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The Impact of Macroeconomic and Regulatory Factors on Bank Efficiency: A Non-Parametric Analysis of Hong Kong's Banking System

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Abstract

This paper assesses the relative technical efficiency of institutions operating in a market that has been significantly affected by environmental and market factors in recent years, the Hong Kong banking system. These environmental factors are specifically incorporated into the efficiency analysis using the innovative slacks-based, second stage Tobit regression approach advocated by Fried et al (1999). A further innovation is that we also employ Tone's (2001) slacks-based model (SBM) to conduct the Data Envelopment Analysis (DEA), in addition to the more traditional approach attributable to Banker, Charnes and Cooper (BCC) (1984).

The results indicate: high levels of technical inefficiency for many institutions; considerable variations in efficiency levels and trends across size groups and banking sectors; and also differential impacts of environmental factors on different size groups and financial sectors. Surprisingly, the accession of Hong Kong to the People's Republic of China, episodes of financial deregulation, and the 1997/98 South East Asian crisis do not seem to have had a significant independent impact on relative efficiency. However, the results suggest that the impact of the last mentioned may have come via the adverse developments in the macro economy and in the housing market.

Keywords: Data Envelopment Analysis, Slacks Adjustment, Hong Kong Banks, Efficiency, Regulation and Environmental Variables.
JEL Classification: C23; C52; G21

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1. Introduction

The concept of efficiency in banking has been considered widely in the literature, utilising both non-parametric and parametric techniques (Hall 2001). However, there has been an on-going debate over whether the estimated efficiency scores ('scale efficiencies' or 'X-efficiencies') are biased, not only due to the techniques utilised to estimate them, but also due to endogenous and/or exogenous factors affecting the bank sample. With respect to the former, for example, McAllister and McManus (1993) argue that the Minimum Efficient Scale (MES) for banks can change as the total asset size of the banks in the sample increases, due to possible differences in the asset portfolios between the smaller and larger banks. With respect to the latter, it has long been recognised that external/environmental factors can have a significant impact on relative efficiency scores.

There have recently been advances made, however, in respect of how researchers incorporate the potential impact of environmental, economic and regulatory factors on bank efficiencies (see, for example, parametric studies by Akhigbe and McNulty, 2003, Berger and Mester, 2003, Chaffai et al, 2001 and Dietsch and Lozano-Vivas, 2000, and non-parametric studies by Lozano-Vivas, Pastor and Pastor, 2002). In the former set of studies, the external variables (which are added as control variables to the functional form equation) are assumed to have a direct effect on the production/cost structure. Hence, each bank is assumed to face a different production/cost frontier. In the latter set of non-parametric studies, the external factor variables are typically introduced as non-discretionary inputs and/or outputs, having a direct effect on the efficient production frontier.

A drawback of this particular non-parametric approach, however, is that there is no standard statistical test to determine whether the researcher has utilised the correct set of non-controllable inputs or outputs. In this paper, therefore, we utilise an innovative non-parametric approach to examine the impact of external/environmental factors on an evolving banking market. Specifically, this is undertaken using an approach that allows a second statistical stage of analysis of the effects of external factors to be determined. These impacts are then incorporated into a revised non-parametric efficiency analysis. We maintain that any analysis of specific financial service sectors in individual countries, or any comparison of financial institutions across a range of different countries, needs to take account of the various exogenous factors specific to those sectors/countries.

With respect to the case of Hong Kong, as discussed in detail in Section 2, it may be argued that such external factors have had a potentially significant impact on the financial sector. For example, in recent years the banking industry has had to contend with: the fallout from the Asian Financial Crisis (1997/98), including the crashes in the local stock and property markets and a crisis of confidence in the Hong Kong dollar; the handover of the colony to the People's Republic of China (1997); and financial deregulation, which culminated in the completion of the deposit rate deregulation in July 2001. More recently, Hong Kong has suffered from the SARS-related effects of Spring 2003. For these reasons, the Hong Kong banking industry would seem to be an ideal choice for a case study of the impact of external factors on banking efficiency.

