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Rational Inefficiency and non-performing loans in Chinese Banking: A non-parametric Bootstrapping Approach

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Abstract

The existing Chinese banking system was born out of a state-planning framework focussed on the funding of state-owned enterprises. Despite the development of a modern banking system, numerous studies of Chinese banking point to its high level of average inefficiency. Much of this inefficiency relates to the high level of non-performing loans held on the banks books. This study argues that a significant component of inefficiency relates to a defunct bureaucratic incentive structure. Using bootstrap non-parametric techniques the paper decomposes cost-inefficiency into X-inefficiency and rational inefficiency caused by bureaucratic rent seeking. In contrast to other studies of the Chinese banking sector, the paper argues that a change in the incentive structure and the competitive threat of the opening up of the banking market in 2007 has produced reduced inefficiency and improved performance.

Keywords: Bank Efficiency, China, X-inefficiency; DEA. Bootstrapping

JEL codes: D23, G21, G28

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1. Introduction

Studies of bank efficiency in China have been in vogue among Chinese scholars for a number of years[1]. These studies have been partly prompted by the impending opening up of the banking system to foreign competition at the end of 2006. The advent of greater foreign competition has galvanised the banking authorities into a strategy of recent and planned IPO listings of the major state banks and increased stake holdings by foreign banks of the smaller commercial banks. The strategy of allowing a larger stake holding in the Chinese banking system by foreign banks as a means of improving efficiency has a good academic pedigree. The link between privatization and efficiency improvement in former government owned enterprises is now very much an established finding (Megginson and Netter, 2001). The link between privatization of banking and efficiency improvement is an emerging research area (see Megginson, 2005 for a survey).

Given the impending listing of the major state owned banks and the tacit acceptance of larger stakes by foreign banks in the smaller commercial banks, it is not surprising that bank efficiency in China has become a popular subject of research in recent years. A number of studies of Chinese banking efficiency have been in published in Chinese scholarly journals but to date there have been only a few studies that are available to non-Chinese readers[2].

Inefficiency relative to 'best practice' is usually blamed on bad management and poor motivation. In the parlance of Leibenstein (1966), this efficiency gap is termed 'X-inefficiency'. The Chinese banking sector has only recently begun to open up to foreign competition. In the context of a banking sector that was formerly an organ of the state system of planning, this paper argues that the measure of bank inefficiency represents the outcome of a rational process and is less symptomatic of a managerial malaise. In other words this paper

[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

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

argues that inefficiency is symptomatic of 'rent seeking' behaviour and not just X-inefficiency in the traditional sense.

This research has three objectives. First it aims to deal with the problem caused by non-performing loans in the use of loans as a measure of bank output. Former studies of bank efficiency in China have used the stock of loans as one of the measures of output. The large amount of non-performing loans (NPLs) and the divestiture of large tranches of NPLs from the balance sheets of the state-owned banks into the asset management companies have distorted this particular output measure. As a means of dealing with this distortion, we subtract all NPLs from the book value of loans as a measure of output. An alternative measure of output we use, that does not involve the distortion caused by NPLs is interest earnings.

Second, the paper decomposes the measure of Cost efficiency (CE) in Chinese banks into technical efficiency (TE), and allocative efficiency (AE). Proponents of the X-efficiency (XE) view argue that TE is consistent with XE. However, with reference to the minimum cost point of operation, overall efficiency must be measured in terms of cost efficiency. This paper argues that while the underutilization of factors is consistent with the notion of X-inefficiency, the wrong factor-mix is indicative of rational decision making and 'rent-seeking'. The decomposition of cost inefficiency into X-inefficiency (technical inefficiency) and rent-seeking inefficiency allows us to examine their evolution over the sample period.

Third, this paper aims to provide an inferential capability to the point-estimates of efficiency through the use of bootstrapping methods. The question this part of the analysis poses is, are the measures of relative efficiency significantly different from the benchmark? Are the measures of X-inefficiency and 'rent-seeking' statistically significant? The threat of entry of foreign banks into the Chinese market will lead to improved management, which will result in improved technical efficiency and lower cost-inefficiency as incumbent banks attempt to cut costs and consolidate their balance sheets. How can the improvement in efficiency be evaluated?

This paper is organized on the following lines. The next section discusses the literature and outlines the non-parametric method of estimating bank efficiency. Section 3 discusses the measurement of inefficiency and discusses the difference between X-inefficiency and 'rent-seeking' inefficiency. Section 4 discusses the data and methodology of bootstrapping as applied to the non-parametric method. Section 5 discusses the results and section 6 concludes.

2. Methodology and Literature Review

Most studies of banking efficiency have focussed on the developed economies[3]. While there have been some studies of other Far Eastern economies[4], the number is small in comparison. Indeed, Berger and Humphrey's (1997) survey of 130 studies of frontier analysis in 21 countries, only 8 were about developing and Asian countries (including 2 in Japan). Studies on US financial institutions were the most common, accounting for 66 out of 116 single country studies.

The basis of the non-parametric method of Data Envelope Analysis (DEA) is the extension by Charnes et al. (1978) (CCR)[5] of the single input-output model of Farrell (1957) to a multiple input-output generalisation. Technical efficiency (TE) is measured as the ratio of projected output (on the efficient frontier) to actual input used. There are a number of papers that describe the methodology of DEA as applied to banking[6], what follows is a brief description.

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[3] Drake and Hall (2003), Cavallo and Rossi (2002), Elyasiani and Rezvanian (2002), Maudos et al. (2002), Drake (2001) Altunbas and Molyneux (1996) and Molyneux and Forbes (1993)

[4] See Rezvanian and Mehdian (2002), Hardy and di Patti (2001), Karim (2001), Laevan (1999), Katib and Matthews (1999), Chu and Lim (1998), Bhattacharyya et al. (1997) and Fukuyama (1995)

[5] Charnes et. al (1978) popularised the DEA method. Tavares (2002) produces a bibliography of DEA (1978-2001). There are 3203 DEA authors whose studies cover a wide range of fields. Banxia.com also compiles DEA papers from 1978 to the present.

