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Non-Performing Loans and Productivity in Chinese Banks: 1997-2006

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ISSN 1749-6101
November 2007, Updated August 2008

ACE 2226

Non-Performing Loans and Productivity in Chinese Banks: 1997-2006 (Revised)

(Revised) June 2008.

Abstract

This study examines the productivity growth of the nationwide banks of China over the ten years to 2006. Using a bootstrap method for the Malmquist index estimates of productivity growth are constructed with appropriate confidence intervals. The paper adjusts for the quality of the output by accounting for the non-performing loans on the balance sheets and test for the robustness of the results by examining alternative sets of outputs. The productivity growth of the state-owned banks is compared with the Joint-stock banks and it determinants evaluated. The paper finds that average productivity of the Chinese banks improved modestly over this period. Adjusting for the quality of loans, by treating NPLs as an undesirable output, the average productivity growth of the state-owned banks was zero or negative while productivity of the Joint-Stock banks was markedly higher.

Keywords: Bank Efficiency, Productivity, Malmquist index, Bootstrapping

JEL codes: D24, G21

Paper prepared for the All China Economics International Conference 12-14 December 2007, City University of Hong Kong. We gratefully acknowledge the helpful comments of an anonymous referee. All remaining errors are ours entirely. We also acknowledge the financial support of the British Academy SG-41928(IR) and Chinese Education Ministry projects for research on Humanity and Social Science No.04JZD0013.

1. Introduction

Banking efficiency and banking reform is a vogue topic among Chinese scholars. Banking sector reform in China, which has been a gradual and on-going process since 1978, has provided Chinese researchers with ample material for the study of efficiency dynamics in banking. A further stage of reform was announced in 1993 with the objective of creating an efficient and commercial banking sector. Following the conditions of the WTO, in theory the Chinese banking market has been open to foreign competition since the end of 2006. Chinese banks have also been encouraged to allow foreign banks and investors to take minority shareholding positions. The listing of three of the big four banks on the international exchange during 2006-7 has been heralded as a financial success not only because of the injection of foreign capital but also foreign managerial expertise to improve bank management, performance and productivity. Given the acceptance strategic investment by foreign banks in the smaller commercial banks; it is no surprise that bank efficiency in China has become a popular topic of research in recent years.

There have been a number of studies of banking efficiency that have been published in Chinese scholarly journals[1], but to date only a few studies are available to non-Chinese readers[2]. The gradualist reforms of the banking sector and the potential of foreign competition is expected to improve efficiency and productivity in the banking sector. Signs of improvement in the Chinese banking sector have included improved profitability and declining non-performing loans and objective evidence of improved performance has begun to emerge[3].

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[1] 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.

[2] A recent exception is a study using non-parametric methods by Chen et. al. (2005) and parametric methods by Fu and Heffernan (2005)

[3] See Fu and Heffernen (2006) and Matthews et al (2007a) (2007b)

This paper examines the productivity of the nationwide banks in China using the Malmquist index approach for the period 1997-2006. The Malmquist index has the advantage of being able to decompose productivity growth into technological change, which captures any expansion in the production frontier, from efficiency improvement, which captures the movement towards the efficient frontier. The Malmquist index is constructed within the framework of Data Envelope Analysis (DEA), which in turn is a non-parametric linear programming method that applies observed input and output data to create a 'best practice' frontier. A problem with the use of DEA is that it assumes the data is not a sample generated from a distribution. Therefore the data captures the true production set with deterministic certainty.

This research has three objectives. First, it aims to measure the productivity of the nationwide operating banks in China using four different models specifying the production technology of inputs and outputs. Second, it considers non-performing loans as an undesirable output. Third, it addresses the problem of inference inherent in the use of DEA as a measure of relative performance. 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.

The results are that the 4 state owned banks showed either no productivity growth or even productivity regress over the decade 1997-2006. Three out of the four models show that the JSBs outperformed the SOBs in terms of total factor productivity growth driven largely by technological progress. The econometric analysis indicates that productivity growth was negatively associated with the size of the bank. The revenue mix measured by the share of non-interest income in total revenue was positively related to productivity growth.

This paper 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.

2. Chinese Banking

In 2006, the Chinese banking system consisted of 19,797 institutions, including 3 policy banks, 4 large state-owned commercial banks (SOB), 12 joint-stock commercial banks (JSB), 113 city commercial banks (CCB), 14 locally incorporated foreign bank subsidiaries and the rest made up 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 1 below shows that the ratio of total bank assets to GDP has increased from 126%, in 1997, to 206% in 2006. The market remains is absolutely dominated by the four state owned banks, although their share of the market has been decreasing steadily through competition from the other commercial banks (JSB and CCB).

Table 1: The Chinese banking Market

Variable	1997	2000	2006
Total Assets to GDP	125.6%	147.1%	205.8%[a]
SOB Employment	1,394.8 thousand	1,4936.3 thousand	1,336.8 thousand
SOB Market share % assets	88.0%	71.4%	51.0%
NPL ratio SOB only	52.7%	31.5%	9.3%
ROAA SOB*	0.93%	0.78%	0.67%
NIM SOB*	1.8%	1.5%	2.5%
Cost-Income Ratio SOB*	48.2%	59.6%	43.3%

Sources: IMF *International Financial Statistics*, Individual Bank Annual Accounts, China Regulatory Banking Corporation website, *Almanac of China's Finance and Banking*, Fitch-Bankscope data base, National Bureau of Statistics of China, * weighted average by asset share, [a] estimated

Return on average assets (ROAA) and net-interest margins (NIM) of the SOBs 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 problem is that interest rates were heavily controlled during this period and partly the large amount of non-performing loans on the books of the commercial banks. However, the non-performing loans (NPL) ratio of the SOBs has been falling, from 53% in 1997 to 9% in 2006.

With the encouragement of the regulatory authorities, Chinese banks have in recent years, had to restructure their balance sheet, develop modern risk management methods, improve capitalization, diversify earnings, reduce costs and improve corporate governance and disclosure[4]. Faced with the potential of increased competition from the end of 2006, the commercial banks have begun the process of restructuring and reducing unit costs. Employment in the state-owned banks has declined in recent years and the major banks have worked to reduce costs as shown in the reduction in the average cost-income ratio.

Up until 1995, control of the banking system remained firmly under the government and its agencies[5]. 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[6], the pressure to reform management, consolidate balance sheets, improve risk management and reduce unit costs has increased with greater foreign exposure. Table 1A of Appendix A shows the extent of foreign ownership of individual 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. Chinese banks should exhibit less inefficiency, and strong productivity improvements between the periods 1997 and 2006, with marked improvements in the latter years.