The paper is organised as follows. In Section 2 we provide a review of the changing nature of banking in Hong Kong and the effects of the Asian financial crisis and the colony's takeover. Section 3 provides a brief literature review. Section 4 discusses the three-stage DEA methodology, based on Fried et al (1999), used to account for potential environmental and market influences on bank efficiency. This section also outlines the slacks-based measure (SBM) of efficiency proposed by Tone (2001) and contrasts this with the more conventional Banker, Charnes and Cooper (BCC, 1984) approach to DEA. Section 5 discusses the profit-oriented approach to the data set utilised. Section 6 presents the Stage 1 , 2 and 3 results. These are the results from the initial Stage 1 DEA analysis, the subsequent Stage 2 regression analysis which quantifies the impact of environmental factors on efficiency, and the Stage 3 DEA analysis which utilises inputs adjusted to take account of the influence of environmental and market factors. To the authors' knowledge, this is the first paper to apply this type of three-stage approach to the study of a financial service sector. This study also extends the Fried et al (1999) procedure by incorporating Tone's (2001) slacks-based measure (SBM). Section 6 also contrasts the SBM efficiency results with the BCC efficiency scores, both across asset size groups and across different sectors of the banking system. Section 7 concludes.

2. Recent Developments Affecting The Hong Kong Banking Industry

Although Hong Kong's successful transformation from a small entrepôt to a world-class financial centre (Jao, 1997; Schenk, 2002) owes much to the relative openness of the former colony, with full convertibility of its currency always being available, a pure *laissez-faire* policy was never adopted. Accordingly, a number of significant events, embracing both structural reform and liberalisation, have served to change the face of the Hong Kong banking industry over the last few decades.

As far as *structural reform* is concerned, Hong Kong has moved from a monolithic system (of "licensed banks") to a three-tier banking system which, since 1990, has distinguished "licensed banks" from "restricted license banks" and "deposit-taking companies" (DTCs). As a *quid pro quo* for the tighter prudential regulation they are forced to endure (Jao, 2003), the (locally-incorporated) licensed banks enjoy greater business freedom than the other two categories of deposit-takers, although they are subject to a minimum size criterion – customer deposits must amount to at least HK$3 billion in aggregate and total assets must total at least HK$4 billion. In comparison, the last two categories of institution are confined to the taking of time deposits; and restricted license banks are subject to a minimum size of deposit requirement of HK$500,000, with DTCs being subject to a minimum size of deposit requirement of HK$100,000 and a minimum deposit maturity restriction of three months. Moreover, no new DTCs will be allowed to operate unless they are majority-owned by licensed banks. Further structural reform, however, as called for by KPMG Barents in a consultancy report produced in 1998 (KPMG Barents, 1998) for the Hong Kong Monetary Authority (HKMA), Hong Kong's *de facto* central bank, entailing "simplification" of the current three-tier structure as a means of enhancing competitiveness in the Hong Kong banking industry, is on hold pending the "bedding down" of new market entry criteria introduced in 2002.

With respect to *financial liberalisation*, a number of moves have been made during the period relevant to this study (i.e. 1995-2001), mainly in an attempt to stimulate competition in the banking industry. Of particular interest is the deregulation of interest rates. As recommended by KPMG Barents, and accepted by the HKMA in July 1999, deposit rate deregulation was completed by July 2001 with the removal of the remaining interest rate caps (the caps on retail deposits of more than seven days maturity and on seven-day time deposits were removed in January and November 1995 respectively, with the cap on time deposits of less than seven days being lifted in July 2000). Assuming that, in the past, the profitability of licensed banks (DTCs were not a party to the "agreement") operating in Hong Kong had been boosted by the application of such controls (which only applied to Hong Kong dollar-denominated deposits of up to HK$500,000 after March 1982), it is to be expected that such liberalising measures will serve to dampen the prospects of those banks affected.

Finally, a number of "environmental" factors have also impacted on the Hong Kong banking industry during the 1995-2001 period. Most significant are the handover of the former colony to the People's Republic of China (PRC) in July 1997 and the effects of the Asian Financial Crisis (AFC) of 1997/8. The former event has strengthened the financial relationship between Hong Kong and Mainland China, under the operation of six "guiding principles" (Jao, 2003), whilst allowing the Hong Kong dollar to continue to circulate as a convertible and separate currency. In the process, however, the fortunes of Hong Kong-domiciled institutions have become more dependent on the Mainland, whose lenders have moved aggressively into Hong Kong markets recently in search of higher quality credits, thereby further depressing lending margins for local banks already facing the effects of deposit-rate deregulation. Similarly, Hong Kong's banks suffered badly during the AFC of 1997/8 as it coincided with a local property market crash. The resultant depression of profits and increase in bad debts was further exacerbated by speculative attacks on the Hong Kong dollar which triggered sharp rises in nominal interest rates in defence of the peg of 7.8 Hong Kong dollars to the US dollar, first adopted in October 1983 ('technical' measures taken to ameliorate the costs of defending the peg are discussed in Jao, 2003, at pp.116-118). These interest rate increases further depressed bank profits (HKMA, 2003). The outcome was a fall of nearly a third in the level of operating profits reported by Hong Kong's banks for the financial year 1998, with bad debts rising by over 300 per cent.