[6] The most recent being Drake (2004)

Let us say that there are N banks. Let x_i represent the input matrix of the i[th] bank, and y_i represent its output matrix. Let the KxN input matrix be denoted X and the MxN output matrix be denoted Y. The efficiency measure of each of the N banks is maximised by the DEA searching for the ratio of all weighted outputs over all weighted inputs, where the weights are selected from the dual of the linear programming problem specified as:

$$\min_{q,l} q$$

$$\text{subject to} \quad \begin{aligned} -y_i + Yf &\geq 0 \\ qx_i - Xf &\geq 0 \\ f &\geq 0 \end{aligned} \qquad (1)$$

where f is an $Nx1$ vector of constants q is a scalar and is the economic efficiency score of the i[th] bank ($0 < q < 1$).

The estimation of cost efficiency involves the comparison of minimum cost at the optimal factor inputs to actual cost at the observed factor inputs. The minimisation exercise becomes:

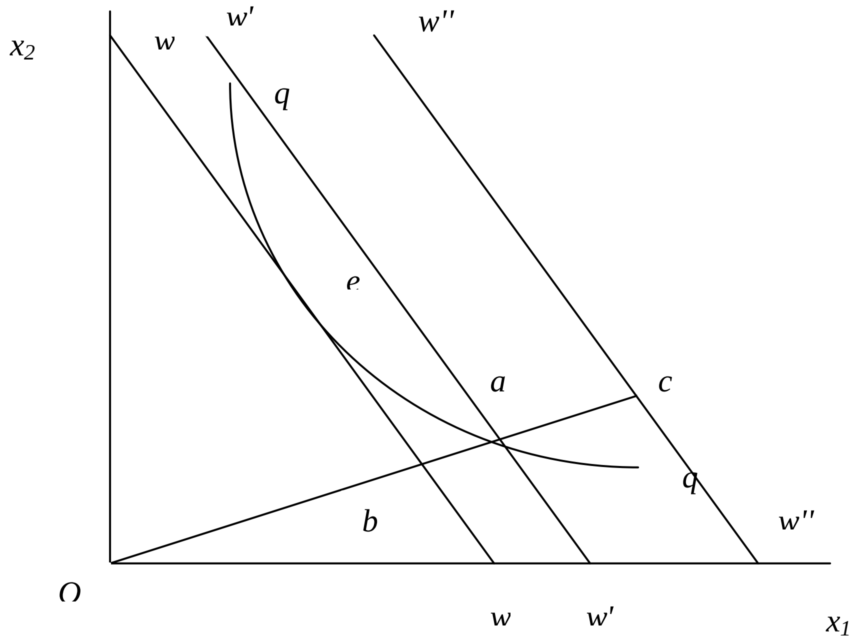
$$\min_{l,z_i} w_i' x_i^*$$

$$\text{subject to} \quad \begin{aligned} -y_i + Yf &\geq 0 \\ x_i^* - Xf &\geq 0 \end{aligned} \qquad (2)$$

where w_i is a vector of input prices for the i^{th} bank and x_i^* is the cost minimising vector of inputs for the i^{th} bank. A graphical illustration helps to differentiate the two concepts in the case of constant returns to scale technology (CRS).

Figure 1 shows an isoquant *qq* producing a given output with factor inputs x_1 and x_2 and isocost *ww,* which traces the ratio of factor prices. The efficient cost minimising position is shown at *e* where *ww* is tangential to *qq*. Employing a factor combination shown by point c, which is to the right of the isoquant *qq* indicates that the firm is technically inefficient. Efficiency is decomposed into technical efficiency and allocative efficiency (AE).

Figure 1: Technical Efficiency and Allocative Efficiency



Technical efficiency (TE) is measured by the ratio *Oa*/*Oc*. The cost to the firm is shown by *w''w''* which is parallel to *ww* and passes through point c. Cost efficiency (CE) is measured by *Ob*/*Oc* and *Ob/Oa* gives allocative efficiency (AE). It can be seen therefore from this decomposition that under constant returns to scale (CRS);

$$AE = \frac{CE}{TE} \qquad (3)$$

However, the CCR model under the assumption of CRS is only appropriate when all banks are at the optimal scale. This requires that the Decision Making Units (DMUs) operate on the flat portion of the long run average cost curve. However, scale inefficiency can be estimated for by altering the CCR model to allow for variable returns to scale (VRS). Banker et. al (1984) (BCC) accounts for scale effects by estimating the most productive scale size for each DMU while identifying its technical efficiency[7]. Therefore technical efficiency is further

[7] Coelli (1996) shows that the use of the CRS specification when some of the banks are not operating at the optimal scale will result in measures of technical efficiency that are mixed up with scale efficiency.

decomposed into measures of pure technical efficiency (PTE) and scale efficiency (SE). Hauner (2005) demonstrates that under the assumption of VRS, cost efficiency (CE) can be further decomposed by the formula;

$$CE = AE.SE.TE \qquad (4)$$

DEA constructs a non-parametric frontier of the best practice amongst the decision-making units (DMUs). An efficiency score for each DMU is measured in relation to this frontier. An efficiency score is constructed under both CRS and VRS. If the efficiency score of each bank produced by these models differ significantly, then the banks are said to experience variable returns to scale (Avkiran, 1999). In the case of VRS, a model can be orientated either by using input minimisation (efficiency gain through input reduction – input orientation) or output maximisation (efficiency gain from output expansion – output orientation).

DEA is relatively insensitive to model specification (input or output orientation) and functional form[8], however the results are sensitive to the choice of inputs and outputs. The weakness of the DEA approach is that it assumes data are free from measurement errors. Furthermore, since efficiency is measured in a relative way, its analysis is confined to the sample used. This means that an efficient DMU found in the analysis cannot be compared in a straightforward way with other DMUs outside of the sample.

A small but growing industry of efficiency studies of Chinese banks has emerged in recent years that have used DEA to measure relative efficiency[9]. The consensus of finding from the DEA studies is threefold. First, because of a continued banking reform programme technical inefficiency has been declining over time. Second, average bank efficiency is lower in the state owned banks (SOBs) than in the joint stock banks. Third, the gap between the two has been narrowing in recent years.

