The estimates obtained in the above studies represent measures of performance relative to an estimate of the true but unobserved frontier. Since these estimates are based on finite samples, they will be subject to sampling variation of the frontier and subject to finite sample bias. The bootstrap reduces finite sample bias and reduces, or even eliminates finite sample errors in the rejection probability of statistical tests (see Horowitz, 2001).

Simar and Wilson (1998, 1999, 2000) propose a smooth bootstrapping methodology to examine the sensitivity of the DEA scores and Malmquist indices to sampling variations with the aim of assigning confidence intervals.

The application of bootstrapping methods to the Malmquist productivity index remains an ongoing area of research (Lőthgreen and Tambour, 1999). Relatively few studies have applied bootstrapping methods to measuring banking productivity. Gilbert and Wilson (1998) calculate confidence intervals for estimates of productivity in Korean banks in 1980-94 and conclude that the period had experienced significant productivity growth against the null hypothesis of no change between periods. Tortosa-Ausina et al (2008), apply bootstrapping to Spanish savings banks over 1992-1998 and confirm the common finding that productivity growth is dominated by technological progress in the post deregulation period. Murillo-Melchor et al (2005) conduct a European wide study of bank productivity over the period 1995-2001 using bootstrap techniques. They confirm the basic finding of Casu et al (2004) that productivity gains were driven by technological progress but find significant differences in inter-country performance[71].

6.4 Banking data

This study employs an unbalanced panel of annual data (1997-2007) for the 5 state-owned or state-controlled commercial banks (SOCB), 9 joint-stock commercial banks (JSCB) and 47 city commercial banks (CCB). The total sample consisted of 314 bank-year observations. The main source of the data was Fitch/Bankscope, and individual annual reports of banks.

Two approaches are normally taken in determining what constitutes bank input and output. The intermediation approach developed by Sealey and Lindley (1977) recognises the main function of the bank is to conduct financial intermediation. Under the intermediation approach, bank assets measure outputs and liabilities measure inputs. In contrast, the production approach recognises that the bank provides intermediation services and payment services to depositors. In the production

[71] Alam (2001) also uses bootstrap confidence intervals to provide an inferential capacity to the point estimates of productivity of large US banks.

approach, physical entities such as labour and capital are inputs while deposits are a measure of output[72]. Goldschmidt (1981) argues that deposits are both inputs and outputs depending on its use in intermediation services or payments services and suggests a weighting mechanism similar to the divisia approach of Barnett et al (1984). Such a separation would need information about the term maturity of deposits. This information is not easily available for banks in China and in any case up until very recently deposit interest rates were regulated and did not reflect market fundamentals.

A further issue is the problem of non-performing loans (NPLs) which have been treated as an undesirable output in a number of studies. Park and Weber (2006) consider loans less NPLs as well as deposits as a valid output of the bank in their study of bank productivity in Korea, where NPLs are viewed as an undesirable output. Stripping out non-performing loans from the stock of loans for each bank creates a new output variable which replaces the stock of total loans and following Scheel (2001) I treat the inverse of NPLs as a positive output[73].

Another argument for adjusting loans for NPLs is to mitigate the effect of the large loan portfolios held by the SOCBs on the efficiency calculation. The unadjusted loan portfolio would bias the efficiency score upwards for the SOCBs which have the largest share of loans but also the highest proportion of NPLs.

[72] Freixas and Rochet (1997) propose a third approach that recognises the specific activities of banks such as risk management and information processing.
[73] See Thanassoulis (2008) for a discussion.

Finally, a variant of the production approach is to recognise that the services provided to depositors and loan obligors are reflected in the net flows of income to the bank. So services to the consumers of banking products whether it is intermediation services or other financial services, will be reflected in the net interest earnings to the bank and net non-interest earnings.

Following Drake (2001) I adopt a hybrid between the intermediation and production approaches. I also recognise that deposits may be viewed as an output or as an input. I therefore consider five types of models, which can act as boundaries for the intermediation and production approaches including undesirable outputs. Model 1 is one where there are three inputs; bank deposits and borrowed funds, fixed assets and operational costs, and three outputs; total loans, other earning assets, and non-interest income. Although non-interest income remains undeveloped in China, it is selected to reflect the growing contribution of this area to banks' total income. Model 2 separates NPLs from Loans and treats NPLs as an undesirable output. Model 3 recognises deposits as an output and Model 4 allows deposits as an output and treats NPLs as an undesirable output. Model 5 has only fixed assets and overheads as inputs but has net interest income and non-interest income as outputs. Model 5 is the closest to the concept of the neo-classical production function which uses stocks of capital and labour to produce a flow of output. In this study overheads acts as a proxy of labour and the outputs are the revenues generated from balance sheet and off-balance sheet business, which also subsumes the lower gross interest income generated by NPLs. Table 6.2 summarises the input/output structure of each model.

Table 6.2 Model structure

Model	Inputs	Outputs
1	Deposits (RDEP), Overheads (ROHD), Fixed Assets (RFA)	Loans (RLOAN), Other earning assets (ROEA), RFEE (net fee income)
2	Deposits (RDEP), Overheads (ROHD), Fixed Assets (RFA)	Loans less NPLs (RPLOAN), Other earning assets (ROEA), RFEE (net fee income), RNPLs as undesirable output
3	Overheads (ROHD), Fixed Assets (RFA)	Loans (RLOAN), Other earning assets (ROEA), RFEE (net fee income), Deposits (RDEP)
4	Overheads (ROHD), Fixed Assets (RFA)	Loans less RNPLs (RPLOAN), Other earning assets (ROEA), RFEE (net fee income), RNPLs as undesirable output, Deposits (RDEP)
5	Overheads (ROHD), Fixed Assets (RFA)	Net interest earnings (RNIE), net fee income (RFEE)

As an indicator of scale and evolution of the variables over the period, Table 6.3 presents the summary statistics of the input and output data by bank group for 1999 as representative of the first half of the period and for 2007 as representative of the second half. Since I am examining the movements in productivity over a period of nine years, the nominal values of data were deflated by the consumer price index.

Table 6.3 Output-Input Variables 1999 and 2007 (million RMB) per bank/year deflated by the consumer price index 1997=1

Variable	Description	Bank Group	Mean	Standard Deviation	Minimum	Maximum
RLOAN	Real stock of loans	SOCB	142078	783544	29024	2464455
			2505421	986477	979895	3464731
		JSCB	48577	25186	16643	80603
			386374	141514	194756	590849
		CCB	11239	9611	4420	33094
			18272	28210	553	138379
ROEA	Real stock of other earning assets	SOCB	685486	370853	224289	1210672
			2496702	1146125	873945	4025218
		JSCB	42189	24770	15157	74369
			313253	133885	116718	568532
		CCB	11875	13207	2024	38144
			18179	33965	1254	172276
RFEE	Real net fees and commissions	SOCB	1664	3496	0	7910
			19834	10308	6403	31032
		JSCB	78	67	15	177
			1691	1648	407	5811
		CCB	11	10	1	28
			35	64	0	277
RNPL	Real non-performing loans	SOCB	642448	411000	50705	1090038
			203324	300511	20482	738243
		JSCB	8232	9834	0	31372
			8496	3750	4136	16922
		CCB	1388	880	370	2792
			359	749	4	3947
RDEP	Real deposits and other sources of funds	SOCB	2063133	1097080	31830	3249698
			4655574	1956532	1709734	7016662
		JSCB	86105	44388	34818	140688
			616877	265686	233158	1094492
		CCB	23308	23520	5328	69579
			32815	56812	2682	281241
RFA	Real fixed assets	SOCB	44935	24472	4856	67995
			62260	22907	29060	88802
		JSCB	2360	951	930	3795
			4574	2006	1800	7620
		CCB	440	237	122	778
			319	470	11	2516
ROHD	Real overhead and other non-interest costs	SOCB	25822	12960	6164	38031
			63999	27516	19420	84296
		JSCB	1339	677	584	2616
			7649	3014	3894	13225
		CCB	391	3259	116	1013
			338	459	23	2278
RNIE	Real net interest earnings	SOCB	40192	21769	844	64969
			150729	49225	88490	202585
		JSCB	2214	978	957	3913
			21112	11803	8669	48866
		CCB	859	659	297	1615
			1095	1420	47	6724

Sources: Fitch/Bankscope, *Almanac of China's Finance and Banking* (various) and author calculations from web sources.

The groups represent collectively the five state-owned or controlled banks (SOCB), the joint stock commercial banks (JSCB), and the city commercial banks (CCB). The table highlights the rapid growth in the average loan book over this period, particularly for the SOCBs and JSCBs. The table also shows the decline in the average level of NPLs for the SOCBs in the eight years between 1999 and 2007. In part this represents the transfer of tranches of NPLs from the four largest SOCBs to the Asset Management Companies in 1999-2000 and in 2003. It also shows that the average rate of decline of NPLs by the CCBs were relatively faster. The figures for the CCBs are not strictly comparable between the two periods given the unbalanced nature of the sample. While the summary statistics for the SOCBs and JSCBs are comparable, the number of CCBs in the sample for 1999 was 9 whereas in 2007 it was 41[74].

6.5 Empirical Results

Positive productivity growth is measured by an estimate greater than unity. Productivity regress is indicated by an estimate of less than unity. We conduct two exercises in the measurement of bank productivity. First we estimate the standard Malmquist measure based on the deterministic Data Envelope Analysis, however this will be a biased estimate. Second, a bootstrap estimate of the median of 2000 bootstrap simulations is examined[75].

In both cases a constant returns to scale technology was assumed. If the production technology is variable returns to scale (VRS), the Malmquist TFP index can be further decomposed into frontier shift, pure efficiency change and scale efficiency[76]. The bootstrap algorithm of Simar and Wilson (1999) uses the conical hull of the observed

[74] Although the sample is an unbalanced panel for the whole period, the TFP calculation necessarily has a balanced panel for each year of calculation. The estimates were weighted by asset share to give an aggregated estimate as a means of minimising potential bias.

[75] We also conduct a third exercise where the estimate of productivity growth is not significantly different from unity as given by the 95% confidence intervals of the bootstrap, the figure is constrained to the null of unity. The aggregated results did not look too different from the unconstrained bootstrap results and are not reported.

[76] See also Ray and Desli (1997)

data to estimate the production set, which amounts to assuming CRS. However, the Malmquist index provides consistent estimates of the true value irrespective of the returns to scale assumption but may give inconsistent results regarding the sources of productivity in the decomposition[77].

Table 6.4 shows the sample mean of the weighted (by group asset share) average of TFP and decomposition for each of the five models discussed above using the two alternative estimates of the pure DEA estimate and the unconstrained median bootstrap value[78]. The final three rows show the average for the 5 models.

Table 6.4 Weighted annual average of productivity growth 1998 – 2007 (weighted by asset share)

Model	Group	DEA standard linear-programming estimates			Bootstrap Unconstrained estimates		
		TFP	Tech	Catch-up	TFP	Tech	Catch-up
1	SOCB	1.005	1.035	0.974	0.997	1.046	0.996
	JSCB	0.980	0.987	0.961	0.975	0.994	0.970
	CCB	1.015	1.010	0.994	1.038	1.019	1.018
2	SOCB	0.997	1.085	0.923	0.992	1.102	0.946
	JSCB	1.032	1.048	0.973	1.052	1.085	0.999
	CCB	1.027	1.029	1.003	1.294	1.087	1.352
3	SOCB	1.009	1.099	0.948	1.006	1.113	0.949
	JSCB	0.967	0.983	0.982	0.952	0.974	1.009
	CCB	1.021	0.993	1.018	1.008	0.979	1.216
4	SOCB	1.008	1.213	0.935	0.996	1.133	0.935
	JSCB	0.999	1.024	0.957	1.038	1.053	1.008
	CCB	1.033	1.011	1.008	1.340	1.048	1.339
5	SOCB	1.053	1.142	0.941	1.054	1.095	0.936
	JSCB	1.022	1.029	0.966	1.019	1.015	0.977
	CCB	1.109	1.146	0.956	1.085	1.206	0.976
Average of all 5 Models	SOCB	1.014	1.115	0.944	1.009	1.098	0.952
	JSCB	1.000	1.014	0.968	1.007	1.024	0.993
	CCB	1.041	1.038	0.996	1.153	1.068	1.180

[77] In a previous study looking at the productivity growth of the national banks of China for a shorter time period Matthews et al (2009) used the third test of Banker (1996) on selected years and found that the null of CRS could not be rejected.

[78] The multiplicative property does not hold because of the time weighting used in construction of the weighted averages.

The TFP productivity growth is decomposed into technical progress and efficiency gains (catch-up) for each of the models. A number of points can be made about the results of Table 6.4. First, the results are broadly similar for both sets of estimates. However, the bootstrap results are quantitatively different from the DEA estimates, indicating significant bias in the raw DEA results and therefore we focus our attention on these[79]. Second, looking at models 1-4, the SOCBs have had significant TFP regress over this period and only moderate growth in the case of model 3, where deposits are considered as an output. Third, staying with models 1-4, the main driver of TFP growth for the national banks has been technical progress defined by the 'best practice' banks. In most cases the best practice (benchmark) banks have shifted the frontier outwards leaving the average banks behind and further to catch up. However, the main driver of TFP growth for the CCBs has been catch-up (models 2, 3 and 4). Technical progress as the driver of TFP is stronger in the case when NPLs are treated as an undesirable output (models 2 and 4). Fourth, the bootstrap estimates show strong TFP growth for the CCBs and unlike that of the other two bank groups, also strong efficiency gains (catch-up). This means that the CCBs are converging on each other (peer group) at a faster rate than the SOCBs and JSCBs within their own groups. Fifth, the results show that the TFP growth of the CCBs and JSCBs was higher relative to SOCBs in the case of model 2 and 4 where NPLs are treated as undesirable outputs but that the technical innovation was stronger in the SOCBs. The reason for this is possibly because the distribution of NPLs is concentrated in the state-owned banking sector but also that the best practice banks in this group have had strong success in reducing their NPL ratios thus reducing their bad output at a faster rate.

[79] Out of 1570 bank year estimates of TFP obtained by the DEA method for the 5 models, 36 percent were biased at the 95% based on the bootstrap results.

Finally, model 5 which has a stronger resonance with the neo-classical production function shows strong TFP growth in the SOCBs and CCBs with technical progress being the main driver.

The striking picture in Table 6.4 is what emerges for the CCBs. Strong TFP growth is driven by moderate innovation effects (excepting model 5) and spectacular efficiency gains (catch-up), suggesting that simply emulating best-practice without strong innovation was sufficient to generate strong productivity gains in the CCBs. The average for all 5 models for each bank group is an indication of a robust measure of overall TFP growth and its drivers.

Table 6.4 also shows that taking the average of all five models to obtain a robust measure, TFP growth by the SOCBs and the JSCBs has on average been zero but productivity growth of the CCBs has been 15% a year. However this verdict belies sharp differences in the drivers between the bank groups. In the case of the SOCBs, technical innovation has been equally offset by regress in efficiency. This means that the best practice SOCBs have shifted the frontier and widened the gap between them and the remaining SOCBs. A similar but much more moderate picture emerges for the JSCBs. With the CCBs both technical innovation and efficiency gains contribute to the strong TFP growth. However, efficiency gains dominate suggesting that emulating the best practice banks have contributed the most to productivity growth.

The boundary is made up of the benchmark or best practice banks. The banks that make up the benchmark and define the extent of technical innovation may change from year to year and by model. However, it is instructive to identify the benchmark banks within each bank group as the bank that has the most frequent display of technical innovation and with highest average growth due to technical innovation. Table 6.5 below presents the benchmark banks for each bank group.

Table 6.5 Best Practice Banks

Bank group	Model 1	Model 2	Model 3	Model 4	Model 5
SOCB	Bank of China	Bank of China	Bank of China	Bank of China	ICBC
	Bank of Communications	Bank of Communications			
JSCB	CMBC	CMBC	China Merchant	China Merchant	China Merchant
		China Merchant			
CCB	Xiamen	Xiamen	Xiamen	Xiamen	Shanghai
	Ningbo	Ningbo			

Increasing deregulation as suggested by the CBRC and the opening up of the Chinese banking market post 2006 would suggest that the second half of the sample period examined should see a significant improvement in TFP growth. To test for this, the sample was split into two periods 1998-2002 and 2003–2007. Table 6.6 below shows the annual weighted average of TFP growth in both periods for all five models and the overall average.

Table 6.6 Total Factor Productivity Growth in sub-samples (weighted averages)

Years	Bank Group	Model 1	Model 2	Model 3	Model 4	Model 5	Average
1998-2002	SOCB	1.014	1.001	1.027	0.996	1.138	1.035
	JSCB	1.005	1.132	1.018	1.176	1.141	1.094
	CCB	1.047	1.481	0.954	1.359	1.206	1.209
2003-2007	SOCB	0.979	0.983	0.984	0.996	0.998	0.988
	JSCB	0.946	0.973	0.886	0.899	0.938	0.928
	CCB	1.030	1.107	1.063	1.321	1.007	1.106

The table shows that the average TFP growth of the SOCBs ranged from 0.1% a year to 13.8% a year in the first half of the period but was universally negative in the second half. Given that Table 6.4 indicates the main driver for TFP growth was technical progress, this suggests that the benchmark banks had raced ahead leaving the other banks in the group with more ground to catch-up, leading to an average productivity regress. The results for the first half of the period also confirm the standard finding that the JSCBs outperformed the SOCBs, particularly when NPLs are treated as an undesirable output. But contrary to the findings of some Chinese scholars this performance is not sustained in the second half of the period. The final column which shows the average TFP for the three bank groups confirm that productivity performance was weaker in the second half of the period[80]. The main result is that the TFP growth of the CCBs was stronger than both groups of the national banks confirming the findings of Ferri (2009) that city commercial banks have increased their performance and are challenging the traditional banks.

Using the distance function method of estimating TFP, Kumbhakar and Wang (2007) find that overall TFP growth for the national banks in China over the period 1993-2002 was 4.5% annually with the SOCBs showing an annual growth of 0.7% a year and the JSCBs showing an average growth of 6.1%. The inputs in the Kumbhakar and Wang (KW) study were labour, fixed assets and deposits and the outputs were loans and other earning assets. The inputs and outputs in this chapter do not correspond exactly with the KW study; however model 1 is the closest in proximity where overheads act a proxy for labour as a factor production. However, if the average of all five models is used as a robust measure, the KW estimates fall within the neighbourhood.

[80] This is also confirmed by a non-parametric test (Mann-Whitney z test) for the differences in the measures of TFP growth between the two periods which showed no evidence (at the conventional 5% level of significance) that the high productivity growth of the first half of the period was sustained in the run-up to the opening up of the banking market to foreign competition.

I now turn to an examination of the convergence characteristics of TFP growth in Chinese banks. The growth convergence literature distinguishes between unconditional *β-convergence* and conditional *β-convergence*. The former relates to convergence to a common point or trajectory and the latter relates to different points or steady-states defined by peer group characteristics. These peer group characteristics are identified by bank specific components that might explain productivity performance.

Recently a number of studies have emerged examining the convergence of bank efficiency and productivity. Weill (2009) tests for *β-convergence* and *σ-convergence* of cost efficiency of banks across 10 EU countries and Casu and Girardone (2008) do the same for 15 EU countries. Single country studies have been conducted by Fung (2006) for bank holding companies in the US and Fung and Leung (2008) for Chinese banks. In what follows, I examine conditional *β-convergence* and *σ-convergence.* I conduct panel estimation with all 5 models to estimate a meta- *β-convergence* equation. The purpose of estimating the meta-convergence function is to identify the factors common to all the five models. Following Fung (2006) and Weill (2009) I specify the following dynamic function.

$$TFP_{i,j,t} - TFP_{i,j,t-1} = \alpha + \beta TFP_{i,j,t-1} + \gamma Z_{i,t-1} + \varepsilon_{i,j,t} \qquad (6.6)$$

Where *TFP* represents total factor productivity, *i* is the bank, *j* is the model and *t* is time. Z represents bank specific variables, ε is a stochastic term and α and β are parameters to be estimated. A similar function is specified for technical progress (frontier shift) and efficiency gain (catch-up).

Following Weill (2009), equation (6.6) is supplemented by a specification for meta-σ-convergence as shown in equation (6.7).

$$\Delta(TFP_{i,j,k} - \overline{TFP}_j)_t = \alpha + \beta(TFP_{i,j,k} - \overline{TFP}_j)_{t-1} + \mu_{i,j,k,t} \quad (6.7)$$

Where k is the bank category (SOCB, JSCB, CCB) and a bar over TFP indicates the average figure for the specific model and for banks within each category (k) and model (j). Sigma (σ)-convergence describes the speed at which the dispersion of productivity narrows over time. Sala-i-Martin (1996) shows that β-convergence is a necessary, but not sufficient condition for σ-convergence.

The bank specific variables that I experimented with were SIZE measured by the log of assets, the cost-income ratio (COST), and a measure of revenue diversification given by the proportion of fee income in total revenue (FEE). In addition I also explored the performance of banks that have a foreign stake-holding (FOR) and I also included a dummy variable to distinguish between the category of bank (JCSB=1 if joint stock bank, zero otherwise and CCB=1 if City Commercial Bank, zero otherwise) and type of model (Model 1 to Model 5). All bank specific variables were lagged one period to account for potential endogeneity.

Table 6.7 summarises the results for TFP, technical innovation and efficiency gain, estimated jointly with Seemingly Unrelated Regression (SURE). The first point to note is that the speed of adjustment for all three indicators occurs within the year.

Such a rapid speed of adjustment has also been confirmed in the findings of Fung and Leung (2008). What it means is that mean reversion occurs instantaneously (within the year) and the *convergence* equations can be treated as static representations. The results also suggest that lower TFP growth is associated with banks that have a higher cost-income ratio and higher TFP growth is associated with banks that have diversified their revenue sources by developing non-interest income.

The convergence functions for technical innovation (frontier shifts defined by best practice) and efficiency (catch-up) also shows instantaneous adjustment. The decomposition of the TFP shows that technical innovation that drives TFP is positively associated with banks that have diversified its revenue sources by developing non-interest income business. Whereas efficiency gains (catch-up) is associated with banks that have reduced their cost-income ratio. This means that the benchmark banks are those that have developed a wider spread of non-interest bank business and the catch-up has been obtained through stronger cost control. The negative coefficient on the lag of log SIZE and the lag of the NPL ratio on the efficiency gain equation suggests that smaller banks with lower NPL ratios are associated with faster catch-up as is the case for the CCBs.

