Bank Productivity Changes in two Asian Giants

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Abstract

China and India have experienced rapid economic growth over the last two decades, and finance is central to growth. Banking is the dominant form of finance in both countries, so an interesting question is what are productivity advances, and the forces driving them, among Chinese and Indian banks? This study looks at the banking sectors' trends in total factor productivity (TFP) changes between 2000 and 2007, and its components. We also consider the relationship between TFP growth and individual banks' financial performance. We find TFP growth is largely driven by technical progress/innovation. It is somewhat faster in China than India and strongest among large banks. Foreign banks display slower growth than locally owned banks but the association between ownership or listings and TFP change is ambiguous. In China TFP growth continues to outpace India's but there may be some deceleration with a shift in the underlying components. TFP advances are found to exert important influences on bank-specific equity prices.

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1. Introduction

After centuries of quiescence, the last two decades have witnessed very rapid economic growth in the world's two most populous countries, China and India. Finance plays a crucial role in growth and in both economies the banks dominate the provision of external finance during the period of studied. For China bond and equity market capitalisation was 26% and 45% respectively in 2002, compared to 115% and 137% for the US. In India, the comparable figures are 36% and 43%.[3]

The main aim of the paper is to look at recent productivity advances in Chinese and Indian banks. First, this study focuses on trends in total factor productivity (TFP) changes in their banking sectors between 2000 and 2007; annual fluctuations are also examined. Second, the components of TFP growth are analysed, along with variations within and between the two countries, and across banks that differ in size, ownership, and listing characteristics. Third, we assess how closely estimates from non-parametric (Data Envelopment-DEA) and parametric (Stochastic Frontier-SFA) analyses concur and what this implies for their relative merits. Finally, we address the question of how TFP growth is related to standard measures of individual banks' financial performance such as return on equity.

This study adds to knowledge by providing explicit comparisons of bank TFP growth in these two giant emerging markets. It brings more recent data into play: one advantage of looking at the period 2000-7 is that most major bank reforms have had a chance to "bed down" by this time. It is the first banking study outside the OECD area to compare and contrast the DEA and SFA approaches. It also adds to the literature by assessing the empirical relationship between TFP change and share prices.

The main findings are first, that TFP growth is largely driven by technical progress/innovation. It is somewhat faster in China than in India and strongest in large banks, though in China, there may be some deceleration with a shift in the underlying components. Second, the influence of ownership varies between the countries and listing is similarly ambiguous. Foreign banks display slower growth than locally owned banks in both countries. Third, for India, the period covering the early 2000s are found to be broadly in line with the aggregate TFP growth findings of most studies that covered the 1990s. Fourth, the Divisia (using SFA) and Malmquist (using DEA) TFP changes are not notably different in aggregate, but often generate pronounced differences in estimates of different components that drive TFP

[3] Source: Heffernan (2005), Table 6-3.

growth. For reasons discussed in section 5, particular attention is paid to the Divisia results. Fifth, TFP advances are found to exert important influences on bank-specific equity prices.

The paper is organised as follows. Section 2 provides a brief review of the banking sectors in India and China. Sections 3 and 4 describe the methodology and data, respectively. Instead of a formal literature review, the analysis of the results in section 5 includes comparisons of the findings with other studies of India and China. Appendix 1 summarises the findings from key papers on TFP changes in emerging markets.[4] Section 6 concludes.

2. Overview of Banking Sectors in China and India

Banking reform in China

Communist China began with a highly centralised economic and financial system. Regulated by the Ministry of Finance, the People's Bank of China (PBC) was the financial hub of each State Economic Plan. All funds were channelled to the PBC, which allocated them in accordance with each plan. The PBC controlled currency in circulation, managed foreign exchange reserves, set interest rates, collected all deposits (via 15,000 branches and sub-branches), and made loans, almost exclusively to state-owned enterprises (SOEs). In addition, there were three specialised banks, none of which operated as independent entities. The Bank of China (BOC),[5] a subsidiary of the PBC, was responsible for all foreign exchange and international transactions. The Agricultural Bank of China (ABC), set up in 1951, operated under the PBC and dealt with the agricultural sector. Rural Credit Cooperatives, which pre-date the PBC, provided basic banking services for their members – mainly peasant farmers. In 1954, the China Construction Bank (CCB) was established as a fiscal agent for the Ministry of Finance, with control over the administration of funds for major construction projects, in line with the relevant economic plan.

In 1978, China embarked upon major economic reforms to increase economic efficiency and improve resource allocation. Emphasis was placed on decentralisation and the gradual introduction of a market based economy within a communist political system. China established a two-tier financial system consisting of the PBC and five state–owned entities: four commercial banks and one insurance firm – the People's Insurance Company of China. Each specialised in a certain sector of the economy, effectively ruling out competition between them. For example, the CCB (now independent of the Finance Ministry), acted as banker to state construction firms, as well as managing the fixed assets of all state enterprises. In 1984, the Industrial and Commercial Bank of China (ICBC) was established to assume the

[4] For a review of the literature on developed markets, see Casu et al. (2004).
[5] Established in 1912 as a private bank.

PBC's deposit taking function as well as granting loans to state owned industrial and commercial enterprises in urban areas. The "tier one" PBC implemented monetary policy and acted as the key regulator.

Phase 2 commenced in 1992. Within the financial sector itself, functional segmentation was reduced to encourage greater competition among the state-owned banks (SOBs). All four used nation-wide branches[6] to lend to households and corporates (mainly state owned enterprises or SOEs). From 1986 universal banking was permitted but it was short-lived. A new law (1995) forced banks to divest themselves of all trust, securities and insurance affiliates. New "joint stock" banks were created and expected to operate on a commercial basis. Entry of foreign bank branches/offices was allowed within certain cities. In 2003, The PBC transferred most of its regulatory powers to the newly created China Banking Regulatory Commission (CBRC), together with insurance (CIRC) and securities regulatory commissions (CSRC).

2002 marked the third phase of reform, which included IPOs for three SOBs, encouraged foreign investment in China's financial firms, and more recently, Chinese investment in foreign firms. Foreign investment in Chinese banks began in earnest in 2002[7] but is still quite modest. By 2007, foreign equity ownership ranged from 5% to 24.7% (25% is the maximum allowed) in 20 Chinese banks.[8] The main banking players which are the focus of the TFP studies in this paper include:[9]

- Four state-owned commercial banks (BOC, CCB, ICBC, ABC) which provide nationwide wholesale (to large and medium sized enterprises) and retail banking services. Overseas branches serve Chinese customers abroad. The average assets of these four banks over the period (1985-2002) were RMB 2,400 billion (or $290 billion).
- Eleven joint stock banks, with shares owned by the state, private sector, and some foreign concerns. The state and/or state-owned enterprises (SOEs) hold 60% to 70% of non-tradable shares - only four have a small proportion of their shares traded on the stock market. These banks tend to focus on offering retail and wholesale banking services in medium sized and large cities. Their average assets over the period were RMB 321 billion ($38.8 billion).
- City commercial banks (124) owned by local government, local enterprises, and

[6] At the end of 1992, each bank had an average of about 30,000 branches and sub-branches, though there were large variations. The ABC had over 56,000 and at the other extreme the Bank of China had 1,352. The ICBC had just under 32,000.
[7] The first case was in 1996. The Asian Development Bank paid US$20 million to buy 1.9% shares in the China Everbright Bank.
[8] Matthews and Zhang (2009), Table 2.
[9] The banks excluded are three rural commercial banks, which are like their urban counterparts but operate in rural areas, and rural Credit Coops (35,544), which offer basic banking services to locally based residents and local enterprises based in rural areas.

households. They offer commercial banking services to city-based small and medium sized enterprises and residents, though they are also trying to attract larger firms headquartered in their respective cities, which would normally do business with a state bank. There is some customer overlap with the 758 urban credit cooperatives, though the coops offer basic banking services (taking deposits, making small loans) to residents and small local firms in urban areas.

- In 2004, there were roughly 204 foreign bank subsidiaries, which are allowed to offer nation-wide foreign exchange facilities to foreigners and Chinese citizens. Since 2005, some supply Renminbi services in 20 cities as part of China's World Trade Organisation[10] commitment to give foreign banks completely open access to Chinese markets by the end of 2006.

So what are the challenges facing the Chinese banking? Though three of the state-owned banks were partly privatised, and other banks (e.g. the joint stocks) compete with them, the state owns, on average, about 78% of the big 4 and 41% of the joint stocks.[11] This extensive state ownership is potentially a problem if these banks are protected from failure and/or are required to meet national policy objectives such as financing strategically important SOEs that might otherwise be insolvent. Certain developed economies could face similar problems if the recent nationalisation of some Western banks (a consequence of the 2007 credit crisis) turns out to be less than temporary.