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[8] Hababou (2002) and Avkiran (1999) provide a relatively thorough discussion of the merits and limits of the DEA.

[9] In addition to the papers cited in footnote 1, other studies by Chinese scholars that have used non-parametric techniques include Xu, Junmin and Zhennsheng (2001), Zhang and Li (2001), Fang et. al. (2004).

3. Rational inefficiency

Berger, Hunter and Timme (1993) argue that X-inefficiency constitutes 20% or more of bank costs. Proponents of the theory of X-efficiency suggest that the familiar average cost curve of a firm is a 'thick band' rather than a thin line. The band defines a range of costs per given level of output, which will depend on the application of pressure and motivation on the personnel employed[10]. Poor motivation and weak pressure resulting in under utilization of factors of production, is part of what Leibenstein (1975) describes as 'organisational entropy'. X-inefficiency arises as a result of low pressure for performance. Some institutions would be protected by government regulation that would reduce the external pressure of competition. But even with a higher degree of pressure from the environment, firms may have organisational deficiencies so that management signals and incentives are lost in the hierarchy of the organisation.

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

[10] See for example Franz (1988)

Leibenstein and Maital (1992) suggest that X-inefficiency and its composition can be measured through the use of DEA analysis. The partitioning of the efficiency scores enables the differentiation between motivational factors and management deficiency. Leibenstein and Maital (1992) argue that the slack analysis of efficiency is a means of separating the proximate causes of X-inefficiency including management performance[11].

The two main scalars produced by DEA analysis is *theta* (*?*), which measures that portion of X-inefficiency that could be eliminated by the proportional reduction of inputs. However, even after reducing inputs, some inputs may still exhibit slack[12] which is measured by *iota* (*?*). Iota measures the total amount of X-inefficiency and therefore the direct management deficiency is measured by *? – ?*.

A slacks based measure of efficiency has been proposed by Tome (2001) which specifically incorporates the slacks into the objective function. This procedure amounts to recognising that in the case of the input-oriented measure of DEA, some organisations may be on the flat part of the isoquant of Figure 1 that is parallel to the axis, so that a further reduction in input could be obtained without sacrificing output[13]. Formally, the system described by (1) is replaced by;

$$\min_{i,l} i = q - e(S^{-} + S^{+})$$

Subject to

$$\begin{aligned} & -y_i + Yf - S^{+} \geq 0 \\ & qx_i - Xf + S^{-} \geq 0 \qquad (5) \\ & l \geq 0, 0 < e < 1 \end{aligned}$$

Where S^{-} and S^{+} are input and outputs slacks respectively. The existence of input slacks is a violation of the neo-classical assumptions of diminishing returns in production in

[11] Chen (2001) uses the decomposition to identify management X-inefficiency in Taiwan's banks.
[12] See Zhu (2003) pp. 39-45
[13] This procedure has been applied to the examination of banks in Hog Kong by Drake et al (2006)

the output oriented case and diminishing marginal productivity of factor inputs in the input oriented case.

An alternative interpretation of slacks in production is 'rent seeking' in the sense of Buchanan (1980) and Tullock (1967, 1980). Rent seeking in its basic form is the appropriation of surplus in the process of production or exchange without any real contribution to the process of either. Where there are government regulations on enterprise, barriers to entry and other anti-competitive rules, officials have the opportunity to extract rents through the mechanism of bribery and corruption. Therefore the term rent seeking has been generally associated with extortion, bribery and corruption. While it is generally accepted that corruption is fairly widespread in the financial sector in China, a number of high profile cases have made this subject a matter of contemporary concern[14]. The fall-out from a number of well-publicized cases could have the effect of reducing activity in this particular area.

However, a hidden but much more pervasive type of rent seeking is the extraction of larger budgets for bureaucracies and what results in the non-pecuniary rewards to workers in government owned enterprises (Tullock, 1967 and McKenzie and Tullock 1981). The prestige of the senior bureaucrats is enhanced if the size of the workforce is expanded to be larger than necessary to meet production targets. Similarly, offices are more grandiose, holidays are longer, and benefits are greater and so on.

Bogetoft and Hougaard (2003) suggest that the existence of slacks in production is the outcome of a rational decision making process that represents on-the-job compensation to managers. Whereas X-inefficiency is viewed by Leibenstein (1966, 1978) as non-maximising behaviour, Stigler (1976) argues that its existence is symptomatic of firms maximising their individual utility functions. Bogetoft and Hougaard (2003) propose that the slacks be part of

[14] The former Governor of the Construction Bank of China Wang Xuebing was sentenced to 12 years jail for accepting bribes of 1.15 million Yuan. The Vice-President of the Bank of China received a suspended death sentence for embezzling 14.5 million Yuan and accepting bribes of 1.4 million Yuan. See also Fan, Rui and Zhao (2006)

the preference set of managers rather than the technology of production. Faced with a target level of output, a give set of inputs and factor prices, the bureaucrat minimises costs subject to a utility function that includes in it arguments the level of output and a subset of factor inputs. In other words for the i^{th} bank, given the K factor inputs, the bureaucrat minimises costs to meet a utility function which contains the M outputs and a subset J of factor inputs, given standard neo-classical technology.

$$\min \; \lambda = w_k' x_{k,i} - l\left(U_0 - U\left(y_{m,i}, x_{j,i}\right)\right)$$

Subject to

$$\begin{aligned} & y_{m,i} = f\left(x_{k,i}\right), m = 1,2,\ldots,M \\ & f_k' > 0,\; f_k'' < 0, k = 1,2,.....K \end{aligned} \qquad (6)$$

The first order conditions are:

$$\begin{aligned} \frac{\partial \lambda}{\partial x_j} &= w_j + l\,(U_m' f_j' + U_{x,j}') = 0,\; j = 1,2,\ldots K - J \\ \frac{\partial \lambda}{\partial x_z} &= w_z + l\,(U_m' f_z') = 0, z = K - J + 1,\ldots., K - 1, K \\ \frac{\partial \lambda}{\partial l} &= U_0 - U\left(f\,(x_{k,i}), x_{j,i}\right) = 0, k = 1,2,....K \end{aligned}$$