The results for sigma-convergence (shown below with *p* values in parenthesis) demonstrate that the dispersion of productivity growth has also narrowed in this period.

$$\Delta(TFP_{i,j,k} - \overline{TFP}_j)_t = -\underset{(0.000)^{***}}{.076} - \underset{(0.000)^{***}}{1.018}(TFP_{i,j,k} - \overline{TFP}_j)_{t-1}$$

Table 6.7 SURE Regression, 1998-2007, *p* values in parenthesis

	Total Factor Productivity growth	Technical Innovation	Efficiency Gain
Intercept	1.144*** (.000)	1.076*** (.000)	1.570*** (.000)
β	-1.031*** (.000)	-1.047*** (.000)	-.988*** (.000)
COST_1	-.003*** (.000)	-	-.002** (.028)
FEE_1	1.051*** (.000)	1.573*** (.000)	-
Ln(SIZE)_1	-	-	-.027*** (.004)
NPL_1	-		-.569*** (.000)
Model 2	.044** (.046)	.131*** (.002)	.052 (.228)
FOR	-	.002 (.155)	-
JSCB	-	-.092** (.046)	-.105** (.004)
CCB	-	-.111*** (.008)	-
R^2	.8986	.5505	.7127

*** significant at the 1%, ** significant at the 5%, * significant at the 10%.

6.6 Conclusion

This chapter has used the Malmquist decomposition to quantify the productivity growth of Chinese banks in the period 1998-2007. The advantage of using the Malmquist method is that it separates the diffusion of technology (efficiency gains) from advances in technology (frontier shifts). The paper also applies bootstrapping techniques to evaluate significant changes in productivity, efficiency gains and innovation. Five models were examined to provide a robust measure of bank productivity performance.

In general, average TFP growth has been neutral over the period for the SOCBs and JSCBs but positive for the CCBs. However, the weighted average figures mask wide differences in individual performance. The benchmark banks that define the production frontier have generated sharp increases in technical innovation, leaving a wider gap between them and the other banks in their respective groups. The CCBs showed improvements in both technical innovation and efficiency (catch-up) gains.

When NPLs are treated as an undesirable output, the JSCBs show strong TFP growth driven by stronger innovation effects. The CCBs show spectacular TFP growth driven largely by efficiency gains but also moderate innovation effects. Efficiency gains (catch-up) were obtained through cost reduction. Technical innovation is associated with greater diversification of revenue away from interest earnings. However, my assessment of the performance of CCBs must be interpreted with caution. The number of CCBs in the sample count for one-third of the actual number of CCBs in China. It is possible that the CCBs that report data publicly are the better ones and there is a sample selection bias in favour of the improving segment in the group.

I find no evidence that innovation and reform in the second part of the sample period, coinciding with the opening up of the Chinese banking market has resulted in an improvement in bank productivity. This may in part be due to the fact that foreign banks still only command a small share of the banking market in China. It is also possible that domestic competition is particularly strong between local banks with the better CCBs challenging the bigger established national banks.

Convergence of productivity growth to the peer group defined by bank specific variables is rapid. Frontier shifts (technical innovation) has been led by banks that have innovated their revenue sources. Catch-up has been led by banks that have controlled their cost-income ratios.

Appendix 6-I Bootstrap Algorithm

The estimates of the distance functions for N banks over 2 periods are obtained following the standard method outlined in Färe et al (1994) for $\hat{d}_t(y_{i,t}, x_{i,t})$ and $\hat{d}_{t+1}(y_{i,t+1}, x_{i,t+1})$. As in Simar and Wilson (1998) a DGP is assumed whereby the N banks randomly deviate from the underlying true frontier in a radial input direction. Bootstrapping involves replicating the DGP and generating 1000 pseudo samples which are used to measure the distance function for either period for each observation in the pseudo sample. This section borrows heavily from Jeon and Sickles (2004)

Step 1: Form (N x 1) vectors $A = \left[\hat{d}_t(y_{1,t}, x_{1,t}), \hat{d}_t(y_{2,t}, x_{2,t})....\hat{d}_t(y_{N,t}, x_{N,t})\right]$ and $B = \left[\hat{d}_{t+1}(y_{1,t+1}, x_{1,t+1}), \hat{d}_{t+1}(y_{2,t+1}, x_{2,t+1})....\hat{d}_{t+1}(y_{N,t+1}, x_{N,t+1})\right]$. The values in A and B are bounded from below at unity.

Step 2: Reflect these values about the boundaries in two-dimensional space to form (4N x 2) matrix in partitioned form;

$$\Delta = \begin{bmatrix} A & B \\ 2-A & B \\ 2-A & 2-B \\ A & 2-B \end{bmatrix}$$

The matrix Δ contains 4N pairs of values corresponding to the two time periods. The estimated covariance matrix of the columns [A B] is $\hat{\Sigma}$ which is the same as that of the reflected data [2 – A, 2 – B], given by the temporal correlation of the original data. The covariance matrix of [2 – A, B] and [A, 2 – B] is $\hat{\Sigma}_R$, where;

$$\hat{\Sigma} = \begin{bmatrix} \hat{\sigma}_1^2 & \hat{\sigma}_{12} \\ \hat{\sigma}_{12} & \hat{\sigma}_2^2 \end{bmatrix} \text{ and } \hat{\Sigma}_R = \begin{bmatrix} \hat{\sigma}_1^2 & -\hat{\sigma}_{12} \\ -\hat{\sigma}_{12} & \hat{\sigma}_2^2 \end{bmatrix}$$

Let Δ_j denote the jth row of Δ. Then $\hat{g}(z) = \frac{1}{4Nh^2}\sum_{j=1}^{4N} K_j\left(\frac{z-\Delta_j}{h}\right)$ is a bivariate kernel density estimator of the 4N reflected data points represented by the rows of Δ, where *K*(.) is the bivariate kernel function, *h* is a bandwidth set to $(4/5N)^{1/6}$ following Silverman (1986) and *z* is (1 x 2) $z_i = [\hat{d}_t(y_{it}, x_{it}), \hat{d}_{t+1}(y_{it+1}, x_{it+1})]$ is the ith row of the (N x 2) matrix of the original distance function estimates.

Step 3: Randomly draw with replacement N rows from Δ to form (N x 2) matrix $\Delta^* = [\delta_{i,j}]$, i=1,2,....N, j=1,2.

Step 4: Compute

$$\bar{\delta}_j = \tfrac{1}{N}\sum_{i=1}^{N}\delta_{i,j}\ , j = 1, 2$$

Step 5: Simulate draws from a bivariate $N(0,,\hat{\Sigma})$ and $N(0,\hat{\Sigma}_R)$ by generating iid pseudo random N(0,1) deviates (z_1, z_2) s.t. $(l_1 z_1, l_2 z_2 + l_3 z_2)$ from $N(0,,\hat{\Sigma})$ and $(l_1 z_1, -l_2 z_1 + l_3 z_2)$ from $N(0,\hat{\Sigma}_R)$. Here l_1, l_2, l_3 are elements of a lower triangular matrix

$$L = \begin{bmatrix} l_1 & 0 \\ l_2 & l_3 \end{bmatrix}$$ obtained from the Cholesky decomposition of the (2 x 2) matrix $\hat{\Sigma}$. These simulated draws form ε* which is (N x 2) containing independent draws from the kernel function. If Δ^*_j is drawn from [A B] or [2 – A 2 - B], the ith row of ε* is from $N(0,,\hat{\Sigma})$, but if ε* is drawn from [2 – A B] or [A 2 – B], the ith row of ε* is from $N(0,\hat{\Sigma}_R)$.

Step 6: Compute (N x 2) matrix

$$\Gamma = (1+h^2)^{-\frac{1}{2}}\left(\Delta^* + h\varepsilon^* - C\begin{bmatrix} \bar{\delta}_{.1} & 0 \\ 0 & \bar{\delta}_{.2} \end{bmatrix}\right) + C\begin{bmatrix} \bar{\delta}_{.1} & 0 \\ 0 & \bar{\delta}_{.2} \end{bmatrix}$$ where C is (N x 1) of unit values which gives a (N x 2) of bivariate deviates from the estimated density of Δ and ε* is an (N x 2) containing N independent draws from the kernel function K_j(.).

Step 7: For each element of $\gamma_{i,j}$ of Γ set; $\gamma^*_{i,j} = \gamma_{i,j} \geq 1$ or $2-\gamma_{i,j}$ otherwise. The (N x 2) matrix $\Gamma^* = [\gamma^*_{i,j}]$ contains simulated distance function values.

Step 8: Pseudo samples ℓ^* are then constructed by setting $x^*_{it,j} = \gamma^*_{i,j} x_{i,t} / \hat{d}_t(y_{it}, x_{it})$ and $y^*_{it,j} = y_{it,j}$ for i = 1, 2, ..N and j = 1,2.

Step 9: Compute the four distance functions;

$\hat{d}^*_t(y^*_{it}, x^*_{it}), d^*_{t+1}(y^*_{it}, x^*_{it}), d^*_t(y^*_{it+1}, x^*_{it+1}), d^*_{t+1}(y^*_{it+1}, x^*_{it+1})$. Repeat steps 3 to 9 B times to get a set of B bootstrap estimates.

Appendix 6-II Bootstrapped Estimations of TFP (2,000 bootstrap)

* sig bias at the 5% level

Banks	Model 1 – 2007/2006				Model 1 – 2006/2005				Model 1 – 2005/2004			
	TFP	Boot Median	L - B	U - B	TFP	Boot Median	L - B	U - B	TFP	Boot Median	L - B	U - B
State-Owned Banks												
ICBC	0.94	0.94	0.91	0.96	1.00	1.01	0.99	1.05	0.96 *	0.92	0.88	0.95
CCB	0.81	0.84	0.79	0.91	1.19 *	1.23	1.19	1.28	1.01	1.00	0.98	1.03
ABOC	3.91 *	2.60	1.75	3.69	0.33 *	0.54	0.37	0.85	1.00	1.00	0.97	1.04
BOC	0.97	0.95	0.89	1.00	1.12	1.12	1.09	1.15	1.07	1.06	1.03	1.09
BoCom	3.09 *	2.03	1.35	2.80	0.34 *	0.55	0.39	0.85	0.99	0.99	0.96	1.02
Joint Stock Commercial Banks												
CMB	0.94	0.94	0.88	1.00	1.07	1.09	1.06	1.14	0.89 *	0.95	0.89	1.03
CMBC	0.90	0.87	0.82	0.92	1.18	1.20	1.15	1.28	0.85	0.87	0.83	0.92
CITIC	0.85	0.86	0.82	0.91	1.05	1.04	0.98	1.07	0.98	0.97	0.93	1.01
SPDB	0.95	0.95	0.89	1.01	1.16	1.15	1.09	1.25	0.90	0.91	0.86	0.95
CIB	0.74 *	0.65	0.59	0.72	1.36	1.47	1.34	1.64	0.88	0.89	0.83	0.96
CEB	0.89	0.90	0.84	0.95	1.15	1.19	1.13	1.29	0.89	0.90	0.87	0.95
HUAXIA	0.79	0.74	0.68	0.81	1.14	1.18	1.12	1.26	0.94	0.94	0.89	1.00
GDB	0.92	0.92	0.89	0.93	0.92	0.98	0.92	1.04	1.13	1.12	1.07	1.19
SDB	0.97	0.99	0.97	1.02	1.02	1.01	0.96	1.07	0.73 *	0.79	0.74	0.84
City Commercial Banks												
BEIJING	0.70 *	0.75	0.70	0.79	1.28	1.25	1.22	1.30	0.98	0.96	0.95	0.98
SHANGHAI	0.98	0.93	0.87	1.01	1.14	1.16	1.13	1.19	1.04	1.07	0.98	1.17
Ping An	0.86	0.97	0.85	1.12	1.03	1.00	0.96	1.06	1.00	1.03	0.98	1.10
TIANJIN	0.63	0.61	0.57	0.65	4.68 *	2.16	1.68	3.67	0.64 *	2.94	1.67	3.76
NANJING	0.89	0.90	0.85	0.94	1.14	1.13	1.08	1.23	1.10 *	1.02	0.97	1.08
DONGUAN	0.78	0.78	0.75	0.84	1.14	1.12	1.09	1.16	0.96	0.97	0.94	1.04
WUXI									0.86	0.90	0.84	0.98
CHONQING	0.80	0.77	0.74	0.81	1.39	1.45	1.35	1.58	1.03	1.02	1.00	1.04
XIAMEN	0.97	1.06	0.94	1.21	1.11	1.12	1.07	1.19	1.03	1.02	0.89	1.16
NINGBO	0.91	0.94	0.91	0.96	1.15	1.12	1.07	1.16	1.04	1.03	1.02	1.05
XIAN					0.99	0.99	0.91	1.10	0.89	0.89	0.85	0.94
WUHAN	0.90 *	0.95	0.92	0.98	3.98 *	1.64	1.39	2.50	0.34 *	0.87	0.56	1.02
QINGDAO	0.93 *	1.03	0.95	1.11	1.05	1.05	1.01	1.10	0.84	0.86	0.82	0.90
JINAN	0.95 *	1.00	0.97	1.00	1.07	1.03	0.97	1.10	0.98	0.99	0.93	1.04
DALIAN	0.98 *	1.09	1.00	1.18	1.05	1.07	1.01	1.13	0.86	0.90	0.85	0.93
HANGZHOU	1.01	1.06	0.99	1.14	1.41	1.34	1.28	1.43	0.78 *	0.84	0.78	0.90
CHANGSHA	1.35	1.42	1.33	1.54	1.41 *	1.26	1.22	1.36	0.96	0.98	0.90	1.08
SHIJIAZHUANG	0.96	1.00	0.94	1.05	1.04	1.04	0.98	1.09	1.03	1.01	0.96	1.08
SHAOXING	0.83	0.85	0.81	0.89	1.02	0.98	0.93	1.02	0.87 *	0.92	0.88	0.95
JINZHOU					0.98	0.94	0.88	1.01	1.14 *	1.25	1.16	1.32
LAIWU	0.98	0.94	0.88	0.99	1.02	0.91	0.74	1.19	1.13 *	0.18	0.13	0.34
JIUJIANG	0.82	0.87	0.77	1.00	1.11	1.10	1.08	1.12	1.04 *	1.13	1.05	1.26
PANZHIHUA	0.92 *	1.03	0.93	1.10	0.87	0.89	0.83	1.00	0.99 *	0.25	0.19	0.42
DONGYING	0.88	0.80	0.74	0.86	1.15	1.29	1.14	1.43	0.71	0.73	0.63	0.86
ZENGZHOU	0.76	0.76	0.75	0.78	0.95	1.03	0.93	1.15				
WEIFANG	0.90	0.96	0.87	1.07	0.94	0.97	0.94	1.00				
LINYI	1.02 *	1.13	1.05	1.20	1.00	0.99	0.89	1.01				
XINXIANG	0.89	0.88	0.83	0.91	3.01 *	1.69	1.33	2.74				
LIUZHOU	0.86	0.86	0.85	0.88	0.99	0.98	0.92	1.02				
HUZHOU	0.87	0.87	0.85	0.89	1.16	1.18	1.15	1.24				
KARAMAY	0.85	0.79	0.71	0.89	1.19	1.13	1.01	1.24				
HUANGSHI	0.84	0.84	0.81	0.88								

Banks	Model 1 – 2007/2006				Model 1 – 2006/2005				Model 1 – 2005/2004			
	TFP	Boot Median	L - B	U - B	TFP	Boot Median	L - B	U - B	TFP	Boot Median	L - B	U - B
XUCHANG	0.96	0.97	0.91	1.02								
JINING	1.02	1.07	1.01	1.12								
CHENGDE	0.69	0.72	0.65	0.81								
HENGYANG	1.02	1.12	1.01	1.23								
GANZHOU	0.82	0.82	0.80	0.85								
GUILIN	0.81	0.79	0.76	0.83								
NIANYANG	0.85	0.86	0.83	0.89								
JIAOZUO	3.41	1.58	1.34	1.99								
DEYANG	0.77	0.78	0.72	0.86								
MINTAI	0.68	0.68	0.62	0.74								
CHOUZHOU	0.90	0.93	0.89	0.99								
ZHANJIANG	0.81 *	0.87	0.81	0.92								
JIAXING	0.93	0.97	0.92	1.01								
TAILONG	0.87	0.88	0.86	0.91								
WEIHI	0.73 *	2.00	1.31	2.85								

Banks	Model 1 – 2004/2003				Model 1 – 2003/2002				Model 1 – 2002/2001			
	TFP	Boot Median	L-B	U-B	TFP	Boot Median	L-B	U-B	TFP	Boot Median	L-B	U-B
State-Owned Banks												
ICBC	0.93	0.96	0.92	1.00	1.10	1.09	1.06	1.11	1.04	1.01	0.96	1.06
CCB	0.92	0.89	0.87	0.93	0.87	0.87	0.84	0.91	1.14	1.14	1.11	1.18
ABOC	0.95	0.96	0.93	1.00	0.92	0.92	0.90	0.93	0.97	0.95	0.92	0.99
BOC	1.24	1.16	1.08	1.26	1.06	1.06	1.00	1.11	1.05	1.02	0.99	1.08
BoCom	1.02	1.02	1.00	1.05	0.95	0.93	0.89	0.96	1.46 *	1.23	1.10	1.35
Joint Stock Commercial Banks												
CMB	1.16	1.18	1.13	1.23	0.80	0.76	0.73	0.80	0.92 *	0.98	0.93	1.06
CMBC	1.03 *	0.81	0.73	0.92	0.97	0.92	0.88	0.97	0.95 *	1.22	1.08	1.33
CITIC	1.26	1.28	1.21	1.32	0.88	0.89	0.86	0.92	0.92	0.89	0.84	0.94
SPDB	1.06	1.04	1.02	1.07	0.91	0.92	0.87	0.98	0.88	0.88	0.82	0.95
CIB	1.02	1.07	1.00	1.13	0.96	1.00	0.93	1.07	1.01	1.04	0.95	1.15
CEB	1.10	1.10	1.05	1.13	0.85	0.84	0.81	0.88	0.94	0.92	0.87	0.98
HUAXIA	1.02 *	1.06	1.03	1.09	0.95	0.89	0.82	0.96	1.02	1.07	1.01	1.13
GDB	1.27	1.23	1.19	1.28	0.83 *	0.89	0.85	0.93	0.95 *	1.00	0.97	1.05
SDB	1.17	1.16	1.08	1.21	0.91	0.91	0.89	0.93	0.96	0.95	0.88	1.02
City Commercial Banks												
BEIJING	1.24	1.26	1.15	1.37	0.94	0.86	0.77	0.96	0.79 *	0.87	0.80	0.91
SHANGHAI	1.14 *	1.18	1.15	1.23	1.03	0.97	0.88	1.09	0.88 *	1.01	0.94	1.10
Ping An	1.05 *	1.08	1.06	1.10	0.92 *	0.82	0.75	0.90	0.76 *	0.95	0.80	1.08
TIANJIN	1.07	1.07	1.06	1.10	0.87	0.91	0.81	1.01	0.89 *	0.95	0.90	0.99
NANJING	0.98 *	1.03	1.01	1.04	1.09 *	0.93	0.90	0.99	0.82 *	0.98	0.87	1.08
DONGUAN	1.05 *	1.00	0.96	1.04	0.95	0.94	0.93	0.96	0.91	0.88	0.85	0.94
WUXI	1.11	1.05	0.97	1.12	0.97	0.98	0.93	1.03	0.87	0.94	0.85	1.03
CHONQING	1.21 *	1.11	1.05	1.17	0.77	0.78	0.77	0.80	0.87	0.90	0.83	0.96
XIAMEN	1.19 *	1.07	1.01	1.17	1.00	1.00	0.95	1.05	0.87	0.93	0.85	1.03
NINGBO	1.00	1.03	1.00	1.06	0.92	0.92	0.89	0.95	0.90	0.88	0.86	0.92
XIAN	1.03	1.03	0.99	1.07	0.86 *	0.78	0.72	0.84	0.88	0.93	0.84	1.02
WUHAN	1.08	1.11	1.05	1.16	0.94 *	0.90	0.88	0.93	0.77	0.82	0.76	0.88
QINGDAO	1.02 *	0.90	0.81	1.00	0.99 *	0.75	0.63	0.87	0.87 *	1.28	1.06	1.44
JINAN	0.89 *	0.93	0.89	0.95	0.91	0.92	0.90	0.93	0.98	1.00	0.96	1.05
DALIAN	0.99	1.00	0.96	1.03	0.82	0.82	0.80	0.85	1.12	1.12	1.06	1.19
HANGZHOU	1.51 *	1.00	0.87	1.21	1.97	1.88	1.41	2.58				
CHANGSHA	1.13 *	1.00	0.91	1.12	0.84 *	0.93	0.88	0.99				
SHIJIAZHUANG	1.00	0.98	0.90	1.05								
SHAOXING	0.86	0.84	0.82	0.90								
JINZHOU	0.63	0.60	0.54	0.67								

Banks	Model 1 – 2001/2000				Model 1 – 2000/1999				Model 1 – 1999/1998			
	TFP	Boot Median	L-B	U-B	TFP	Boot Median	L-B	U-B	TFP	Boot Median	L-B	U-B
State-Owned Banks												
ICBC	0.90	0.90	0.87	0.93	1.02	1.00	0.99	1.03	1.04	1.03	1.00	1.06
CCB	0.97	0.98	0.94	1.03	0.95	0.89	0.81	0.96	1.11 *	1.23	1.12	1.36
ABOC	1.09	1.11	1.09	1.13	0.95	0.94	0.92	0.95	0.99	1.00	0.98	1.04
BOC	1.05	1.10	1.02	1.14	1.18	1.11	1.08	1.19	0.84	0.89	0.75	1.06
BoCom	1.00	0.93	0.88	1.01	1.00	0.97	0.87	1.11	0.81	0.73	0.67	0.85
Joint Stock Commercial Banks												
CMB	1.01 *	0.93	0.84	1.00	1.17	1.16	1.10	1.25	1.09	1.09	1.06	1.16
CMBC	0.86	0.86	0.77	0.96	0.95	0.90	0.77	1.07	1.06	1.04	1.00	1.11
CITIC	0.96 *	0.92	0.88	0.95	1.10	0.99	0.87	1.13	1.22 *	1.04	0.95	1.20
SPDB	0.91	0.87	0.86	0.92	1.10	1.06	0.98	1.15	1.24	1.20	0.95	1.44
CIB	0.79	0.79	0.72	0.86	0.94	0.82	0.72	0.96	1.02	1.02	1.01	1.02
CEB	1.03	0.95	0.85	1.05	1.29	1.25	1.11	1.38	1.03	1.01	0.97	1.06
HUAXIA	1.03	1.11	1.03	1.27	1.04	0.97	0.88	1.08	1.21	1.15	1.06	1.24
GDB	0.75	0.74	0.69	0.79	1.04	1.05	0.98	1.12	1.15 *	1.02	0.92	1.13
SDB	0.91	0.86	0.82	0.93	0.87	0.83	0.79	0.88	1.28	1.28	1.05	1.45
City Commercial Banks												
BEIJING	0.73	0.65	0.61	0.76	1.10	1.16	1.03	1.37	0.92	1.00	0.91	1.07
SHANGHAI	0.31 *	0.57	0.37	0.79	1.07	0.95	0.93	1.07	1.03 *	0.96	0.95	1.03
Ping An	0.79 *	0.73	0.68	0.78	1.04	1.02	1.00	1.10	0.98	0.98	0.94	1.01
TIANJIN	0.97	1.00	0.96	1.06	1.20	1.17	1.12	1.26	1.13	1.14	1.00	1.19
NANJING	0.99 *	1.04	1.00	1.12	1.08	1.06	1.04	1.12				
DONGUAN	1.06	1.14	1.04	1.18	1.00	0.89	0.82	1.01				
WUXI	0.94	0.91	0.91	0.94	1.03 *	0.88	0.74	1.01				
CHONQING	1.38	1.19	0.97	1.43	0.83	0.92	0.78	1.14				
XIAMEN	0.88	0.91	0.86	0.96	1.07	1.04	0.98	1.11				
NINGBO	0.92	0.93	0.90	0.96								
XIAN	0.90 *	0.85	0.80	0.89								