Non-performing loans (NPLs) are also a problem. In 2004, the NPL rate was just under 16% for the big four banks, and 5% to 12% for the joint stock and city commercials. These figures exclude all the bad debt transferred from banks to four asset management companies ("bad" banks) prior to the partial listing of the CCB, BOC and ICBC in 2005-2006. Also, the definition of bad loans itself is narrower than the one used by Basel. Taking these points together, Allen et al. (2008) estimate that NPLs could be double the official rates. The government could acquire these NPLs by drawing down about 10% of its foreign reserves but at the expense of future moral hazard problems.

Other challenges include the absence of a fully convertible currency. Capital inflows and outflows are controlled as are some prices of key utilities such as energy and water. Though non-state-owned enterprises produce two-thirds of China's manufacturing output, the *Economist* (2008) reports that privatising bigger SOEs has largely ceased, including those that dominate key sectors - banking, telecoms, energy and the media. Overall, bank efficiency

[10] China became a member of the World Trade Organization in 2001.
[11] Sources: http://money.finance.sina.com.cn for listed banks; 2007 annual reports for non-listed banks.

could be increased by reducing NPLs and state control while improving corporate governance, accounting and legal standards. Such changes could further stimulate economic activity.

Banking Reform in India

Unlike China, India inherited a well developed "western" banking system at the time of independence in 1949 and until 1979, had never operated a centralised economic system to the degree witnessed in China. Parts of the economy have always had a thriving private sector, private property ownership[12] is permitted and in its early years the financial system (inherited from the British) operated largely unrestricted. Nonetheless, by the 1960s the economy was characterised by rigid state controls designed to meet the objectives of national five year economic plans. The state effectively assumed control of the financial sector to raise saving and investment rates and channel funds to priority sectors: agriculture and heavy industry. In 1969 the 14 largest commercial banks were nationalised to ensure funds were allocated in line with the economic plan, and to create branches in rural and semi-urban areas which had no direct access to bank services. To increase the amount of agricultural credit regional rural banks were established in 1975. In 1980, another six commercial banks were nationalised. Specialised development financial institutions (DFIs) were created, such as the National Bank for Agricultural and Rural Development (1982) to coordinate and supervise the rural credit cooperatives. Other DFIs included the Export Import Bank of India and the National Housing Bank.

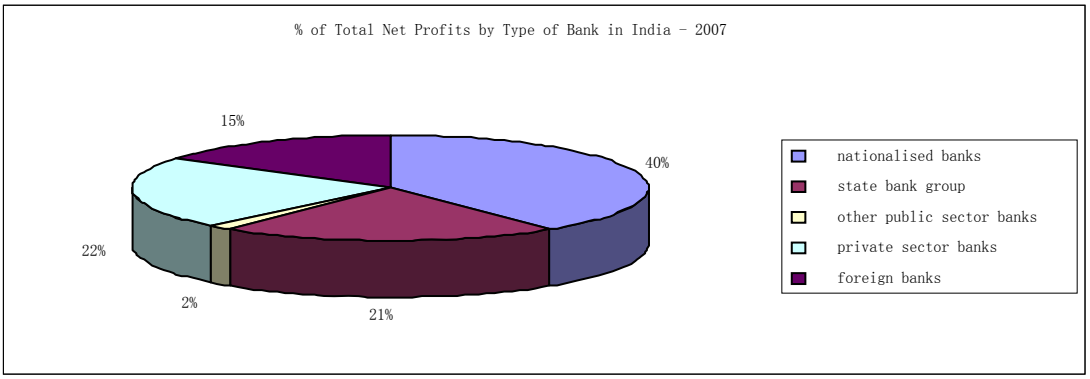
In 1991 India suffered severe balance of payments problems because of the effects of the first Gulf War in 1990-91 with soaring oil prices and a large, rapidly growing fiscal deficit. This prompted a programme of economic reform, which included increasing the role of the private sector in a more open economy, encouraging market forces to play a greater role in resource allocation, and redefining the state's role in economic development. Not all the planned reforms were implemented but the economy witnessed the successful removal of controls over industry, an end to import licensing, dismantling tariffs, and allowing foreign ownership (either 100% or majority) in most sectors. India became one of the fastest growing emerging markets in the 1990s, averaging about 6.7% per annum between 1992 and 1997 – which has been attributed to a number of factors including reforms. Between 1997 and 2002, the growth rate slowed to an average of 5.4%, increasing pressure for more reform.

Here we concentrate on banking reforms which were part of the plan to create a market based

[12] In China, there was no formal recognition of private property ownership until October 2007 when the Property Law took effect.

financial sector. The objectives were to keep banks financially sound while encouraging more competition, and reducing government ownership of state banks. The key changes included adopting the Basel 1/2 supervisory standards and a new bank supervisor (Board for Financial Supervision-1994),[13] revisions to deposit/loan rate controls, lower liquidity and cash reserve ratios and reduced state ownership of banks. New private bank licenses were granted and restrictions on foreign banks' operations lifted. For example, foreign and domestic banks face the same regulations for accepting deposits and loans. Nonetheless, the state continues as a major player. Chart 1 shows the types of banks and their respective percentage contributions to this sector's total net profit.

Chart 1: The Indian Banking Sector in 2007



Source: Reserve Bank of India (2008b), Appendix Table III.16; authors' calculations. Our definition of public banks includes the nationalised banks, the state bank group and other public sector banks, which together account for 63% of net profits in 2007. This chart excludes about 200 regional rural commercial banks, 1900 urban and regional coops and nationalised rural coops and banks.

The state owns 50 to 100% of 28 banks, including the state bank group (the State Bank of India and its seven associates), nationalised banks and other public sector banks - which explains the term "public" banks used here – a bank which is at least 50% owned by the state. Legislation passed in 2000 to reduce the government's minimum shareholding in state banks to 33% has not become law. As part of their liberalisation policy, the government allowed the entry of 9 new private banks, in addition to the 25 that existed before; more new entrants have since been approved by the Reserve Bank.

There are concerns about the performance of Indian banks and financial institutions, and state ownership. Poor asset quality is another issue. In 2001 NPLs ranged between 14% and 17% depending on the analyst (e.g. RBI vs. private), similar to China and above the safe level of 1-3%. Also, the loan classification system falls below international standards. Under pressure to satisfy Basel 1, banks engage in *evergreening*, or rolling over of interest and principal on over

[13] Though part of the Reserve Bank of India, it is supposed to be autonomous.

due debt.[14]

Despite introducing risk management systems and committees in some banks are unwilling to force corporate borrowers to repay their loans due to an ineffective legal system with opaque bankruptcy laws, especially in the area of foreclosure. However, a Securitisation Bill[15] (2002), allows secured creditors to recover security more easily without judicial interference. Guidelines on asset recovery have been issued, resulting in several banks establishing asset reconstruction companies and debt recovery tribunals.

For years, the government has identified certain priority sectors (e.g. agriculture, micro and small enterprises, retail trade and education) that must receive 40% of total loans made by commercial banks. The state banks actually exceed this requirement. Not only is lending to other sectors reduced but there are fewer incentives for due diligence and monitoring. Among the priority sector loans about 23% are classified as non-performing. Private and foreign banks have tried to avoid them by investing in government bonds. Productivity is lower and operating costs high (due to high wage costs) compared to other developing countries.

To conclude, India's economic "miracle", with its impressive growth rates, is likely the result of reforms that made key sectors of the economy more market based. However, the banking reforms have some way to go. Their key problems include the state ownership and control of the banking sector, too many rules on lending to priority sectors, and the absence of clear bankruptcy laws. Given these restrictions, it is surprising that the percentage of NPLs is not higher, though this probably reflects a more serious problem: not enough loans are being made in an economy still largely dependent on its banking sector for finance.

Though the banking sectors in China and India emerged from quite different backgrounds they share three key attributes. First, the two countries are heavily dependent on bank finance to support economic growth. Second, both banking sectors are still dominated by state ownership, which may explain high NPL rates and inefficiency. Finally banking reform in each country has been gradual.

3. Methods

Productivity is a popular measure of firm performance in the literature. It is defined as the ratio of the outputs(s) that a firm produces to the input(s) it uses. Total factor productivity

[14] See Heffernan (2005).
[15] The Securitisation and Reconstruction of Financial Assets and Enforcement of Security Interest Act (SARFAESI), April, 2002.