3. Methodology and Literature

This section outlines the methodology and reviews the literature on the measurement of bank productivity in general and China in particular. Data Envelope Analysis 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

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[4] CBRC Annual Report 2006 http://www.cbrc.gov.cn/english/home/jsp/index.jsp

[5] 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.

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[7]. 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)[8]. 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;

$$y_t = \max\{\hat{y}_t : (x_t, y_t) \in S_t\} \qquad (1)$$

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

6 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

7 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).

8 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. See Ray and Desli (1997)

inefficiency) is the output distance function of Shephard (1970) or Färe (1988) defined as;

$$d_t(y_t, x_t) = \inf\{\theta : (y_t/\theta, x_t) \in S_t\} \qquad (2)$$

An illustration using the one input one output case is shown in Figure 1B of Appendix B. 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;

$$d_{t+1}(y_{t+1}, x_{t+1}) = \inf\{\theta : (y_{t+1}/\theta, x_{t+1}) \in S_{t+1}\} \qquad (3)$$

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:

$$M = \left[\frac{d_{t+1}(y_{t+1}, x_{t+1})}{d_{t+1}(y_t, x_t)} \frac{d_t(y_{t+1}, x_{t+1})}{d_t(y_t, x_t)}\right]^{\frac{1}{2}} \qquad (4)$$

In their study of productivity growth in industrialised countries, Färe et al (1994) decompose (4) for changes in efficiency (catch up) and changes in frontier technology (innovation). This can be seen by expressing (4) as:

$$M = \frac{d_{t+1}(y_{t+1}, x_{t+1})}{d_t(y_t, x_t)}\left[\frac{d_t(y_{t+1}, x_{t+1})}{d_{t+1}(y_{t+1}, x_{t+1})} \frac{d_t(y_t, x_t)}{d_{t+1}(y_t, x_t)}\right]^{\frac{1}{2}} \qquad (5)$$

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

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 choice of the variables for the input and output vectors is invariably a contentious issue in the banking literature. The literature typically identifies two approaches, the *intermediation approach* and the *production approach*. The intermediation approach is based on the principal function of the bank as a financial intermediary which raises deposits and transforms these into earning assets such as loans and other earning assets. In this approach outputs are typically interest earning assets (loans and securities) while deposits along with labour and physical capital is treated as inputs.

With the production approach, banks are viewed as producers of financial services associated with individual loan and deposit accounts. These services are produced by utilising physical capital and labour. In this approach the number of accounts of different loan and deposit categories and the number of transactions is taken as measures of outputs. In reality it is difficult to obtain data on the number of accounts and number of transactions in a given time period. In practice scholars adopt the value-added approach of Berger and Humphrey (1991) in which the real values of corresponding balance sheet items are used as measures of outputs. Therefore in this approach loans, other earning assets and deposits will be viewed as outputs while labour and physical capital is used as the inputs (for example Berg et al, 1992 below).

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 1980-89 and found productivity regress prior to deregulation and strong productivity gains due to catch-up after deregulation. They use the variant of the production approach that had long term loans, short term loans and deposits as measures of output. The Malmquist decomposition was used by Wheelock and Wilson (1999) to examine bank productivity in the USA for the period 1984-93. Using the intermediation method they separate deposits into demand deposits (non-interest paying) and other deposits (interest paying) with the latter used as an input and the former an output. They report 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 use 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) 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.

A number of studies of the productivity of Chinese banks have been conducted by Chinese scholars but with little consensus in the findings. Chen (2002) uses the production method for the period 1994-2000 and finds that productivity growth was dominated by efficiency gains over technological improvements. In contrast Ni and Wan (2006) examine much the same panel of state-owned and joint-stock commercial banks in the period 1998-2002 and find an increasing trend in productivity driven by technological improvement with the joint-stock commercial banks showing a faster growth than the large state-owned banks. Both studies use almost the same measures of output but differ in inputs[9] which may explain the difference in findings.

Tan and Wang (2006) and Hou (2006) use the intermediation method whereby deposits are part of the input set, to study the periods 1997-2003, and 1996-2002 respectively. Tan and Wang measure outputs by gross income and profit and finds that overall efficiency decreased over the period and only towards the end of the period did total factor productivity improve. The main driver of TFP was growth in technical progress. This basic finding was also confirmed by Hou (2006) who explained technological progress using panel estimation methods in terms of bank specific and environmental factors. Zhang and Wu (2005) use a mixture of the intermediation and production methods to study the periods 1999-2003. Output is measured by profit and customer deposits while inputs are physical assets, labour and non-deposit loanable funds. They find that efficiency change (catch-up) dominated technological progress in explaining the growth in TFP. However, the main

[9] Chen (2002) uses physical assets and operating expenses as inputs while Ni and Wan (2006) add the number of branches and number of employees to the input set.

improvements in technology were accrued to the state-owned banks whereas in the main catch-up was in the joint-stock commercial banks.

Sun and Fang (2007) pose the question whether the existence of foreign banks in China have stimulated increased productivity and efficiency in domestic banks. They use the value-added variant of the production approach to study the 1996-2004 period. Inputs were taken as interest expenses, operational expenses and total assets, and interest income, non-interest income and profit were taken as output. Their finding was that productivity growth occurred only in the 2001-2004 period and concludes that the impact of foreign banks was not significant.

Table 2 below provides a non-comprehensive summary of the studies on banking productivity performance in China and the rest of the world. The one common finding of the Chinese studies was that the average productivity performance of the joint-stock commercial was greater than the average performance of the state-owned banks. In all other respects there is little consensus as to whether TFP was driven by technological progress (frontier shift) or efficiency gains. Partly this was may have been due to the relatively small sample employed (typically the 14 national banks), partly to differences in the set of inputs and outputs used but importantly none of the studies employed a bootstrap methodology to provide an inferential capability that provided statistical significance.

The application of bootstrapping methods to the Malmquist productivity index is an ongoing area of research (Lőthgreen and Tambour, 1999). Relatively few studies have applied bootstrapping methods to measure banking productivity. Gilbert and Wilson 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[10].

Under the intermediation approach, bank assets measure outputs, and liabilities measure inputs whereas the production approach recognises that the bank provides intermediation services and payment services to depositors. In the production approach, physical entities such as labour and capital are inputs while deposits are a measure of output. 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 mechanism of Barnett (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. This study adopts a mixture of models that blend both the intermediation and production methods to test the robustness of the measures of bank productivity.