Banks	Model 1 – 1998/1997			
	TFP	Boot Median	L - B	U - B
State-Owned Banks				
ICBC	0.98	0.99	0.94	1.08
CCB	1.07 *	0.97	0.84	1.04
ABOC	0.93	0.95	0.93	0.97
BOC	1.03	1.04	0.98	1.11
BoCom	1.07 *	0.96	0.93	1.04
Joint Stock Commercial Banks				
CMB	1.08	1.13	0.96	1.18
CMBC	1.37	1.29	1.12	1.41
CITIC	0.96	1.08	0.89	1.19
SPDB	1.16 *	0.92	0.86	1.08
CIB	2.15 *	1.55	1.10	2.06
CEB	1.11	1.20	1.10	1.29
HUAXIA	1.04	1.03	1.00	1.06
GDB	0.94 *	1.00	0.96	1.05
SDB	1.02	1.13	1.00	1.38
City Commercial Banks				
BEIJING	1.18	1.22	1.17	1.30
SHANGHAI	1.05 *	1.35	1.19	1.47

Banks	Model 2 – 2007/2006				Model 2 – 2006/2005				Model 2 – 2005/2004				Model 2 – 2004/2003			
	TFP	Boot	L-B	U-B	TFP	Boot	L-B	U-B	TFP	Boot	L-B	U-B	TFP	Boot	L-B	U-B
State-Owned Banks																
ICBC	0.93	0.92	0.89	0.95	1.03	1.05	1.01	1.10	0.88 *	0.84	0.81	0.87	0.93	0.93	0.89	0.97
CCB	0.79	0.84	0.78	0.91	1.22	1.23	1.19	1.27	1.05	1.05	1.03	1.07	0.92	0.89	0.86	0.92
ABOC	4.38 *	2.85	2.04	4.00	0.33 *	0.55	0.37	0.85	1.05	1.06	1.02	1.13	0.92	0.95	0.90	1.00
BOC	0.98	0.97	0.91	1.02	1.14	1.16	1.12	1.19	1.11	1.10	1.08	1.13	1.23 *	1.15	1.07	1.23
BoCom	3.28 *	2.12	1.47	2.95	0.35 *	0.59	0.40	0.89	1.03	1.03	1.00	1.06	1.00	1.01	0.99	1.04
Joint Stock Commercial Banks																
CMB	0.89	0.87	0.82	0.92	1.17	1.21	1.16	1.29	0.96 *	1.03	0.97	1.11	1.17	1.19	1.13	1.24
CMBC	0.79	0.76	0.71	0.80	1.19	1.13	1.03	1.23	0.92	0.92	0.87	0.98	1.07 *	0.91	0.81	1.01
CITIC	0.70	0.70	0.67	0.74	1.25	1.22	1.20	1.28	1.00	1.01	0.96	1.06	1.28	1.26	1.19	1.32
SPDB	0.79	0.78	0.73	0.83	1.32	1.27	1.19	1.38	0.98	0.98	0.92	1.04	1.09	1.06	1.04	1.10
CIB	0.73 *	0.65	0.60	0.72	1.38	1.43	1.32	1.57	0.94	0.94	0.87	1.02	1.07	1.13	1.05	1.22
CEB	2.97 *	1.72	1.17	2.46	0.35 *	0.61	0.41	0.94	0.95	0.97	0.94	1.02	1.15	1.12	1.06	1.17
HUAXIA	0.75	0.74	0.69	0.78	1.11	1.11	1.02	1.19	1.02	1.03	0.97	1.09	1.05	1.09	1.04	1.13
GDB	0.87	0.89	0.86	0.93	0.96	0.95	0.91	0.99	1.07	1.06	1.01	1.13	1.32	1.28	1.24	1.32
SDB	0.83 *	0.88	0.84	0.89	1.21	1.20	1.14	1.27	0.81 *	0.90	0.84	0.95	0.77 *	0.69	0.62	0.76
City Commercial Banks																
BEIJING	0.68	0.72	0.66	0.75	1.33	1.33	1.30	1.37	1.02	1.03	1.00	1.05	1.26	1.29	1.17	1.39
SHANGHAI	1.01	0.96	0.90	1.04	1.07	1.04	1.01	1.09	1.10	1.18	1.08	1.30	1.16 *	1.21	1.16	1.26
Ping An	0.80 *	0.96	0.87	1.05	1.02	1.00	0.93	1.06	1.15	1.21	1.15	1.29	1.08	1.10	1.05	1.12
TIANJIN	0.63	0.61	0.56	0.64	4.69 *	2.26	1.74	3.78	0.65 *	2.59	1.41	3.51	1.07 *	1.08	1.07	1.13
NANJING	0.86	0.86	0.81	0.90	1.16	1.18	1.11	1.29	1.13 *	0.97	0.60	1.08	0.99	0.85	0.79	1.04
DONGUAN	0.77	0.77	0.73	0.83	1.18	1.20	1.16	1.29	0.99	1.01	0.88	1.09	1.06 *	0.98	0.83	1.05
WUXI									0.92	0.80	0.41	1.03	1.11	1.14	0.95	1.22
CHONQING	0.76	0.75	0.69	0.79	1.57 *	2.19	1.64	3.59	1.02	1.04	1.00	1.23	1.23	1.13	1.02	1.31
XIAMEN	1.06	1.12	0.97	1.29	1.14 *	1.66	1.19	2.36	1.06 *	0.62	0.40	1.05	1.19 *	1.82	1.21	2.10
NINGBO	0.90 *	0.95	0.90	1.00	1.18	1.20	1.12	1.41	1.07 *	0.35	0.22	0.90	1.01 *	1.86	1.30	1.97
XIAN					1.05	1.00	0.91	1.11	1.00	0.93	0.66	1.02	1.06	1.00	0.90	1.10
WUHAN	0.90 *	0.98	0.92	1.04	4.26 *	2.07	1.62	3.82	0.34 *	0.83	0.57	0.98	1.14	1.16	0.96	1.25
QINGDAO	0.75	0.78	0.65	0.86	1.19 *	1.51	1.19	2.17	0.86	0.66	0.39	0.89	1.05	1.05	0.84	1.28
JINAN	0.90	0.95	0.89	1.00	1.17	1.37	1.08	2.17	1.09	0.85	0.44	1.12	0.92 *	0.60	0.58	0.90
DALIAN	0.88 *	0.99	0.90	1.08	0.97	0.93	0.84	1.00	0.94	0.85	0.49	0.99	0.90 *	1.26	0.93	1.84
HANGZHOU	0.96	1.02	0.94	1.12	1.42	1.37	1.24	1.70	0.83 *	0.36	0.14	0.81	1.51 *	0.81	0.79	1.23
CHANGSHA	1.36	1.44	1.34	1.58	1.47	1.37	1.32	1.60	0.96	0.71	0.31	0.99	1.14 *	0.62	0.55	0.90
SHIJIAZHUANG	0.95	0.99	0.91	1.07	1.13 *	1.25	1.15	1.65	1.06	1.03	0.94	1.11	1.00	0.94	0.68	1.06
SHAOXING	0.88	0.76	0.68	0.92	1.11	1.15	1.08	1.30	0.92 *	0.40	0.35	0.52	0.89 *	1.50	1.38	1.89
JINZHOU					0.91	0.89	0.82	0.94	1.82 *	0.96	0.39	1.81	0.66 *	0.31	0.23	0.47
LAIWU	0.70 *	0.52	0.42	0.56	1.15 *	1.39	1.17	2.11	1.23 *	0.53	0.39	0.55				
JIUJIANG	0.85	1.07	0.80	1.22	1.15 *	1.66	1.56	1.70	1.24 *	0.38	0.32	0.49				
PANZHIHUA	0.94 *	1.52	1.31	1.55	0.93 *	1.31	1.07	1.57	1.12 *	0.42	0.33	0.53				
DONGYING	0.90 *	0.59	0.59	0.70	1.26 *	2.00	1.75	2.02	0.80 *	0.27	0.22	0.30				
ZENGZHOU	0.71	0.70	0.60	0.73	1.12 *	1.58	1.20	1.90								
WEIFANG	0.95	0.98	0.80	1.15	1.02 *	0.21	0.20	0.36								
LINYI	0.89	0.97	0.87	1.06	1.44 *	2.63	1.66	3.14								
XINXIANG	0.86 *	0.64	0.56	0.77	3.71 *	16.82	5.25	28.59								
LIUZHOU	0.79 *	0.64	0.61	0.70	1.12 *	2.81	2.31	3.09								
HUZHOU	0.86 *	0.98	0.90	1.00	1.21 *	2.31	2.02	2.45								
KARAMAY	0.55 *	0.72	0.70	0.88	1.08	1.02	0.99	1.24								
HUANGSHI	0.75 *	0.61	0.58	0.65												
XUCHANG	0.95	0.98	0.79	1.06												

anks	Model 2 – 2007/2006				Model 2 – 2006/2005				Model 2 – 2005/2004				Model 2 – 2004/2003			
	TFP	Boot	L -B	U - B	TFP	Boot	L -B	U - B	TFP	Boot	L -B	U -B	TFP	Boot	L -B	U -B
INING	0.80 *	0.57	0.48	0.60												
HENGDE	0.75 *	0.11	0.09	0.13												
IENGYANG	1.04	1.08	0.87	1.19												
ANZHOU	0.83 *	0.60	0.59	0.64												
UILIN	0.75 *	0.64	0.62	0.66												
IANYANG	0.85 *	0.65	0.63	0.69												
IAOZUO	4.29	6.45	3.05	12.94												
EYANG	0.66 *	0.42	0.36	0.53												
IINTAI	0.65 *	0.38	0.35	0.41												
HOUZHOU	0.79 *	0.55	0.54	0.56												
HANJIANG	1.15 *	0.44	0.40	0.53												
IAXING	0.88 *	0.69	0.57	0.82												
AILONG	0.79 *	0.49	0.47	0.53												
VEIHI	0.61 *	2.13	1.28	3.22												

Banks	Model 2 – 2003/2002				Model 2 – 2002/2001				Model 2 – 2001/2000			
	TFP	Boot	L-B	U-B	TFP	Boot	L-B	U-B	TFP	Boot	L-B	U-B
State-Owned Banks												
ICBC	1.11	1.10	1.05	1.13	1.02	0.98	0.92	1.04	0.85	0.83	0.81	0.86
CCB	0.85	0.87	0.83	0.90	1.14	1.15	1.12	1.20	0.99	1.00	0.95	1.06
ABOC	0.89	0.87	0.86	0.90	0.93	0.93	0.90	0.97	1.06	1.08	1.05	1.14
BOC	1.05	1.05	0.99	1.09	1.05	1.03	0.99	1.08	1.05	1.09	1.01	1.13
BoCom	0.95	0.92	0.89	0.96	1.49 *	1.27	1.14	1.41	1.02	0.95	0.90	1.04
Joint Stock Commercial Banks												
CMB	0.82	0.83	0.79	0.88	0.93	0.98	0.92	1.06	1.01	0.96	0.88	1.03
CMBC	0.98	0.96	0.92	1.01	0.96	1.00	0.68	1.21	0.96 *	0.35	0.26	0.71
CITIC	0.89	0.92	0.89	0.95	0.93	0.91	0.86	0.96	0.98 *	0.93	0.91	0.96
SPDB	0.94	0.98	0.92	1.05	0.89	0.96	0.89	1.06	0.92	0.90	0.88	0.95
CIB	0.96	1.02	0.95	1.08	1.05	0.98	0.88	1.12	0.81	0.84	0.72	0.91
CEB	0.84	0.85	0.81	0.90	0.94	0.93	0.88	1.01	1.02	0.93	0.82	1.03
HUAXIA	0.95	0.93	0.86	1.01	1.02	1.07	1.01	1.13	1.12	1.01	0.76	1.20
GDB	0.79 *	0.84	0.80	0.89	1.04	1.05	0.99	1.12	0.72	0.73	0.68	0.79
SDB	1.71	1.85	1.67	2.05	1.00	1.05	0.98	1.16	0.87	0.83	0.74	0.91
City Commercial Banks												
BEIJING	0.95	0.89	0.79	0.99	0.78	0.85	0.77	0.89	0.79	0.70	0.60	0.81
SHANGHAI	1.04	0.99	0.89	1.11	0.84 *	0.98	0.89	1.16	0.33	0.48	0.25	0.76
Ping An	0.94	0.88	0.80	1.00	0.72	0.60	0.47	0.83	0.79 *	0.70	0.62	0.78
TIANJIN	0.85	0.90	0.80	1.04	0.89	0.84	0.75	0.95	1.05 *	0.53	0.52	0.78
NANJING	1.09	1.21	0.96	1.29	0.81 *	0.79	0.63	0.81	0.99	1.03	0.96	1.13
DONGUAN	0.97	0.83	0.69	0.98	0.91	0.88	0.78	1.03	0.97 *	1.31	1.19	1.59
WUXI	0.98	1.07	0.95	1.18	0.81	0.88	0.71	1.03	0.95	0.99	0.93	1.05
CHONQING	0.79 *	0.33	0.26	0.76	1.01 *	0.60	0.58	0.69	1.76 *	1.08	0.78	1.54
XIAMEN	1.03 *	0.85	0.79	1.01	0.94 *	0.83	0.71	0.92	0.86 *	0.98	0.94	1.01
NINGBO	0.92	1.03	0.79	1.14	0.88 *	0.75	0.66	0.86	0.77	0.78	0.75	0.80
XIAN	0.88	0.81	0.72	0.93	0.88 *	0.75	0.62	0.85	1.04 *	0.70	0.68	0.79
WUHAN	0.97	0.97	0.93	1.07	0.71 *	0.46	0.44	0.55				
QINGDAO	1.00	0.67	0.51	1.07	0.78 *	0.68	0.61	0.69				
JINAN	0.94	0.98	0.90	1.04	1.05 *	0.89	0.76	1.00				
DALIAN	0.86	0.75	0.57	0.88	1.01	0.95	0.83	1.09				
HANGZHOU	1.91 *	6.23	3.22	6.48								
CHANGSHA	0.84 *	1.95	1.21	2.07								

Banks	Model 2 – 2000/1999					Model 2 – 1999/1998					Model 2 – 1998/1997				
	TFP		Boot	L-B	U-B	TFP		Boot	L-B	U-B	TFP		Boot	L-B	U-B
State-Owned Banks															
ICBC	1.07		1.07	1.05	1.12	1.01		0.99	0.95	1.02	0.98		1.02	0.95	1.13
CCB	1.02		1.00	0.91	1.10	1.08		1.21	1.08	1.36	1.06		0.96	0.81	1.09
ABOC	0.91		0.90	0.86	0.91	0.83		0.80	0.71	0.90	1.06		1.02	0.99	1.08
BOC	1.18	*	1.10	1.08	1.16	0.84		0.88	0.75	1.05	1.02		1.02	0.97	1.08
BoCom	1.10		1.12	1.03	1.20	0.88		0.83	0.73	0.99	1.04	*	0.94	0.87	1.04
Joint Stock Commercial Banks															
CMB	1.23		1.26	1.22	1.35	1.15		1.16	1.06	1.28	1.11		1.14	0.98	1.52
CMBC	0.89	*	1.14	0.92	1.53	1.29	*	0.83	0.74	1.00	1.35		1.23	0.96	1.49
CITIC	1.30		1.25	1.19	1.30	1.35		1.28	1.13	1.53	0.95		1.07	0.87	1.38
SPDB	1.20		1.18	1.09	1.23	1.40		1.43	0.98	2.46	1.14		1.42	1.04	2.59
CIB	0.96		0.89	0.64	1.08	1.02	*	1.44	1.20	1.49	2.16		5.27	1.79	11.33
CEB	1.39		1.38	1.26	1.53	1.20		1.08	0.71	1.28	1.12		1.29	1.04	2.34
HUAXIA	1.04	*	0.65	0.52	0.94	1.15	*	1.65	1.38	2.06	1.02	*	1.82	1.24	1.93
GDB	1.19		1.17	1.12	1.24	1.20		1.15	1.04	1.45	0.91		0.94	0.87	1.21
SDB	1.02		0.97	0.73	1.05	1.69		2.53	1.65	3.81	1.02	*	2.15	1.17	4.62
City Commercial Banks															
BEIJING	1.22		1.31	1.13	1.57	0.91	*	1.83	1.36	1.93	1.18	*	3.20	1.33	5.62
SHANGHAI	1.14		1.11	1.07	1.18	1.09	*	1.42	1.19	1.50	1.02	*	3.00	1.55	3.59
Ping An	1.38	*	0.84	0.76	1.11	0.99	*	1.41	1.40	1.65					
TIANJIN	1.27	*	1.14	1.11	1.24	1.10	*	1.58	1.19	1.95					
NANJING	1.08	*	1.34	1.21	1.36										
DONGUAN	1.17	*	0.83	0.65	0.99										
WUXI	1.08		0.91	0.66	1.15										
CHONQING	0.87		1.06	0.73	1.28										
XIAMEN	1.09	*	1.21	1.15	1.55										

Banks	Model 3 – 2007/2006				Model 3 – 2006/2005				Model 3 – 2005/2004			
	TFP	Boot	L- B	U- B	TFP	Boot	L- B	U- B	TFP	Boot	L -B	U- B
State-Owned Banks												
ICBC	0.99	0.98	0.94	1.00	0.88	0.87	0.84	0.90	1.12	1.13	1.11	1.18
CCB	0.82	0.84	0.74	0.95	1.09	1.13	1.06	1.21	0.93	0.90	0.84	0.94
ABOC	1.15	1.16	1.09	1.28	0.97	0.97	0.93	0.98	1.01	1.03	0.99	1.09
BOC	1.06	1.03	0.95	1.12	1.10	1.11	1.07	1.16	1.04	1.05	1.03	1.09
BoCom	0.79	0.80	0.76	0.84	1.15	1.21	1.15	1.30	0.82	0.80	0.75	0.83
Joint Stock Commercial Banks												
CMB	0.90 *	0.84	0.78	0.89	0.95	0.91	0.90	0.95	0.79	0.81	0.76	0.89
CMBC	0.99	0.93	0.87	1.00	1.03	1.01	0.95	1.12	0.83	0.82	0.78	0.88
CITIC	0.73 *	0.67	0.63	0.71	1.04	1.06	1.01	1.11	0.99	0.96	0.91	1.01
SPDB	0.89	0.83	0.74	0.91	1.05	1.10	1.03	1.22	0.93	0.92	0.87	0.96
CIB	0.86 *	0.70	0.64	0.81	1.00	0.99	0.92	1.07	0.90	0.94	0.88	1.02
CEB	0.76 *	0.66	0.59	0.73	1.11	1.21	1.09	1.33	0.80	0.80	0.77	0.84
HUAXIA	0.85 *	0.73	0.67	0.83	0.92	0.86	0.81	0.94	0.88	0.85	0.78	0.90
GDB	0.97	0.95	0.91	0.99	0.94	0.97	0.85	1.08	0.84	0.84	0.79	0.88
SDB	0.98 *	1.05	0.98	1.10	1.09 *	1.22	1.12	1.39	0.70	0.69	0.64	0.74
City Commercial Banks												
BEIJING	0.63	0.59	0.53	0.63	1.23	1.21	1.15	1.27	0.97	0.96	0.94	0.97
SHANGHAI	1.08	1.08	0.99	1.13	1.03	1.01	0.97	1.05	1.07	1.13	1.03	1.24
Ping An	0.75	0.77	0.68	0.88	0.93	0.88	0.83	0.96	0.90	0.90	0.85	0.96
TIANJIN	1.24 *	0.84	0.70	1.06	2.23 *	1.36	1.04	2.06	0.58 *	2.40	1.47	3.09
NANJING	0.95	0.94	0.86	1.01	0.93	0.91	0.87	0.97	1.10	1.08	1.01	1.16
DONGUAN	0.75	0.73	0.66	0.82	1.03	1.00	0.95	1.05	0.88 *	0.94	0.89	1.01
WUXI									0.67	0.62	0.57	0.67
CHONQING	0.76 *	0.70	0.68	0.76	1.31	1.40	1.26	1.54	0.90 *	0.86	0.83	0.89
XIAMEN	1.13 *	1.38	1.15	1.67	0.89	0.84	0.80	0.90	0.75 *	0.64	0.55	0.72
NINGBO	1.01	1.04	0.98	1.13	1.04	1.03	0.99	1.09	1.02	1.02	0.98	1.06
XIAN					0.74	0.70	0.64	0.75	0.76	0.76	0.73	0.80
WUHAN	0.99	1.04	0.96	1.11	5.93 *	2.98	2.67	4.79	0.19 *	0.36	0.22	0.40
QINGDAO	0.91 *	1.05	0.94	1.10	1.00	1.04	1.00	1.06	0.76	0.76	0.73	0.79
JINAN	0.99 *	1.08	0.99	1.09	0.97	0.98	0.95	1.01	1.14	1.13	1.11	1.15
DALIAN	0.93	1.05	0.90	1.11	0.84 *	0.78	0.74	0.83	0.77 *	0.72	0.67	0.77
HANGZHOU	0.86	0.92	0.85	0.98	1.13	1.07	0.89	1.19	0.61	0.59	0.53	0.62
CHANGSHA	0.96	1.07	0.91	1.20	1.64	1.65	1.57	1.81	0.76	0.75	0.69	0.82
SHIJIAZHUANG	0.94	0.85	0.74	0.98	1.73 *	2.10	1.76	2.75	0.87	0.82	0.74	0.91
SHAOXING	0.74	0.74	0.69	0.75	0.95	0.95	0.93	0.96	0.87	0.85	0.83	0.87
JINZHOU					0.82	0.80	0.77	0.85	0.93	0.97	0.91	1.03
LAIWU	0.98	0.88	0.80	0.99	0.38	0.35	0.28	0.41	2.13 *	0.41	0.33	0.64
JIUJIANG	0.88 *	1.06	0.91	1.23	1.09	1.08	1.04	1.12	0.81	0.76	0.69	0.84
PANZHIHUA	0.77	0.76	0.74	0.78	0.81 *	0.86	0.81	0.97	0.95 *	0.26	0.21	0.41
DONGYING	1.02	1.01	0.93	1.09	1.09 *	1.23	1.10	1.29	0.62	0.61	0.55	0.69
ZENGZHOU	0.90	0.87	0.82	0.94	0.80	0.87	0.79	0.90				
WEIFANG	0.71	0.67	0.59	0.73	0.94	0.97	0.91	1.01				
LINYI	1.28 *	1.56	1.34	1.59	1.10	1.27	1.10	1.38				
XINXIANG	0.92	0.91	0.84	0.97	3.27	2.18	1.67	3.30				
LIUZHOU	0.88	0.90	0.85	0.94	0.91	0.90	0.84	0.94				
HUZHOU	0.96	1.01	0.94	1.05	0.98	0.97	0.88	1.02				
KARAMAY	0.78 *	0.68	0.61	0.78	1.07 *	0.92	0.81	1.06				
HUANGSHI	0.80	0.82	0.77	0.85								
XUCHANG	1.09	1.08	0.99	1.15								
JINING	0.89 *	0.80	0.71	0.89								
CHENGDE	0.52 *	0.45	0.40	0.52								
HENGYANG	1.24	1.46	1.21	1.64								