(TFP) change describes the rate of change of outputs relative to inputs.[16] In the banking literature total factor productivity change is usually estimated using non-parametric methods, for example, data envelopment analysis (DEA), and/or the parametric techniques such as stochastic frontier approach (SFA). Their key differences are discussed in section 5. We employ both approaches to estimate an input (as opposed to output) distance function[17] because unlike the West the key bank outputs in these countries are subject to greater regulatory control.[18] Based on these estimates, Chinese and Indian bank total factor productivity (TFP) changes are computed, which consist of several components. Expressed in terms of a production function or its dual, the cost function, these include:

- Technical Change (TΔ): shifts in the production function/downward movement of the AC (average cost) curve due to the adoption of superior technology, and
- Technical Efficiency Change (TEΔ), which measures the "catch up" effect or movement toward best practice technology due to changes such as improved resource allocation or reduced organisational slack. More precisely, it is made up of PTEΔ + *Z* under Divisia or PTEΔ*SEΔ under Malmquist (see below for more detail), where:
    (a) Pure Technical Efficiency Change (PTEΔ): movement towards the production function/ downward movement toward the AC curve
    (b) Scale Effects (SEΔ): increasing, decreasing or constant returns to scale or a rightward movement ALONG the downward sloping cost curve, assuming IRS (increasing returns to scale), and
    (c) *Z* Effects (*Z*): environmental effects (such as economic booms or increased competition) that are allowed to have a bank-specific impact. If favourable, they cause a drop in the AC curve. These can only be estimated in a parametric framework (e.g. Divisia) - see below.

Data Envelopment Analysis (Non-Parametric)

Early applications of the Malmquist (1953) total factor productivity (TFP) change index include Caves et al. (1982a and 1982b). It measures the TFP change between two time points by computing the ratio of the distances of each time point relative to a common technology. For a detailed derivation see, among others, Casu et al. (2004). The estimating equation for the Malmquist TFP index (hereafter denoted by M to conserve space) is calculated as:

[16] For extensive discussion, see Fried et al. (1993), Kumbhakar and Lovell (2000), and Coelli, et al. (2005).
[17] An input distance function measures the extent to which a bank is input efficient in producing a given set of outputs. Shephard (1953, 1970) defines the input distance function as: $d(x, y) = \max\{\lambda : (x/\lambda) \in L(y)\}$ where the input set *L(y)* represents the set of all input vectors, *x*, which can produce the output vector, *y*.
[18] The econometric software (DEAP2.1 and FRONTIER 4.1) used for DEA and SFA in this study was developed and supplied by Professor Tim Coelli, to whom we are grateful.

$$M\left(x^t, y^t, x^{t+1}, y^{t+1}\right) = \frac{d_v^{t+1}(x^{t+1}, y^{t+1})}{d_v^t(x^t, y^t)} \qquad (PTE\Delta)$$

$$\times \left[\frac{d_c^{t+1}(x^{t+1}, y^{t+1}) / d_v^{t+1}(x^{t+1}, y^{t+1})}{d_c^t(x^t, y^t) / d_v^t(x^t, y^t)} \right] \qquad (SE\Delta)$$

$$\times \left[\frac{d_c^t(x^{t+1}, y^{t+1})}{d_c^{t+1}(x^{t+1}, y^{t+1})} \times \frac{d_c^t(x^t, y^t)}{d_c^{t+1}(x^t, y^t)} \right]^{1/2} \qquad (T\Delta) \qquad (1)$$

where

y: output vector
x: input vector
t, t+1: two adjacent time periods
v: variable return to scale (VRS) technology
c: constant return to scale (CRS) technology

Between periods *t* and *t+1*, M>1 implies TFP growth;[19] M=1 shows constancy while M<1 is TFP regress, and similarly for PTEΔ, SEΔ, and TΔ.

Stochastic Frontier Analysis (Parametric)

As shown by Färe and Primont (1995), the input distance function is the dual of the cost function. Cost inferences can be drawn from an input distance function and since it is used in both the parametric and non-parametric approaches, this method also facilitates a direct comparison between the two. The Divisia series for TFP change[20] (hereafter denoted as D to conserve space) is generated in a multiple-output/input context – for more detail see Kumbhakar and Lovell (2000) or Kumbhakar and Wang (2007).

Expressed in continuous time, the formulae for Divisia TFP change are:

$$T\hat{F}P = \hat{Y} - \hat{X} = \sum_m R_m \hat{y}_m - \sum_n S_n \hat{x}_n = (1 - v^{-1}) \sum_m R_m \hat{y}_m + \dot{d} - \dot{u} + \sum_j I_j \dot{z}_j \qquad (2)$$

where Y and X are vectors for *m* outputs and *n* inputs; $\hat{\zeta}$ and $\dot{\zeta}$ are proportionate and absolute time derivatives for a variable ζ, and $v^{-1} \equiv -\sum_{m=1}^{M} \frac{\partial \ell nd}{\partial \ell ny_m}$, $R_m \equiv \frac{\partial \ell nd / \partial \ell ny_m}{\sum_m \partial \ell n \ln d / \partial \ell ny_m}$,

$S_n \equiv \partial \ell nd / \partial \ell nx_n$ and, for bank j, $I_j \equiv \partial u / \partial \ell nz_j$.

The last four terms of RHS of (2) capture first, scale effects (SEΔ); second, technical change (or innovation - TCΔ); third, pure technical efficiency change (PTEΔ); last, the *Z* or environmental effects. Input distance functions must satisfy the properties of symmetry of

[19] To obtain TFP growth in Malmquist, take the log then the difference of the M number, which is a level index.
[20] Unlike Malmquist, Divisia reports the proportionate growth in TFP from the previous date.

cross effects, and linear homogenous in inputs. These restrictions are:

$$\beta_{nj} = \beta_{jn}\,,\ \delta_{ml} = \delta_{lm}\,,\ \sum_{n=1}^{N}\beta_n = 1\,,\ \sum_{n=1}^{N}\rho_{nm} = \sum_{n=1}^{N}\beta_{nj} = \sum_{n=1}^{N}\lambda_{nt} = 0$$

They can be applied by normalising all inputs by one input. This yields the translog function:

$$\begin{aligned} -\ln x_{1it} &= \alpha_0 + \sum_{n=1}^{N}\beta_n \ln(x_{nit}/x_{1it}) + \sum_{m=1}^{M}\delta_m \ln y_{mit} + \sum_{n=1}^{N}\sum_{m=1}^{M}\rho_{nm}\ln(x_{nit}/x_{1it})\ln y_{mit} \\ &+ \frac{1}{2}\left[\sum_{n=1}^{N}\sum_{j=1}^{N}\beta_{nj}\ln(x_{nit}/x_{1it})\ln(x_{jit}/x_{1it}) + \sum_{m=1}^{M}\sum_{l=1}^{M}\delta_{ml}\ln y_{mit}\ln y_{lit}\right] + \eta_t t + \frac{1}{2}\eta_{tt}t^2 \\ &+ \sum_{n=1}^{N}\lambda_{nt}t\ln(x_{nit}/x_{1it}) + \sum_{m=1}^{M}\gamma_{mt}t\ln y_{mit} - u_{it} + v_{it} \end{aligned} \tag{3}$$

where

y: output vector
x: input vector
t: a time trend variable
u: inefficiency term following half-normal distribution
v: normally distributed random error term

Following Kumbhakar et al. (1991) and Battese and Coelli (1995), the inefficiency term (*u*) is assumed to be half normally distributed with its mean dependent on some exogenous variables (*z*) as well as the time trend variable (*t*).

$$u_{it} \sim N(\mu_{it}, \sigma_u^2) \text{ with } u_{it} \geq 0 \text{ and}$$

$$u_{it} = \xi_0 + \xi_i t + \xi_2 t^2 + z_{it}'\psi + \varepsilon_{it} \tag{4}$$

The method of maximum likelihood is used for simultaneous estimation of the parameters of the stochastic frontier translog distance function (3) and the inefficiency effects model (4). The Divisia total factor productivity (TFP) change of bank *i* between period *t* and *t+1* is computed from the estimated parameters. Cumulative TFP indices are constructed from the annual data for both M and D, so that TFP growth in year *t* is defined as $[(TFP_t/TFP_{t-1}) - 1]$. TFP is normalised at 1 in 2000.

4. Data

The data are collected from Bankscope, the Almanac of China's Finance and Banking, the Reserve Bank of India, and banks' annual reports. It is a balanced panel of annual data on major commercial banks in China (26) and India (63) over the period 2000-2007, totalling

712 observations.[21] The Chinese sample includes the state-owned, national joint-stocks, large city commercials, and foreign banks. India's consist of the public sector, domestic private and foreign banks. They account for 85% and 92% of total assets in respectively, China and India in 2007. A pool of sample banks from both countries is used in the estimations, so the results reflect the dispersion of TFP changes within the whole sample, making cross-county comparisons more dependable.[22]

This study uses the "intermediation approach"[23] to specify outputs and inputs. Banks act as the intermediary between depositors and investors. Hence, inputs include:

- Purchased funds: total deposits plus borrowed funds
- Labour: proxied by overhead expenses - data on the number of employees are unavailable
- Physical capital: fixed assets

Outputs consist of:

- Total net loans: aggregate total loans less non-performing loans
- Other earning assets: total assets less the sum of total loans and total fixed assets
- Off-balance-sheet (OBS) activities: non-interest income - data on the size/value of OBS activities are unavailable.