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[10] Alam (2001) also uses bootstrap confidence intervals to provide an inferential capacity to the point

Table 2: 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 price index)	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 Hassan (2003)	Turkey	1981-90	Labour, physical capital, deposits	Short-term loans, long-term loans, other earning assets, non-interest income	Productivity loss 1982-86. 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.
Chen (2002)	China	1994-99	Physical assets, operating expenses	Deposits, loans, profit	Technological regress but strong catch-up drives TFP. JSB exhibited higher TFP variation
Ni and Wan (2006)	China	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)	China	1997-03	Labour, physical assets, deposits	Profit, gross income	TFP growth negative until final year, driven by technological regress. Efficiency improvements
Hou (2006)	China	1996-02	Deposits, physical assets, op. expenses	Interest earnings, non-interest earnings	Declining trend in technical efficiency. TFP driven by technological progress

estimates of productivity of large US banks.

Zhang and Wu (2005)	China	1999-03	Labour, non-deposit funds	Deposits, Profits	TFP driven by efficiency catch-up. SOBs driven by technical progress

Specifically, we consider four types of models. Model 1 is one where there are two inputs, the number of employees (*LAB*), and fixed assets (*FA*) and four outputs, total deposits (*DEP*), total loans (*LOANS*), other earning assets (*OEA*), and non-interest income (*NII*). In this respect Model 1 is based on the production approach of Berger and Humphrey (1991) but following Casu et al (2004), Isik and Hassan (2003), and Drake (2001) we include non-interest income as an output. 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 is one where there are 3 inputs (*LAB, FA, DEP*) and three outputs selected under the conventional intermediation approach (*LOANS, OEA, NII*).

Following Park and Weber (2006)[11], we also separate desirable from undesirable outputs. 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. Park and Weber found that adjusting loans for NPLs accentuated the general finding that technical progress outstripped efficiency regress in Korea.

Subtracting non-performing loans from the stock of loans for each bank creates a new output variable (*LOANSQ*) which replaces total loans in models 1 and 2 to create models 3 and 4 respectively. Another argument for adjusting loans for NPLs is to mitigate the effect of the large loan portfolios held by the big-4 SOBs on the efficiency calculation. The unadjusted loan portfolio would bias the efficiency score upwards for the SOBs which have the largest share of loans but also the highest proportion of NPLs. To our knowledge this has not been previously examined in the Chinese context.

4. Banking data

This study employs annual data (1997-2006) for 14 banks; four state-owned banks (SOB), and ten national joint-stock commercial banks (JSB). Data for one of the joint-stock banks was unavailable for 2004 - 2006 (China Everbright); and in those years 13 banks data were used. The total sample consisted of 137 bank-year observations. The main source of the data was Fitch/Bankscope. Other sources were individual annual reports of banks and the *Almanac of China's Finance and Banking* (various issues). The choice of banks was based on the fact that they face a common market and compete nationwide.

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. In general, balance sheet data are 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). Table 3 presents the summary statistics of the input and output data for the full sample 1997-2006 as an indicator of the scale of the variables used. The high standard deviation and the range of the figures is an indication of the dominance of the 4 state owned banks. Since we are examining the movements in productivity over a period of nine years, the nominal values of data were deflated by the consumer price index.

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[11] See also Berg et (1992)

Table 3: Output-Input Variables 1997 - 2006 (million RMB) per bank/year

Variable	Description	Mean	SD	Min	Max
LOANS RMB mill	Total stock of loans	721175	935119	5915	3533978
OEA RMB mill	Investments	472282	690894	9198	3790661
NII RMB mill	Net Fees and Commissions	1730	3400	-3386	16344
LOANSQ RMB mill	Loans less NPLs	568421	762874	1290	3400040
LAB	Total Employed	112119	170526	1186	541525
DEP RMB mill	Total stock of Deposits	1157869	1548240	16522	6802964
FA RMB mill	Fixed assets	21409	29099	356	112272

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

The choice of input data is well established in the literature and draws precedence from the work of Drake (2001), Canhoto and Dermine (2003), Noulas (1977), Isik and Hassan (2003) and Tan and Wang (2006). The choice of outputs is conventional in so far as loans and other earning assets are commonly specified in the banking literature. However, the inclusion of non-interest earnings as an output measure and non-performing loans as a negative output, blends the production and intermediation approaches. The use of non-interest income as a measure of bank output is increasingly common as discussed in Casu et al (2004), Isik and Hassan (2003), Mukherjee et al (2001) and Drake (2001). In China non-interest income remains a modest contribution to bank revenue but it is increasing in significance. In 1997 non-interest income accounted for only 0.3 per cent of total revenue but by 2006 it was 11.2 per cent. Although small by Western banks standards, the dramatic rise in fee-generated income in the space of a decade is testimony to the growing importance of this area of banking business to China.

5. Empirical Results

Tables 4a - d show the estimates of total factor productivity and its decomposition under CRS for each of the banks in the data set for the full period 1997-2006. As noted in footnote 8, 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. The bootstrap algorithm of Simar and Wilson (1999) uses the conical hull of the observed 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. Consequently, the null hypothesis of CRS was tested against the alternative of VRS for each year using the third test of Banker (1996) in Models 1 and 2, which is a Kolmogorov-Smirnoff test. Except for the year 2001, the null of CRS could not be rejected and we proceeded cautiously with the assumption of CRS[12].

In this exercise the availability of a full balanced panel meant that only 13 banks were used. The tables also reports the 95% confidence intervals for each estimate obtained from 1000 bootstrap generations for each bank based on Simar and Wilson (1999). Appendix C outlines the steps of the bootstrap algorithm. A '*' by each estimate denotes that it is significantly biased (outside the standard error band). The banks have been grouped into the 4 SOBs, the 5 top JSBs and the 5 bottom JSBs. Tables 4 a-c show that out of 156 estimates of the Malmquist productivity growth and decomposition, 102 have significant statistical bias. It is clear therefore that little

[12] However, this result must be interpreted with caution in the light of the Monte-Carlo findings of Simar and Wilson (2002). It was also found that only 5 out 10 years could not reject CRS in models 3 and 4 which compounds the caution relating to the assumption of CRS.

confidence can be placed on the point estimates of total factor productivity in using the 4 variants of inputs and outputs.