Banks	Model 3 – 2007/2006				Model 3 – 2006/2005				Model 3 – 2005/2004			
	TFP	Boot	L- B	U- B	TFP	Boot	L- B	U- B	TFP	Boot	L -B	U- B
GANZHOU	0.80	0.84	0.77	0.87								
GUILIN	0.84	0.78	0.74	0.84								
NIANYANG	0.87	0.86	0.82	0.92								
JIAOZUO	5.08 *	3.14	2.39	4.03								
DEYANG	0.67	0.64	0.62	0.70								
MINTAI	0.63	0.56	0.50	0.65								
CHOUZHOU	0.85	0.78	0.76	0.87								
ZHANJIANG	0.53	0.51	0.43	0.57								
JIAXING	0.91	0.93	0.82	1.01								
TAILONG	0.85	0.88	0.85	0.90								
WEIHI	0.52 *	1.34	0.92	1.85								

Banks	Model 3 – 2004/2003				Model 3 – 2003/2002				Model 3 – 2002/2001			
	TFP	Boot	L- B	U- B	TFP	Boot	L- B	U- B	TFP	Boot	L -B	U- B
State-Owned Banks												
ICBC	0.88	0.89	0.85	0.92	1.03	1.03	0.98	1.07	1.07	1.03	0.99	1.09
CCB	0.99	1.01	0.98	1.05	0.83 *	0.76	0.71	0.82	1.05	1.07	0.99	1.15
ABOC	0.90	0.89	0.82	0.95	0.81 *	0.77	0.75	0.81	0.80	0.78	0.73	0.82
BOC	1.33 *	1.23	1.15	1.32	1.07	1.07	1.01	1.11	1.05	1.03	0.99	1.08
BoCom	1.14	1.15	1.13	1.16	0.80 *	0.72	0.67	0.78	1.80	1.63	1.44	1.90
Joint Stock Commercial Banks												
CMB	1.18	1.18	1.13	1.22	0.66 *	0.55	0.52	0.61	0.90 *	0.98	0.90	1.07
CMBC	1.10 *	0.86	0.77	1.00	0.95 *	0.88	0.85	0.93	0.85 *	1.03	0.95	1.11
CITIC	1.39 *	1.54	1.41	1.61	0.82	0.82	0.81	0.84	0.94 *	0.88	0.83	0.94
SPDB	1.11 *	1.13	1.11	1.14	0.79	0.75	0.68	0.79	0.62 *	0.54	0.50	0.60
CIB	1.04 *	1.13	1.05	1.21	0.80 *	0.72	0.69	0.77	1.07	1.19	1.06	1.33
CEB	1.28 *	1.42	1.33	1.48	0.73 *	0.67	0.63	0.71	0.84 *	0.76	0.72	0.84
HUAXIA	1.00 *	1.05	1.01	1.07	0.84 *	0.71	0.65	0.80	0.89	0.90	0.89	0.91
GDB	1.27	1.25	1.20	1.31	0.71	0.75	0.70	0.81	0.83	0.85	0.78	0.91
SDB	1.28	1.24	1.13	1.34	0.84 *	0.80	0.78	0.82	0.80	0.73	0.65	0.82
City Commercial Banks												
BEIJING	1.25	1.26	1.16	1.39	0.95	0.87	0.79	0.97	0.74	0.78	0.72	0.81
SHANGHAI	1.21 *	1.32	1.28	1.38	1.21	1.29	1.13	1.49	0.83	0.91	0.83	0.99
Ping An	1.11 *	1.19	1.14	1.21	0.83 *	0.64	0.58	0.74	0.67 *	0.90	0.72	1.04
TIANJIN	1.11 *	1.16	1.15	1.19	0.67 *	0.64	0.61	0.66	0.80	0.83	0.78	0.84
NANJING	0.97 *	1.02	0.99	1.03	1.17 *	1.07	1.04	1.15	0.63	0.67	0.63	0.67
DONGUAN	1.01	0.96	0.92	1.03	0.91	0.91	0.89	0.92	0.76	0.78	0.74	0.81
WUXI	1.27	1.33	1.21	1.45	0.90	0.87	0.84	0.91	0.60 *	0.56	0.53	0.59
CHONQING	0.90 *	0.73	0.65	0.82	0.75	0.75	0.71	0.78	0.85 *	1.02	0.89	1.11
XIAMEN	1.08	1.04	1.00	1.10	0.91	0.90	0.88	0.93	0.94	0.94	0.88	1.00
NINGBO	1.04	1.06	1.02	1.08	0.80	0.76	0.71	0.81	0.73 *	0.70	0.68	0.72
XIAN	1.13	1.09	1.02	1.15	0.85 *	0.72	0.64	0.83	0.77 *	0.99	0.82	1.08
WUHAN	1.32 *	1.72	1.48	1.83	0.93	0.90	0.89	0.95	0.78	0.83	0.73	0.94
QINGDAO	1.14 *	0.93	0.85	1.06	1.06 *	0.84	0.71	0.98	0.87 *	1.31	1.09	1.47
JINAN	0.83	0.84	0.80	0.86	0.96	0.95	0.94	0.97	0.83	0.84	0.83	0.85
DALIAN	1.08 *	1.19	1.10	1.25	0.78 *	0.68	0.64	0.74	0.82	0.86	0.80	0.89
HANGZHOU	1.99 *	1.46	1.36	1.65	1.97	1.89	1.41	2.65				
CHANGSHA	1.06 *	0.78	0.73	0.91	0.70	0.70	0.67	0.71				
SHIJIAZHUANG	1.00	1.03	0.90	1.17								
SHAOXING	0.54	0.53	0.48	0.57								
JINZHOU	4.85 *	2.41	2.17	2.92								

Banks	Model 3 – 2001/2000				Model 3 – 2000/1999				Model 3 – 1999/1998				Model 3 – 1998/1997			
	TFP	Boot	L-B	U-B	TFP	Boot	L-B	U-B	TFP	Boot	L-B	U-B	TFP	Boot	L-B	U-B
State-Owned Banks																
ICBC	0.88	0.87	0.86	0.90	1.04	1.04	1.03	1.07	1.06	1.04	1.01	1.08	0.93	0.93	0.86	0.99
CCB	0.90	0.91	0.87	0.96	0.86	0.80	0.68	0.89	1.23 *	1.41	1.25	1.70	1.46	1.45	1.41	1.54
ABOC	1.14	1.13	1.12	1.16	0.99	0.99	0.97	1.01	0.89	0.88	0.80	0.95	0.94	0.95	0.89	1.01
BOC	1.10	1.18	1.06	1.21	1.24	1.22	1.19	1.27	0.84	0.88	0.75	1.05	1.03	1.03	0.98	1.10
BoCom	1.00	0.92	0.89	1.02	0.92	0.86	0.79	0.98	0.89	0.82	0.77	0.90	1.14	1.07	1.05	1.14
Joint Stock Commercial Banks																
CMB	0.95	0.88	0.78	0.96	0.94	0.90	0.80	1.00	0.96	0.96	0.92	1.01	1.31	1.50	1.21	1.67
CMBC	0.86	0.82	0.75	0.92	0.66	0.59	0.49	0.71	0.97	0.91	0.81	1.05	1.60	1.52	1.37	1.64
CITIC	0.95	0.93	0.89	0.96	1.12	1.03	0.90	1.18	1.33	1.21	1.12	1.37	0.93	1.05	0.88	1.13
SPDB	0.83	0.81	0.78	0.85	0.94 *	0.84	0.74	0.94	2.21	2.26	1.89	2.91	1.20 *	0.96	0.91	1.12
CIB	0.73	0.71	0.64	0.77	0.64	0.60	0.52	0.69	1.00	0.99	0.99	1.04	2.19	2.95	2.13	3.69
CEB	1.01 *	0.83	0.79	0.89	1.24	1.21	1.07	1.34	1.08	1.10	1.05	1.12	1.11	1.19	1.09	1.28
HUAXIA	1.08 *	1.22	1.11	1.39	0.90 *	0.78	0.67	0.89	1.19	1.11	0.99	1.33	1.04	1.06	1.01	1.09
GDB	0.69	0.65	0.61	0.71	0.81	0.79	0.75	0.83	1.31	1.20	1.04	1.34	0.99	1.08	0.99	1.20
SDB	0.73	0.73	0.70	0.77	0.76	0.72	0.65	0.78	2.38	2.46	2.30	2.73	0.47	0.46	0.40	0.50
City Commercial Banks																
BEIJING	0.80	0.74	0.69	0.81	0.92	0.90	0.79	1.06	0.86 *	0.92	0.87	0.94	1.06	1.04	1.02	1.11
SHANGHAI	0.33 *	0.58	0.35	0.80	0.98	0.84	0.78	0.98	1.03 *	0.97	0.95	1.02	1.06 *	1.37	1.17	1.46
Ping An	0.76 *	0.68	0.65	0.73	0.73	0.76	0.69	0.83	0.80	0.78	0.74	0.81				
TIANJIN	0.99	1.04	0.98	1.12	1.06	1.01	0.91	1.14	1.42	1.47	1.22	1.76				
NANJING	0.93	0.96	0.90	1.02	0.98	0.96	0.94	1.00								
DONGUAN	1.26	1.26	1.21	1.35	0.76	0.73	0.64	0.83								
WUXI	0.90	0.92	0.89	0.94	1.16 *	0.84	0.74	1.02								
CHONQING	2.07	1.78	1.45	2.17	0.64	0.74	0.63	0.82								
XIAMEN	0.79	0.79	0.76	0.82	0.74	0.71	0.59	0.78								
NINGBO	0.91	0.91	0.89	0.94												
XIAN	0.79 *	0.71	0.68	0.76												

Banks	Model 4 – 2007/2006				Model 4 – 2006/2005				Model 4 – 2005/2004			
	TFP	Boot	L - B	U - B	TFP	Boot	L - B	U - B	TFP	Boot	L - B	U - B
State-Owned Banks												
ICBC	0.99	0.98	0.94	1.00	0.88	0.86	0.83	0.89	1.06	1.05	1.02	1.11
CCB	0.82	0.85	0.75	0.96	1.09	1.10	1.03	1.17	1.01	1.01	0.96	1.05
ABOC	1.12	1.11	1.03	1.22	1.11*	1.20	1.12	1.28	1.02	1.06	1.01	1.13
BOC	1.06	1.04	0.96	1.13	1.10	1.11	1.07	1.15	1.04	1.04	1.02	1.08
BoCom	0.79	0.81	0.78	0.85	1.19	1.20	1.15	1.26	0.89	0.90	0.88	0.94
Joint Stock Commercial Banks												
CMB	0.89	0.83	0.78	0.88	0.96*	0.90	0.86	0.96	0.87	0.92	0.86	1.00
CMBC	0.94	0.88	0.79	0.97	0.95	0.88	0.77	0.99	0.92	0.93	0.87	1.00
CITIC	0.68	0.63	0.57	0.68	1.12	1.09	1.01	1.19	1.02	1.00	0.96	1.05
SPDB	0.81	0.74	0.65	0.85	1.13	1.18	1.06	1.37	1.04	1.04	0.98	1.10
CIB	0.86	0.71	0.64	0.81	1.01	0.98	0.92	1.07	0.98	1.04	0.97	1.13
CEB	2.36	1.05	0.71	1.60	0.28*	0.45	0.30	0.68	0.86	0.88	0.84	0.93
HUAXIA	0.85	0.78	0.69	0.87	0.90	0.85	0.76	0.93	0.98	0.97	0.91	1.04
GDB	0.97	0.97	0.90	1.06	0.94	0.90	0.81	0.95	0.81	0.80	0.76	0.83
SDB	0.89	0.99	0.88	1.07	1.23*	1.37	1.26	1.56	0.79	0.79	0.73	0.86
City Commercial Banks												
BEIJING	0.62	0.58	0.53	0.63	1.23	1.20	1.15	1.27	1.01	1.02	0.99	1.03
SHANGHAI	1.08	1.07	0.99	1.14	1.03	1.00	0.96	1.06	1.07	1.12	1.03	1.21
Ping An	0.74	0.81	0.73	0.91	0.93	0.92	0.84	0.99	1.03	1.05	1.00	1.12
TIANJIN	1.23*	0.83	0.70	1.04	2.23*	1.35	1.04	2.05	0.58*	2.21	1.39	2.88
NANJING	0.94	0.93	0.85	1.01	0.93	0.91	0.88	0.98	1.10*	0.92	0.53	1.09
DONGUAN					1.03	1.02	0.97	1.12	0.88	0.88	0.67	0.96
WUXI	0.75	0.72	0.66	0.82					0.70*	0.47	0.24	0.64
CHONQING	0.76	0.72	0.64	0.79	1.31*	1.75	1.32	2.49	0.89	0.88	0.82	1.00
XIAMEN	1.16	1.30	1.13	1.59	0.89	1.22	0.87	1.51	0.78*	0.37	0.24	0.64
NINGBO					1.04	1.10	1.01	1.18	1.03*	0.29	0.21	0.67
XIAN	1.00	1.08	1.00	1.21	0.69	0.63	0.56	0.69	0.86	0.79	0.51	0.89
WUHAN	0.98	1.02	0.94	1.14	5.93	3.71	2.80	7.11	0.19*	0.34	0.22	0.38
QINGDAO	0.80	0.85	0.71	0.96	1.13*	1.55	1.20	2.11	0.78*	0.52	0.32	0.74
JINAN	0.98*	1.12	1.01	1.21	1.08*	1.50	1.12	2.37	1.25*	0.88	0.46	1.20
DALIAN	0.92*	1.10	0.95	1.19	0.85	0.80	0.73	0.86	0.87*	0.66	0.36	0.81
HANGZHOU	0.85*	0.97	0.86	1.05	1.20	1.21	0.99	1.63	0.67*	0.21	0.08	0.50
CHANGSHA	0.96	1.05	0.90	1.17	1.64	1.72	1.59	2.24	0.76*	0.45	0.20	0.72
SHIJIAZHUANG	0.93	0.82	0.71	0.96	1.73*	2.34	1.85	3.93	0.88*	0.79	0.67	0.88
SHAOXING					1.05*	1.23	1.17	1.24	0.97*	0.39	0.39	0.47
JINZHOU	0.83	0.72	0.67	0.88	0.77	0.78	0.76	0.80	1.14*	0.52	0.21	1.06
LAIWU	0.80*	0.66	0.52	0.68	0.39	0.50	0.31	0.62	2.36*	1.32	1.14	1.36
JIUJIANG	0.88*	1.17	0.90	1.31	1.09*	1.48	1.39	1.51	1.24*	0.39	0.32	0.50
PANZHIHUA	0.73*	0.94	0.93	0.96	0.85*	1.19	1.05	1.29	1.07*	0.42	0.32	0.49
DONGYING	1.04*	0.78	0.78	0.89	1.10*	1.55	1.44	1.55	0.74*	0.23	0.23	0.25
ZENGZHOU	0.85	0.80	0.74	0.89	0.84*	1.01	0.87	1.08				
WEIFANG	0.76	0.68	0.53	0.83	0.95*	0.19	0.17	0.28				
LINYI	1.24*	1.51	1.33	1.65	1.82*	4.86	3.04	5.73				
XINXIANG	0.92*	0.71	0.64	0.84	3.70*	21.57	7.24	33.86				
LIUZHOU	0.87*	0.80	0.73	0.86	1.10*	3.18	2.45	3.21				
HUZHOU	0.96*	1.18	1.13	1.24	1.40*	3.31	2.81	3.58				
KARAMAY	0.53*	0.66	0.64	0.83	1.07	0.99	0.97	1.30				
HUANGSHI	0.78*	0.72	0.64	0.74								

Banks	Model 4 – 2007/2006				Model 4 – 2006/2005				Model 4 – 2005/2004			
	TFP	Boot	L - B	U - B	TFP	Boot	L - B	U - B	TFP	Boot	L - B	U - B
XUCHANG	1.09	1.18	0.96	1.21								
JINING	0.80 *	0.52	0.46	0.61								
CHENGDE	0.67 *	0.10	0.08	0.11								
HENGYANG	1.24	1.50	1.18	1.64								
GANZHOU	0.88 *	0.77	0.69	0.77								
GUILIN	0.84 *	0.81	0.77	0.82								
NIANYANG	0.87 *	0.69	0.67	0.70								
JIAOZUO	5.47	11.40	5.05	22.69								
DEYANG	0.65 *	0.47	0.42	0.52								
MINTAI	0.64 *	0.40	0.40	0.40								
CHOUZHOU	0.92 *	0.72	0.72	0.74								
ZHANJIANG	0.90 *	0.35	0.25	0.43								
JIAXING	0.91 *	0.70	0.58	0.86								
TAILONG	0.83 *	0.58	0.52	0.61								
WEIHI	0.49 *	1.65	1.07	2.37								

Banks	Model 4 – 2004/2003					Model 4 – 2003/2002					Model 4 – 2002/2001				
	TFP		Boot	L-B	U-B	TFP		Boot	L-B	U-B	TFP		Boot	L-B	U-B
State-Owned Banks															
ICBC	0.90		0.92	0.88	0.95	0.98		0.95	0.90	0.99	1.04		0.99	0.94	1.05
CCB	0.98		0.99	0.98	1.03	0.85		0.84	0.79	0.90	1.01		0.96	0.89	1.04
ABOC	0.83		0.80	0.73	0.87	0.83	*	0.78	0.76	0.83	0.76	*	0.72	0.66	0.76
BOC	1.33	*	1.23	1.15	1.33	1.12		1.16	1.11	1.21	1.06		1.03	1.00	1.08
BoCom	1.13		1.14	1.12	1.17	0.81	*	0.74	0.70	0.80	1.83		1.67	1.48	1.90
Joint Stock Commercial Banks															
CMB	1.21		1.22	1.17	1.27	0.66	*	0.59	0.55	0.64	0.90		0.97	0.90	1.08
CMBC	1.14	*	0.98	0.85	1.11	0.94	*	0.88	0.84	0.93	0.89		0.92	0.59	1.10
CITIC	1.43		1.57	1.42	1.69	0.83		0.82	0.81	0.84	0.95		0.92	0.87	0.96
SPDB	1.16		1.18	1.16	1.20	0.81		0.80	0.75	0.83	0.61		0.57	0.52	0.62
CIB	1.09	*	1.20	1.10	1.29	0.83	*	0.78	0.75	0.81	1.09		1.07	0.95	1.25
CEB	1.37	*	1.53	1.42	1.63	0.72	*	0.68	0.63	0.71	0.83	*	0.74	0.69	0.82
HUAXIA	1.04	*	1.11	1.05	1.15	0.83		0.73	0.66	0.84	0.89		0.89	0.85	0.90
GDB	1.27		1.23	1.19	1.31	0.68		0.73	0.68	0.79	0.87		0.85	0.76	0.93
SDB	1.15		1.13	1.02	1.25	1.01	*	0.90	0.81	1.00	0.81		0.78	0.69	0.86
City Commercial Banks															
BEIJING	1.26		1.27	1.17	1.40	0.96		0.89	0.81	0.99	0.74		0.77	0.71	0.80
SHANGHAI	1.22	*	1.34	1.29	1.40	1.21		1.31	1.14	1.51	0.83	*	0.95	0.85	1.13
Ping An	1.13	*	1.20	1.14	1.24	0.86	*	0.71	0.64	0.84	0.63		0.47	0.46	0.66
TIANJIN	1.11	*	1.17	1.15	1.23	0.67		0.66	0.62	0.72	0.81		0.71	0.67	0.82
NANJING	0.97		0.81	0.76	0.99	1.18		1.41	1.11	1.48	0.67	*	0.55	0.54	0.55
DONGUAN	1.07		1.00	0.85	1.08	0.91	*	0.75	0.64	0.90	0.76	*	0.69	0.60	0.70
WUXI	1.28		1.51	1.25	1.61	0.91		0.93	0.86	1.02	0.62	*	0.56	0.52	0.61
CHONQING	0.95	*	0.80	0.61	0.91	0.75	*	0.29	0.24	0.66	1.24	*	0.99	0.94	1.05
XIAMEN	1.08	*	1.72	1.17	2.00	0.92	*	0.74	0.70	0.86	1.01	*	0.81	0.81	1.00
NINGBO	1.05	*	1.96	1.43	2.11	0.80		0.81	0.57	0.87	0.88	*	0.84	0.82	0.87
XIAN	1.18		1.13	1.08	1.18	0.90		0.84	0.75	0.97	0.75	*	0.60	0.59	0.63
WUHAN	1.32	*	1.62	1.35	1.78	0.93		0.93	0.89	1.00	0.79	*	0.60	0.60	0.66
QINGDAO	1.23		1.38	1.07	1.42	1.11		0.81	0.63	1.32	0.75	*	0.63	0.63	0.64
JINAN	0.87	*	0.55	0.53	0.78	0.99		1.05	0.94	1.05	0.99		0.85	0.85	0.99
DALIAN	1.05	*	1.68	1.19	2.54	0.83	*	0.69	0.55	0.79	0.76	*	0.63	0.59	0.65
HANGZHOU	1.99	*	1.38	1.38	1.59	1.91	*	6.26	3.22	6.48					
CHANGSHA	1.09	*	0.53	0.50	0.72	0.69	*	1.41	0.90	1.42					
SHIJIAZHUANG	1.00		0.93	0.66	1.11										
SHAOXING	0.55	*	0.85	0.56	0.95										
JINZHOU	5.33		10.19	3.99	14.63										