To assess how bank characteristics as well as environmental factors affect banks' TFP changes (through their impact on technical efficiency), this study employs several bank/country-level variables. The ratio of equity to total assets measures the extent to which bank owners put their own money at risk relative to total assets. The higher the ratio the more protection there should be against dud assets. A listed dummy variable measures the impact of shareholding/corporate governance reform of the domestic banks. It takes a value of unity if the bank is listed on a stock exchange; zero otherwise. Studies on corporate governance[24] suggest listed firms which are monitored by investors (especially institutional) are more accountable, so should outperform the non-listed banks.

Three ownership dummies are constructed to estimate the effects of different types of ownership on technical efficiency. They are valued at one if the bank is a

[21] Throughout the paper, for India, the year 2000 refers to the financial year beginning in April, 1999 and ending in March, 2000.

[22] Most cross-country studies (e.g. Brissimis et al. 2008; Casu et al. 2004) carried out the estimations for each country separately, which means that the TFP change indices only reflect the dispersion of TFP changes within each sample. Therefore comparisons of TFP growth between countries cannot be made. An exception is Koutsomanoli-Filippaki et al. (2009), who used a pooled dataset to estimate bank efficiency and productivity change in 11 Central and Eastern European countries.

[23] See Heffernan (2005), p. 474-6 for a discussion of the intermediation and production approaches.

[24] See, among others, McConnell and Servaes (1990) and Shleifer and Vishny (1986).

public/private/foreign bank; zero otherwise. A bank is defined as "public" if the state owns more than 50% of it. It is private/foreign when domestic private /foreign investors hold more than 50% of its shares. Three size (measured by assets) dummies are created to assess its impact on technical efficiency - banks are divided into three groups by tertile. It is argued that larger banks with extensive branch networks and a broad customer base are more likely to use new technology to improve technical efficiency. To avoid an exact singular matrix problem, the private bank ownership and medium sized bank dummies are dropped from the estimation.

Two country-level variables are included to assess whether the macroeconomy or competition in the banking sector affects technical efficiency. Rising real GDP growth may be linked to increases in technical efficiency. The five-bank concentration ratio is defined as the sum of the asset share of the five largest banks (in terms of asset size) in each country divided by total banking assets in a country's banking sector. If market concentration is an indication of market power then higher profits might lead to wasted resources thereby undermining technical efficiency. But if it reflects the survival of more efficient banks, concentration could boost overall efficiency. A time trend variable (t) is included to differentiate between the technical and pure efficiency changes as shown in equations (3) and (4). The t^2 term in equation (4) allows for the possibility that technical efficiency is non-monotonic.

Table 1 summarises the descriptive statistics of the variables used in the study over the sample period 2000-2007. There is considerable variation in the financial characteristics of the sample banks as well as in the country-specific control variables. China's average annual real GDP growth rate is higher, at 10%, compared to 7% for India. On average Chinese banks are substantially larger than those in India, measured by both inputs and outputs. 65% of China's commercial banks are in the large bank category, against 20% in India. China's banking system is far more concentrated - the top five banks control three-quarters of the market. But on average, capital adequacy is lower in China (6%) than India (9%). India has nearly twice China's share of listed banks. A quarter of India's banks are foreign owned, three times the number for China. Just over half of China's banks are private against just under one-third of India's.

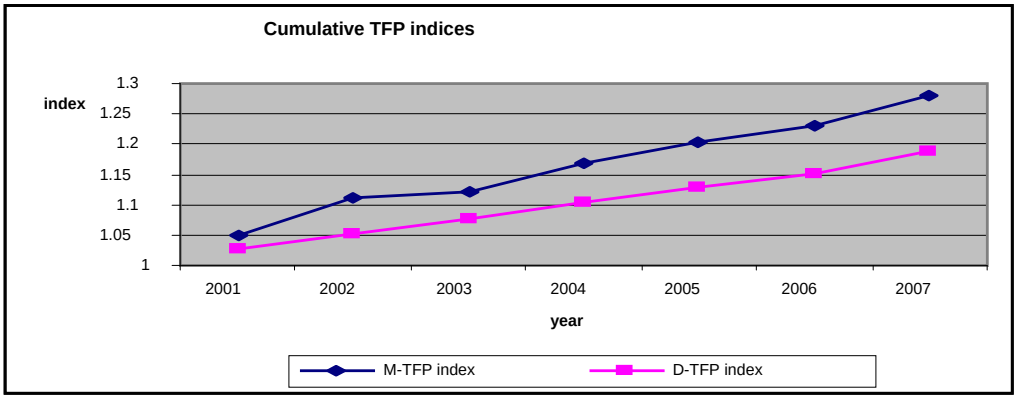
(Table 1 inserted here)

5. Analysis of the Econometric Results

As illustrated in Figure 1, both the Malmquist (M) and Divisia (D) indices show that in aggregate, banks in China and India experience steady TFP growth relative to the base year, 2000. But both are moderate – barely half these two economies' real GDP growth rates in the

period, which is consistent with Kaldor's (1966) observation that productivity grows more slowly in services than in manufacturing. The annual average TFP growth rate is 0.46% faster in China using D (see Table 2[25]), which may be linked to China's higher annual average real GDP growth rate during the sample period (see Table 1). Decomposition of both measures of TFP change show technical progress or innovation to be the key factor testifying to an outward shift in the best-practice frontier.

Figure 1: Comparison of the Cumulative TFP Indices



Notes: M-TFP index: Malmquist total factor productivity (TFP) index; D-TFP index: Divisia TFP index.

Zhao et al. (2007) (using Malmquist) report an annual average TFP growth rate of 5.1% for banks in India - about 1% higher than our M result of 3.8%, for a slightly different estimation period (1998-2005).[26] Other studies using SFA report similar Indian bank TFP growth rates even though the sample years differ. For example, Bhattacharyya et al. (1997) cover 1970-92 and report TFP growth spikes (as high as 7%) immediately after banking reform. But their overall annual average growth rate of 2.6% is only slightly higher than the 2.35% obtained (using SFA) for our period of study: 2000-2007. Sensarma (2006) find annual average growth rates (1986-2000) are 2.2., 2.8, and 5.3 per cent for foreign, public and state Indian banks, respectively. Kumbhakar and Sarkar (2003) argue their findings (growth rates of 2.9% for private; rising to 3.3% for public banks over the period 1985-96) do not support the idea that deregulation results in a sustained TFP acceleration. Our study appears to confirm this observation because average annual growth rates vary little over the periods. Is Zhao et al. an outlier because they use the M approach? We discuss this issue below.

(Table 2 inserted here)

Our findings for these banking sectors are lower than those of Cates (2009) computed for the whole of the Indian and Chinese economies. They were, respectively, 2.7% and 4% computed between 1999 and 2008 and are attributed to the rapidity with which existing/new

[25] The difference is 0.21% using Malmquist.
[26] See Appendix 1 for a summary of papers that look at bank productivity in emerging markets.

technologies are taken on, the speed of adopting domestic scientific technologies, and the way production is organised. Lower banking sector TFP growth would be expected in light of Kaldor's observations.

The main source of the growth is technical progress in all but one of the Indian studies,[27] which is consistent with our findings. As column 6 of table 5 shows, it would have been higher but for the almost universal decline in efficiency across all types of banks in both countries, independent of size, ownership, and whether or not they are listed. The gains from technical change are reduced by adverse technical efficiency change. The one exception is large banks in India which have the highest TFP growth rates - unlike other banks, the favourable *Z* effects more than offset the presumed organisational slack.

For China, the results vary considerably depending on the study. Matthews et al. (2009) find evidence of notable technical progress among the joint stock banks for the period 1997-2006. But declines in technical efficiency offset this gain, leaving TFP growth varying from -0.4% for state banks, rising to roughly 6% for the joint stocks. Matthews and Zhang (2009) report large differences between the best practice frontier and other banks. Between 1997 and 2002 they find that the annual average TFP growth for state banks is 3.5%, falling to -1.2% between 2003 and 2007. The respective figures for the joint stocks are 9.4% and -7.1%; for city commercials they are 20% and 10.6%.[28] Technical progress is the key driver except for the city commercials, where there are substantial efficiency gains in addition to moderate innovation. In Yao et al. (2008) innovation and greater efficiency make roughly the same contribution (2.6% and 2.9%, respectively), giving an annual average TFP growth of 5.6%. With the exception of Matthews and Zhang (2009), these studies' smaller samples may explain why their results differ from ours even though both employ a similar estimation technique (Malmquist) over roughly the same period. Kumbhakar and Wang (2007) find scale and *Z* effects are the key contributors to a TFP growth rate of 4.5%, with a positive but smaller contribution from technical progress and improvements in pure technical efficiency. They include the decade up to 2002, while our study looks at the first 7 years of the new century. The annual average for our D shows a lower TFP growth at 2.8% - largely due to technical innovation but dampened by falls in efficiency. To the extent these two studies are comparable (both employ SFA), it would suggest that China's banks' TFP growth rates are declining, with a shift in the underlying cause.