3. Brief Literature Review

To date there has been relatively little research conducted in the efficiency of the Hong Kong banking system. Kwan (2002a), however, conducted an analysis into the X – Efficiency of commercial banks in Hong Kong. A panel data sample is utilised and based on quarterly data from 1992:Q1 to 1999:Q4, and as of end 1999 the cross section consisted of 51 banks. Unlike this study, Kwan adopts the stochastic cost frontier approach rather than the non-parametric DEA approach. Furthermore, the conventional intermediation is adopted in respect of the specification of outputs and inputs (input prices). Finally, no attempt is made to control for environmental factors which may have impacted on the Hong Kong banking system or on subsets of banks.

The key findings of Kwan (2002a) are that the mean level of X-inefficiency for all banks over the sample was around 32%, and that inefficiency levels generally declined over the sample period (from 41% in 1992:Q1 to 29% in 1999:Q4). Kwan attributes the latter to the impact of technological innovation.

Interestingly, X-Efficiency is found to decline with bank size, which is the opposite of the results typically obtained for the US.

Kwan (2002b) extends the previous analysis by examining bank unit operating costs across Asian economies. A basic regression approach is adopted in which unit costs are regressed against a vector of control variables (such as: ratio of loans to total earning assets; equity to assets ratio and ratio of loan loss provisions to total loans), a vector of country specific dummies and a vector of time specific dummies. Kwan finds the unit operating costs of Hong Kong banks to be very similar to those for banks in Singapore, but significantly lower than in the other Asian economies studied (Phillipines, South Korea, Indonesia, Thailand and Malaysia). A more interesting finding from the perspective of this study, however, is that from 1992 to 1997 banks on average were improving their operating performance over time. From 1997, however, Kwan finds a marked increase in per unit operating costs which he associates with the 1997 financial crisis and the fact that banks were incurring additional costs in dealing with problems loans while output was declining simultaneously. Hence, these results strongly suggest that Hong Kong banks may have been strongly affected by environmental / external factors during the 1990s.

4. Non-parametric Estimation Methodology

The non-parametric efficiency approach was originally developed by Farrell (1957) and later elaborated by Banker, Charnes and Cooper (1984) and by Fare, Grosskopf and Lovell (1985). The constructed relative efficiency frontiers are non-statistical or non-parametric in the sense that they are constructed through the envelopment of the decision-making units (DMUs), with the “best practice” DMUs forming the non-parametric frontier. This non-parametric technique was referred to as Data Envelopment Analysis (DEA) by Charnes, Cooper and Rhoades (1978).

A particular advantage of non-parametric techniques such as DEA, relative to parametric techniques, such as stochastic frontier analysis (see Drake and Simper, 2003 and Ferrier and Lovell, 1990), is that the latter must assume a particular functional form which characterises the relevant economic production function, cost function, or distance function. Hence, any resultant efficiency scores will be partially dependent on how accurately the chosen functional form represents the true production relationship (i.e., the relationship between inputs/resources and outputs). As DEA is non-parametric and envelops the input/output data of the DMUs under consideration, the derived efficiency results do not suffer from this problem of functional form dependency. Examples of DEA applied to the analysis of banking include Drake and Weyman-Jones (1996), Bauer et al (1998), Tortosa-Ausina (2002), Drake and Hall (2003) and Maudos and Pastor (2003).

In the case of the standard Banker, Charnes and Cooper (BCC, 1984) variable returns to scale DEA programme, for each DMU in turn, using x and y to represent its particular observed inputs and outputs, technical efficiency is calculated by solving the following input-based linear programme:

$$\min_{\theta,\lambda} : \theta$$

subject to:
$$X\lambda \leq x_0$$
$$Y\lambda \geq \theta y_0$$
$$\sum \lambda = 1 \qquad (1)$$

where, $\lambda \geq 0$.