Banks	Model 4 – 2001/2000				Model 4 – 2000/1999				Model 4 – 1999/1998				Model 4 – 1998/1997			
	TFP	Boot	L-B	U-B	TFP	Boot	L-B	U-B	TFP	Boot	L-B	U-B	TFP	Boot	L-B	U-B
State-Owned Banks																
ICBC	0.88	0.90	0.88	0.93	1.06	1.04	1.02	1.07	1.06	1.06	1.02	1.09	0.89	0.86	0.79	0.9
CCB	0.90	0.88	0.84	0.94	0.89	0.85	0.74	0.96	1.10	1.15	0.99	1.37	1.37	1.32	1.26	1.4
ABOC	1.05	1.04	1.02	1.06	1.03	1.02	1.00	1.05	0.95	0.96	0.89	1.03	1.01	1.02	0.98	1.0
BOC	1.10	1.17	1.06	1.21	1.24	1.23	1.20	1.27	0.84	0.86	0.75	1.00	1.03	1.02	0.97	1.0
BoCom	1.02	0.95	0.90	1.05	1.02	1.00	0.95	1.05	0.93	0.86	0.80	0.98	1.15	1.13	1.06	1.2
Joint Stock Commercial Banks																
CMB	0.98	0.94	0.85	1.02	1.00	0.96	0.88	1.06	1.11	1.16	1.05	1.30	1.40 *	1.75	1.45	2.4
CMBC	0.94 *	0.33	0.25	0.67	0.68	0.72	0.58	0.92	1.34 *	0.94	0.79	1.12	1.54	1.46	1.20	1.6
CITIC	0.96 *	0.91	0.89	0.94	1.24 *	1.16	1.11	1.22	1.41	1.36	1.25	1.61	0.93	1.04	0.88	1.2
SPDB	0.84	0.84	0.79	0.86	1.08 *	0.97	0.86	1.06	2.04	2.22	1.60	3.94	1.19	1.46	1.05	2.6
CIB	0.74	0.70	0.60	0.77	0.67 *	0.51	0.43	0.63	0.99 *	1.36	1.19	1.46	2.02 *	9.65	3.29	20.1
CEB	1.06 *	0.91	0.87	0.99	1.31	1.33	1.20	1.46	1.22	1.12	0.74	1.31	1.12	1.25	1.04	2.2
HUAXIA	1.16	1.07	0.80	1.30	0.96 *	0.56	0.45	0.82	1.08 *	1.46	1.23	1.89	0.95 *	1.64	1.11	1.6
GDB	0.70	0.70	0.64	0.78	0.89	0.90	0.84	0.96	1.33	1.22	1.07	1.59	0.98	1.09	0.97	1.4
SDB	0.69	0.66	0.58	0.70	0.90 *	0.77	0.60	0.85	2.54 *	4.10	2.79	5.44	0.46 *	0.77	0.47	1.3
City Commercial Banks																
BEIJING	0.82	0.74	0.65	0.82	0.97	0.88	0.74	1.07	0.83 *	1.57	1.16	1.62	1.03 *	2.54	1.11	4.4
SHANGHAI	0.33	0.48	0.25	0.72	1.00 *	0.86	0.82	0.95	1.09 *	1.41	1.19	1.47	1.03 *	3.00	1.58	3.7
Ping An	0.82	0.79	0.75	0.85	0.86 *	0.40	0.36	0.49	0.63 *	0.70	0.66	0.73				
TIANJIN	1.04 *	0.53	0.51	0.73	1.13 *	0.90	0.90	1.00	1.11 *	1.46	1.14	1.89				
NANJING	0.99	1.03	0.95	1.12	0.97 *	1.10	1.10	1.11								
DONGUAN	1.19 *	1.83	1.75	2.06	0.83 *	0.50	0.41	0.52								
WUXI	0.90	0.93	0.90	0.96	1.15	0.93	0.75	1.35								
CHONQING	1.96 *	1.11	0.88	1.57	0.81	1.05	0.76	1.10								
XIAMEN	0.80 *	0.87	0.87	0.88	0.82	0.81	0.61	1.01								
NINGBO	0.85 *	0.98	0.98	0.98												
XIAN	0.94 *	0.64	0.62	0.65												

Banks	Model 5 – 2007/2006					Model 5 – 2006/2005					Model 5 – 2005/2004				
	TFP		Boot	L - B	U -B	TFP		Boot	L - B	U -B	TFP		Boot	L - B	U -B
State-Owned Banks															
ICBC	0.93		0.92	0.91	0.93	1.03		1.03	1.00	1.06	1.00		1.00	0.99	1.01
CCB	1.01		1.05	0.96	1.15	0.95		0.94	0.90	0.96	1.00		1.00	0.96	1.05
ABOC	1.12	*	1.08	1.10	1.11	1.03		1.04	1.02	1.10	1.28	*	1.46	1.31	1.73
BOC	1.02		1.03	0.98	1.09	0.97		0.96	0.94	0.99	0.92		0.91	0.87	0.93
BoCom	0.79		0.78	0.76	0.79	1.11		1.13	1.09	1.17	0.88		0.89	0.87	0.92
Joint Stock Commercial Banks															
CMB	0.97		0.99	0.95	1.03	1.03	*	1.04	1.03	1.05	0.92		0.94	0.87	1.06
CMBC	0.95		0.92	0.88	0.96	0.88		0.90	0.87	0.96	1.16		1.14	1.07	1.21
CITIC	0.70		0.69	0.66	0.70	1.13	*	1.13	1.12	1.16	1.13		1.14	1.11	1.20
SPDB	0.91		0.87	0.80	0.94	1.11	*	1.13	1.10	1.21	0.97		0.94	0.89	0.99
CIB	0.88	*	0.84	0.82	0.87	1.06	*	1.06	1.05	1.06	0.90		0.91	0.86	0.96
CEB	0.83		0.79	0.72	0.86	1.14		1.17	1.11	1.26	0.93		0.92	0.88	0.97
HUAXIA	0.92	*	0.92	0.91	0.91	1.06		1.07	1.06	1.10	1.00		0.99	0.94	1.06
GDB	0.79		0.78	0.73	0.83	1.10	*	1.03	0.93	1.10	0.61		0.58	0.47	0.62
SDB	0.92		0.92	0.88	0.95	1.03	*	1.07	1.03	1.19	0.93		0.92	0.86	0.99
City Commercial Banks															
BEIJING	0.70		0.72	0.67	0.75	1.19	*	1.17	1.16	1.20	1.08		1.07	1.06	1.09
SHANGHAI	0.92		0.92	0.86	0.94	1.14	*	1.14	1.12	1.15	0.97		0.98	0.93	1.05
Ping An	0.81	*	0.91	0.85	0.93	1.23	*	1.25	1.22	1.32	0.80		0.82	0.79	0.87
TIANJIN	0.67		0.69	0.64	0.70	4.84	*	2.57	1.71	4.06	0.60	*	1.98	0.95	3.47
NANJING	0.94		0.96	0.90	1.00	1.01	*	1.00	0.99	1.01	0.83		0.82	0.79	0.85
DONGUAN	0.92		0.89	0.83	0.97	0.88	*	0.88	0.87	0.89	0.98		1.00	0.97	1.05
WUXI											0.77		0.79	0.75	0.84
CHONQING	0.79		0.80	0.78	0.81	1.13	*	1.14	1.11	1.16	0.96		0.96	0.95	0.98
XIAMEN	1.00		1.00	0.90	1.12	0.96	*	0.96	0.93	0.96	0.81		0.78	0.66	0.87
NINGBO	0.98		1.00	0.96	1.05	1.11	*	1.11	1.10	1.13	0.99		0.99	0.98	1.03
XIAN						0.94	*	0.93	0.87	0.96	0.90		0.90	0.86	0.94
WUHAN	0.83	*	0.90	0.84	0.91	4.86	*	2.84	2.61	4.13	0.11	*	0.19	0.14	0.21
QINGDAO	0.76		0.80	0.75	0.84	1.02	*	1.02	1.01	1.03	0.59		0.60	0.58	0.63
JINAN	0.76		0.81	0.76	0.81	1.37	*	1.37	1.36	1.38	1.04		1.04	1.03	1.05
DALIAN	0.51		0.57	0.50	0.63	1.30	*	1.28	1.21	1.35	0.71		0.69	0.68	0.71
HANGZHOU	0.87		0.88	0.83	0.92	1.00	*	0.94	0.81	1.01	0.85		0.84	0.84	0.85
CHANGSHA	0.93		0.98	0.86	1.05	1.04	*	1.07	1.00	1.17	1.08		1.03	0.91	1.12
SHIJIAZHUANG						1.53	*	1.73	1.50	2.20	0.65		0.65	0.58	0.72
SHAOXING	0.75		0.76	0.72	0.76	1.10	*	1.10	1.10	1.11	0.90		0.89	0.88	0.90
JINZHOU						1.05	*	1.06	1.05	1.06	0.69		0.71	0.68	0.73
LAIWU	0.73	*	0.70	0.65	0.73	0.68	*	0.65	0.55	0.70	1.43	*	0.41	0.23	0.84
JIUJIANG	0.40	*	0.47	0.41	0.52	1.70	*	1.69	1.65	1.71	0.76		0.75	0.70	0.80
PANZHIHUA	0.64		0.64	0.64	0.66	0.97		1.00	0.96	1.11	0.99	*	0.40	0.23	0.74
DONGYING	0.92	*	0.82	0.82	0.87	0.95	*	0.99	0.95	1.02	0.68		0.67	0.67	0.68
ZENGZHOU	1.01		1.03	1.01	1.03	0.82	*	0.82	0.81	0.83					
WEIFANG						0.93	*	0.93	0.89	0.94					
LINYI	1.18		1.20	1.17	1.22	0.91	*	0.90	0.86	0.92					
XINXIANG	0.86		0.84	0.79	0.88	1.95	*	1.41	0.95	1.98					
LIUZHOU	0.79		0.79	0.75	0.79	0.97		0.96	0.92	0.98					
HUZHOU	0.87		0.86	0.84	0.88	1.05	*	1.04	0.97	1.07					
KARAMAY	3.44	*	2.66	2.29	3.28	1.33		1.16	1.02	1.32					
HUANGSHI	0.76		0.77	0.73	0.78										

Banks	Model 5 – 2007/2006					Model 5 – 2006/2005				Model 5 – 2005/2004			
	TFP		Boot	L - B	U -B	TFP	Boot	L - B	U -B	TFP	Boot	L - B	U -B
XUCHANG	0.97		0.98	0.91	1.01								
JINING	0.78		0.73	0.67	0.80								
CHENGDE	0.61		0.60	0.55	0.64								
HENGYANG	1.40		1.47	1.25	1.67								
GANZHOU	0.68		0.69	0.66	0.70								
GUILIN	0.63		0.63	0.62	0.63								
NIANYANG	0.78	*	0.80	0.78	0.80								
JIAOZUO	2.78	*	1.72	1.20	2.54								
DEYANG	0.87		0.87	0.84	0.87								
MINTAI	0.98		0.98	0.97	0.98								
CHOUZHOU	1.01		1.01	1.01	1.03								
ZHANJIANG	0.56		0.56	0.49	0.62								
JIAXING	0.93		0.91	0.83	0.98								
TAILONG	0.81		0.81	0.78	0.82								
WEIHI	0.41	*	0.93	0.70	1.12								

Banks	Model 5 – 2004/2003				Model 5 – 2003/2002				Model 5 – 2002/2001			
	TFP	Boot	L - B	U - B	TFP	Boot	L - B	U - B	TFP	Boot	L - B	U - B
State-Owned Banks												
ICBC	0.91	0.91	0.87	0.94	0.91	0.91	0.90	0.92	1.06	1.04	0.97	1.12
CCB	0.97	0.97	0.96	0.98	1.01 *	0.97	0.95	0.99	0.87	0.87	0.83	0.94
ABOC	0.84	0.87	0.80	0.95	0.95 *	0.89	0.88	0.89	0.88	0.84	0.76	0.89
BOC	1.33 *	1.21	1.13	1.31	1.08	1.08	1.07	1.09	1.09	1.07	1.04	1.12
BoCom	1.06	1.06	1.02	1.09	0.99 *	0.94	0.97	0.95	1.57	1.37	1.20	1.59
Joint Stock Commercial Banks												
CMB	1.04	1.05	0.99	1.12	0.82 *	0.77	0.81	0.78	1.04	1.06	0.98	1.19
CMBC	1.01	0.98	0.92	1.06	1.05 *	1.05	1.05	1.04	1.51	1.58	1.45	1.70
CITIC	1.14	1.22	1.10	1.36	0.98 *	0.97	1.02	0.99	0.96	0.96	0.95	0.98
SPDB	0.99 *	1.03	1.00	1.04	0.98 *	0.97	0.95	0.96	0.79	0.78	0.78	0.80
CIB	0.95	0.98	0.91	1.06	0.97 *	0.94	0.94	0.94	1.11	1.17	1.10	1.31
CEB	0.96	1.07	0.96	1.17	0.87 *	0.82	0.84	0.85	0.96	0.97	0.93	1.00
HUAXIA	0.93	0.98	0.93	1.02	1.04 *	1.01	1.01	1.00	1.05	1.03	1.02	1.06
GDB	1.28 *	1.21	1.18	1.27	0.86 *	0.99	1.06	0.88	0.90	0.92	0.82	1.03
SDB	0.84	0.85	0.78	0.91	1.08 *	0.99	0.99	0.98	0.98	1.00	0.95	1.09
City Commercial Banks												
BEIJING	1.03	1.03	0.93	1.13	1.10 *	1.03	0.97	0.97	0.93	1.00	0.92	1.02
SHANGHAI	1.04	1.08	1.02	1.13	1.20 *	1.27	1.33	1.34	1.02	1.06	0.98	1.17
Ping An	0.96	1.03	0.94	1.12	0.83 *	0.78	0.80	0.80	0.57	0.59	0.55	0.62
TIANJIN	0.53 *	0.59	0.53	0.65	0.89 *	0.84	0.84	0.84	1.26	1.28	1.25	1.32
NANJING	0.90 *	0.95	0.90	0.97	0.37 *	0.37	0.33	0.37	1.41	1.50	1.34	1.69
DONGUAN	0.86	0.88	0.86	0.88	1.17 *	1.17	1.17	1.17	0.68	0.68	0.65	0.69
WUXI	1.07	1.16	1.05	1.29	1.03 *	0.97	0.96	0.99	0.73	0.71	0.66	0.74
CHONQING	0.34	0.33	0.30	0.35	0.99	0.99	0.98	1.00	1.32	1.29	1.22	1.33
XIAMEN	1.10	1.06	1.01	1.15	1.07 *	1.18	1.22	1.12	0.96	0.95	0.87	1.04
NINGBO	0.84	0.85	0.81	0.88	0.86 *	0.81	0.81	0.82	0.84	0.82	0.80	0.86
XIAN	0.96	0.98	0.95	0.99	1.15 *	1.19	1.16	1.17	0.75 *	0.72	0.70	0.74
WUHAN	2.16	1.94	1.67	2.22	0.82 *	0.87	0.86	0.87	0.63	0.75	0.61	0.96
QINGDAO	0.81	0.72	0.63	0.82	1.20 *	1.23	1.40	1.22	1.38	1.38	1.25	1.55
JINAN	0.62 *	0.67	0.63	0.69	1.12 *	1.09	1.08	1.08	0.87	0.88	0.85	0.90
DALIAN	1.03	1.02	0.92	1.13	1.05 *	1.02	0.98	1.04	1.14	1.09	1.09	1.16
HANGZHOU	1.28	1.30	1.17	1.42	2.33 *	1.58	1.34	1.96				
CHANGSHA	0.64	0.65	0.56	0.76	0.80 *	0.83	0.83	0.83				
SHIJIAZHUANG	1.39	1.36	1.20	1.54								
SHAOXING	0.41	0.40	0.36	0.41								
JINZHOU	1.03 *	1.15	1.06	1.19								

Banks	Model 5 – 2001/2000				Model 5 – 2000/1999			
	TFP	Boot	L - B	U - B	TFP	Boot	L - B	U - B
State-Owned Banks								
ICBC	0.90	0.90	0.88	0.92	1.09	1.10	1.09	1.14
CCB	0.91	0.91	0.89	0.94	1.12	1.12	1.11	1.17
ABOC	1.02 *	0.99	0.98	1.02	1.07	1.05	1.01	1.07
BOC	1.09	1.17	1.06	1.18	1.08	1.02	0.92	1.12
BoCom	1.01	0.96	0.87	1.07	0.80	0.84	0.80	0.86
Joint Stock Commercial Banks								
CMB	0.95	0.94	0.87	0.99	1.10	1.13	1.07	1.23
CMBC	0.73	0.68	0.60	0.76	0.86 *	1.01	0.87	1.21
CITIC	1.10	1.10	1.08	1.13	1.08	1.07	1.04	1.08
SPDB	0.95 *	0.92	0.87	0.95	1.04	1.07	1.02	1.16
CIB	0.89	0.90	0.88	0.92	0.83	0.84	0.83	0.86
CEB	1.21	1.12	1.06	1.22	1.07	1.14	1.05	1.28
HUAXIA	1.03	1.01	1.01	1.04	0.97	0.98	0.96	1.02
GDB	0.62	0.63	0.57	0.70	1.35	1.39	1.32	1.49
SDB	1.03	1.04	1.02	1.11	0.90	0.91	0.89	0.96
City Commercial Banks								
BEIJING	1.02	0.88	0.83	1.03	0.82	0.92	0.82	0.93
SHANGHAI	0.80 *	0.63	0.51	0.79	0.90	0.89	0.89	0.94
Ping An	0.86	0.89	0.86	0.91	1.45	1.56	1.43	1.75
TIANJIN	0.99	0.98	0.95	1.05	0.84	0.83	0.83	0.87
NANJING	0.87	0.90	0.85	0.95	0.86	0.84	0.74	0.93
DONGUAN	1.49	1.50	1.48	1.58	0.75	0.74	0.69	0.77
WUXI	0.96	0.98	0.96	1.01	0.86 *	0.64	0.52	0.81
CHONQING	1.90	1.54	1.27	1.92	0.39	0.46	0.38	0.49
XIAMEN	0.84	0.82	0.74	0.90	0.79	0.82	0.71	0.94
NINGBO	1.03	1.03	1.03	1.04				
XIAN	0.89 *	0.87	0.85	0.89				

Banks	Model 5 – 1999/1998				Model 5 – 1998/1997			
	TFP	Boot	L - B	U - B	TFP	Boot	L - B	U - B
State-Owned Banks								
ICBC	1.39	1.35	1.30	1.39	0.75	0.74	0.67	0.82
CCB	0.54	0.53	0.52	0.57	2.82	2.90	2.63	3.22
ABOC	0.43	0.42	0.38	0.46	2.44	2.55	2.44	2.75
BOC	0.82	0.87	0.72	1.05	1.11	1.15	1.05	1.25
BoCom	0.42	0.41	0.38	0.46	2.23	2.15	2.14	2.28
Joint Stock Commercial Banks								
CMB	0.60	0.60	0.51	0.68	2.38	2.40	2.13	2.67
CMBC	0.54	0.56	0.51	0.65	2.24	2.12	1.83	2.45
CITIC	0.97	0.85	0.64	1.04	1.10	1.15	0.93	1.41
SPDB	1.30	1.31	1.06	1.65	1.77	1.70	1.44	1.99
CIB	0.58	0.59	0.52	0.63	3.19	3.15	2.33	4.28
CEB	0.98	0.99	0.86	1.11	1.95	1.79	1.45	2.24
HUAXIA	0.57	0.59	0.53	0.69	1.97	1.93	1.78	2.20
GDB	0.77	0.77	0.60	0.93	1.14	1.16	0.96	1.41
SDB	1.50	1.49	1.29	1.74	0.99	0.95	0.82	1.09
City Commercial Banks								
BEIJING	0.51	0.52	0.49	0.55	1.28	1.30	1.23	1.35
SHANGHAI	0.64	0.64	0.63	0.67	3.44	3.28	2.84	3.56
Ping An	0.53	0.54	0.47	0.60				
TIANJIN	0.84	0.82	0.70	0.94				

Chapter 7

Chinese Banking: A Network Data Envelopment Analysis Framework

"An approximate answer to the right problem is worth a good deal more than an exact answer to an approximate problem" *John Tukey*

7.1. Introduction

The past twenty years have seen a multitude of studies employing conventional DEA analysis in evaluating bank efficiency. These studies have provided some information about the relative position of certain banks against local 'best practice'. In the case of significant inefficiency, the management of the inefficient bank is alerted that there is a production problem, but is none the wiser as to where the focus of change needs to concentrate. In principle, the methodology of network data envelopment analysis provides management with information about the areas of operational inefficiency.

As Avkiran (2009) notes, "An organization that is not constantly acquiring knowledge, sourced internally from various divisions, or externally, is condemned to lose its competitive advantage". It is argued that management focus has been shifting from strategic planning to organizational learning (Bartlet and Ghosal, 1985) whereby management develops a capacity to respond flexibly and rapidly to change. As Avkiran (2009) argues, responding to change is more effective if operational inefficiencies are readily identifiable and so efficiency analysis of organisational divisions within the production unit is an integral part of organisational learning. The banking industry is a rapidly evolving global institution. As Matthews and Thompson

(2008) describe it, the modern bank is a multifaceted financial institution, staffed by multi-skilled personnel, conducting multi-task operations. The modern bank is evolving from a vertically integrated structure towards a more complex network of specialist functions in what Llewellyn (1996) calls contract banking – a contract to deliver financial services organised on multiple sources. In this aspect, Chinese banks are no different from its Western economy counterparts. While it can be argued that Chinese bank management lags behind Western banks, its rapid evolution and continuing pace of reform has narrowed the managerial gap. Understanding the source of operational inefficiencies is as important to Chinese bank mangers as to their Western counterparts.

This chapter applies the concept of network DEA introduced in Chapter 3 to evaluate the internal efficiency of the 14 national banks that dominate the Chinese banking market. The chapter is organised on the following lines. The next section describes the motivation and conceptual framework. Section 3 reviews the theoretical model and the optimisation exercise. Section 4 presents the data. Section 5 shows the results. Section 6 discusses the value-added from the exercise and concludes.