[27] Scale effects largely explain TFP growth in Kumbhakar and Sarkar (2003).
[28] The figures are computed from Table 7 of Matthews and Zhang (2009), which is based on the annual average of TFP growth, averaged across 5 models.

Based on M, the annual average TFP growth is about 1.4%[29] higher than D for both the full and Indian sub-samples; for China it is 1.2% (Table 2). The components of TFP change reveal more dramatic differences. Table 2 shows the technical efficiency change estimates are negative under D; for M they are negative for Indian banks but positive for China and (though close to zero) for the full sample, too. Scale effects are minuscule but positive with D, which sits awkwardly with a larger and negative contribution to TFP growth based on the M estimates. Furthermore, India displays the faster technical change according to the M approach by a margin of 0.92% per annum. And efficiency change is negative in India, but substantially positive in the Chinese banks under the M approach. Under D, environmental factors also make a positive contribution, with twice the impact in India as in China, which may be because the contribution of the services sector to GDP is much higher in India than China. Based on 2005 IMF figures, the services share of output was 56% for India but 32% for China, whereas industry's share of output was 22% in India compared to 53% in China. It may also be due to greater structural change in China's banking system, or more regional disparities between the banks in the sample.

Equivalence tests are used to further explore the apparent difference in results depending on whether M or D is used. The natural logarithm of DEA-M TFP changes is regressed on the level of the SFA-D TFP changes. Table 3 confirms that both M and D resemble each other quite closely at the aggregate level, which is largely consistent with other studies that use aggregate data. But once disaggregated, there is a significant negative relationship between the two approaches for both technical change and technical efficiency change, while they are close for pure efficiency change and scale efficiency change. Crucially, the R^2s reported in Table 3 reveal a very poor correlation between various M and D estimates. The disturbingly different results mean the two approaches point to dissimilar conclusions. Though not reported here, notable differences between M and D are also found when we differentiated by ownership, size, and whether or not a bank is listed.[30]

(Table 3 inserted here)

To summarise, both parametric and non-parametric techniques yield far from similar quantitative estimates especially in terms of the components of TFP growth. This finding is at odds with Casu et al. (2004) for some EU states, but their methods differ from the ones used

[29] The banks' cumulative TFP index increased by 19% (D) or 28% (M) between 2000 and 2007, making the annual average for M 1.4% higher.
[30] The results are available from the authors on request.

here[31] and they look at developed economies. Is one approach more suitable than the other? We argue in favour of the stochastic frontier (parametric) D method over M for several reasons. First, environmental (*Z*) effects can be tested and it contains an error term (allowing for statistical noise), both of which are excluded when M is estimated. Furthermore, since the quantitative estimates differ, investigators cannot be safely advised to estimate a Malmquist type model, certainly on its own. Admittedly the translog flexible form employed under the D method is not perfectly flexible,[32] though it is far less rigid than the classical production functions employed in earlier research. Also D requires a large sample size for reliable estimates but with up to 712 observations (see below), what could otherwise be an argument in favour of M ceases to apply. For these reasons, the remaining discussion in this section focuses on the results using the stochastic frontier/Divisia index "D" model.

To assess the impact of bank characteristics and environmental factors (*Z* effects) we review the results of the simultaneous estimation of equations (3) and (4). Technical inefficiency is the dependent variable in equation (4), and comes from the Divisia model - Malmquist does not allow for Z effects. Table 4 shows that the coefficient on real GDP growth is right signed (in developed countries, higher growth has been associated with less managerial slack) though not significant. Listed banks are significantly more efficient as are foreign and large banks against domestic and small banks. The significant negative coefficient on E:A suggests banks with a higher capital ratio are more efficient, a result which is consistent with other banking studies such as Kumbhakar and Wang (2007). Finally, the negative and significant sign on the five firm concentration ratio indicates that consolidation is associated with the emergence of more efficient banks. There is no suggestion that higher profits (associated with more consolidation) are leading to wasted resources and increased inefficiency.[33]

(Table 4 inserted here)

Mean difference t-tests are used to address the issue of whether bank ownership, size, and listing are linked to TFP growth within and between the two countries. The remaining sub-sections discuss the key findings (see Table 5) by posing rhetorical questions.

(Table 5 inserted here)

TFP Growth in Banking: In which country does it advance faster, China or India?

[31] These authors use an output distance function to estimate the Malmquist TFP change. Their parametric method, following Berger and Mester (1999), uses a cost function approach to estimate "productivity growth". Environmental variables are not considered.

[32] D imposes log linearity and symmetry when other more general specifications might be considered. It is an unweighted geometric mean of Laspeyres & Paasche which is a functional form restriction since other convex combinations might have been used as alternatives, e.g. the Cox Box transform.

[33] Looking at the determinants of technical efficiency for China or India produce similar results. They are available from the authors on request.

As a whole Chinese banks significantly outperform Indian banks. In most other categories (private, foreign, small and medium sized banks, and listed/unlisted) China displays a faster TFP growth; significantly so in six of these - the two exceptions being foreign and listed banks. They may outpace their Indian counterparts because China's higher real GDP growth rate led to a speedier rise in their urban wage rates, creating a greater incentive to innovate and economise on labour. A consequence would be a quicker rise in labour (and possibly total factor) productivity. But note the significantly faster TFP trend growth rate for large Indian banks; it is insignificantly faster for Indian public banks. India's adoption of IT has been especially pronounced and as a result there is a thriving business in the sub-contracting of financial services on behalf of OECD banks,[34] which may have stimulated its larger banks to acquire this advanced IT.

Do private banks outperform public banks in TFP growth?

In China they did,[35] and significantly, while in India, the reverse is true: public banks significantly outperformed private banks. Recall from Table 1 that China has proportionally more private banks (51%) than India (32%). By inference, private banks may have made a greater contribution to the higher overall TFP growth rate in China. Furthermore, since technical change explains virtually all of TFP growth Chinese private banks may have been more innovative over this period whereas in India, private banks had innovated earlier and public banks were catching up.

Do foreign and domestic banks exhibit different TFP growth rates?

Overall, and when both countries are considered separately, foreign banks exhibit slower TFP growth rates than their private and public counterparts. The difference is always significant, except in the case of India's private domestic banks. Sensarma (2006) also finds foreign banks are the worst performers in India during an earlier period, 1986-2000. Two factors may help to explain these findings. First, foreign banks face more operative restrictions especially with respect to retail activities and particularly in China. Second, foreign banks are likely to have had higher initial levels of technology. To the extent that "catch up" occurs, foreign banks' TFP is less likely to grow more rapidly.

Do different sized banks display differences in TFP growth?

Table 5 shows that for both countries, taken separately and overall, large banks display

[34] According to the Reserve Bank of India (2008a), in the 3 years to 2007-8, India's invisible exports of financial services grew six-fold to $5 billion.

[35] Kumbhakar and Wang (2007) and Matthews et al. (2009) find joint stocks outperformed the four large state-owned banks in China, which is consistent with our findings. But the definition we use for public banks (more than 50% owned by the state) means some joint stocks are in the public bank category.

significantly greater TFP growth than medium sized or small banks. The (largely) fixed cost of upgrading information technology may be one explanation, which would have been less of an obstacle for the largest banks in these countries. Medium-sized banks outperform small banks for the combined and Indian samples, but not significantly so. In China, the opposite was found but again, the difference is not significant.

Is there a difference in TFP growth rates between listed and unlisted banks?

For the whole sample and the Indian sub-sample, listed banks significantly outperformed unlisted banks, but this was not the case for China. Unlike India, listed Chinese banks remain largely state-owned whose objectives may be less clear. So these findings are not inconsistent with the view that pressure from shareholders spurs faster advances in productivity. A second contributory explanation may be that size and shareholder ownership are positively correlated, though for China, where there is a positive correlation, no significant difference is found.

Are TFP changes reflected in actual bank performance over time?

The short period rules out Granger causality tests to investigate the effects of the Divisia TFP change on bank performance, so a panel data approach[36] is used to estimate:

$$\Delta BKPF_{it} = \alpha + \beta \Delta TFP_{i,t-1} + \lambda t + \varepsilon_{it} \qquad (5)$$

where:

$\Delta BKPF_{it}$: the change in bank performance between time *t-1* and *t*, using different measures of bank performance: ROAA, ROAE, Tobin's Q, and annual stock returns.
$\Delta TFP_{i,t-1}$: Divisia TFP change lagged by one year
t: time trend

Table 6 reports the results which indicate that in general, the TFP coefficients are insignificantly positive for India; for China they are negative but insignificant. The exception is annual stock returns, where the coefficient is significantly positive, meaning TFP growth among Chinese and Indian banks is reflected in significantly improved stock returns a year later. It suggests the market picks up news about positive TFP growth, the one measure of performance not computed or reported by banks. Nonetheless, investors appear to treat advances in productivity, or factors driving it, or associated with it, as good news. Furthermore the coefficient on Tobin's Q is significantly positive for the whole sample indicating that bank market value rather than book value is stimulated by bank TFP changes.