The FOC show that an allocative inefficiency is created that favours factors inputs x_j above that implied by the optimal factor mix. In the context of figure 1, the ray from the origin to the tangency point e on figure 1 defines the optimal factor mix. At point 'a' the DMU is technically efficient but is allocatively inefficient. A bank can organise its input factors to be on its production frontier but be using the wrong factor mix. Rent seeking in monopolistic public utilities involves over-staffing, 'elaborate offices and a lot of trips to important conferences' or 'expensive subsidised restaurants' (McKenzie and Tullock, 1981). The wrong factor mix in the case of the Chinese banking sector can be interpreted as excess staffing[15]. The management of the banks may reduce technical efficiency (X-inefficiency as it has been

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

sometimes interpreted) by moving the cost frontier from *w''w''* to *w'w'*, but would still remain cost inefficient as shown by the gap *ab*/*Oc*. The gap between the minimum cost optimal factor mix and the technically efficient minimum cost associated with the efficient production frontier with the sub-optimal factor mix (or allocative inefficiency) can be interpreted as the inefficiency associated with 'rent seeking'[16].

4.0 Data and Bootstrapping

This study employs annual data (1997-2004) for 15 banks; the four state-owned banks, ten joint-stock commercial banks and one joint-venture bank. Data for one of the joint-stock banks was unavailable for 2004 (China Everbright) and in that year 14 banks data was used. The total sample consisted of 119 bank year observations. The main source of the data was Fitch/Bankscope and the *Almanac of China's Finance and Banking* (various). The choice of banks was based on the fact that they face a common market and compete nationwide. The one joint-venture bank in the sample is an example of a bank that has strong foreign intervention and would according to the consensus of evidence, be expected to exhibit a high level of efficiency, even though it can be argued that as a regional bank it would not necessarily be competing in the same markets as the other banks in the sample.

Two approaches are normally taken in determining what constitutes bank input and output. Under the intermediation approach, bank assets measure outputs and liabilities measure inputs. In contrast, inputs in the production approach are physical entities such as labour and capital and the outputs are the flows of income generated from the different channels of bank services. In this study, we consider two sets of outputs. First, we use three inputs and three outputs selected under the intermediation approach for the estimation of technical efficiency. Traditionally the intermediation approach would use as inputs the

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

number of employees (*LAB*), fixed assets (*FA*) and total deposits (*DEP*), and outputs would be total loans, other earning assets (*OEA*), and other operating income (*NII*). However, the operation of the Asset Management Companies in stripping out large tranches of NPLS from the state-owned banks distorts the use of loans as a valid output measure. We therefore consider the quality of the loan portfolio by stripping out non-performing loans (NPLs) from the stock of loans for each bank (*LOANSQ*). The 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.

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

The second of the set of outputs used is interest income (*II*) and non-interest income (*NII*). The advantage of these measures is that are relatively uncontaminated by the NPL problem. Interest income will represent the income generated from active loans and not NPLs. While non-interest income is relatively undeveloped in China, it is selected to reflect the growing contribution of this channel to bank's total income.

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 is available although the data revisions alter the figures from year to year and up until recently the accounting standards of Chinese banks differed from international standards (Ng and Turton 2001). The number of employees are available for the big four state owned banks but not for all of the joint-stock banks over all years. Similarly, the availability of personnel expenses varies across banks. In the years that personnel expenses were not available, the ratio of personnel expenses to total operating expenses in the adjacent year to the missing was applied. In the years where the number of employees was not available, the ratio of labour to fixed assets in the most recent year available was applied[17]. Where there were no personnel expenses available, it was assumed that the bank faced the same capital costs as banks of comparable size, which gave personnel costs as a residual.

Table 1 presents the summary statistics of the input and output data for 2004 as a snapshot indicator of the scale of the variables used. The high standard deviation is an indication of the dominance of the 4 state owned banks.

Table 1: Output-Input Variables 2004 (million RMB)

Variable	Description	Mean	Standard Deviation
LOANSQ	Loans adjusted for NPLs	861,603	972690.4
OEA	Other Earning Assets	572,112.7	698281.2
NII	Non-interest income	3,306.0	5083.0
II	Interest Income	49,995.9	59,974.9
LAB	Number employed (labour)	110,050.4	172260.9
DEP	Total Deposits	1,403,333.1	1766172.3
FA	Fixed Assets (less depreciation)	23,455.5	30074.6
PL	Price of labour	.08	.046
PF	Price of funds	.01	.020
PK	Price of fixed assets	.64	.279

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

One of the criticisms levelled at the DEA approach is that it produces estimates of efficiency that are not open to statistical inference. In other words if a DMU has a score of 0.95, in what statistical sense is it 5% inefficient relative to the benchmark? Without the capability for statistical inference, non-parametric methods would be weak alternatives to parametric methods of estimating efficiency. However, uncertainties also exist in the

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

estimation of efficiency using DEA. The most obvious uncertainty is what comes from measurement error. Measurement error in the context of data on Chinese banks is particularly acute. There are three potential sources of error. First, differences between local bank's accounting procedures and those of international bodies, second differences between local bank's accounting conventions and third, researcher assumptions relating to the generation of missing observations. Other uncertainties arise from the estimation of the efficiency frontier; changes to the inputs and/or outputs can cause large differences in the resulting scores. Furthermore there may be errors in the sampling variation caused by the difficulty in obtaining a sufficiently large and consistent sampling frame.

Simar and Wilson (1998, 2000a, 2000b) propose a bootstrap procedure for non-parametric frontier models. Bootstrapping is based on the notion that if the data can be viewed as a random sample from an underlying population under a model (data generating process - DGP), then the process of continuous random draws from the sample under the model generates also random draws from the population. The random draw can be viewed as a pseudo-sample and as a group of new benchmarks to compute the efficiency score for a given point. Following the Simar-Wilson method, 1000 bootstrap values of the individual DMU for all types of efficiency scores are generated in each year[18]. It is not the intention of this paper to give a detailed explanation of the Simar-Wilson bootstrapping method but a brief description of the method and algorithm is provided below.