Table 4a: Productivity Measures, Model 1, Standard error bounds in parenthesis

Bank	Malmquist	Catch-up	Frontier shift
Agricultural Bank of China	0.4621 (0.4363, 0.6859)	0.6296 (0.4300, 0.7389)	0.7341 (0.7305, 1.2099)
Bank of China	1.0621* (1.3761, 1.7874)	1.5543* (0.7425, 1.4656)	0.6833* (0.9278, 2.0212)
China Construction Bank	0.3116 (0.2545, 0.4180)	0.4436 (0.3050, 0.5217)	0.7024 (0.6215, 1.0199)
Industrial Bank Co Ltd	0.4894* (0.7372, 1.3205)	1.0000 (0.6335, 1.6044)	0.4894* (0.6561, 1.2327)
Bank of Communication	0.9259 (0.6883, 0.9761)	1.0423* (0.4715, 0.8599)	0.8883* (1.0231, 1.5074)
CITIC Industrial Bank	0.6281* (1.3119, 2.0213)	1.0000 (0.5361, 1.1254)	0.4894* (1.3931, 2.7048)
China Merchant Bank	0.5592* (0.9006, 1.5268)	1.0000* (0.4588, 0.9739)	0.5592* (1.1502, 2.3151)
Shanghai-Pudong Development Bank	0.5942* (0.7556, 1.1320)	1.0000 (0.5105, 1.0343)	0.5942* (0.9303, 1.5676)
China Minsheng Bank	0.6499* (0.9083, 1.3805)	1.0000 (0.6441, 1.2821)	0.64992* (0.9751, 1.4536)
Industrial Bank Co Ltd	0.4894* (0.7372, 1.3205)	1.0000 (0.6335, 1.6044)	0.4894* (0.6561, 1.2327)
Hua Xia Bank	0.7093* (0.9560, 1.4560)	1.0466 (0.6129, 1.2131)	0.6777* (1.0582, 1.6218)
Shenzhen Development Bank	0.2175* (0.4585,0.7715)	0.4805 (0.3422, 0.7243)	0.4527* (0.8317, 1.4134)
Guangdong Development Bank	0.7846* (0.8366, 1.1353)	0.9739 (0.7654, 1.2902)	0.8056 (0.7992, 1.374)

Table 4b: Productivity Measures, Model 2, Standard error bounds in parenthesis

Bank	Malmquist	Catch-up	Frontier shift
Agricultural Bank of China	1.0036* (0.8485, 0.9465)	0.9486 (0.8897, 1.0510)	1.0579* (0.8601, 0.9919)
Bank of China	1.0280 (0.9646, 1.3188)	1.0000 (0.6089, 1.0397)	1.0280* (1.1270, 1.6736)
China Construction Bank	1.0431 (0.9046, 1.0864)	1.0602 (1.0069, 1.2527)	0.9839* (0.7978, 0.9675)
Industrial and Comm Bank China	1.1170* (0.8838, 1.0331)	1.0020 (0.8156, 1.0058)	1.1148 (0.9634, 1.1446)
Bank of Communication	0.9259 (0.6883, 0.9761)	1.0423* (0.4715, 0.8599)	0.8883* (1.0231, 1.5074)
CITIC Industrial Bank	0.6281* (1.3119, 2.0213)	1.0000 (0.5361, 1.1254)	0.4894* (1.3931, 2.7048)
China Merchant Bank	0.7499* (1.0295, 1.4790)	1.0000 (0.5783, 1.1059)	0.7499* (1.1757, 1.8527)
Shanghai-Pudong Development Bank	0.5942* (0.7556, 1.1320)	1.0000 (0.5105, 1.0343)	0.5942* (0.9303, 1.5676)
China Minsheng Bank	0.6499* (0.9083, 1.3805)	1.0000 (0.6441, 1.2821)	0.64992* (0.9751, 1.4536)
Industrial Bank Co Ltd	1.2107 (1.0093, 1.8375)	1.0000* (0.2596, 0.8031)	1.2107* (2.0305, 3.4981)
Hua Xia Bank	0.7093* (0.9560, 1.4560)	1.0466 (0.6129, 1.2131)	0.6777* (1.0582, 1.6218)
Shenzhen Development Bank	0.7150* (0.7507,1.0617)	0.9809 (0.9279, 1.5380)	0.7290 (0.6284, 0.8519)
Guangdong Development Bank	0.7846* (0.8366, 1.1353)	0.9739 (0.7654, 1.2902)	0.8056 (0.7992, 1.374)

Table 4c: Productivity Measures, Model 3, Standard error bounds in parenthesis.

Bank	Malmquist	Catch-up	Frontier shift
Agricultural Bank of China	0.3847* (0.3874, 0.6276)	0.5236 (0.3389, 0.6070)	0.7347* (0.7928, 1.3809)
Bank of China	1.0627* (1.3868, 1.8048)	1.5543* (0.7126, 1.4605)	0.6833* (0.9209, 2.1134)
China Construction Bank	0.2264 (0.1952, 0.3440)	0.3172 (0.1691, 0.3548)	0.7136* (0.7498, 1.3435)
Industrial and Comm Bank China	0.6195* (0.7269, 1.1843)	0.9258 (0.5826, 1.0977)	0.6691* (0.8202, 1.4910)
Bank of Communication	1.0276* (1.9608, 3.1976)	1.7090* (0.8470, 1.6662)	0.6013* (1.4537, 2.7264)
CITIC Industrial Bank	0.5449* (1.8324, 2.7091)	1.0000 (0.5347, 1.1527)	0.5449* (1.7883, 3.8510)
China Merchant Bank	0.5746* (0.8876, 1.5353)	1.0000* (0.4406, 0.9721)	0.5746* (1.1544, 2.3589)
Shanghai-Pudong Development Bank	1.7830* (0.8117, 1.5887)	1.0000* (0.0225, 0.2021)	1.7830* (6.1013, 16.9400)
China Minsheng Bank	0.3847* (1.2096, 1.9079)	0.8131 (0.4365, 0.9262)	0.4731* (1.5395, 3.1522)
Industrial Bank Co Ltd	0.4974* (0.8627, 1.5605)	1.0000 (0.5769, 1.5683)	0.4974* (0.7606, 1.571)
Hua Xia Bank	0.4087* (1.759, 2.7824)	0.9979 (0.5516, 1.1367)	0.4096* (1.8503, 3.6536)
Shenzhen Development Bank	0.2194* (0.4682, 0.8424)	0.4128 (0.2041, 0.5287)	0.5314* (1.2121, 2.4761)
Guangdong Development Bank	0.4253* (0.5894, 1.0280)	0.6073 (0.3294, 0.7123)	0.6345* (1.0925, 2.0750)

Table 4d: Productivity Measures, Model 4, Standard error bounds in parenthesis.