(Table 6 inserted here)

6. Conclusions

This study is the first to compare and contrast total factor productivity (TFP) changes between

[36] Based on the Breusch and Pagan Lagrangian Multiplier tests, the random effects panel data approach is used.

and among the banking sectors of the two Asian giants. Since rapid economic growth has been a feature of both China and India, and finance is crucial to growth, it is interesting to examine productivity change in two economies where banks remain the key source of finance. For well over a decade, these countries have witnessed gradual bank reforms aimed at increasing productivity and efficiency. Their governments have reduced control over deposit and loan rates, policy directed lending, market segmentation, and restrictions on foreign bank participation. Nonetheless, the state continues to own a substantial number of banks, and foreign bank ownership is restricted.

In this environment we assess TFP growth and its components both within and between the two countries and across banks that differ in terms of size, ownership and listing. The issue of whether TFP growth is reflected in bank-specific performance (e.g. ROAE) is also considered. Both non-parametric (DEA) and parametric (SFA) models are used to estimate TFP change from 2000-2007, but some substantial differences in the disaggregated results (confirmed by equivalence tests) led us to focus on the findings from the estimation of a Divisia TFP index.

China significantly outpaced India in overall bank TFP growth. High urban wage rates (due to high real GDP growth rates) may have increased the incentive for Chinese banks to innovate faster. Technical progress is the main reason for TFP growth in both countries, which would have been higher but for the negative impact of the two efficiency change components, suggesting that better resource allocation and/or reduced slack could improve overall TFP growth rates in Chinese and Indian banking.

The finding that innovation is the main reason for TFP growth may be the underlying reason for the results that TFP change is significantly higher among large banks but lower for foreign banks. Larger banks can better absorb the largely (fixed) costs of IT while domestic banks are able to adopt the better technology foreign banks bring with them at the time they enter the market.

More than 40% of the banking sector is state-owned in both countries. But while TFP growth is significantly faster for public banks in India the reverse is true for China, which could be due to the comparably higher proportion of private Chinese banks, especially if they are more innovative than their public counterparts.

The coefficient on annual TFP change is positive when annual stock returns is the dependent variable: it had a significant impact a year later, suggesting the market is sensitive to bank TFP growth rates.

Many published papers attempt to associate higher productivity change with bank reform in the absence of an explicit test. However, the gradual nature of these reforms makes it difficult to separate out cause and effect. Here, bank TFP growth rates are not unlike those found in other papers although both the pace of reforms and periods covered do differ. So while it is not possible to assess how much of the TFP growth is due to reforms per se, it may be that their measured nature is reflected in positive but not exceptionally rapid TFP changes.

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Table 1 Summary statistics

	All sample banks				China				India			
	Mean	**Max**	**Min**	**S.D.**	**Mean**	**Max**	**Min**	**S.D.**	**Mean**	**Max**	**Min**	**S.D.**
Outputs												
Net loans	15912.52	462991.17	0.40	51175.04	47993.56	462991.17	3.63	86397.45	2672.72	61389.48	0.40	5360.13
Other earning assets	14020.68	542863.53	2.14	49178.95	42413.81	542863.53	3.84	84307.46	2302.88	41365.13	2.14	4763.35
Off-balance-sheet activities	154.72	7027.39	0.03	485.67	329.26	7027.39	0.03	838.15	82.70	1498.03	0.05	162.86
Inputs												
Purchased funds	30917.62	941162.41	3.32	103492.47	94083.82	941162.41	8.18	175833.69	4849.03	87831.87	3.32	9242.02
Physical capital	482.75	13048.07	0.02	1691.34	1513.20	13048.07	0.10	2879.08	57.48	815.46	0.02	109.59
Labour	412.15	11244.41	0.19	1228.83	1107.70	11244.41	0.19	2087.14	125.10	2185.25	0.32	243.18
Z variables												
Listed bank dummy	0.34	1.00	0.00	0.47	0.21	1.00	0.00	0.41	0.40	1.00	0.00	0.49
Dummy for public bank	0.42	1.00	0.00	0.49	0.41	1.00	0.00	0.49	0.43	1.00	0.00	0.50
Dummy for private bank	0.37	1.00	0.00	0.48	0.51	1.00	0.00	0.50	0.32	1.00	0.00	0.47
Dummy for foreign bank	0.20	1.00	0.00	0.40	0.08	1.00	0.00	0.27	0.25	1.00	0.00	0.44
Dummy for large bank	0.33	1.00	0.00	0.47	0.65	1.00	0.00	0.48	0.20	1.00	0.00	0.40
Dummy for medium bank	0.33	1.00	0.00	0.47	0.22	1.00	0.00	0.41	0.38	1.00	0.00	0.49
Dummy for small bank	0.33	1.00	0.00	0.47	0.13	1.00	0.00	0.34	0.42	1.00	0.00	0.49
Equity to assets ratio	0.08	0.68	-0.12	0.09	0.06	0.54	-0.12	0.09	0.09	0.68	0.02	0.09
5-bank concentration ratio	0.52	0.83	0.40	0.15	0.75	0.83	0.66	0.06	0.42	0.44	0.40	0.01
Real GDP growth rate	0.08	0.12	0.04	0.02	0.10	0.12	0.08	0.01	0.07	0.10	0.04	0.02
Total no. of observations	712				208				504			

Notes: All financial data (excluding financial ratios) are expressed in constant 2000 prices using individual-country CPI deflators, and then reported in million US dollars using exchange rate of the last date of each calendar year. Net loans: aggregate total loans less non-performing loans; Other earning assets: total assets less the sum of total loans + total fixed assets; Off-balance-sheet (OBS) activities: non-interest income; Purchased funds: total deposits plus borrowed funds; Labour: overhead expenses; Physical capital: fixed assets; Listed bank dummy = 1 if a listed bank, 0 otherwise; Dummy for public bank = 1 if the state owns more than 50% of it, 0 otherwise; Dummy for private bank =1 if domestic private investors hold more than 50% of its shares; Dummy for foreign bank = 1 if foreign investors hold more than 50% of its shares; Dummy for large bank equals 1 if it is in the largest/first tertile of the sample banks in terms of total assets, 0 otherwise; Dummy for medium bank equals 1 if it is in the second tertile; Dummy for small bank equals 1 if it is in the third tertile; 5-bank concentration ratio is defined as the sum of the asset share of the five largest banks (in terms of asset size) in each country divided by total banking assets in each country's banking sector.

Table 2: Malmquist vs. Divisa TFP change decomposition (average 2000-2007)

Data Envelopment Analysis - Malmquist (M)	All Banks	Banks-China	Banks-India
Malmquist TFP change	3.85%	4.00%	3.79%
Pure efficiency change	0.66%	1.67%	0.26%
Technical change	3.85%	3.21%	4.13%
Technical efficiency change	0.00%	0.76%	-0.32%
Scale efficiency change	-0.65%	-0.89%	-0.58%

Stochastic Frontier Approach - Divisia (D)	All Banks	Banks-China	Banks-India
Divisia TFP change	2.49%	2.81%	2.35%
Pure efficiency change	-1.25%	-1.25%	-1.25%
Technical change	3.18%	3.71%	2.97%
Technical efficiency change	-0.72%	-0.91%	-0.65%
Scale effect	0.03%	0.02%	0.03%
Z effects (z)	0.52%	0.33%	0.60%

Malmquist TFP change = Technical change x Technical efficiency change, where Technical efficiency change = Pure technical efficiency change x Scale efficiency change. Divisia TFP change = Technical change + Technical efficiency change + Scale effect, where Technical efficiency change = Pure technical efficiency change + *Z* effects.

Table 3: Regression Results of Equivalence Tests

Dep. Var.	Indep. Var.	Coefficient	S.E.	Z stat.	P value
ln TFP change (M)	TFP change (D)	0.304***	0.165	1.84	0.066
	Constant	0.025***	0.006	4.21	0
	LM test	18.68			0
	R squared	0.0111			
ln cumulative TFP change index	cumulative TFP change index (D)	0.899***	0.069	13.09	0
	Constant	-0.851***	0.077	-11.1	0
	LM test	462.81			0
	R squared	0.0846			
ln pure efficiency change (M)	pure technical efficiency change(D)	41.461***	9.281	4.47	0
	Constant	0.521***	0.116	4.51	0
	LM test	8.81			0.003
	R squared	0.0311			
ln scale efficiency (effects) change	scale efficiency (effects) change	0.679	0.994	0.68	0.495
	Constant	-0.011***	0.004	-2.67	0.008
	LM test	32.21			0
	R squared	0.0737			
ln technical change(M)	technical change (D)	-1.421***	0.584	-2.43	0.015
	Constant	0.085***	0.019	4.42	0
	LM test	26.25			0
	R squared	0.0116			
ln technical efficiency change (M)	technical efficiency change (D)	-0.304*	0.175	-1.74	0.083
	Constant	-0.009*	0.005	-1.82	0.068
	LM test	19.7			0
	R squared	0.0048			

Notes: Table 3 illustrates the degree of correlation between the DEA and SFA approaches. The natural logarithm of DEA-Malmquist TFP changes is regressed on the level of the SFA-Divisia TFP changes. ln: natural log; M: Malmquist; D: Divisia. LM test: Breusch and Pagan Lagrangian multiplier test for random effects (H0: no random effects). *, **, *** denotes 10%, 5%, and 1% significance levels.