Following Simar and Wilson (1998, 2000a, 2000b). The efficiency scores calculated with the original data are used to construct pseudo data. The bootstrap procedure is based on the idea that there exists a DGP, which can be determined by Monte Carlo simulation. By using the estimated distribution of the DGP to generate a large number of random samples, a set of pseudo estimates of the efficiency scores $\hat{q}_i$ are obtained. However this 'naive'

[18] Recent bootstrapping applications to DEA have been conducted by Löthgren and Tambour (1999); in the case of banking efficiency by Casu and Molyneux (2005); and in the case of Chinese rural credit cooperatives, Dong and Featherstone (2004).

bootstrap yields inconsistent estimates (Simar and Wilson, 2000a). A homogeneous bootstrap procedure that produces consistent values of $\hat{q}_i$ from a kernel density estimate is given in Simar and Wilson (2000b). The bootstrap algorithm is summarised in the following steps[19].

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

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

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

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

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

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

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

[19] The algorithm is run on MATLAB and the codes are available from the authors on request.

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

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

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

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

Step 9. Translate the polar coordinates in L^* to Cartesian coordinates. This yields the bootstrap sample $\{(x^*_i, y^*_i)\}^K_{i=1}$.

Step 10. For the given point (x, y), compute $\hat{q}^*(x, y)$ by solving the DEA program taking $\{(x^*_i, y^*_i)\}^K_{i=1}$ as the benchmarks and compute the bias-corrected efficiency scores $\tilde{q}(x, y) = \hat{q}^2 / \hat{q}^*$

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

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

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

5.0 Empirical Results

Table 2 presents the results of the bootstrap estimation. For reasons of brevity we present the results for five years and for CRS only but the relatively small sample in each year could bias the scale efficiency estimates, which raises doubts about the VRS assumption[20]. Furthermore the evidence of scale economies in banking is mixed. Early studies tended to confirm the existence of constant returns to scale[21], however more recent findings suggest that there are significant scale economies for large banks[22]. Finally, the bootstrap estimates under the VRS assumption showed implausibly low levels of cost efficiency and no difference between the estimates of cost efficiency and technical efficiency (no scale or allocative inefficiency) for all but two of the JSBs (for both types of output). The SOBs had implausibly high scores for cost and technical efficiency. In favour of the CRS measure, the estimates of cost efficiency obtained this way are similar to the findings of Fu and Heffernan (2005) for roughly the same sample period using stochastic frontier methods.

[20] The cluster of four large state-owned banks biases the scale efficiency estimates for the big-4.
[21] See Hunter and Timme (1986) and Berger et. al. (1987).
[22] Berger and Mester (1997) and Altunbas and Molyneux (1996).

Table2
Bootstrap Estimates of Inefficiency: 2000-2004, (%) CRS

Bank	Output	2000		2001		2002		2003		2004	
		X	Rent	X	Rent	X	Rent	X	Rent	X	Rent
ABOC	NPL	51.7***	20.3***	49.1***	29.6***	48.4***	22.1***	33.7***	35.0***	35.7***	27.4***
	Prod	43.7***	17.5***	41.7***	22.4***	25.3***	29.8***	38.5***	26.0***	40.1***	20.9***
BOC	NPL	23.2***	13.8**	19.6***	27.8***	18.6***	0	18.0***	0	20.4***	0
	Prod	23.1***	0	18.8***	0	17.1***	0	19.1***	0	20.8***	0
CCB	NPL	38.7***	23.7***	40.3***	18.4***	33.1***	23.0***	10.0***	44.2***	14.2***	35.1***
	Prod	42.1***	4.4***	41.9***	15.9***	18.8***	24.5***	18.2***	31.4***	27.0***	23.4***
ICBC	NPL	45.7***	15.6***	44.0***	10.6***	28.7***	24.6***	26.9***	26.6***	31.6***	22.6***
	Prod	35.9***	15.3***	44.2***	7.1***	14.8***	22.1***	37.1***	15.3***	29.1***	22.9***
BCom	NPL	38.1***	0	33.2***	0	27.5***	21.4***	14.9***	33.6***	16.3***	29.1***
	Prod	30.0***	0	29.3***	0	22.1***	17.5***	34.5***	16.2***	36.0***	5.7***
CITIC	NPL	30.6***	20.2***	25.2***	21.4***	34.4***	0	22.6***	15.3***	26.7***	8.9**
	Prod	20.4***	8.0***	20.0***	31.1***	22.7***	5.8***	26.6***	16.9***	34.8***	4.4**
CMB	NPL	18.7***	30.7***	27.5***	12.9**	41.2***	0	41.5***	0	46.1***	0
	Prod	34.0***	5.3***	16.1***	34.5***	23.6***	0	25.6***	13.0**	45.6***	0
CMBC	NPL	12.6***	29.4***	14.0***	29.3***	13.1***	21.1***	17.8***	8.5**	14.7***	15.0***
	Prod	15.1***	26.6***	11.3***	26.9***	6.5***	21.0***	21.9***	0	13.1***	16.5***
EVBRT	NPL	33.6***	15.3***	28.9***	17.2***	34.9***	8.5***	28.0***	11.0***	-	-
	Prod	29.5***	17.0**	24.3***	20.3***	21.0***	8.4***	25.9***	10.6**	-	-
FSB	NPL	46.1***	0	57.8***	0	31.0***	0	30.0***	0	21.5***	0
	Prod	42.4***	0	34.4***	0	23.5***	0	16.1***	0	7.9**	0
GDB	NPL	28.1***	28.3***	24.5***	20.6***	22.4***	22.8***	16.6***	19.8***	27.9***	14.4***
	Prod	21.6***	30.3***	26.8***	22.5***	9.6***	7.7*	19.9***	10.6***	18.7***	19.8***
HXIA	NPL	23.3***	29.2***	27.5***	24.6***	26.6***	10.2***	12.6**	28.1***	19.7***	20.0***
	Prod	25.7***	34.6***	16.7***	35.2***	14.4**	14.4***	30.7***	12.4***	35.2***	11.6***
IBCL	NPL	18.8***	34.6***	23.5***	0	21.3***	16.1***	14.8***	22.7***	33.5***	0
	Prod	34.8***	26.1***	19.5***	29.6***	16.1**	9.2**	22.9***	9.9***	26.2***	13.8**
SDB	NPL	27.3***	34.8***	17.3***	25.9***	14.3***	23.9***	13.5***	24.8***	8.8***	30.6***
	Prod	20.4***	36.7***	21.2***	30.7***	13.3***	10.3**	24.6***	10.6***	19.0***	13.9*
SPB	NPL	25.3***	40.0***	26.0***	28.4***	31.8***	5.9*	32.6***	0	34.0***	0
	Prod	26.3***	32.9***	24.5***	29.3***	28.8***	0	23.6***	9.8*	32.9***	0