Bank	Malmquist	Catch-up	Frontier shift
Agricultural Bank of China	0.4974* (0.7083, 0.9396)	0.4461 (0.3099, 0.4644)	1.1151* (1.754, 2.5327)
Bank of China	1.0280* (1.1311, 1.8204)	1.0000 (0.6098, 1.0099)	1.0280* (1.5509, 2.3578)
China Construction Bank	0.5242* (0.6633, 0.9885)	0.4251 (0.2239, 0.4551)	1.2332* (1.8189, 3.1432)
Industrial and Comm Bank China	0.5205* (0.5934, 0.8620)	0.3920* (0.1800, 0.3875)	1.32377* (1.8985, 3.3426)
Bank of Communication	0.9442* (1.0735, 1.6368)	0.9672* (0.4055, 0.8915)	0.9762* (1.4834, 2.7995)
CITIC Industrial Bank	0.8718* (2.1857, 4.4171)	1.0004 (0.5667, 1.1919)	0.8715* (2.2100, 5.4806)
China Merchant Bank	0.7762* (1.5344, 2.3761)	1.0000 (0.5933, 1.1702)	0.7762* (1.5909, 2.8590)
Shanghai-Pudong Development Bank	2.4432 (1.8925, 4.1542)	1.0000* (-0.0561, 0.4120)	2.4432 (2.0436, 41.644)
China Minsheng Bank	0.8922* (1.7427, 3.6739)	1.0000 (0.7186, 1.4233)	0.8922* (1.6044, 3.5296)
Industrial Bank Co Ltd	1.2846* (1.6997, 3.4786)	1.0000* (0.2804, 0.7386)	1.2846* (3.7000, 6.6736)
Hua Xia Bank	0.8463* (1.9575, 3.4540)	1.0547 (0.6823, 1.3436)	0.8024* (1.7472, 3.7025)
Shenzhen Development Bank	0.7492* (1.0595, 2.1492)	0.5636 (0.2986, 0.6328)	1.3294* (2.0061, 5.0530)
Guangdong Development Bank	0.6581* (0.9730, 1.4484)	0.6687 (0.3897, 0.7972)	0.9841* (1.4231, 2.7491)

Mean estimates were obtained from 1000 bootstrap generations for each pair of years for the 14 banks for the period 1997-2003 and 13 banks for 2004-2006. To make the presentation easier, the 14 banks were sub-divided into the big-4 SOBs, the next largest five banks and the bottom five banks. Tables 5 a – d report the weighted (by asset share) mean values of the bias adjusted bootstrap estimates of the models 1 – 4.

Under the intermediation approach, bank assets measure outputs and liabilities measure inputs whereas the production approach recognises that the bank provides intermediation services and payment services to depositors. In the production approach, physical entities such as labour and capital are inputs while deposits are a measure of output. 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 mechanism of Barnett (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.

This study adopts a mixture of models that blend both the intermediation and production methods to test the robustness of the measures of bank productivity. The tables present the Malmquist productivity index, the increase in efficiency (catch-up) and technical progress for each model with indicators of statistical significance. An indicator of significance states that the bias-corrected estimate is significantly different from unity (no change).

Table 5a: Weighted means of productivity and decomposition. Model 1 Loans Unadjusted, 2 inputs 4 outputs

Model	Year	SOB-4	Top-5 JSB	Lower-5 JSB
Model 1 Malmquist TFP	1998/97	1.0474***	1.3861***	2.2090***
	1999/98	0.9692	1.2426	1.0510
	2000/99	0.9058***	0.9819***	0.7940***
	2001/00	0.8987***	0.9044***	0.7840***
	2002/01	0.9721***	1.0741**	0.9207***
	2003/02	0.9500***	0.9787	0.8456***
	2004/03	1.0642***	1.0182	1.3756**
	2005/04	1.1154***	1.1085***	0.8609***
	2006/05	0.8760***	1.0267	0.9082***
	1997/06	0.9409	1.8350***	1.0949
Model 1 Efficiency (Catch-up)	1998/97	0.9124	1.0034	1.4908*
	1999/98	0.9452	1.1260	1.2334
	2000/99	1.0980	0.8731	0.6195***
	2001/00	0.8275***	0.9687	0.8937
	2002/01	0.8654***	1.0479	1.0795
	2003/02	0.9903	1.1818**	0.9505
	2004/03	0.9857	0.9661	0.8777
	2005/04	1.3681***	1.3681	0.9143
	2006/05	0.9840	0.9998	0.8815*
	1997/06	0.9033	0.9271	0.7994*
Model 1 Technical Progress	1998/97	1.1726	1.4022**	1.4497**
	1999/98	1.0421	1.1467	0.8831
	2000/99	0.8708*	1.1677	1.3617**
	2001/00	1.0886	0.9553	0.8864
	2002/01	1.1364*	1.0920	0.8863
	2003/02	0.9720	0.8478	0.8940
	2004/03	1.0852	1.0802	3.1427***
	2005/04	0.8203***	1.1873	0.9609
	2006/05	0.8996	1.0505	1.0376
	1997/06	1.0271	2.0031***	1.4296**

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

Table 5b: Weighted means of productivity and decomposition. Model 2 Loans Unadjusted, 3 inputs 3 outputs

Model	Year	SOB-4	Top-5 JSB	Lower-5 JSB
Model 2 Malmquist TFP	1998/97	1.0202**	1.1099***	1.1557***
	1999/98	0.9841	1.0370	1.0490**
	2000/99	1.0235	0.9912	1.0032
	2001/00	1.0541**	0.8929***	0.9244***
	2002/01	1.0086	1.1093***	1.0451*
	2003/02	0.9721***	0.9543***	0.9375***
	2004/03	0.9963	1.0349	1.2462
	2005/04	0.9854	0.9658	0.9593
	2006/05	1.0457***	1.0029	0.9393***
	1997/06	0.9912	1.0240	1.1471
Model 2 Efficiency (Catch-up)	1998/97	1.0405	0.9381	0.9043
	1999/98	1.1994***	1.1455*	1.1022
	2000/99	1.0488	0.9010	0.8745**
	2001/00	1.0125	0.9869	0.9987
	2002/01	0.8162***	1.0159	1.0708
	2003/02	0.9309***	0.9433	0.9197
	2004/03	0.9182**	0.9492	0.7849***
	2005/04	0.9648	0.9759	1.1429**
	2006/05	1.0176	0.9866	0.9463
	1997/06	0.9527	0.7797***	0.9015
Model 2 Technical Progress	1998/97	0.9844	1.1927***	1.4968***
	1999/98	0.8301***	0.9274	0.9632
	2000/99	0.9949	1.1197	1.1812***
	2001/00	1.0488	0.9106*	0.9324
	2002/01	1.2783***	1.1936***	0.9829
	2003/02	1.0470*	1.0169	1.0224
	2004/03	1.12812**	1.1264	4.0554***
	2005/04	1.0250	1.0114	0.8581***
	2006/05	1.0267	1.0295	1.0020
	1997/06	1.0618	1.3290***	1.5166***

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

Table 5c: Weighted means of productivity and decomposition. Model 3 Loans adjusted, 2 inputs 4 outputs