Table 4: What are the Determinants of Technical Efficiency?

	All Banks	
Independent variables	coefficient	S.E.
Constant	0.1654*	0.0894
t	0.0117	0.0193
t^2	0.0002	0.0019
Listed bank dummy	-0.0294*	0.0022
Dummy for public bank	-0.0011	0.0231
Dummy for foreign bank	-0.0533*	0.0164
Dummy for large bank	-0.1316*	0.0258
Dummy for small bank	0.0577*	0.0027
Equity to assets ratio	-0.2751*	0.0699
5-bank concentration ratio	-0.1709*	0.0972
Real GDP growth rate	-0.0680	0.0924
Log-likelihood	622.3327	
Number of observations	712	
Mean technical efficiency	0.9270	

This table is used to discuss the factors influencing technical efficiency, a component of TFP change. The results in table 4 are generated from the simultaneous estimation of equations (3) and (4). Technical inefficiency is the dependent variable in equation (4), and comes from the Divisia model - Malmquist does not allow for Z effects. A negative coefficient in column 2 is interpreted as increased efficiency. For example, a negative coefficient on the ratio of E:A means banks with higher ratios are statistically more efficient. * denotes 10% significance level. t: time trend variable; Listed bank dummy: equals 1 if it is a listed bank, 0 otherwise; Dummy for public bank equals 1 if the state owns more than 50% of it, 0 otherwise; Dummy for private bank equals 1 if domestic private investors hold more than 50% of its shares, 0 otherwise; Dummy for foreign bank equals 1 if foreign investors hold more than 50% of its shares, 0 otherwise; Dummy for large bank equals 1 if it is in the largest/first tertile of the sample banks in terms of total assets, 0 otherwise; Dummy for medium bank equals 1 if it is in the second tertile, 0 otherwise; Dummy for small bank equals 1 if it is in the third tertile, 0 otherwise; 5-bank concentration ratio is defined as the sum of the asset share of the five largest banks (in terms of asset size) in each country divided by total banking assets in each country's banking sector. Log-likelihood: log likelihood value of the maximum likelihood estimation. Mean technical efficiency refers to the annual average technical efficiency of the relevant sample banks.

Table 5: Divisia Decomposition Tests

	Technical Δ	Technical efficiency Δ	Pure Technical efficiency Δ	Scale effect	Z effects	TFP Δ	Mean difference t-test
All							
All sample banks	3.18%	-0.72%	-1.25%	0.03%	0.52%	2.49%	
All China sample banks	3.71%	-0.91%	-1.25%	0.02%	0.33%	2.81%	** (vs. All India sample banks)
All India sample banks	2.97%	-0.65%	-1.25%	0.03%	0.60%	2.35%	
Ownership							
Public banks-All	3.20%	-0.55%	-1.24%	0.02%	0.70%	2.67%	*** (vs. Foreign banks-All)
Public banks-China	3.71%	-1.29%	-1.24%	0.01%	-0.05%	2.43%	* (vs. Foreign banks-China)
Public banks-India	2.99%	-0.26%	-1.25%	0.02%	0.99%	2.76%	** (vs. Private/Foreign banks-India)
Private banks-All	3.39%	-0.81%	-1.25%	0.01%	0.44%	2.59%	*** (vs. Foreign banks-All)
Private banks-China	3.76%	-0.52%	-1.25%	0.01%	0.72%	3.24%	** (vs. Public/Foreign banks-China; Private banks-
Private banks-India	3.15%	-1.00%	-1.25%	0.01%	0.25%	2.15%	
Foreign banks-All	2.78%	-0.94%	-1.25%	0.09%	0.31%	1.93%	
Foreign banks-China	3.38%	-1.54%	-1.25%	0.15%	-0.29%	2.00%	
Foreign banks-India	2.70%	-0.86%	-1.25%	0.09%	0.38%	1.93%	
Size							
Large banks-All	3.37%	0.20%	-1.25%	0.02%	1.45%	3.59%	*** (vs. Medium/Small banks-All)
Large banks-China	3.70%	-0.59%	-1.25%	0.004%	0.66%	3.12%	*** (vs. Medium banks-China); ** (vs. Small banks-
Large banks-India	2.94%	1.21%	-1.26%	0.04%	2.47%	4.18%	** (vs. Large banks-China); *** (vs. Medium/Small
Medium banks-All	3.15%	-1.20%	-1.24%	0.003%	0.04%	1.94%	
Medium banks-China	3.73%	-1.56%	-1.24%	0.01%	-0.32%	2.17%	** (vs. Medium banks-India)
Medium banks-India	3.00%	-1.12%	-1.24%	0.001%	0.13%	1.89%	
Small banks-All	3.03%	-1.22%	-1.24%	0.07%	0.03%	1.89%	
Small banks-China	3.71%	-1.52%	-1.24%	0.12%	-0.28%	2.31%	** (vs. Small banks-India)
Small banks-India	2.95%	-1.18%	-1.24%	0.06%	0.06%	1.84%	
Listing							
Listed banks-All	3.10%	-0.28%	-1.25%	0.02%	0.98%	2.84%	** (vs. Unlisted banks-All)
Listed banks-China	3.43%	-0.05%	-1.27%	0.02%	1.22%	3.40%	
Listed banks-India	3.03%	-0.33%	-1.25%	0.02%	0.92%	2.72%	*** (vs. Unlisted banks-India)
Unlisted banks-All	3.23%	-0.98%	-1.24%	0.04%	0.26%	2.29%	
Unlisted banks-China	3.79%	-1.17%	-1.24%	0.02%	0.07%	2.64%	** (vs. Unlisted banks-India)
Unlisted banks-India	2.93%	-0.88%	-1.24%	0.04%	0.36%	2.09%	

Notes: Based on the annual average (2000-07) of TFP growth. The scale effect is the component of TFP change that is related to returns to scale. Technical change indicates the shift of production frontier. Technical efficiency change describes how the proportion of inputs used efficiently changes over time, either closer to or away from production frontier. It is further decomposed into two parts of effects, pure technical efficiency change and Z effects that are induced by some bank characteristics and environmental factors. TEC=PTEC+Z; TFPC=SE+TE+TEC. *, **, *** denotes 10%, 5%, and 1% significance levels, respectively. The t test reports the t statistics of the mean difference t tests. The Wilcoxon rank-sum test (is a non-parametric test for the mean difference between two different samples) was also conducted as a robustness check. In all but two cases, both tests concur.

Table 6: Regression results - Does TFP growth affect bank performance?

		All listed banks			Listed banks in China			Listed banks in India		
Dependent Variable	Independent Variable	Coefficient	S.E.	p value	Coefficient	S.E.	p value	coefficient	S.E.	p value
LnΔROAA	lnΔTFP	-0.00102	0.00483	0.833	-0.01165	0.0071	0.11	0.00466	0.00703	0.507
	T	0.00003	0.00015	0.823	0.00025	0.00006	0	-0.00019	0.00024	0.446
	Constant	1.38625	0.00075	0	1.38566	0.00044	0	1.38725	0.00119	0
	LM test	15.19		0.0001	0.03		0.857	13.74		0.0002
	R squared	0.0013			0.4379			0.017		
LnΔROAE	lnΔTFP	0.04792	0.09635	0.619	-0.35475	0.36492	0.346	0.15406	0.13763	0.263
	t	-0.00067	0.00306	0.826	0.00318	0.00303	0.311	-0.00474	0.00476	0.319
	Constant	1.38947	0.01505	0	1.38732	0.02082	0	1.40766	0.02329	0
	LM test	13.15		0.0003	2.45		0.1179	12.51		0.0004
	R squared	0.1125			0.1314			0.1982		
LnΔQ	lnΔTFP	**0.0080****	0.00392	0.044	-0.00517	0.0212	0.81	0.00211	0.0048	0.661
	t	-0.00019	0.00012	0.136	-0.00062	0.00018	0.003	0.00005	0.00017	0.769
	Constant	1.38679	0.0006	0	1.38939	0.00121	0	1.38567	0.00081	0
	LM test	0.65		0.4217	0.06		0.814	2.01		0.1559
	R squared	0.2243			0.3618			0.0313		
lnSR	lnΔTFP	2.17183	1.40609	0.122	**13.686*****	3.56671	0.002	**3.33995***	2.01777	0.098
	t	-0.06673	0.04467	0.135	0.03236	0.02964	0.292	-0.11767	0.06976	0.092
	Constant	1.62414	0.21966	0	0.89872	0.20346	0	1.85164	0.34142	0
	LM test	6.76		0.0093	0.0001		0.9982	6.72		0.0096
	R squared	0.0608			0.3339			0.0518		
No. of observations		137			23			114		

Notes: Table 5 reports the results of estimating equation (11): where TFP growth is the independent variable and a variety of measures of changes in bank performance are used, namely return on average assets (ROAA), return on average equity (ROAE), Tobin's Q (Q), and annual stock return (SR). lnΔTFP: the natural log of the Divisia TFP change lagged by a year. lnΔROAA: $\ln(ROAA_t - ROAA_{t-1})$; lnΔROAE: $\ln(ROAE_t - ROAE_{t-1})$; lnΔQ: $\ln(Q_t - Q_{t-1})$; Tobins's Q_t = (average assets – average equity + market capitalization)/average assets; lnSR: ln annual stock return = $(price_t - price_{t-1} + dividend_t)/price_{t-1}$. t: time trend. LM test: Breusch and Pagan Lagrangian multiplier test for random effects (H_0: no random effects). *, **, *** denotes 10%, 5%, and 1% significance levels.