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

The significant pattern than can be gleaned from Table 2 is the general decline in both types of measured inefficiency over time. Other patterns that emerge from careful observation is the frequency of coincidence of zero cells in the rent-seeking inefficiency boxes for both measures of output and the frequency of commonality of the estimates. However, it is not easy to glean patterns from simply ‘eye-balling’ the data. Table 3 summarises the average of the bootstrapped DEA scores for the full sample broken down into X-inefficiency and Rent seeking inefficiency for the state-owned banks (SOB) and Joint-stock banks (JSB), for the two different sets of outputs.

Table 3
Mean inefficiency, NPL adjusted loans and Production method (CRS)

	X-inefficiency	Rent-Seeking Inefficiency
SOB NPL – adjusted output	36.4%	30.6%
JSB NPL – adjusted output	31.3%	18.8%
't' statistic for difference in mean	1.70*	3.90***
SOB – production method output	30.6%	30.2%
JSB – production method output	25.7%	20.3%
't' statistic for difference in mean	2.39**	2.89***
Correlation coefficient – all banks	0.5324***	0.7249***
Spearman's Rank correlation – all banks	0.4019***	0.7244***

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

The first two rows of Table 3 show the mean inefficiency estimates for the full sample for the SOBs and JSBs. The third row shows that the differences in the means are statistically significant. Similarly, the mean inefficiency scores for the SOBs and JSBs using the production method are shown rows four and five. Again the 't' test shows significant difference in means. So in contrast to the consensus of finding, Table 3 shows that the SOBs have a significantly higher level of X-inefficiency and rent-seeking inefficiency than the JSBs. The two output sets produce remarkably similar measures of inefficiency. A correlation over the full sample shows a significant relation (row 7) and the ranking of banks efficiency by the different output methods show a significant commonality (row 8).

However, the important question is how do these relative measures of efficiency evolve over time? We address this question by regressing the change in the respective measure of inefficiency on its lagged value. The estimated coefficient on the lagged value of inefficiency can be treated as the parameter of adjustment. A significant negative value indicates that inefficiency is declining (efficiency improving). The larger the absolute value of the parameter, the faster the speed of adjustment. The regressions are conducted as a panel of the form $\Delta Y_{i,t} = a + bY_{i,t-1} + e_{i,t}$ with heteroscedastic adjustment of the standard errors. The results are shown in Table 4 below.

Table 4: Beta value Inefficiency adjustment, CRS

Inefficiency	Bank Group	b - NPL adjusted	t value	b - production method	t value
X-inefficiency	SOB	-.197	-3.05***	-.671	-3.50***
	JSB	-.543	-8.29***	-.877	-10.07***
	All Banks	-.454#	-8.13***	-.826	-10.42***
Rent-seeking	SOB	-.826	-7.09***	-.448	-3.19***
	JSB	-.507	-5.59***	-.489	-5.10***
	All Banks	-.648	-7.51***	-.469	-6.00***

with SOB intercept dummy, *** significant at the 1%

The most important result of Table 4 is that under both definitions of output there is strong statistical evidence of a negative trend in both types of inefficiency. In this respect, the results of this paper differ from the findings of Chen et. al. (2005) who find no discernible trend improvement in cost efficiency[23]. The speed of decline in X-inefficiency (improvement in technical efficiency) is less for the SOBs than the JSBs, on both measures but it is particularly marked in the case of the NPL adjusted Loans. One can infer that once NPLs have been removed the big 4 collectively are much closer to the frontier than the JSBs and thus the speed of reduction of inefficiency is commensurately lower. There is a faster speed of decline of rent-seeking inefficiency by the SOBs in the NPL adjusted case but no significant difference in the speed of decline of rent-seeking inefficiency in the production case. While the results are mixed relating to the differences in the speed of adjustment of the

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

two sets of banks, the common finding is that both types of inefficiency has declined significantly during this period for all the banks in the sample.

Using parametric methods, Fu and Heffernan (2005) find cost inefficiency in the order of 50% over the period 1993-2002. These findings are consistent with the bootstrap estimates obtained here and also the broad findings of Chinese scholars cited in this paper. Such findings have typically generated a consensus of pessimism about the future of Chinese banking. Our findings suggest grounds for optimism in that in terms of relative efficiency, Table 3 shows that the trend is towards improved performance.

6.0 Conclusion

This paper argues that cost inefficiency can be partitioned into X-inefficiency and rent-seeking inefficiency. If this decomposition is accepted then it follows that part of the cost-inefficiency of Chinese banks is not due to managerial malaise but rational decision making. It is the case then that the implication for the current thrust of official bank policy in China is positive. According to Leibenstein (1966), X-efficiency is improved through managerial motivation and external pressure. Impending competition and the deregulation of the Chinese banking market can be expected to motivate managers to improve performance and utilise existing factors of production fully. Competition for well-qualified staff between the different banking firms will raise rewards and attract the best graduates. The potential outflow of the best staff to the higher paying institutions will motivate a greater focus on training, modernization and efficiency.