Model	Year	SOB-4	Top-5 JSB	Lower-5 JSB
Model 3 Malmquist TFP	1998/97	1.0100***	1.5740***	2.1236***
	1999/98	0.9720	1.2321***	1.1266***
	2000/99	0.9968	1.0392	0.9340
	2001/00	0.9642*	0.8812***	0.7990***
	2002/01	0.9793**	1.0601*	0.9093***
	2003/02	0.8831***	0.9373***	0.8687***
	2004/03	0.9795***	0.9385**	1.0715***
	2005/04	1.0511***	1.0657***	0.8861***
	2006/05	0.8767***	1.0450	0.9231**
	1997/06	0.8417**	1.9463***	1.2565**
Model 3 Efficiency (Catch-up)	1998/97	0.8843	1.0907	1.5923**
	1999/98	0.6997***	0.9417	0.8562
	2000/99	1.1559	0.9098	0.7959***
	2001/00	0.8287***	0.9444	0.9223
	2002/01	0.8870**	1.0569	1.0153
	2003/02	1.0111	1.1687***	0.9818
	2004/03	0.9930	0.9019	1.1145
	2005/04	1.4162***	1.0081	0.9886
	2006/05	0.9859	1.0115	0.8873
	1997/06	0.6838***	0.8446	0.7248**
Model 3 Technical Progress	1998/97	1.1748	2.6606***	1.3130*
	1999/98	1.4604***	1.3542***	1.3452**
	2000/99	0.9022	1.1531	1.1975*
	2001/00	1.1664**	0.9460	0.8696*
	2002/01	1.1312*	1.1268	0.9308
	2003/02	0.8836***	0.8254***	0.8896
	2004/03	0.9907	1.0559	0.9773
	2005/04	0.7441***	1.0741	0.9055
	2006/05	0.8990	1.0573	1.0505
	1997/06	1.1938	3.5628***	1.8122**

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

Table 5d: Weighted means of productivity and decomposition. Model 4 Loans adjusted, 3 inputs 3 outputs

Model	Year	SOB-4	Top-5 JSB	Lower-5 JSB
Model 4 Malmquist TFP	1998/97	1.0391***	1.3754***	1.1822***
	1999/98	0.8773***	1.0900**	1.1222***
	2000/99	1.1032***	1.0970***	1.2217***
	2001/00	0.9939	0.9010***	0.9312***
	2002/01	0.9744***	1.1029***	1.2080***
	2003/02	0.9518***	1.0137	0.9672
	2004/03	0.9875	0.9834	1.0341
	2005/04	0.9715***	0.9738	0.9351
	2006/05	1.0685***	1.0194	0.9416***
	1997/06	0.9510	2.1974***	2.0477***
Model 4 Efficiency (Catch-up)	1998/97	0.7628***	0.9536	0.8164*
	1999/98	0.9692	1.0873	1.0199
	2000/99	0.9187	0.8688*	0.9381
	2001/00	0.9613	1.0122	1.0216
	2002/01	0.7993***	1.0862	1.2010***
	2003/02	0.9162***	0.9287	0.8144***
	2004/03	0.9973	0.9070	1.0098
	2005/04	0.9479**	0.9685	1.1590**
	2006/05	1.0294	0.9966	0.9228
	1997/06	0.4329***	0.7152***	0.6496***
Model 4 Technical Progress	1998/97	1.5591***	2.5068***	1.76969***
	1999/98	0.9169	1.0391	1.1148
	2000/99	1.2116***	1.2832***	1.34073***
	2001/00	1.0391	0.9014*	0.9205
	2002/01	1.2802***	1.1168	1.0084
	2003/02	1.0438	1.1029*	1.1886***
	2004/03	1.0006	1.0955	1.0388
	2005/04	1.0289	1.0253	0.8307***
	2006/05	1.0374	1.0357	1.0301
	1997/06	2.3739***	3.3114***	2.1407**

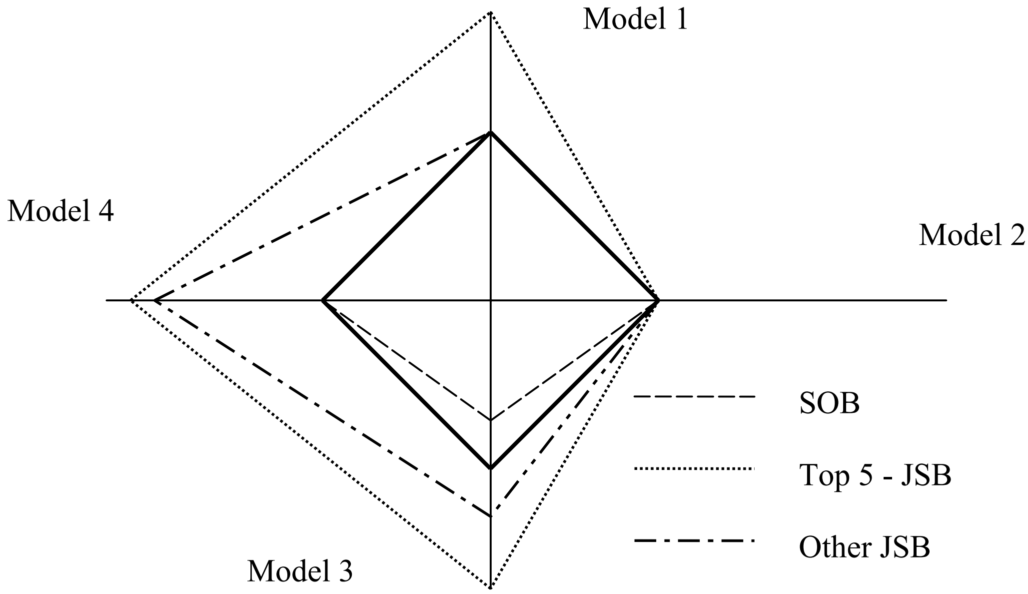
*** significant at the 1%, ** significant at the 5%, * significant at the 10%

The tables show the movements in productivity growth figures for each year, but the overall growth for the period 1997-2006 is more revealing. The difference between model 1 and model 2 is that deposits are treated as an output in model 1 and as an input in model 2. The ideal composition would have a proportion of demand deposits as an output (production of payment services) and time deposits as input for intermediation services. Therefore we can interpret the results from the two models as boundary values for actual productivity growth. The figures show that there was significant productivity growth on the basis of model 1 for the top 5 JSBs driven by technical progress (frontier shift) but no significant growth in productivity for the SOBs or the lower 5 JSBs. With model 2, there was no significant growth in overall productivity for all three groups although there was significant technical progress outweighed by efficiency regress for the top 5 JSBs.