7.2 Conceptual Framework

The standard application of DEA to banking follows either the intermediation or production methods. These methods were reviewed in earlier chapters and will not be elaborated here. In this chapter inputs are captured by operational costs (non-interest expenses) and interest expenses. Output is measured by net interest income and net non-interest income. This method effectively measures the bank's profit efficiency because the variables are directly from the profit and loss account of the bank's income statement[81]. If there is k=1,2,...K DMUs, q=1,2,...Q outputs (y_q), and n=1,2,...N inputs (x_n) and the price of inputs for each k DMU is given by $\{\widetilde{w}_{n,k}\}$ and the price of outputs for each k DMU is given by $\{\widetilde{p}_{q,k}\}$, the profit efficiency model within the DEA framework as described by Zhou (2003) is;

$$Max \sum_{q=1}^{Q} \widetilde{p}_{q,k} y_{q,k} - \sum_{n=1}^{N} w_{n,k} x_{n,k} \qquad (7.1)$$

$$\text{Subject to} \quad \begin{aligned} &\sum_{k=1}^{K} \lambda_k x_{n,k} \le x_n ; n = 1,2,...N \\ &\sum_{k=1}^{K} \lambda_k y_{q,k} \ge y_q ; q = 1,2,...Q \\ &k = 1,2,...K ; \lambda_k \ge 0 \end{aligned} \qquad (7.2)$$

Equations (7.1) and (7.2) describe the optimisation for the constant returns to scale model (CRS). In the case of the variable returns to scale model the additional constraint of add $\sum_{k=1}^{K} \lambda_k = 1$ is made.

The internal functional structure of Chinese banks have evolved progressively from the simple task of taking deposits from households and making loans to state owned enterprises. The modern Chinese bank has a functional structure dominated by the retail bank activity. Wholesale, Investment and Private banking is in its infancy and even today Consumer banking remains undeveloped. However, the sector churning from the surplus household sector to the deficit corporate sector has moved over to a more balanced internal structure which can be characterised by three profit centres,

[81] Examples of other studies that have used these input and output variables include Miller and Noulas (1996), Avkiran (1999), and Sturm and Williams (2004).

namely, corporate banking, consumer banking and treasury banking. Table 7.1 shows the typical divisional functionalities of the modern Chinese bank.

The traditional business of banking in China was taking deposits from households and lending to SOEs. During the 1990s and following the first stage of banking reform, the banks gradually extended loans to the non-SOE sector.

Table 7.1 The divisional functionalities of commercial bank

Corporate Banking	Consumer Banking	Treasury
Providing services to corporate customers, government authorities and financial institutions • current accounts • deposits • overdrafts • lending • custody • trade related products • other credit facilities • foreign currency • derivative products	Providing services to retail customers • current accounts • demand deposits • time deposits • investment savings products • credit and debit cards • consumer loans and mortgages.	• foreign exchange transactions • customer-based interest rate and foreign exchange derivative transactions • money market transactions • bill market transactions • proprietary trading and asset and liability management

Corporate banking remains the dominant area of bank lending in China however in recent years consumer loans, largely mortgages, have emerged as a fast growing area of business. Lending to households began in earnest with reform of house ownership. Under the planning regime, houses were allocated to workers according to rank by the SOEs. In the mid 1990s, the central government allowed workers of SOEs to purchase properties from the enterprises they worked for. Lending to households began to grow from small ticket loans for auto purchase and home improvements to full mortgages.

Consumer banking in recent years is dominated by mortgage lending. Auto-financing was popular in the late 1990s and early 2000s but has shrunk because of high default rates, while mortgages are viewed as relatively safe because of its collateralised nature. In 2007, mortgages accounted for more than 70 percent of consumer loans[82]. Other areas of consumer banking such as credit cards remain undeveloped. Chinese households use credit cards in the same way Western consumers use debit cards, and pay off all their borrowing within the stipulated credit period. Consequently the credit card sector remains a loss-making business in China.

The growth of high income earners has prompted banks to develop a hitherto unknown area of consumer banking in China, namely private banking. Private banking provides tailor made products to VIP customers. For example ICBC reports 3 million 'Elite Club' customers out of a total of 170 million consumer customers, in 2007.

Treasury operations have developed as the residual function of the banks, sandwiched between corporate and consumer banking. The current commercial banking law stipulates that the bank's loan-to-deposit ratio should not exceed 75%. Treasury management has evolved as a result of managing the funding surplus to meet liquidity requirements and maximise profit. Treasury operations have evolved from interbank and money-market activity which has traditionally been a passive exercise to active bond and bill transactions in the government and commercial bill market.

Sector churning continues to be present in Chinese banks. Typically, the consumer

[82] CBRC Annual Report 2007

banking division continues to internally finance the Corporate and Treasury divisions of the bank, although the picture has become more complex in recent years. In the next section, I develop a framework to examine the internal flow of financing and revenue generation within the three profit centres as a network DEA (NDEA) framework.

7.3 Methodology

The general NDEA model was introduced in chapter 3 and will not be elaborated further. However, what was described in Chapter 3 was a system that could be described as a serial network that sees the organisational structure as a vertical integration of production in stages or divisions. In this chapter I introduce an adapted version that satisfies the particular framework of Chinese banks discussed in the previous section. Basically the version described in this chapter can be thought of as a parallel structure which separates production into consecutive units that interact with each other.

Basically, there are $k = 1,2,\ldots 14$ banks (DMUs) in the analysis. There are five SOCBs and 9 JSCBs in total. There are two primary inputs, interest expense and non-interest expense, denoted as $\{x_i, x_n\}$ respectively. Interest expense is the total interest cost of borrowed funds (customer's deposits and interbank borrowing). Non-interest expenses include, personnel expenses and rental, building maintenance, information technology etc. Final outputs are net interest income and net non-interest income denoted as $\{y_i, y_n\}$. The intermediate input $\{x_m\}$ and output $\{y_m\}$ relates to interest income only[83].

The inputs and outputs corresponding to the k =1,2,...14 banks in the analysis must satisfy the following properties:

$$\begin{aligned} &x_{q,k} \geq 0 \\ &y_{q,k} \geq 0 \\ &q = i,n \\ &k = 1,2,...14 \end{aligned}$$

There are three profit centres. These are corporate (centre 1), consumer (centre 2) and Treasury (centre 3). For the k^{th} bank the allocation of the primary input and final output is described by;

$$\begin{aligned} &x_{i,k}^1 + x_{i,k}^2 + x_{i,k}^3 \leq x_{i,k} \\ &x_{n,k}^1 + x_{n,k}^2 + x_{n,k}^3 \leq x_{n,k} \\ &y_{i,k}^1 + y_{i,k}^2 + y_{i,k}^3 \leq y_{i,k} \\ &y_{n,k}^1 + y_{n,k}^2 + y_{n,k}^3 \leq y_{n,k} \end{aligned} \qquad (7.3)$$

Non-negative intensity factors are used to capture the extent of the participation of a given profit centre in the production process. So for final outputs $\{\alpha_j, \beta_j, j=1,2,3\}$ is the profit centre contribution of net interest and net non-interest income respectively. For primary inputs $\{\gamma_j, \delta_j, j=1,2,3\}$ is the profit centre utilisation of interest and non-interest expense respectively. For intermediate input and output only interest

[83] In reality the non-interest expense of each profit centre will be included in the internal price charged to other profit centres.

expense and interest income is used for the reasons discussed above. The intermediate output $\{a_j, j=1,2,3\}$ is the profit centre internal production of interest income and the intermediate input $\{b_j, j=1,2,3\}$ is the profit centre utilisation of interest expense. The parallel structure of the internal flow of funds between the three profit centres is described in Figure 1 below.

Figure 7.1 Divisional flow of funds

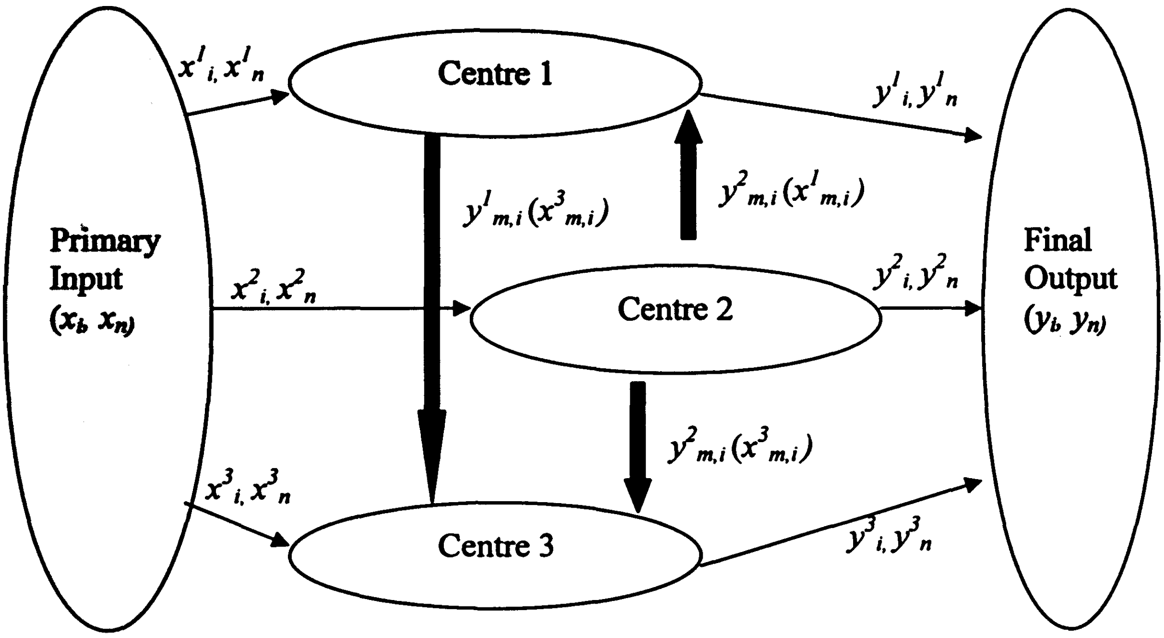


Figure 7.1 shows the internal flow of funds among three divisions. As aforesaid, Centre 2 (Consumer banking) is the funding provider. Therefore the surplus from Centre 2 is channelled to either Centre 1 (Corporate banking) or Centre 3 (Treasury banking). Here I assume the surplus funding will go to Centre 1 first than flow to Centre 3. The implicit assumption is that corporate banking is the key business and the return is strong and stable. The surplus from Centre 1 goes to Centre 3. The figure shows that the intermediate output from centre 1 and 2 act as intermediate inputs to Centre 3 but there is no intermediate output from Centre 3. Similarly, the intermediate output of Centre 2 feeds into Centre 3 as intermediate inputs.

The structure of each profit centre is described by the following sets of equations;

Profit centre 1 (Corporate banking)

Final output

$$y_{i,k}^{1} \leq \alpha_1 \sum_{j=1}^{3} y_{i,k}^{(j)}$$
$$y_{n,k}^{1} \leq \beta_1 \sum_{j=1}^{3} y_{n,k}^{(j)} \tag{7.4}$$

Primary input

$$x_{i,k}^{1} \geq \gamma_1 \sum_{j=1}^{3} x_{i,k}^{(j)}$$
$$x_{n,k}^{1} \geq \delta_1 \sum_{j=1}^{3} x_{n,k}^{(j)} \tag{7.5}$$

Intermediate output

$$y_{m,i,k}^{1} \leq a_1 \sum_{j=1}^{3} y_{m,i,k}^{(j)} \tag{7.6}$$

Intermediate input

$$x_{m,i,k}^{1} \geq b_1 \sum_{j=1}^{3} x_{m,i,k}^{(j)} \tag{7.7}$$

Profit centre 2 (Consumer banking)

Final output

$$y_{i,k}^{2} \leq \alpha_2 \sum_{j=1}^{3} y_{i,k}^{(j)}$$
$$y_{n,k}^{2} \leq \beta_2 \sum_{j=1}^{3} y_{n,k}^{(j)} \tag{7.8}$$

Primary input

$$x_{i,k}^{2} \geq \gamma_2 \sum_{j=1}^{3} x_{i,k}^{(j)}$$
$$x_{n,k}^{2} \geq \delta_2 \sum_{j=1}^{3} x_{n,k}^{(j)} \tag{7.9}$$

Intermediate output

$$y_{m,i,k}^{2} \leq a_2 \sum_{j=1}^{3} y_{m,i,k}^{(j)} \tag{7.10}$$

Intermediate input

$$x_{m,i,k}^{2} \geq b_2 \sum_{j=1}^{3} x_{m,i,k}^{(j)} \tag{7.11}$$

Profit centre 3 (Treasury banking)

Final output

$$y_{i,k}^{3} \leq \alpha_3 \sum_{j=1}^{3} y_{i,k}^{(j)}$$
$$y_{n,k}^{3} \leq \beta_3 \sum_{j=1}^{3} y_{n,k}^{(j)} \tag{7.12}$$

Primary input

$$x_{i,k}^{3} \geq \gamma_3 \sum_{j=1}^{3} x_{i,k}^{(j)}$$
$$x_{n,k}^{3} \geq \delta_3 \sum_{j=1}^{3} x_{n,k}^{(j)} \tag{7.13}$$

Intermediate output

$$y_{m,i,k}^{3} \leq a_3 \sum_{i=1}^{3} y_{m,i,k}^{(j)} \qquad a_3 = 0 \tag{7.14}$$

Intermediate input

$$x_{m,i,k}^{3} \geq b_3 \sum_{j=1}^{3} x_{m,i,k}^{(j)} \tag{7.15}$$

With conditions

$$\sum_{j=1}^{3}\alpha^{(j)}=1;\sum_{j=1}^{3}\beta^{(j)}=1;\sum_{j=1}^{3}\gamma^{(j)}=1;\sum_{j=1}^{3}\delta^{(j)}=1;\sum_{j=1}^{3}a^{(j)}=1;\sum_{j=1}^{3}b^{(j)}=1$$

$$\sum_{j=1}^{3}x_{m,i,k}^{(j)}=\sum_{j=1}^{3}y_{m,i,k}^{(j)}$$

The solution of the NDEA problem uses the DEA-Solver Pro Version 6 software[84]. The software employs a weighted network slacks based model (NSBM) assuming variable-returns to scale and non-orientation. The objective function for the DMU and constraints for divisional (profit centre) weights taken from Tone and Tsutsui (2007) are shown below.

$$\rho^{*}=\min\frac{\sum_{j=1}^{3}\omega^{(j)}\left[1-\frac{1}{2}\sum_{q=1}^{2}\frac{s_{q}^{(j-)}}{x_{q}^{(j)}+x_{m,q}^{(j)}}\right]}{\sum_{j=1}^{3}\omega^{(j)}\left[1+\frac{1}{2}\sum_{q=1}^{2}\frac{s_{q}^{(j+)}}{y_{q}^{(j)}+y_{m,q}^{(j)}}\right]} \quad (7.16)$$

Subject to

$$\sum_{j=1}^{3}\omega^{(j)}=1,\omega^{(j)}\geq 0;(\forall j) \quad (7.17)$$

$$\sum_{j=1}^{3}\alpha^{(j)}=1;\sum_{j=1}^{3}\beta^{(j)}=1;\sum_{j=1}^{3}\gamma^{(j)}=1;\sum_{j=1}^{3}\delta^{(j)}=1;\sum_{j=1}^{3}a^{(j)}=1;\sum_{j=1}^{3}b^{(j)}=1$$
$$\left(\alpha^{(j)},\beta^{(j)},\gamma^{(j)},\delta^{(j)},a^{(j)},b^{(j)}\right)\geq 0;(\forall j) \quad (7.18)$$

$$\sum_{j=1}^{3}x_{m,q,k}^{(j)}=\sum_{j=1}^{3}y_{m,q,k}^{(j)} \quad (7.19)$$

[84] www.saitech-inc.com

Where k = {1,2,..14} DMUs (banks), j = {1,2,3} divisions (profit centres), m represent intermediate output or input, q = {1,2} outputs (and inputs), ω is the divisional weight, $s^{(-)}$ is the input slack and $s^{(+)}$ is the output slack.

Constraint (7.17) says that the divisional weights are all non-negative and sum to unity, which means that each division is separately accounted for. Constraint (7.18) indicates non-negative divisional intensities that sum to unity (variable returns to scale). Constraint (7.19) says that the sum of intermediate inputs from the respective divisions is the sum of intermediate outputs from the respective divisions.

The objective function for divisional efficiency is shown in equation (7.20) below. The solution of (7.20) for the optimal input and output slacks are substituted in (7.14) to yield the overall efficiency score which is a weighted sum of the divisional scores.

$$\rho^{(j)} = \frac{1-\frac{1}{2}\left(\sum_{q=1}^{2}\frac{s_q^{(j-)}}{x_q^{(j)}+x_{m,q}^{(j)}}\right)}{1+\frac{1}{2}\left(1+\frac{1}{2}\sum_{q=1}^{2}\frac{s_q^{(j+)}}{y_q^{(j)}+y_{m,q}^{(j)}}\right)} \qquad (7.20)$$

Following Avikran (2009) we employ the non-orientated case because it can accommodate the simultaneous contracting of inputs and expansion of outputs. The use of the slacks based model instead of the conventional CCR or BCC models allow the analysis to capture the non-radial reduction in inputs and non-radial increase in outputs. The CCR and BCC models assume proportional expansion or contraction which may be unnecessarily restrictive in a banking setting where banks offer bundled services. For example interest charges may be low with the prospect or intention to charge higher service charges etc.

7.4 Data

The 14 national banks used in the previous chapters were chosen for this exercise, the principal reason being the ease at which the data can be collected from their respective annual statements. Data from 2007 to 2009 were collected for this study. The 2007~09 data on the internal flows of funds were obtained from individual bank annual statements, with observations updated in the following year statements. As mentioned in the previous section, the primary input data consists of interest expenses and non-interest expenses. Primary output is net non-interest income and net interest income. Inter-divisional flows of funds were published by nine banks in 2009 in the sample. Table 2 indicates which banks provided detailed data.

Table 7.2 Data Availability

Bank Mnemonic	Bank Name	Data Available?
CCB	China Construction Bank	Y (2007~09)
ICBC	Industrial & Commercial Bank of China	Y (2007~09)
ABOC	Agricultural Bank of China	Y (2007~09)
BOC	Bank of China	Y (2007~09)
CMB	China Merchant Bank	Y (2007~09)
CMBC	China Minsheng Bank Limited	Y (2008~09)
GDB	Guangdong Development Bank	N
BoCom	Bank of Communications	N
CEB	China Everbright Bank	Y (2007~09)
Citic	Citic Bank	Y (2007~09)
Huaxia	Huaxia Bank	N
SDB	Shengzhen Development Bank	Y (2008~09)
SPDB	Shanghai Pudong Development Bank	N
IBC	Industrial Bank of China	N

The internal flow of funds data for the banks that do not provide a complete matrix of flows is estimated. Table 7.3 shows the primary input and output data for each bank in 2009 in the sample. The full data set is shown in Appendix 7-I.

Table 7.3 Primary inputs and outputs in 2009

Banks	Corporate				Consumer				Treasury		
	Primary Input		Primary Output		Primary Input		Primary Output		Primary Input		Primary Output
	Interest Expenses	Operational Expenses	Net Interest income	Net Fee Income	Interest Expenses	Operational Expenses	Net Interest income	Net Fee Income	Interest Expenses	Operational Expenses	Net Interest income
CCB	50651	34538	124389	19884	60325	49854	62817	17882	13161	3420	22199
ICBC	59584	46233	132807	32486	85662	41551	70598	22499	13021	12123	42416
ABOC	34176	33119	102659	19983	71062	54447	57057	15657	9270	8257	21915
BOC	36731	34830	97918	25185	48227	35016	48672	13108	11170	7270	11196
CMB	11870	10982	21562	2831	7744	13835	6971	4780	3928	1098	11801
CMBC	13024	17374	19012	3037	3036	3617	4307	1291	3826	5449	8921
GDB	6339	4103	7414	978	1478	2418	2334	768	1950	440	21773
BoCom	21431	10678	49457	6041	12576	12761	11985	5,358	13994	2083	6430
CEB	10529	6306	15819	1671	2706	3162	3611	1444	3589	65	171
Citic	14522	8962	27686	2137	3245	5327	5347	1359	1532	574	1919
Huaxia	6886	2099	20961	573	1386	1237	1228	451	7378	225	-5350
SDB	5724	3898	8568	893	1257	2574	2838	368	1500	231	934
SPDB	16043	2668	22744	1236	3327	1572	5332	971	6374	286	6369
IBC	10614	6425	20041	1745	1806	3786	3948	1,371	7752	688	5879

For corporate banking business, the banks need to pay interest to the external corporate depositors. These depositors may or may not be the bank's credit customers. For example, in 2007 ICBC had 2.72 million corporate customers, of which only 59 thousand were credit customers. Banks provide services to non-credit customers (depositors) while charging fees for the services provided, such as remittance, foreign exchanges etc. Same as Corporate banking, Consumer banking needs to pay interest to individual depositors. As for Treasury banking, the primary interest input is the expenses to other depositors, like inter-bank borrowing.

As for data collection, all banks published the total interest expenses and interest expenses on (corporate/consumer) customer deposits. The residual amount is treated as the primary input for Treasury Banking. Considering banks have different definition for corporate deposits but almost identical understanding regarding what constitutes consumer deposits, to make the data more comparable, here I subtract interest expenses to consumer deposits from the total interest expenses to customer deposits as the primary input for Corporate banking. Some banks did not directly disclose the interest paid to corporate and consumer depositors. However, the daily or monthly average corporate/consumer deposits and respective average interest rate were given in the management discussion. I use these information to calculate the actual interest paid to depositors.

Apart from interest expenses, the other primary input is operating expense. All banks disclosed the total operating expenses but not all banks have divisional data. To construct the full data set for each division, the banks are firstly divided into two groups: SOCBs and JSCBs. From the available divisional data from the banks in Table 7.2 the average percentage of each group for three divisions is calculated. Table 7.4 shows an example for year 2009. The other two years data are shown in Appendix 7-II.

Table 7.4 Average percentage of operating expenses for three divisions 2009

Available Banks		**Corporate**	**Consumer**	**Treasury**	**Total**
SOCBs	CCB	39%	57%	4%	100%
	ICBC	45%	41%	12%	98%
	ABOC	35%	57%	9%	100%
	BOC	43%	43%	9%	95%
	Average	**41%**	**49%**	**8%**	**98%**
JSCBs	CMB	41%	51%	4%	96%
	CMBC	64%	13%	20%	97%
	CEB	66%	33%	1%	100%
	Citic	55%	33%	4%	91%
	SDB	53%	35%	3%	91%
	Average	**56%**	**33%**	**6%**	**95%**

The average percentage shares of operating expenses for three divisions are applied to all remaining SOCBs and JSCBs. The final divisional operating expense for each bank is calculated as the product of the total operational expenses and the percentage of each division.

The same method is used to simulate the data set for net fee income. For most of the banks, only corporate banking and consumer banking charge fees from clients. Some banks reported a small amount of fee income from Treasury banking. As the percentage is normally less than 8% of total fee income from known data, I assume that only corporate and consumer divisions contribute fee income to simplify the process of data construction. Similarly, the average percentage of total net fee income for corporate banking for SOCBs and JSCBs groups is calculated, and an example is shown in Table 7.5. The calculated average % is applied to all other SOCBs and JSCBs to construct the net fee income for the corporate banking division. The fee income of Consumer division is the residual amount after subtracting the corporate net fee income from the total net fee income. Appendix 7-III shows all three years calculation.