Appendix 1: Summary of Literature on Bank Productivity Studies in Emerging Markets

AUTHOR	COUNTRY	SAMPLE	PERIOD	METHOD	MAIN FINDINGS
Kumbhakar and Wang (2007)	China	14 nationwide banks (big four + 10 national joint-stocks; 132 observations in total)	1993-2002	SFA-input distance function with environmental variables	KW find joint-equity banks to be relatively more efficient than wholly state-owned banks, with TFP growth at 5.5% and 1.4% per annum, respectively. Overall, TFP growth was 4.4% per annum over the sample period 1993-2002.
Matthews et al. (2009)	China	14 nationwide banks	1997-2006	DEA-Malmquist & bootstrapping	After adjusting for the quality of loans (NPLs treated as an undesirable output) the mean TFP growth of the state banks (big 4) was -0.4%; that of the joint stocks was considerably higher at 6%, and largely due to technical progress. TFP growth would have been even higher but for declines in efficiency, which fell by nearly 8% for the big four.
Matthews and Zhang (2009)	China	63 commercial banks:5 state-owned, 9 joint-stocks, 49 city banks	1997-2007	DEA-Malmquist & bootstrapping	Overall the annual average TFP growth rates are 1.1%, 1.2%. and 15.3% for, respectively, the state-owned, joint-stock and city commercial banks, though when the sample is split into two periods, both the state and joint stock banks have negative growth rates from 2003-7. Innovation is the key driver except for the city banks, where efficiency is dominant, reinforcing moderate technical progress. There were marked differences between the best practice frontier banks and the rest.
Yao et al. (2008)	China	15 banks	1998-2005	DEA- Malmquist - output oriented	Total factor productivity rose by 5.6% per annum, which the authors attribute to ownership reform and foreign competition. The average annual growth rate jumped after China's 2001 accession to the WTO, exceeding 10%. Both efficiency growth and technological progress made an equal contribution to TFP growth with average annual figures of 2.88% and 2.64%, respectively.
Bhattacharyya et al. (1997)	India	27 public banks including the State Bank of India and its subsidiaries; banks that were nationalised in 1960; banks nationalised in 1980.	1970-1992	SFA-translog cost function	This study analyzes the productivity growth of Indian public sector banks. Nationalisation curtailed banks' productivity growth which the authors attribute to a shift from maximising profits to new responsibilities to satisfy development plans. Banks' overall productivity growth was as high as 7% with the onset of bank deregulation, though the average annual TFP growth rate was 2.6%. The sources of the improvement were technical progress and, to a lesser degree, improved efficiency. They argue that deregulation of this mature commercial banking system created a competitive environment conducive to these changes.
Kumbhakar and Sarkar (2003)	India	27 public and 23 private banks	1985-1996	SFA-translog cost function	The anticipated increase in TFP growth was not realised following deregulation. Annual averages were 2.9% for private banks and 3.3% for public banks.

Appendix 1: Summary of Literature on Bank Productivity Studies in Emerging Markets – cont'd

Sensarma (2006)	India	27 public, 25 domestic private, 22 foreign, 9 new domestic private	1986-2000	SFA-translog cost function with environmental variables	Banks improved their performance over the period in terms of both efficiency and productivity. Compared with their state owned and private domestic counterparts, foreign banks were the worst performers throughout the period.
Zhao et al. (2007)	India	27 public, 20 domestic, 18 foreign (845 observations in total).	1992-2004	DEA-input oriented	The results suggest that, after some initial adjustment, the Indian banking sector underwent sustained productivity growth, driven mainly by technological progress. The type of ownership affected bank efficiency but not TFP growth, though ownership per se was far less influential than increased competition. Foreign banks were technological innovators during deregulation which increased competitive pressure in the Indian banking market.
Gilbert and Wilson (1998)	Korea	24 nationwide and regional banks	1980-1994	DEA-input oriented & bootstrapping	Korean banks responded to privatization and deregulation by changing their mix of inputs and outputs, yielding large TFP gains for the nationwide banks. The results for the regional banks were mixed.
Park and Weber (2006)	Korea	229 observations	1992-2002	DEA-directional technology distance function	Overall, the banking sector's TFP growth was positive because technical progress more than offset declines in efficiency.
Leightner and Lovell (1998)	Thailand	31 banks	1989-1994	DEA-output oriented	When the standard outputs (e.g. net interest income and non-interest income) are used in the DEA estimation, the average bank in Thailand experienced relatively rapid growth in output and in total factor productivity. But if outputs were defined as credit granted and investments in securities (Bank of Thailand objectives), output growth was largely unchanged but TFP shrank for Thai banks and grew for foreign banks.
Williams and Nguyen (2005)	Korea, Malaysia, Philippines, Indonesia, Thailand	231 commercial banks; 2030 observations	1990-2003	SFA-translog profit function	Unlike the majority, this study used a translog profit function to estimate "productivity" change. State and foreign banks underperformed private banks, and in the period following privatisation (banks in Asia are often privatised through listing), there was a notable improvement in productivity performance.
Koutsomanoli-Filippaki et al. (2009)	10 central eastern European countries	186 banks (871 observations)	1998-2003	SFA-directional technology distance function with environmental variables	Though bank TFP growth diverged across countries, productivity for the CEE region declined in the early years, then improved due to institutional and structural reforms. TFP growth, due largely to technical progress, was more pronounced among private banks than state banks, though foreign banks outperformed both.

Appendix 1: Summary of Literature on Bank Productivity Studies in Emerging Markets – cont'd

Brissimis et al. (2008)	10 newly acceded EU countries	364 banks	1994-2005	DEA-input oriented & bootstrapping	The authors find that both banking sector reform and competition exert a positive impact on bank efficiency, but it is not until the end of the period that reform has a significant effect on TFP growth.
Isik and Hassan (2002)	Turkey	between 39 and 54 commercial banks depending on the year-139 observations	1988-1996	DEA and parametric economic frontier approach	On average, the cost and profit efficiencies are 72% and 83% respectively. Cost inefficiency is due to technical rather than allocative inefficiency, which the authors attribute to poor management operating at the wrong scale, with increasing evidence of scale diseconomies in an oligopolistic banking sector. Foreign banks are found to be significantly more efficient, and private banks more efficient than public banks, as are banks that are listed.
Isik and Hassan (2003a)	Turkey	Turkish commercial banks (458 observations)	1981-1990	DEA-Malmquist TFP change index (input oriented)	All Turkish commercial banks enjoyed variable but significant productivity gains which were largely due to improved efficiency, which in turn was caused by better resource management rather than scale economies. With financial liberalisation, the gap in performance between private and public banks narrowed.
Isik and Hassan (2003b)	Turkey	54 annual commercial bank observations	1992-1996	DEA-Malmquist TFP change index (input oriented)	A severe financial crisis in 1994 resulted in a 17% decline in bank productivity due to technical regress (10%) and a fall in efficiency (7%). The decline was most pronounced for foreign banks, followed by private domestic banks. There was little change among state banks. Based on size, small banks suffered the most. Within 2 years the sector returned to pre-crisis levels of productivity and efficiency.
Tsionas et al. (2003)	Greece	all 17 Greek commercial banks	1993-1998	DEA-input oriented	The trend TFP growth was 3.8%. For large banks it was 4.4%, almost all of it due to innovation. Smaller banks appeared unable to exploit new technology - their TFP change was negative.
Rezitis (2008)	Greece	10 banks	1993-2004	SFA-output distance function	The author looks at the effects of M&As on TFP growth. Post merger banks experienced a decline in TFP growth which was due to a rise in technical inefficiency and a shift from scale economies to diseconomies. TFP growth increased for banks that were not involved in mergers over the period.