Models 3 and 4 treat NPLs as an undesirable output and the results are much clearer once NPLs have been taken out of the picture. The JSBs register strong productivity growth in the case of model 3, driven by technological progress, whereas the SOBs show significant productivity regress. With model 4 the JSBs again register strong productivity growth driven by technological progress (frontier shifts) but also significant mean efficiency regress. In the case of the SOBs there is strong productivity regress with model 3 but no significant growth with model 4.

We can interpret the results from Models 3 and 4 in the following way. All the banks have had some productivity growth driven largely by technological progress. However, this has favoured the benchmarks banks that have improved productivity faster than the rest leading to average efficiency regress. Figure 1 below summarises the performance of the three groups of banks according to the type of model against the null hypothesis of zero productivity growth (Malmquist index M = 1)

Figure 1



The bold line indicates the null of zero overall productivity growth (M = 1) for the full time period 1997-2006 under the assumption of each model. The SOBs show no significant productivity growth and show a significant productivity regress on the assumption of model 3, whereby NPLs are treated as a negative output and deposits are treated as an output. The top 5 JSBs show significant productivity growth in the case of model 1, model 3 and model 4 while the lower 4 JSBs show significant productivity growth in the case of model 3 and model 4. The adjustment for NPLs indicates a marked difference in performance between the SOBs and the JSBs over the full period. This is not surprising as the SOBs had a larger proportion of NPLs over this period than the JSBs.

In the case of model 2, we can see from Table 5b that all three groups of banks do not exhibit significant productivity growth at the 10% level of significance. While this is consistent with the results for the other three models concerning the SOBs, it is not a consistent result for the JSBs. One possible explanation is that loans growth for both groups of JSBs matched closely the growth in its deposits[13]. Thus using deposits as an input will gravitate the results towards neutrality in the growth of TFP. In the case of the top 5 JSBs, technical progress using Model 2 is offset by average efficiency regress. In all 4 models the top 5 JSBs exhibit strong technical progress which favoured the benchmark banks. In this sense the results are consistent with the other three models.

However, in the case of the bottom 5 JSBs Table 5b shows that strong significant technical progress was matched by neutral efficiency gains giving the implausible result of zero productivity growth (in the statistical sense). However, according to Simar and Wilson (2000) the bias corrected bootstrap has a mean square error that is larger than the uncorrected bootstrap, but the gap declines with increased number of bootstraps. The mean level of TFP growth for the period 1997-2006 for the lower 5 JSBs was 1.1471 with a lower bound of 0.988 at the 10% level of significance. The potential for a type 2 error in inference is strong. An increased number of bootstraps could produce a tighter 90% range where the mean estimate of TFP will be significantly different from unity which would be consistent with the decomposition of strong technical progress and zero catch-up.

We now turn to an analysis of the characteristics of productivity growth by examining its determinants. The raw material of what is to be explained on a yearly basis is the bootstrap mean value of the Malmquist productivity index for each bank under the assumption of each of the models 1-4. Table 6 shows some selected results from panel corrected heteroskedastic adjustment[14]. The bank specific variables are;

[13] The top 5 JSBs had average loan growth of 17.8% and deposit growth of 18.7% and for the lower 5 JSBs the figures were 21.0% and 21.7% respectively. The SOBs experienced a fall in the loan-deposit ratio from 73% to 54%.
[14] The standard fixed effects model was rejected on conventional F test for each of the models.

LSIZE is the natural logarithm of total assets, COST is the cost-income ratio, *SOB* is a dummy variable for state-owned banks, *FOR* is the foreign ownership stake given by Table 2, *FEE* is the proportion of revenue from net fees and commissions, *IPO* is a dummy variable for the year of the bank listing on the domestic stock exchange.

Table 6: Dependant variable: Malmquist productivity index. Panel heteroskedastic adjusted standard errors; No: of obs=123, No: of groups=14.

Variable	Model 1		Model 2		Model 3		Model 4	
Intercept	3.51***	2.38***	1.83***	1.71***	3.49***	2.45***	2.07***	1.99***
LSIZE	-.19*	-.11***	-.06***	-.06***	-.19*	-.11**	-.08***	.08***
COST	-.003	-	-.001	-	-.001	-	-.001	-
SOB	.315	-	.152**	.133**	.312	-	.133	.128
FOR	.017**	.015***	.007***	.007***	.010	.008*	.002	.002
FEE	.018***	.019***	.002*	.002***	.016***	.017***	.003*	.003**
IPO	-.129	-.152	.004	-	-.146**	-.176**	-.020	-
R-sq	0.1505	0.1310	0.1185	0.1078	0.1757	0.1533	0.1362	.1316

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

The two consistent determinants for all four models is size, measured by total assets, and the composition of revenue. The sign on the variable LSIZE suggests that the larger the bank, the lower the growth in productivity. An indicator of managerial flexibility and capability to diversify output is given by the composition of earnings from off-balance sheet sources. The sign on FEE suggests that the greater the composition of fee income in revenue, the greater the productivity growth. There is weak evidence that foreign financial institutional shareholding is associated with higher productivity growth but this affect is weakened when NPLs are treated as an undesirable output. There is no evidence that productivity growth is obtained through cost reduction and there is little evidence that state-owned banks have a productivity advantage. The extension of ownership from state and local government to the domestic public through listing on the domestic exchanges has had mostly no statistical effect on productivity. Where significant, this variable enters with a negative sign.

6.0 Conclusion

This paper has used the Malmquist decomposition to quantify the productivity growth of Chinese banks in 1997-2006. The advantage of use 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. In common with many other studies of Chinese banks, we find that in general the performance of the JSBs outstrip the SOBs.

Using deposits as an output, only the top 5 JSBs showed significant productivity gains driven by strong technological advances over this period. When deposits are treated as an input, productivity growth is zero with technological gains being offset by average efficiency regress. But there is weak evidence that technical progress in the bottom 5 JSBs is translated into positive TFP growth.

Once NPLs are treated as an undesirable output the picture becomes clearer. At best there is on average no productivity growth for the SOBs and at worst, there is average productivity regress. Technological gains have been swamped by average efficiency losses. However, the JSBs show strong productivity growth driven by spectacular innovation effects. While adopting technologies that improved the productivity of the average JSB, the average JSB failed to keep up with the benchmark banks and moved further away from the frontier. Treating the different models as boundary values the story is that at best the SOBs experienced zero productivity growth and at worst experienced productivity regress, whereas the JSBs at best experienced strong productivity growth and at worst experienced zero productivity growth.

An econometric analysis confirms that the larger banks had lower productivity growth than smaller banks. This may be explained by the political and social opposition the SOBs face in attempting to restructure factor inputs and downsize as a means of improving performance. It also explains the concentration of the activity of the Asset Management Companies on the SOBs in aiding the divestiture of their large NPL holdings. Higher productivity growth was also associated with banks that had diversified into non-interest earnings activity. The higher the proportion of revenue from non-interest earnings indicates greater management flexibility and an increase in the productivity of the banks.