Table 7.5 Average percentage of net fee income for three divisions 2009

Available Banks		Corporate	Consumer	Total
SOCBs	CCB	41%	59%	100%
	ICBC	59%	41%	100%
	ABOC	56%	44%	100%
	BOC	55%	45%	100%
	Average	**53%**	**47%**	**100%**
JSCBs	CMB	35%	65%	100%
	CMBC	65%	35%	100%
	CEB	53%	47%	100%
	Citic	51%	49%	100%
	SDB	76%	24%	100%
	Average	**56%**	**44%**	**100%**

The greatest difficulty in data construction is to build inter-divisional flows of funds. As shown in Figure 7.1 of the previous section, inter-divisional interest expenses and interest incomes are chosen as the intermediate input and output. From the sample data, total six directions of divisional flow of funds are found over 2007 to 2009. Table 7.6 illustrates the divisional flow of funds and the flow direction of surplus funding.

Table 7.6 Divisional flow of funds

Scenario	Corporate: Funding Surplus (+) / Deficit (-)	Consumer: Funding Surplus (+) / Deficit (-)	Treasury: Funding Surplus (+) / Deficit (-)	The direction of flow of surplus funding					
				Corporate to Consumer	Corporate to Treasury	Consumer to Corporate	Consumer to Treasury	Treasury to Corprate	Treasury to Consumer
1	-	+	-	No	No	Yes	Yes	No	No
2	+	+	-	No	Yes	No	Yes	No	No
3	-	-	+	No	No	No	No	Yes	Yes
4	+	-	-	Yes	Yes	No	No	No	No
5	+	-	+	Yes	No	No	No	No	Yes
6	-	+	+	No	No	Yes	No	Yes	No

The scenario 1 and 2 are the most common directions of surplus funds. In 2009, there are 4 banks under scenario 1 and 5 banks under scenario 2, represent 64% of the sampled banks. The other three scenarios are rare situations. Therefore this study focuses more on the scenario 1 and 2. The 5 large SOCBs benefit from a wider national branch network and therefore their individual consumer deposits are much larger than consumer lending giving rise to 'sector churning'. The surplus funds act as a funding source for Corporate banking and/or Treasury banking. In the case of the JSCBs, due to limited network, the situation is reversed. For some banks, both Corporate and Consumer banking can be self-funded. In this scenario, Treasury banking will be the only user of the funding surplus.

Table 7.7 shows the self-fund status of Corporate, Consumer and Treasury divisions in 2009. It can clearly be seen that all SOCBs have surplus funding from Consumer Banking divisions. In the JSCBs group, the majority of banks are able to be self-funded for their consumer banking business. The only exceptions are the two banks SDB and IBC. The funding users in JSCB groups are mixed. In most of the cases, Treasury banking is the user for surplus funds. However it is very interesting to see that Treasury became the funding providers in three banks: CMBC, GDB and IBC.

Table 7.7 Divisional flow of funds 2009

Banks		Scenario	Corporate: Funding Surplus (+) / Deficit (-)	Consumer: Funding Surplus (+) / Deficit (-)	Treasury: Funding Surplus (+) / Deficit (-)
SOCBs	CCB	1	-	+	-
	ICBC	1	-	+	-
	ABOC	1	-	+	-
	BOC	2	+	+	-
	BoCom	2	+	+	-
JSCBs	CMB	1	-	+	-
	CMBC	6	-	+	+
	GDB	6	-	+	+
	CEB	2	+	+	-
	Citic	2	+	+	-
	Huaxia	2	+	+	-
	SDB	4	+	-	-
	SPDB	2	+	+	-
	IBC	5	+	-	+

The inter-divisional interest incomes (from the perspective of the lending divisions) or interest expenses (from the borrowing division's perspective) are calculated as the arithmetic product of the funding gap multiplied by inter-divisional funding rate. As the inter-divisional pricing rate is not available, I construct a simple inter-divisional pricing reference rate, taken into consideration the published PBOC base rate and the actual rate disclosed in the annual accounts of some of the banks. Table 7.8 shows the reference rate used for data simulation for 2007.

Table 7.8 Reference rate 2007

Reference Rate	SOCBs CCB	SOCBs ICBC	JSCBs CMBC	JSCBs CITIC	JSCBs SDB	JSCBs Average	Overall Average
Corporate loan interest	6.59%		6.78%	6.36%		6.57%	6.58%
Corporate Bill discounting	3.66%			3.97%		3.97%	3.82%
Consumer loan interest	6.05%			6.09%		6.09%	6.07%
Corporate deposit interest – Overall weighted rate	1.41%	1.48%					1.45%
- time deposit rate	2.42%	2.60%	3.20%	2.83%	2.99%	3.01%	2.81%
- Demand deposit rate	1%	0.99%	1%	1.02%	0.96%	0.99%	0.99%
Consumer deposit interest – Overall weighted rate	1.71%	1.96%	2.17%	1.98%		2.08%	1.96%
- time deposit rate	2.33%	2.58%	2.29%	2.79%	2.30%	2.46%	2.46%
- Demand deposit rate	0.79%	0.80%	0.80%	0.77%	0.78%	0.78%	0.79%
Deposit rate with PBOC							1.79%
Inter-bank placement rate							1.73%

The 1.79% deposit rate with the central bank PBOC is adopted as the inter-divisional benchmark rate for the corporate banking division for 2007. I take into consideration the following factors: first, the surplus funding can only be placed either to inter-bank market or deposit with PBOC by Corporate banking. Second, the inter-divisional rate should cover the overall funding cost. As shown in Table 7.8, the average rate paid to corporate deposits is 1.45%. Therefore the slightly higher rate of 1.79% is used to consider the incentive for Corporate banking to lend to internal divisions.

The rate of 2.5% is used as the inter-divisional pricing for consumer banking. This is to cover the average consumer deposit rate of 1.96%. The higher funding cost in the consumer sector is caused by the Chinese consumer customer behaviour. Starved of the usual channels for saving available to the western consumer, the Chinese individual saver prefers time deposit to sight deposits to gain higher interest income. This is in turn is caused by the current underdeveloped investment market for individual investors in China. The current popular and available investment products and markets for individual investors are bank deposit, the stock market, and residential and commercial properties. The latter markets require larger amount of funds and educated market knowledge, which may not fit every individual's needs. Furthermore, historically China is a country with a high deposit-income ratio (as mentioned in Chapter 4). Bank deposit is still the first choice of savings instrument for many Chinese families.

Although the funding cost in consumer banking is higher than in corporate banking, the inter-divisional pricing charged by consumer banking cannot be much higher than the inter-bank market rate. Otherwise it will drive off the internal funding users, either corporate Bank or Treasury, to seek external sources of cheaper funding. By setting 2.5% as the internal pricing, Consumer banking still has about 55 base points as the internal gain, which can be viewed as an acceptable rate considering the risk free nature of internal lending.

As explained in the previous discussions, in most cases Treasury banking is a purely internal funding user, other than a funding provider. Therefore, the inter-divisional interest expenses paid by Treasury banking are the sum of inter-divisional incomes of Corporate and Consumer divisions.

The inter-divisional pricing rates for 2009 are 2.1% for Corporate and 2.31% for Consumer, while for 2008, the pricing rates are 2.84% and 2.79% for Corporate and Consumer divisions respectively. The detailed reference rate for 2008 and 2009 are shown in Appendix 7-IV.

Table 7.9 shows the intermediate input and output including both actual and simulated data for 2009. The data for 2007 and 2008 are in Appendix 7-V.

Table 7.9 Intermediate input and output (actual and simulated data) 2009

Banks	Intermediate input / output Net Interest Expense (-) / Income (+) from/to Internal Divisions		
	Corporate	Consumer	Treasury
CCB	-18525	84613	-65434
ICBC	-35965	108571	-72606
ABOC	-27152	96417	-69273
BOC	6742	52808	-59332
CMB	-121	5224	-5141
CMBC	-3038	490	2548
GDB	-820	266	554
BoCom	1003	11419	-12422
CEB	4419	516	-4934
Citic	1337	3229	-3679
Huaxia	1456	611	-2067
SDB	1736	-664	-383
SPDB	168	583	-751
IBC	539	-1218	679

One thing to mention is that the amount of funding surplus and deficit of some banks is spot data in some years, not averaged period data covering full financial years. Therefore, the calculated interest income or expense may be not very accurate if the year-end figures were significantly different from the average amount. Ideally one should use the daily averaged funding surplus or deficit amount for data construction. Some banks did published daily average data but not all. Further study may continue to improve the data quality by using quarterly average data as the listed banks published financial reports on quarterly basis. Quarterly data would level out the fluctuation in 1 year period.

Through simulation for intermediate input and output data, the primary output of net interest income for the three divisions can be constructed. The method for the calculation for primary net interest income is given as;

Net interest income = external interest income – external interest expense (i.e. primary input interest expenses) +/- inter-divisional interest income/ expense (i.e. intermediate input/output)

Here the external interest income is the interest income earned from corporate loans including commercial bill discounting for Corporate banking, while the interest income from consumer loans, which are largely from mortgage business, for Consumer banking. As for Treasury banking, the external interest income is the difference between gross interest income and interest income from corporate and consumer loans.

7.5 Results

This section presents the results of the network DEA (NDEA). One finding is that the mean of network DEA result is lower than the black box DEA results. The full results are shown in Appendix 7-VI. Table 7.10 shows the results in 2009 as an illustration. For purposes of comparison, the results from a standard black box DEA is included in column 3. The black box DEA is the BCC model, VRS with input orientation[85]. The black box DEA indicates 7 efficient banks out of the sample of 14, of which 6 remain on the efficient frontier in the NDEA exercise. Seven banks are measured as efficient in the NDEA exercise. China Everbright Bank (CEB) has moved into the efficient set,

[85] There were only marginal differences in the output orientation case.

while Huaxia Bank has moved into the inefficient set. However, in the main the NDEA exercise has not largely altered the dichotomous set of efficient and inefficient banks. What the exercise has revealed is the principal source of inefficiency for the inefficient banks.

Table 7.10 Profit Efficiency of Chinese Banks 2009: Network DEA

	Black Box		WNDEA		Division 1	Division 2	Division 3
Bank	Rank	Score	Rank	Score*	Corporate	Consumer	Treasury
CCB	1	1	1	1	1	1	1
ICBC	1	1	1	1	1	1	1
ABOC	9	0.942554	8 (↑)	0.8585	1	0.7348	0.8408
BOC	1	1	1	1	1	1	1
CMB	8	0.999683	9 (↓)	0.7344	0.8423	1	0.361
CMBC	13	0.794665	14 (↓)	0.5079	0.5749	0.8192	0.1297
GDB	1	1	1	1	1	1	1
BoCom	11	0.879032	11	0.7135	1	1	0.1405
CEB	10	0.924757	1(↑)	1	1	1	1
Citic	14	0.719277	10 (↑)	0.7294	0.6086	0.8126	0.767
Huaxia	1	1	12 (↓)	0.6677	1	1	0.0032
SDB	1	1	1	1	1	1	1
SPDB	1	1	1	1	1	1	1
IBC	12	0.7964	13 (↓)	0.6603	0.8527	1	0.1282
Mean		0.932598		0.847979	0.919893	0.954757	0.669314
Std Dev		0.097038		0.173273	0.14952	0.09177	0.412014

*Weighted arithmetic mean of Divisional Scores. Equal weight (33.33%) is given to three divisions in this study.

The exercise has revealed that the ranking of the banks performance from the standard DEA against the NDEA has changed markedly. The Spearman's rank correlation coefficient is 0.6992 ($p > .0054$). This means that by and large the benchmark banks in the DEA exercise retain their position on the frontier under the NDEA but the position of the inefficient banks has changed.

In the case of Huaxia Bank, the relative score has moved its position from 1st in the DEA exercise to 12th in the NDEA exercise. The root course of the inefficiency for Huaxia is the Treasury banking centre indicating the weakest link of the profit generation process. A possible reason for this can be found in the raw data presented in table 7.3. Huaxia bank is the only one among the sampled banks making loss in their treasury business. Compared with the reference bank CEB, the interest expense relating to earnings in the Treasury division is doubled than that of CEB. The inefficiency in China Minsheng Bank (CMBC) can be traced to all three profit centres in roughly equal parts. From Table 7.3 it can be seen that this bank makes a profit in all three divisions but underperforms relative its peers in each division.

From Table 7.10 it can be seen that Treasury operation is less performed than other two divisions. The manager can focus on the Treasury operation to isolate the extent of the inefficiency by examining the projections (or slack analysis) and the benchmarks afforded by the peer group. The projections show how much the inputs need to contract or outputs need to improve to reach efficiency. The benchmark peer group alerts the manager as to which banks she can emulate to improve efficiency. Table 7.11 shows the results for Treasury operations in 2009.

Table 7.11 Projections for Treasury banking profit centre 2009

Bank	Divisional Score	(Input) Interest expenses			(Input) Operational Expenses			(Output) Net Interest Income			Peer group (weight)
		Data	Projection	Change(%)	Data	Projection	Change(%)	Data	Projection	Change(%)	
CCB	1	13161	13161	0	3420	3420	0	22199	22199	0	CCB(1)
ICBC	1	13021	13021	0	12123	12123	0	42416	42416	0	ICBC(1)
ABOC	0.8408	9270	9270	0	8257	7940.7162	-3.83	21915	25565.754	16.66	ICBC(0.272) ABOC(0.536) CMB(0.191)
BOC	1	11170	11170	0	7270	7270	0	11196	11196	0	BOC(1)
CMB	0.361	3928	2830.7081	-27.94	1098	673.6959	-38.64	11801	21806.859	84.79	CCB(0.079)
CMBC	0.1297	3826	2056.4423	-46.25	5449	551.8906	-89.87	8921	21971.896	146.29	ICBC(0.01)
GDB	1	1950	1950	0	439.56	439.56	0	21773.427	21773.427	0	GDB(1)
BoCom	0.1405	13994	3920.5159	-71.98	2083.44	1323.5727	-36.47	6430.185	20949.563	225.8	CCB(0.108)
CEB	1	3589	3589	0	65	65	0	171	171	0	CEB(1)
Citic	0.767	1532	1532	0	574	416.1727	-27.5	1919	2157.9827	12.45	GDB(0.034) Citic(0.519) SDB(0.447)
Huaxia	0.0032	7378	6631.719	-10.11	224.94	222.7881	-0.96	0.42416*	126.3997	29700	CCB(0.001) CEB(0.038) Huaxia(0.858)
SDB	1	1500	1500	0	231	231	0	934	934	0	SDB(1)
SPDB	1	6374	6374	0	285.9	285.9	0	6369.334	6369.334	0	SPDB(1)
IBC	0.1282	7752	2066.2032	-73.35	688.44	470.4526	-31.66	5878.9489	21777.838	270.44	CCB(0.01) GDB(0.99)
Average	0.7499	7031.7857	5648.042		3014.9486	2530.9821		11566.023	15672.504		
St Dev	0.3201	4502.5824	4337.8866		3811.5226	3804.6147		11892.796	12476.977		

** Negative numbers in DEA are converted into small positive numbers.*

It can be seen that Huaxia bank is the worst performer in Treasury operations. An examination of the projections results shows that the problem is not one of inputs but one of outputs. Once again, the managers of Huaxia bank need to make great effort to achieve at least RMB126 million of net interest income in their Treasury business. One possible reason for Huaxia to make loss in the Treasury business might be the large amount of interest payment (the initial input). Compare with its peer CEB, Huaxia bank reported RMB7,378 million interest payment (vs. RMB3,589 million of CEB) in 2009. To further investigate this issue, I examined the financial reports and found out that Huaxia bank booked RMB5,721 million interest expenses on REPO operations. As a reference, the total interest expenses paid to customer deposits were only RMB8,282 million. Similar to Huaxia bank, the peer CEB spent RMB10,528 million on customer deposit interests, but only paid RMB136 million payment on REPO operations. The managers of Huaxia may re-consider the scope of their REPO business in the future to improve Treasury efficiency.

A test for the veracity of the NDEA results can be obtained by separating the efficient from the inefficient banks as indicated by the standard DEA and network DEA to evaluate which separating indicator is superior in terms of identifying the set of inefficient banks. The network DEA exercise was conducted across the 14 for all three years of available data 2007-2009. This produces a meta-frontier of efficiency scores using the network framework. Similar exercise was conducted using the standard DEA. The results of both are presented in Table 7.12 below. The column labelled NDEA is the overall score of the network DEA calculated as a harmonic mean of the three divisions whereas WNDEA is the score calculated as the weighted arithmetic mean. For purposes of comparison with the black box DEA (DEA) the weighted arithmetic mean is reported in Table 7.10 and in the Appendix 7-VI. The overall score (NDEA) is reported here in Table 7.12.

The results confirm the findings of the individual year exercises. The summary statistics show that the measure of average efficiency in the network DEA is lower than in black box DEA and the dispersion are higher. As with the individual years, the main area of inefficiency is concentrated in Treasury operations.

The question that is investigated is, which of the two efficiency scores are better at identifying the set of efficient banks? One way of testing for this is to conduct a profiling of the inefficient and efficient banks according to the efficiency score from the network DEA results compared with the black box DEA results and test for some correspondence with accounting measures of financial performance such as ROA or cost-income ratio (CI).

Table 7.13 shows the sample means and standard deviations of the return on assets (ROA) and cost-income ratio (CI) for the efficient and inefficient banks for the full sample period 2007-2009. The null hypothesis is that those banks identified in the efficient set will not have a higher ROA and a lower CI than those identified in the inefficient set. I conduct a conventional difference in means, 't' test and since normality cannot be guaranteed, also a non-parametric test (Mann-Whitney). While the results are not unambiguous it can be seen from the results of Table 7.13 that the null can be rejected at conventional levels of significance in the case of the NDEA being used as a filter to profile the banks at least three out of four cases, but in the case of the DEA results the null is rejected only one out of four cases.

Table 7.12 Meta-Frontier DEA and network DEA 2007-2009

No.	Bank-year DMU	DEA Score	NDEA Score	WNDEA Score	Corporate Score	Consumer Score	Treasury Score
1	CCB_07	1.000	0.846	0.864	1.000	1.000	0.590
2	ICBC_07	0.985	1.000	1.000	1.000	1.000	1.000
3	ABOC_07	0.989	1.000	1.000	1.000	1.000	1.000
4	BOC_07	0.963	1.000	1.000	1.000	1.000	1.000
5	CMB_07	1.000	0.459	0.596	0.532	1.000	0.255
6	CMBC_07	0.675	0.215	0.423	0.480	0.681	0.109
7	GDB_07	0.834	0.010	0.667	1.000	0.997	0.003
8	BoCom_07	0.823	0.340	0.575	0.966	0.662	0.098
9	CEB_07	0.726	0.614	0.690	0.436	0.632	1.000
10	Citic_07	0.743	0.206	0.438	0.518	0.698	0.098
11	Huaxia_07	0.787	0.007	0.309	0.421	0.504	0.003
12	SDB_07	1.000	1.000	1.000	1.000	1.000	1.000
13	SPDB_07	0.687	0.263	0.328	0.214	0.518	0.252
14	IBC_07	0.602	0.183	0.565	0.637	1.000	0.059
15	CCB_08	1.000	0.887	0.900	1.000	0.701	1.000
16	ICBC_08	1.000	1.000	1.000	1.000	1.000	1.000
17	ABOC_08	0.825	0.877	0.886	1.000	0.658	1.000
18	BOC_08	0.921	0.730	0.727	0.973	0.728	0.482
19	CMB_08	0.900	0.525	0.529	0.584	0.610	0.394
20	CMBC_08	0.541	0.284	0.382	0.377	0.665	0.104
21	GDB_08	1.000	0.710	0.740	0.629	0.591	1.000
22	BoCom_08	0.779	0.356	0.540	0.886	0.650	0.084
23	CEB_08	0.679	0.498	0.502	0.542	0.554	0.411
24	Citic_08	0.653	0.165	0.413	0.561	0.602	0.075
25	Huaxia_08	0.766	0.008	0.667	1.000	1.000	0.002
26	SDB_08	0.665	0.153	0.428	0.691	0.525	0.067
27	SPDB_08	1.000	1.000	1.000	1.000	1.000	1.000
28	IBC_08	0.669	0.348	0.567	0.581	1.000	0.119
29	CCB_09	0.969	1.000	1.000	1.000	1.000	1.000
30	ICBC_09	1.000	1.000	1.000	1.000	1.000	1.000
31	ABOC_09	0.875	0.689	0.714	1.000	0.660	0.483
32	BOC_09	1.000	1.000	1.000	1.000	1.000	1.000
33	CMB_09	0.885	0.461	0.504	0.636	0.560	0.314
34	CMBC_09	0.704	0.340	0.430	0.472	0.674	0.144
35	GDB_09	1.000	1.000	1.000	1.000	1.000	1.000
36	BoCom_09	0.869	0.393	0.698	1.000	1.000	0.093
37	CEB_09	0.835	0.126	0.499	0.689	0.757	0.052
38	Citic_09	0.699	0.591	0.605	0.523	0.606	0.687
39	Huaxia_09	0.835	0.009	0.667	1.000	1.000	0.002
40	SDB_09	1.000	0.982	0.982	0.947	1.000	1.000
41	SPDB_09	1.000	0.856	0.877	1.000	1.000	0.629
42	IBC_09	0.745	0.336	0.516	0.638	0.773	0.138
	mean	0.848	0.559	0.696	0.784	0.810	0.494
	st. dev	0.139	0.354	0.230	0.243	0.191	0.417

Table 7.13 Financial Ratio profiling Chinese Banks 2007-2009

Statistic	Return on Assets (ROA) %	Cost-income ratio (CI) %
Full sample Mean	0.934	38.53
Standard Deviation	0.279	4.79
NDEA Efficient set Mean	1.016	36.33
Standard Deviation	0.222	5.13
NDEA Inefficient set Mean	0.908	39.21
Standard Deviation	0.292	4.54
Difference in means 't'	1.90 (p > | t | = .064)*	-2.98 (p > | t | = .005)**
Wilcoxon rank sum 'z'	-1.24 (p > | z | = .214)	1.95 (p > | z | = .051)*
DEA Efficient set Mean	1.015	37.47
Standard Deviation	0.271	5.14
DEA Inefficient set Mean	0.898	38.90
Standard Deviation	0.283	4.66
Difference in means 't'	1.88 (p > | t | = .067)*	1.43 (p > | t | = .591)
Wilcoxon rank sum 'z'	-1.31 (p > | z | = .193)	0.72 (p > | z | = .469)

*** significant at the 5% level of significance; * significant at the 10%*

A further exercise looks at the ranking obtained from the network DEA and the black box DEA against the accounting measures and the simple correlation. The null hypothesis is that the ranking produced by the network DEA will have no correspondence to the ranking of the banks in terms of ROA or CI and similarly for the ranking produced by the DEA exercise. Similarly the null is that there is no relationship between the scores produced by either of the benchmarking exercises and accounting measures of performance. Table 7.14 shows the results.