Bureaucratic rent seeking is a rational response to a particular set of incentives based on the dictates of planning policy. It would be no surprise to learn that over the years of protected growth, as the banks were vessels for the channelling of unprofitable loans to state-owned enterprises, the response of the banking sector was to develop rent seeking strategies and act as employment sponges for the educated youth in China. It can be expected that the dismantling of protection and the invitation to list the state-owned banks and the joint stock banks will alter the incentive structure for managers and consequently there should be a trend reduction in rent-seeking inefficiency.

This paper has used non-parametric methods to conduct an analysis of inefficiency in a sample of Chinese banks. The estimates of bank inefficiency were buttressed with bootstrapping techniques to enable statistical inference. In general, the estimates from bootstrapping support the view that relative efficiency has improved. However, these results must still be interpreted with caution. The improvement in efficiency is in terms of the benchmark banks, which are themselves 'best-practice' Chinese banks. The real benchmarks should be foreign banks competing on an equal footing or foreign banks operating in their home countries under similar conditions of development and risk.

It is not the intention of this paper to paint a rose hued picture of the state of Chinese banking. Managerial problems and corporate governance issues still bedevil banking in China. However, the argument of this paper is that the threat of an open market to foreign banks has resulted in significant improvements in bank efficiency, with faster improvements being shown by the JSBs. The main message of this paper is that a change in the incentive structure has motivated Chinese bank managers to ‘up their game’. Consequently, Chinese banks are in better shape than they have ever been.

References

Altunbas, Y., and Molyneux, P. (1996). "Cost economies in EU banking system", ***Journal of Economics and Business***, Vol. 48, Issue 3, 217-230.

Avkiran, N.K. (1999). "An application reference for data envelopment analysis in branch banking: helping the novice researcher", ***International Journal of Bank Marketing***, 17(5), 206-220.

Banker, R.D., Charnes, A., and Cooper, A.A. (1984). "Some models for estimating technical and scale inefficiencies in data envelopment analysis", ***Management Science***, 9, pp. 1078-1092.

Berger, A.N., and Mester L. (1997), "Inside the Black Box: What explains difference in efficiencies of financial institutions", ***Journal of Banking and Finance***, 21, 895-947

Berger, A.N., and Humphrey, D.B. (1997). "Efficiency of Financial Institutions: International Survey and Directions for Future Research", ***European Journal of Operational Research***, 98, 175-212.

Berger A N., Hunter W C and Timme S G (1993), "The Efficiency of Financial Institutions: A Review and Preview of Research Past, Present and Future", ***Journal of Banking and Finance***, 17, 221-249

Berger A N., Hanweck G A. and Humphrey D B. (1987), "Competitive Viability in Banking, scale, scope and product mix economies", ***Journal of Monetary Economics***, 20, 501-520

Bhattacharyya, A., Lovell, C.A.K., and Sahay, P. (1997). "The Impact of Liberalization on the Productive Efficiency of Indian Commercial Banks", ***European Journal of Operational Research***, 98, 332-345.

Bogetoft P and Hougarrd J L (2003), "Rational Efficiencies", ***Journal of Productivity Analysis***, 20, 243-291

Buchanan J (1980), "Rent Seeking and Profit Seeking", in ***Toward a Theory of the Rent Seeking Society***, (eds) J Buchanan, R Tollison, and G Tullock, College Station: Texas A&M University Press

Casu B and Molyneux (2005), "A Comparative Study of Efficiency in European Banking", School of Accounting, Banking & Finance, University of Wales Bangor, Discussion Paper

Cavallo, L., and Rossi, S.P.S. (2002). "Do Environmental Variables Affect the Performance and Technical Efficiency of the European banking systems? A Parametric Analysis using the Stochastic Frontier Approach", ***The European Journal of Finance***, 8, 123-126.

Charnes, A., Cooper, W.W., and Rhodes, E. (1978). "Measuring the Efficiency of Decision Making Units", ***European Journal of Operational Research***, 2, 429-44.

Chen T-S (2001), An Estimation of X-inefficiency in Taiwan's Banks", ***Applied Financial Economics***, 11, 237-242

Chen X, Skully M and Brown K (2005), "Banking Efficiency in China: Applications of DEA to pre-and post-Deregulation eras: 1993-2000", ***China Economic Review***, 16, 2229-245

Chu, S.F., and Lim, G.H. (1998). "Share Performance and Profit Efficiency of Banks in an Oligopolistic Market: evidence from Singapore", ***Journal of Multinational Financial Management***, 8, 155-168.

Coelli, T. (1996). "A guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program", CEPA Working Paper 96/08, University of New England, Australia.

Crain W M and Zardkoohi A (1980), "X-inefficiency and Non-Pecuniary Rewards in a Rent-Seeking Society: A Neglected Issue in the Property Rights Theory of the Firm", ***American Economic Review***, 70, 784-792

Drake L, Hall M and Simper R (2006), "The impact of macroeonomic and regulatory factors on bank efficiency: A non-parametric analysis of Hong Kong's banking system", ***Journal of Banking and Finance***, 30, 1443-1466

Drake L (2004). "Costs and Efficiency in Banking: A Survey of the Evidence from the US, the UK and Japan", in Mullineux A W and Murinde V (Eds) ***Handbook of International Banking***, Cheltenham: Edward Elgar

Drake, L. (2001). "Efficiency and productivity change in UK banking", ***Applied Financial Economics***, 11, 557-571.

Drake, L., and Hall, M.J.B. (2003). "Efficiency in Japanese banking: An empirical analysis", ***Journal of Banking and Finance***, 27, 891-917.

Dong F and Featherstone A (2004), "Technical and Scale Efficiencies for Chinese Rural Credit Cooperatives: A Bootstrapping Approach in Data Envelope Analysis", Center for Agricultural and Rural Development, Iowa State University, Working Paper 04-WP 366

Elyasiani, E., and Rezvanian, R. (2002). "A Comparative Multiproduct Cost study of Foreign-owned Bank and Domestic-owned US banks", ***Applied Financial Economics***, 12, 271-284.

Fang C, Sun W, Wang Z, Wang H (2004), "State-Owned Bank's Efficiency Measurement and their Behaviour Character Study", ***Journal of Qualitative and Technical Economics***, 4, 42-45 (Chinese language)

Färe, R., Grosskopf, S., Norris, M. and Zhang, Z. (1994). "Productivity growth, technical progress and efficiency change in industrialised countries", ***The American Economic Review***, Volume 84, 66-83.