The results obtained are necessarily backward looking and describe the evolution of the Chinese banking system in the decade to 2006. The market share (of assets) of the SOBs has fallen from 89% in 1997 to 51% in 2006 and the remarkable growth of the JSBs is reflected in their productivity performance. However, it should be borne in mind that this represents the growth phase of the JSBs and may not be sustained once the banks reach the maturity phase.

The analysis also revealed weak evidence that the stronger the foreign financial institutional stake in the bank, the greater the productivity growth of the bank. However, as Appendix A shows, this aspect is relatively recent in the sample frame and until further data is available, requires a cautious assessment.

Appendix A

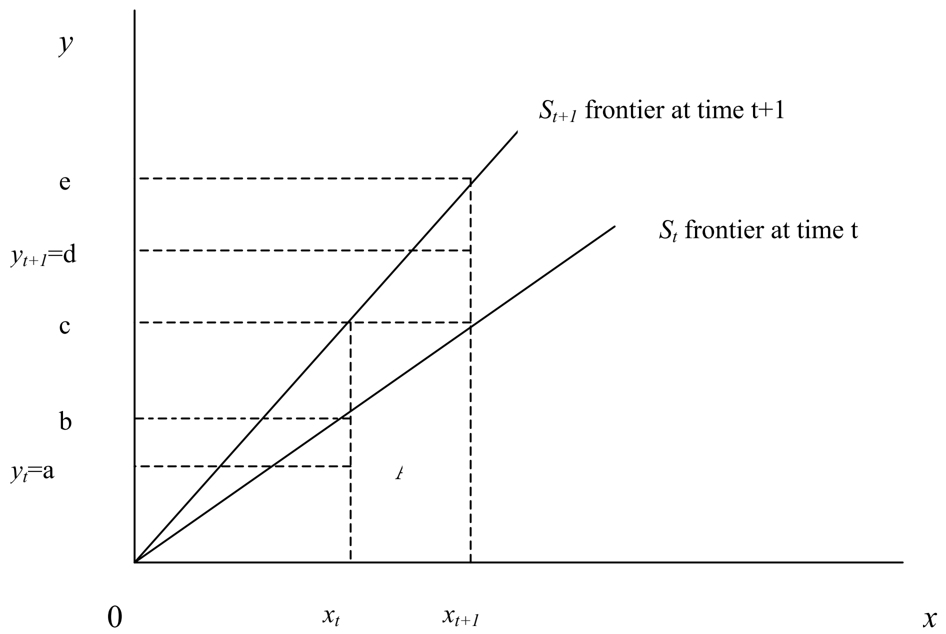
Table 1A: Foreign Bank Ownership Stake

Chinese Bank	Foreign Bank	Stake – first acquisition
Bank of Beijing	ING	19.2% - Aug 2007
Bank of Shanghai	HSBC (8%) and other foreign institutions	18.0% - Dec 2001
Shanghai Pudong Development Bank	Citigroup(4.6%), Barclays, J P Morgan, Morgan Stanley	5.3% - Dec 2003
Tianjin City Commercial Bank	ANZ	20% - July 2006
Industrial Bank	Hang Seng (12.8%), Tetrad Ventures	20.8% - April 2004
Bank of Communications	HSBC (19.9%), Barclays, J P Morgan,	21.5% - June 2004
Xian City Comm. Bank	Scotia Bank	12.4% - Oct 2004
Jinan City Comm. Bank	C Bank of Australia	11% - Nov 2004
Shenzen Develop. Bank	Seahaven (17.9%), Barclays, Nikko Asset Management	19.3% - Dec 2004
China Minsheng Bank	Fullerton (7.9%), Barclays, J P Morgan	8.9% - Jan 2005
Hangzhou City Com Bank	C Bank of Australia	19.9% - June 2007
China Construction Bank	Bank of America (8.5%) Fullerton, Other foreign	15.2% - June 2005
Bank of China	RBS-China(8.3%), Fullerton, Other foreign	20.6% - Aug 2005
ICBC	Goldman Sachs, Allianz, American Express	10% - Aug 2005
Nanjing City Com. Bank	BNP Paribas	19.2% - Oct 2005
China Bohai Bank	Standard Charter Bank	20.0% - Dec 2006
Guangdong Development Bank	Citigroup (20%), IBM	24.7% - Dec 2006
Hua Xia Bank	Deutsche bank (9.9%) Sal Oppenheim Jr	14.0% - Oct 2005

Source: *Business Week* October 31, 2005 and *Fitch Bankscope*

Appendix B

Figure 1B



Points A and B represent observations in period's t and t+1 respectively. The rays from the origin S_t and S_{t+1} represent frontiers of production for period's *t* and *t+1* respectively. Relative efficiency is measure in one of two ways. The relative efficiency of production of a firm at point A compared to the frontier S_t is described by the distance function $d_t(y_t,x_t)$ = 0a/0b. But compared with the period *t+1* frontier S_{t+1}, it is $d_{t+1}(y_t,x_t)$ = 0a/0c. The relative efficiency of production of a firm at point B compared to the period *t+1* frontier S_{t+1} is $d_{t+1}(y_{t+1},x_{t+1})$ = 0d/0e. Compared with the period *t* frontier S_t, the relative efficiency is $d_t(y_{t+1},x_{t+1})$ = 0d/0c.

Appendix C

The estimates of the distance functions for N banks over 2 periods are obtained following the standard method outlined in Färe et al (1992) 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 $\mathrm{A} = \lfloor \hat{d}_t(y_{1,t}, x_{1,t}), \hat{d}_t(y_{2,t}, x_{2,t}) .... \hat{d}_t(y_{N,t}, x_{N,t}) \rfloor$ and $\mathrm{B} = \lfloor \hat{d}_{t+1}(y_{1,t+1}, x_{1,t+1}), \hat{d}_{t+1}(y_{2,t+1}, x_{2,t+1}) .... \hat{d}_{t+1}(y_{N,t+1}, x_{N,t+1}) \rfloor$. 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 $(4/5\mathrm{N})^{1/6}$ 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

$$\Gamma = (1 + h^2)^{-1/2}\left(\Delta^* + h\varepsilon^* - C\begin{bmatrix} \bar{\delta}_{.1} & 0 \\ 0 & \bar{\delta}_{.2} \end{bmatrix}\right) + C\begin{bmatrix} \bar{\delta}_{.1} & 0 \\ 0 & \bar{\delta}_{.2} \end{bmatrix}$$ 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 λ^* 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 1000 times to get a set of 1000 bootstrap estimates.

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