As Fried et al (1999) point out:

"The solution to the DEA problem yields the Farrell radial measure of technical efficiency plus additional non-radial input savings (slacks) and output expansions (surpluses). In typical DEA studies, slacks and surpluses are neglected at worst and relegated to the background at best." (P 250)

Such output and input slacks are essentially associated with the violation of neoclassical assumptions. If we take the input oriented DEA approach, for example, input slacks would be associated with the assumption of strong or free disposability of inputs which permits zero marginal productivity of inputs and hence extensions of the relevant isoquants to form horizontal or vertical facets. In such cases, units which are deemed to be radial or Farrell efficient (in the sense that no further proportional reductions in inputs is possible without sacrificing output), may nevertheless be able to implement further additional reductions in some inputs. Such additional potential input reductions are typically referred to as non-radial input slacks, in contrast to the radial slacks associated with DEA or Farrell inefficiency, ie, radial deviations from the efficient frontier.

Recently, Tone (2001) has proposed a slacks-based measure (SBM) for DEA which specifically incorporates slacks in the objective function. Furthermore, as with the BCC approach, the efficiency scores are reference set dependent. An exposition of the SBM approach is provided below.

Given a set of inputs $X = (x_{ij}) \in \Re^{m \times n}$ and outputs $Y = (y_{ij}) \in \Re^{s \times n}$, the slacks from a DEA-based program can be written as, $x_0 = X\lambda + s^-$ and $y_0 = Y\lambda + s^+$, with $\lambda \geq 0$, $s^- \geq 0$, and $s^+ \geq 0$, where s^- and s^+ are the input and output slacks respectively. The SBM linear program for λ, s^- and s^+ is given by the following expression;

min
$$\tau = t - \tfrac{1}{m}\sum_{i=1}^{m} S_i^- / x_{io}$$

subject to:
$$1 = t + \tfrac{1}{s}\sum_{r=1}^{s} S_r^+ / y_{ro}$$
$$tx_o = X\Lambda + S^-$$
$$ty_o = Y\Lambda - S^+ \qquad (2)$$

where, $\Lambda = t\lambda \geq 0$, $S^- = ts^- \geq 0$, and $S^+ = ts^+ \geq 0$. The optimal solution is when and $\tau = 1$ hence a DMU will have zero input and output slacks and be fully efficient on the frontier.[1] That is, to be SBM-efficient also implies BCC efficiency and this is known as Pareto-Koopmans efficiency. Conversely, for inefficient DMUs, the SBM relative efficiency scores must be lower than, or equal to, the BCC scores by construction. However, even though the Tone SBM program explicitly incorporates the information contained in the slacks, it does not directly deal with environmental factors affecting DMUs.

As discussed briefly in Section 1, there has recently been an interest in the literature concerning how researchers can account for the impact of external variables when measuring firm efficiency. There has been widespread use of various parametric techniques, whereby it is assumed that the external factors affect either the production/cost efficiency frontier or directly affect technical efficiency (see, for example, Coelli et al (1999)). In the non-parametric case, however, the external factors are typically assumed to be non-discretionary and to directly affect the efficiency scores; see, for example, Lozano-Vivas et al (2002).[2]

In this paper, we propose two specifications. The first follows Fried et al (1999) and uses the BCC adjustment procedure, while in the second we incorporate both the Tone (2001) SBM approach and the Fried et al (1999) adjustment procedure. In both cases, the two-stage procedure is such that the total radial and non-radial input slacks (from either programs (1) or (2)) are obtained and separately regressed on a set of factors that are likely to affect the efficiency of Hong Kong banks. That is, we estimate,

$$IS_j^k = f_j\left(Z_j^k, \beta_j, \varepsilon_j\right) \tag{3}$$

where: IS_j^k is the input slack j for bank k; Z_j^k is a vector of j external factors that are likely to affect the efficiency of bank k and hence its input slack IS_j^k; β_j is a vector of parameters to be estimated; and finally, ε_j is the disturbance term. It is important to note that, in the original Fried et al (1999) procedure, only the BCC program was utilised.

To determine the main external variables that could have an effect on Hong Kong bank efficiency, we began with a large data set that included both macroeconomic and regulatory variables:

Macroeconomic: Private consumption expenditure; government expenditure; GDP fixed capital formation; net export of goods; net export of services; discount window base rate; unemployment; retail sales values; expenditure on housing; and the current account balance.