Table 7.14 Rank correlation tests

	ROA	Cost-Income ratio
NDEA (correlation)	0.3682** p>|t|=.0164	-.3240** p>|t|=.0364
NDEA (Spearman's rank)	0.3608** p>|t|=.0189	-.3695** p>|t|=.0194
DEA (correlation)	0.2670* p>|t|=.0874	-.1328 p>|t|=.4017
DEA (Spearman's rank)	0.2516 p>|t|=.1080	-.1054 p>|t|=.5067

** significant at the 5% level of significance; * significant at the 10%

Clearly the NDEA efficiency score outperforms the conventional DEA, although a larger sample of results may provide a more precise differentiation. The results of this exercise suggests that not only is the network framework valuable in terms of identifying the areas of inefficiency within the internal structure of the bank but also the resulting efficiency score is a better indicator of efficiency in terms of having a stronger correspondence with accounting measures of efficiency.

7.6 Conclusion

This chapter has applied a novel method of benchmarking to banking data. While network DEA is gaining credence and has seen a number of applications[86], its use in banking let alone Chinese banking has hitherto been scarce[87]. The purpose of the chapter has been threefold. First, it aims to illustrate an interesting application of the network DEA framework to the internal profit centres of Chinese banking. Second, in applying the method to the data it aims to provide an insight into the internal efficiency of Chinese banks and provide information for the manager to allocate resources so as to reap the maximum benefits in terms of relative performance both

[86] Recent applications include Hsieh and Lin (2010) to Hotels, Tsutsi and Tone (2009) to Electric utilities, Liu and Lu (2010) to R&D, Cook, Zhu, Bu and Yang (2010) to supply chain management.
[87] A recent e xception is Avkiran (2009) and Matthews (2010).

internally and externally. Third, it has shown that the results from the network DEA exercise have a closer correspondence to accounting measures of performance, which adds to it validity.

The chapter reports success in all three of these three objectives. The illustration of network DEA to banking is a natural extension of the study of Chinese banks contained in Chapters 5 and 6. Its application has revealed aspects of the internal workings of the system that lie hidden in the convention DEA method. From a managerial perspective, the method not only identifies the performance of the internal divisions relative to each other but also relative to its peer groups and benchmark units.

Appendix 7-I Network DEA: Primary inputs and outputs

Primary inputs and outputs in 2007

Banks	Corporate				Consumer				Treasury		
	Primary Input		Primary Output		Primary Input		Primary Output		Primary Input		Primary Output
	Interest Expenses to External Depositors	Operational Expenses	Net Interest income	Net Fee Income	Interest Expenses to External Depositors	Operational Expenses	Net Interest income	Net Fee Income	Interest Expenses to External Depositors	Operational Expenses	Net Interest income
CCB	39853	37787	109412	7471	39164	44799	52958	20344	13031	5015	29577
ICBC	52294	38431	115352	10778	64042	35479	62774	23400	16486	10670	46339
ABOC	28195	22685	84076	10788	49369	31803	47190	12207	8288	5418	26261
BOC	52324	31504	65617	15844	43869	29408	43330	8995	19956	10502	45059
CMB	8825	7727	18347	1621	4430	8193	8345	4666	4433	818	7210
CMBC	11327	6528	17271	855	1854	4815	3502	1,536	4308	447	1808
GDB	4053	3163	10387	410	1880	2333	4881	736	5175	216	-3946
BoCom	16563	8619	41324	2906	9628	9468	8614	4,189	9524	2127	4465
CEB	8471	4070	13797	509	1837	2276	2912	676	3025	30	1064
Citic	10739	5273	20882	826	1934	3558	3429	1258	2651	565	2322
Huaxia	6078	3415	14387	161	794	2576	1487	290	4758	227	-4038
SDB	4468	1026	7092	106	580	757	2122	190	3390	70	392
SPDB	9489	5407	20728	404	1977	3988	3044	726	2797	370	179
IBC	7366	4481	18328	543	624	3305	2923	975	12856	307	-2169

Primary inputs and outputs in 2008

Banks	Corporate				Consumer				Treasury		
	Primary Input		Primary Output		Primary Input		Primary Output		Primary Input		Primary Output
	Interest Expenses to External Depositors	Operational Expenses	Net Interest income	Net Fee Income	Interest Expenses to External Depositors	Operational Expenses	Net Interest income	Net Fee Income	Interest Expenses to External Depositors	Operational Expenses	Net Interest income
CCB	55494	31180	126010	15350	61666	45984	58417	15286	11994	2429	40628
ICBC	70350	41650	125747	24907	89903	33043	87334	18953	16043	11462	49956
ABOC	37063	32798	106407	8667	74752	50644	51375	15131	9986	10820	36105
BOC	40991.38	31402	86750	22110	50719.07	29417	44681	10948	15102	8340	31194
CMB	13107	10300	24249	2747	6817	12080	6528	4,761	4825	1140	16104
CMBC	15951	15996	17581	2925	2477	3239	4661	975	6093	5373	8138
GDB	7286.545	3592	11955	880	1734.455	2286	2638	692	3335	457	22215
BoCom	24059	9611.2	48636.18	4153.39	13479	11293.16	9859.343	4683.61	11797	2402.8	7339.4739
CEB	11165	5108	17376	1251	2571	3138	3606	906	6401	55	1354
Citic	18003	6981	28931	1719	2509	5168	5302	1,289	3581	700	2274
Huaxia	9442.609	1885	22190	461	1314.391	1199	1937	362	8926	240	-6440
SDB	7162.315	3758	9686	653	1394.685	2331	2467	300	4985	205	901
SPDB	16214	2190	20389	1005	2821	1394	5188	790	4111	279	6999
IBC	11115	5691.95	16712.83	1469.44	1274	3622.15	6226.692	1154.56	11417	724.43	5779.4742

Primary inputs and outputs in 2009

Banks	Corporate				Consumer				Treasury		
	Primary Input		Primary Output		Primary Input		Primary Output		Primary Input		Primary Output
	Interest Expenses to External Depositors	Operational Expenses	Net Interest income	Net Fee Income	Interest Expenses to External Depositors	Operational Expenses	Net Interest income	Net Fee Income	Interest Expenses to External Depositors	Operational Expenses	Net Interest income
CCB	50651	34538	124389	19884	60325	49854	62817	17882	13161	3420	22199
ICBC	59584	46233	132807	32486	85662	41551	70598	22499	13021	12123	42416
ABOC	34176	33119	102659	19983	71062	54447	57057	15657	9270	8257	21915
BOC	36731.13	34830	97918	25185	48227.26	35016	48672	13108	11170	7270	11196
CMB	11870	10982	21562	2831	7744	13835	6971	4,780	3928	1098	11801
CMBC	13024	17374	19012	3037	3036	3617	4307	1,291	3826	5449	8921
GDB	6339.102	4103	7414	978	1477.898	2418	2334	768	1950	440	21773
BoCom	21431	10677.63	49456.79	6041.47	12576	12761.07	11985.02	5357.53	13994	2083.44	6430.185
CEB	10529	6306	15819	1671	2706	3162	3611	1444	3589	65	171
Citic	14522	8962	27686	2137	3245	5327	5347	1,359	1532	574	1919
Huaxia	6885.722	2099	20961	573	1385.657	1237	1228	451	7378	225	-5350
SDB	5723.958	3898	8568	893	1257.042	2574	2838	368	1500	231	934
SPDB	16043.03	2668	22744	1236	3326.974	1572	5332	971	6374	286	6369
IBC	10614	6425.44	20040.86	1744.96	1806	3786.42	3948.191	1371.04	7752	688.44	5878.9489

Appendix 7-II Average percentage of operating expenses for three divisions

Year 2007:

Available Banks		Corporate	Consumer	Treasury	Total
SOCBs	CCB	41%	49%	5%	95%
	ICBC	44%	40%	12%	97%
	ABOC	38%	53%	9%	100%
	BOC	37%	35%	12%	85%
	Average	40%	44%	10%	94%
JSCBs	CMB	46%	49%	5%	100%
	CEB	64%	36%	0%	100%
	Citic	54%	36%	6%	96%
	Average	55%	40%	4%	99%

Year 2008:

Available Banks		Corporate	Consumer	Treasury	Total
SOCBs	CCB	38%	56%	3%	97%
	ICBC	46%	36%	13%	94%
	ABOC	35%	54%	11%	100%
	BOC	44%	41%	12%	96%
	Average	40%	47%	10%	97%
JSCBs	CMB	43%	51%	5%	99%
	CMBC	63%	13%	21%	97%
	CEB	62%	38%	1%	100%
	Citic	48%	36%	5%	88%
	SDB	59%	37%	3%	88%
	Average	55%	35%	7%	96%

Year 2009:

Available Banks		Corporate	Consumer	Treasury	Total
SOCBs	CCB	39%	57%	4%	100%
	ICBC	45%	41%	12%	98%
	ABOC	35%	57%	9%	100%
	BOC	43%	43%	9%	95%
	Average	41%	49%	8%	98%
JSCBs	CMB	41%	51%	4%	96%
	CMBC	64%	13%	20%	97%
	CEB	66%	33%	1%	100%
	Citic	55%	33%	4%	91%
	SDB	53%	35%	3%	91%
	Average	56%	33%	6%	95%

Appendix 7-III Average percentage of net fee income for three divisions

Year 2007:

Available Banks		Corporate	Consumer	Total
SOCBs	CCB	24%	76%	100%
	ICBC	31%	69%	100%
	ABOC	47%	53%	100%
	BOC	58%	42%	100%
	Average	40%	60%	100%
JSCBs	CMB	25.17%	75%	100%
	CEB	42.79%	57%	100%
	Citic	39.71%	60%	96%
	Average	36%	64%	100%

Year 2008:

Available Banks		Corporate	Consumer	Total
SOCBs	CCB	40%	60%	100%
	ICBC	57%	43%	100%
	ABOC	36%	64%	100%
	BOC	55%	45%	100%
	Average	47%	53%	100%
JSCBs	CMB	35%	65%	100%
	CMBC	66%	34%	100%
	CEB	58%	42%	100%
	Citic	46%	54%	100%
	SDB	77%	23%	100%
	Average	56%	44%	100%

Year 2009:

Available Banks		Corporate	Consumer	Total
SOCBs	CCB	41%	59%	100%
	ICBC	59%	41%	100%
	ABOC	56%	44%	100%
	BOC	55%	45%	100%
	Average	53%	47%	100%
JSCBs	CMB	35%	65%	100%
	CMBC	65%	35%	100%
	CEB	53%	47%	100%
	Citic	51%	49%	100%
	SDB	76%	24%	100%
	Average	56%	44%	100%

Appendix 7-IV Reference rate and inter-divisional pricing rate

2008	SPDB	IBC	GDB	Huaxia	BoCom	Average reference rate	Inter-divisional pricing rate
Corporate deposit rate – weighted average	2.06%	2.37%	2.32%	2.51%	2.20%	2.29%	2.84%
Consumer deposit rate – weighted average	2.30%	1.95%	2.32%	2.18%	2.46%	2.24%	2.79%

2009	SPDB	IBC	GDB	Huaxia	BoCom	Average reference rate	Inter-divisional pricing rate
Corporate deposit rate – weighted average	1.56%	1.57%	1.62%	1.53%	1.49%	1.55%	2.10%
Consumer deposit rate – weighted average	1.82%	1.56%	1.78%	1.89%	1.74%	1.76%	2.31%

Appendix 7-V Intermediate input and output

Year 2007:

Banks	Intermediate input / output Net Interest Expense (-) / Income (+) from/to Internal Divisions		
	Corporate	Consumer	Treasury
CCB	-11096	57129	-45018
ICBC	-28160	84742	-56582
ABOC	-50697	63631	-12872
BOC	-8084	51595	-42155
CMB	-390	4294	-3904
CMBC	1604	280	-1884
GDB	-1361	4509	-3148
BoCom	1966	9030	-10995
CEB	2785	1082	-3867
Citic	2078	1514	-3177
Huaxia	681	111	-792
SDB	1332	-365	-967
SPDB	-20	122	-102
IBC	903	-1305	401

Year 2008:

Banks	Intermediate input / output Net Interest Expense (-) / Income (+) from/to Internal Divisions		
	Corporate	Consumer	Treasury
CCB	-22347	76493	-52023
ICBC	-56035	123456	-67421
ABOC	-46332	81462	-35088
BOC	-3394	53831	-49750
CMB	752	5862	-6616
CMBC	-1162	-200	1362
GDB	1957	671	-2628
BoCom	2994	10255	-13250
CEB	5971	109	-6079
Citic	3942	1913	-5576
Huaxia	1534	599	-2133
SDB	2389	-1189	-83
SPDB	-283	407	-124
IBC	591	-1782	1191

Appendix 7-VI Profit Efficiency of Chinese Banks
Black Box DEA vs. Network DEA

Year 2007

	Black Box		NDEA		Division 1	Division 2	Division 3
Bank	Rank	Score	Rank	Score*	Corporate	Consumer	Treasury
CCB	1	1	1	1	1	1	1
ICBC	1	1	1	1	1	1	1
ABOC	1	1	1	1	1	1	1
BOC	1	1	1	1	1	1	1
CMB	1	1	1	1	1	1	1
CMBC	13	0.81706	14	0.577	0.4013	0.8117	0.5178
GDB	12	0.872095	1	1	1	1	1
BoCom	1	1	10	0.8231	1	1	0.4694
CEB	11	0.880839	1	1	1	1	1
Citic	1	1	11	0.8068	0.6923	0.7282	1
Huaxia	10	0.906387	12	0.6678	1	1	0.0033
SDB	1	1	1	1	1	1	1
SPDB	1	1	1	1	1	1	1
IBC	14	0.751137	13	0.5913	0.5464	1	0.2275
Mean		0.944823		0.890429	0.902857	0.967136	0.801286
Std Dev		0.08417		0.165682	0.201296	0.085129	0.345454

*Weighted arithmetic mean of Divisional Scores. Equal weight (33.33%) is given to three divisions in this study.

Year 2008

	Black Box		NDEA		Division 1	Division 2	Division 3
Bank	Rank	Score	Rank	Score*	Corporate	Consumer	Treasury
CCB	1	1	1	1	1	1	1
ICBC	1	1	1	1	1	1	1
ABOC	9	0.901599	1	1	1	1	1
BOC	1	1	9	0.8063	1	1	0.4188
CMB	1	1	8	0.9068	1	1	0.7204
CMBC	14	0.702102	14	0.4173	0.4448	0.6895	0.1176
GDB	1	1	1	1	1	1	1
BoCom	10	0.824466	11	0.6157	0.9381	0.8039	0.1051
CEB	11	0.820177	1	1	1	1	1
Citic	13	0.707431	13	0.4587	0.6712	0.6212	0.0838
Huaxia	1	1	10	0.6678	1	1	0.0033
SDB	8	0.962282	1	1	1	1	1
SPDB	1	1	1	1	1	1	1
IBC	12	0.763563	12	0.5948	0.6608	1	0.1236
Mean		0.90583		0.8191	0.908207	0.936757	0.612329
Std Dev		0.117782		0.222371	0.179161	0.130785	0.437854

*Weighted arithmetic mean of Divisional Scores. Equal weight (33.33%) is given to three divisions in this study.

Year 2009

	Black Box		NDEA		Division 1	Division 2	Division 3
Bank	Rank	Score	Rank	Score*	Corporate	Consumer	Treasury
CCB	1	1	1	1	1	1	1
ICBC	1	1	1	1	1	1	1
ABOC	9	0.942554	8 (↑)	0.8585	1	0.7348	0.8408
BOC	1	1	1	1	1	1	1
CMB	8	0.999683	9 (↓)	0.7344	0.8423	1	0.361
CMBC	13	0.794665	14 (↓)	0.5079	0.5749	0.8192	0.1297
GDB	1	1	1	1	1	1	1
BoCom	11	0.879032	11	0.7135	1	1	0.1405
CEB	10	0.924757	1(↑)	1	1	1	1
Citic	14	0.719277	10 (↑)	0.7294	0.6086	0.8126	0.767
Huaxia	1	1	12 (↓)	0.6677	1	1	0.0032
SDB	1	1	1	1	1	1	1
SPDB	1	1	1	1	1	1	1
IBC	12	0.7964	13 (↓)	0.6603	0.8527	1	0.1282
Mean		0.932598		0.847979	0.919893	0.954757	0.669314
Std Dev		0.097038		0.173273	0.14952	0.09177	0.412014

*Weighted arithmetic mean of Divisional Scores. Equal weight (33.33%) is given to three divisions in this study.

Chapter 8

Conclusion

"The archer who misses the target turns to himself and not to another for the cause of his failure." *Confucius*

"Eighty percent of results come from twenty percent of efforts" *The Pareto Principle*

This study began with the modest aim of extending my study of the efficiency of ICBC bank branches in China to that of banks in China as a whole. It soon became clear that there were two problems with this objective. First, a non-parametric based study of bank efficiency of any economy or banking system would be insufficient material for a PhD. Second, there was nothing that could be said in a fresh study of Chinese banking using *Data Envelopment Analysis* that has not already been said in almost 180 publications in Chinese economic journals on bank efficiency[88]. The consensus of findings in the Chinese scholarly literature is that the SOCBs are less efficient than the JSCBs and the JSCBs are getting more efficient over time and increasing their market share at the expense of the state-owned sector.

Studies of Chinese bank productivity using the Malmquist method tend to support the findings of standard DEA. Mostly, average productivity growth by the JSCBs has been higher than average productivity growth in the SOCBs but technical innovation has been defined by the best of the big-4 with the smaller JSCBs catching-up through efficiency gains.

[88] Not to mention the armies of Chinese MSc dissertation students in the UK, USA, Australia and mainland Europe that repeat Chinese banking efficiency studies.

This study confirms some of these findings but its main contribution is in three areas. First, it uses a bootstrap technology due to Simar and Wilson (2000a, 2000b) that provides bias-corrected estimates of efficiency and TFP productivity growth that has inferential capability. Previous studies are necessarily biased according to Simar and Wilson and they fail to provide standard error bands to the estimates, therefore there is no way that an estimate of inefficiency or productivity growth could be said to be statistically significant.

The second contribution is in the interpretation of the results. Second stage regressions are used to explain the bootstrap estimates of inefficiency and TFP growth in chapters 5 and 6. Furthermore the standard DEA method is supplanted with a network framework that opens out the working of the internal flow of funds of the bank to provide the manager a measure of internal efficiency.

Chapter 5 decomposed cost inefficiency into technical and allocative inefficiency. The interpretation given to these estimates is that technical inefficiency is Leibenstein's X-inefficiency and allocative inefficiency is symptomatic of rent-seeking behaviour. This chapter is an extension of a paper published with my supervisor in the *China Finance Review* (2007) for a smaller sample of banks and smaller time frame that examined unconditional *beta-convergence*. In this study, I find that the average level of X-inefficiency is larger than rent-seeking inefficiency and there is no difference between the Big-4 and JSCBs in the levels of X-inefficiency and rent-seeking inefficiency. However, once NPLs are removed from the loan portfolio, it turns out that X-inefficiency is higher in the JSCBs and rent-seeking inefficiency is higher in the Big-4. This completely plausible as historically, the state-owned banks have the constraint of social and political obligation to maintain a higher level of staffing and branch network than the JSCBs.

The second stage modelling of both types of inefficiency revealed differences in the speed of decline of both types of inefficiency between the Big-4 and the JSCBs when loans were unadjusted. However, once NPLs were taken out of the scene, there was no difference between the two types of banks. The results suggest that over the period 1997-2006 also showed that the speed of decline of X-inefficiency was twice that of rent-seeking inefficiency indicating the social problems and costs of shedding labour. The dynamic second-stage equations can also be interpreted as conditional beta-convergence which further separates this chapter from the published paper. The results also suggest that there may be a trade-off between X-inefficiency and rent-seeking inefficiency in the reduction of X-inefficiency as suggested by Crain and Zardkoohi (1980).

Chapter 6 applies the bootstrap technology to measuring TFP growth of the banks and its components, growth in technical efficiency and growth due to catch up. The sample covers the SOCBs, JSCBs and CCBs, which separates this chapter in terms of coverage and time period from a published paper with my supervisor in The Chinese Economy (2009). The contribution of this chapter is show that the CCBs are growing faster than the SOCBs and JSCBs by emulating best-practice and also to suggest that contrary to expectations there was no significant improvement in TFP growth of the banks in the run up to WTO. Second stage modelling of the bootstrap values revealed that efficiency gains were obtained through cost reduction and NPL divestment. These new results are used in a paper with my supervisor forthcoming in *China Economic Review* (in press).

Chapter 7 applies a novel technology that to my knowledge has yet to be used in Chinese banking. My interest in the application of the method of network-DEA was stimulated by a workshop attended during the 2008 Asia-Productivity Conference in Taipei, Taiwan. While Matthews (2010) examines the role of the risk management practice and organisational process as intermediate outputs and inputs in a serial network framework for Chinese banks, in chapter 7 I examine the efficiency of the income generating process in a parallel network process. The contribution of this chapter is to reveal the internal efficiency in the profit generating process between three cost centres, namely consumer, corporate and Treasury banking. Not only does the technology indicate to the manager the location of the relative inefficiency but by benchmarking against the best practice banks, she can learn how much inputs should be reduced to achieve full efficiency. This chapter also suggests that the efficiency scores obtained from the network DEA have a better association with accounting measures of performance such as *return on assets* and *cost-income ratio*.

Chinese banking is evolving at such a rapid pace that any study conducted using past data will be out of date before it is published. The studies conducted in this thesis are no exception. The global financial crisis, continuing reform of the regulatory process, competition from within and pressure from foreign banks provide a tension in the Chinese banking system that govern its dynamic path. The speed of reduction of inefficiency indicated in Chapter 5 suggests that allocative inefficiency (rent-seeking?) may have all but eradicated in Chinese banking. Technical

(X-inefficiency) may also have diminished to manageable proportions. The process of catch-up between the inefficient banks and efficient banks will continue to narrow the gap between them and contribute to overall productivity growth. Chinese banks will learn from its foreign counterparts and in time possibly improve on it. The researcher will have a tough time in using her research to predict the path of Chinese banking.

The technology of investigation will also develop and new methods will come to the PhD student in the future which will reveal new insights into the past behaviour of Chinese banks and their managers. However, it is difficult to say these methods will be any better in foreseeing the future of Chinese banking than informed guesses by industry practitioners. As a practitioner of 14 years experience in frontline business generation and risk management I have been able to bring my experience to this study to ask the pertinent questions. As a PhD student, I return to the practice of banking armed with techniques and insights that not only give me a macro appreciation of the banking market in China but also the means to improve operational efficiency in my area of work.

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