Farrell, M.J. (1957). "The measurement of productive efficiency of production", ***Journal of the Royal Statistical Society***, Series A, 120, 253-281.

Franz R S (1988), ***X-Efficiency: Theory, Evidence and Applications***, Kluwer Academic Press: Dordrecht

Fu X and Heffernan S (2005), "Cost X-efficiency in China's Banking Sector", ***Cass Faculty of Finance Working Paper*** #WP-FF-14-2005

Fukuyama, H. (1995). "Measuring efficiency and productivity growth in Japanese banking: A non-parametric frontier approach", ***Applied Financial Economics***, 5, pp. 95-117.

Hababou, M. (2002) ."Tutorial in DEA". http.//members.tripod.com/moezh/DEAtutorial/DEAtutorial.html.

Hardy, D.C., and di Patti, B.E. (2001). "Bank reform and bank efficiency in Pakistan", ***IMF Working Paper***, WP/01/138.

Hauner D (2005), "Explaining Efficiency Differences among large German and Austrian Banks", ***Applied Economics***, 37, 969-980

Hunter W C and Timme S G (1986). "Technical Change, organisational form and the structure of bank productivity", ***Journal of Money, Credit and Banking***, 18, pp 152-166

Karim, M.Z.A. (2001). "Comparative bank efficiency across select ASEAN countries", ***ASEAN Economic Bulletin***, 18(3), 289-304.

Katib, M.N., and Matthews, K. (1999). "A non-parametric approach to efficiency measurement in the Malaysian banking system", ***The Singapore Economic Review***, 44 No.2, 89-114.

Laeven, L. (1999). "Risk and efficiency in East Asian banks", ***World Bank, Policy Research Working Papers*** 2255.

Leibenstein H (1978), "X-inefficiency Xists: Reply to an Xorcist", ***American Economic Review***, 68, 203-211

Leibenstein H (1975), "Aspects of the X-Efficiency Theory of the Firm", ***The Bell Journal of Economics***, 6, 2, 580-606

Leibenstein H (1966), "Allocative Efficiency vs. X-Efficiency", ***American Economic Review***, 56, 3, 392-415

Leibenstein H and Maital S (1992), "Empirical Estimation and Partitioning of X-inefficiency: A Data Envelope Approach", ***American Economic Review***, 82, 428-433

Löthgren M and Tambour M (1999), "Testing Scale Efficiency in DEA Models: A Bootstrapping Approach", ***Applied Economics***, 31, 1231-1237

Maudos, J., Pastor, J.M., Perez, F. and Quesada, J. (2002). "Cost and profit efficiency in European banks", ***Journal of International Financial Markets, Institutions and Money***, 12, 33-58

McKenzie R B and Tullock G (1975), ***The New World of Economics***, Homewood, Illinois: Richard D Irwin inc

Megginson W L (2005), "The Economics of Bank Privatization", ***Journal of Banking and Finance***, 29

Megginson W L and Netter J M (2001), "From State to Market: A Survey of Empirical Studies on Privatization", ***Journal of Economic Literature***, 34, 321-389

Molyneux, P., and Forbes, W. (1993). “Market structure and performance in European banking”, ***Institute of European Finance***, RP 93/5.

Ng S and Turton C (2001), ***PRC vs International Accounting Standards***, Deutsche Bank Hong Kong, January 9

Qing W and Ou Y (2001), "Chinese Commercial Banks: Market Structure, Efficiency and its Performance" ***Economic Science***, 100871, 34-45 (Chinese language)

Rezvanian, R., and Mehdian, S. (2002). “An examination of cost structure and production performance of conventional banks in Singapore”, ***Journal of Banking and Finance***, 26, 79-98.

Simar L and Wilson P W (2000a), "Statistical Inference in Non-Parametric Frontier Models: The State of the Art", ***Journal of Productivity Analysis***, 13, 49-78

Simar L and Wilson P W (2000b), "A General Methodology for Bootstrapping in Non-Parametric Frontier Models", ***Journal of Applied Statistics***, 27, 779-802

Simar L and Wilson P W (1998), "Sensitivity Analysis of Efficiency Scores: How to Bootstrap in Non-Parametric Frontier Models", ***Management Science***, 44, 49-61

Stigler G (1976), “The Xistence of X-efficiency”, ***American Economic Review***, 66, 213-216

Tavares, G. (2002). ***A bibliography of data envelopment analysis (1978-2001)***, Rutcor Research Report, Rutgers University, USA.

Tone K (2001), “A Slacks-based measure of efficiency in data envelope analysis, ***European Journal of Operational Research***, 130, 498-509

Tullock G (1980), "Efficient Rent Seeking", in ***Toward a Theory of the Rent Seeking Society***, (eds) J Buchanan, R Tollison, and G Tullock, College Station: Texas A&M University Press

Tullock G (1967), "The Welfare Costs of Tariffs, Monopolies, and Theft", ***Western Economic Journal***, 5, 224-232

Wei Y and Wang L (2000), "The Non-Parametric Approach to the Measurement of Efficiency: The Case of China Commercial Banks", ***Journal of Financial Research***, 3, 88-96 (Chinese language)

Xu Z, Junmin Z and Zhenseng J (2001), "An Analysis of the Efficiency of State-Owed Banks with Examples", ***South China Financial Research***, 16, 1, 25-27 (Chinese language)

Xue F and Yang D (1998), "Evaluating Bank Management and Efficiency using the DEA Model", ***Econometrics and Technological Economy Research***, 6, 63-66 (Chinese language)

Zhao X (2000), "State-Owned Commercial Banks Efficiency Analysis", ***Journal of Economic Science***", 6, 45-50 (Chinese language)

Zhang W and Li Y-S (2001), "Extension Study of the Internal Appraisal for City Commercial Banks", (Chinese language)

Zhu, J. (2003). ***Quantitative models for performance evaluation and benchmarking*** Kluwer Academic Publishers.