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1 The results for program (2) were obtained from the DEA Solver professional program, see Cooper, Seiford and Tone (2000).

2 However, within the efficiency literature, many non-banking studies have further analysed the 'raw' efficiency scores by utilising a two-stage procedure. For example, in Chilingerian (1995) potential environmental effects on the overall and technical efficiency of physicians were found to be significant with the implication that the 'raw' DEA scores may be biased due to their failure to incorporate these external factors. Similarly, Gillen and Lall (1997) analysed airport productivity and found that factors, such as the number of airline hubs, the number of gates, and whether an airport had a rotational runway, also affected the DEA efficiency scores. Finally, in a recent study, Linna et al (2003) found that socio-economic factors also had a significant impact on the technical efficiency of Finnish health centres.

Regulatory: Dummy variable for the Hong Kong property crash / Asian financial crisis; dummy variable for handover to the People's Republic of China; dummy variable for 1999 (Hong Kong Monetary Authority agreed to phase out the remaining interest rate controls (i.e., caps); and a dummy variable for 2001 (remaining interest rate controls removed).

Once the total radial and non-radial input slacks have been regressed on an appropriate set of external/environmental variables, the inputs are adjusted using the difference between the predicted maximum input slack $I\hat{S}_j^{k\ \text{Maximum}}$ and the predicted slack $I\hat{S}_j^k$. That is,

$$x_j^{k\ \text{adjusted}} = x_j^k + \left[I\hat{S}_j^{k\ \text{Maximum}} - I\hat{S}_k^k\right] \quad (4)$$

The DEA programs (1) and (2) are then re-estimated using the adjusted inputs and the first stage outputs to obtain new Stage Three efficiency scores.

To the authors' knowledge, little use has been made in banking studies to date of either the Tone (2001) SBM DEA program or the Fried et al (1999) approach to adjusting DEA results for the potential impact of environmental factors. Such adjustments are likely to be very important, however, in the case of a banking market such as Hong Kong's which has undergone substantial changes over the last decade or so (see Section 2).

5. Data

A profit-oriented, non-parametric specification (with revenue components as outputs and cost components as inputs) is employed, rather than the usual 'intermediation,' 'production,' or 'value added' specifications. Specifically, rather than specifying the usual inputs (labour, capital, deposits, etc), which are often proxied by costs rather than specified as physical units, we specify the various cost elements from the profit and loss account as the relevant inputs. Berger and Mester (2003) argue (in the context of a stochastic frontier approach) that "use of the profit approach may help take into account unmeasured changes in the quality of banking services by including higher revenues paid for the improved quality, and may help capture the profit maximisation goal by including both the costs and revenues" (page 80). Hence, the three inputs specified are employee expenses, other non-interest expenses and loan loss provisions.

With respect to the last mentioned input variable, it has long been argued in the literature that the incorporation of risk/loan quality is vitally important in studies of banking efficiency. Akhigbe and McNulty (2003), for example, utilising a profit function approach, include equity capital "to control, in a very rough fashion, for the potential increased cost of funds due to financial risk" (page. 312). Altunbas et al (2000) and Drake and Hall (2003) also find that the failure to adequately account for risk can have a significant impact on relative efficiency scores. In contrast to Akhigbe and McNulty, however, Laevan and Majnoni (2003) argue that risk should be incorporated into efficiency studies via the inclusion of loan loss provisions. That is, "following the general consensus among risk agent analysts and practitioners, economic capital should be tailored to cope with unexpected losses, and loan loss reserves should instead buffer the expected component of the loss distribution. Consistent with this interpretation, loan loss provisions required to build up loan loss reserves should be considered and treated as a cost; a cost that will be faced with certainty over time but that is uncertain as to when it will materialise" (page 181). Hence, we also incorporate loan loss provisions as an input in the DEA relative efficiency analysis.

Similarly, rather than specifying the various categories of income-earning assets as outputs (as in the intermediation approach), we specify as outputs the various revenue-generating elements from the profit and loss account. The three outputs specified are, therefore, net interest income, net commission income and total other income. The summary statistics for the inputs and outputs are presented in Table 1, where all data is deflated with respect to the Hong Kong GDP deflator and presented in US $ Millions. Input and output data were obtained from the Bank-scope resource package produced by Bureau Van Dijk (BVD) over the period 1995-2001.[3]

Hence, from the perspective of an input-oriented DEA relative efficiency analysis, the more efficient units will be better at minimising the various costs incurred in generating the various revenue streams and, consequently, better at maximising profits. This specification also potentially circumvents the bias in results that could be found if following the 'intermediation' and/or 'value added' approach. For example, Tortosa-Ausina (2002) found that the 'intermediation' approach generally gives lower overall efficiency scores than the 'value added' approach. Furthermore, in respect of the 'intermediation approach' this paper concludes that "by ignoring payment, liquidity, and safe keeping services (measured by deposits), important firm/business lines are ignored. Disregarding this output category could therefore lead to a biased appraisal of the banking industry in which it seems that some firms cluster together" (page 210).

Although our approach is a departure from the usual DEA approach, it is in the spirit of recent research by Berger and Mester (2003) in the context of their stochastic frontier analysis. In their investigation of the causes of the recent changes in the performance of US banks, for example, Berger and Mester found that "banks tried to maximise profits by raising revenues as well as reducing costs. Over time, banks have offered wider varieties of financial services and provided additional convenience. These additional services or higher service quality, which are difficult to control for in cost and profit functions, may have raised costs but also raised revenues by more than these cost increases" (page 29-30). Furthermore, they conclude that, "methods that exclude revenues may be misleading" (page 1). Clearly, a DEA specification which includes physical units or cost proxies as inputs and balance sheet asset items as outputs would therefore be potentially misleading by virtue of the exclusion of revenue effects.

While Berger and Mester (2003) adopted this more comprehensive approach to performance analysis in the context of the parametric stochastic frontier approach, this paper represents one of the first attempts (to the authors' knowledge) to apply this approach using a non-parametric, economic and regulatory-adjusted methodology. However, in recognition of the fact that the use of a profit oriented approach is a departure from the usual DEA specification in banking, we contrast these results with a more traditional intermediation based approach in Section 6.4.

[3] The panel data sample consists of 413 observations over the period 1995 to 2001. The number of banks in the sample in each year is: 1995, 59; 1996; 66; 1997; 52; 1998; 66; 1999; 62; 2000; 61; 2001; 47.

The classification system adopted by Bank-scope, the source of the data, distinguishes "commercial banks" from "investment banks", "non-banking credit institutions" and "bank holding and holding companies". The first two categories correspond to the "licensed banks" and the "restricted licensed banks" plus "deposit-taking companies" respectively of the three-tier banking system noted earlier. The remaining two categories are self explanatory. The reason for looking at the performance of the individual banking types is to explore whether regulation, which differentially affects (as discussed above) the scope and terms of the banks' business operations, materially affects bank efficiency. Furthermore, in the context of a study which incorporates the four main sectors of the Hong Kong banking industry (Commercial Banks, Investment Banks, Bank Holding and Holding Companies, and Non Banking Credit Institutions), our use of the non-parametric, profit-oriented DEA methodology does not assume that all institutions necessarily have the objective of profit maximisation.

Institutions which are less overtly profit oriented, for example, would typically emerge as inefficient in this analysis. Furthermore, we feel that, following Berger and Mester (2003), a comprehensive empirical analysis of financial performance, which includes both firm-specific data and external factors, can only be satisfactorily conducted in the context of a profit-oriented framework which focuses on revenues as well as costs. This is especially important in the context of the Hong Kong banking sector where, as emphasised in Section 2, factors such as increasing foreign competition, interest rate deregulation, the South East Asian crisis, etc, had their impact on costs, interest margins, loan loss provisions and profitability. Similarly, the business response of many of the Hong Kong banks was an attempt to restore profitability by diversifying into new, fee generating, lines of business. None of these factors would be fully captured by the traditional DEA approaches to the specification of inputs and outputs.

6. Results

6.1 Stage 1: Un-Adjusted Efficiency Scores.

Although the overall panel data sample size is too large to produce detailed results for each bank, it is worth noting that the application of the SBM approach can produce very different efficiency scores for individual banks compared with the BCC measure. As explained in Tone (2001), by construction the SBM score cannot be greater than the BCC score, and any SBM-efficient unit must also be BCC-efficient. Nevertheless, some of the differences are very considerable. To take one of the more extreme examples, Aeon Credit Service (Asia) exhibited an efficiency score of 82.58 in 1999 according to the BCC measure. According to the SBM measure, however, this institution recorded an efficiency score of only 39.78. Hence, it is clear that units which are deemed to be reasonably efficient according to the more conventional DEA measures may be found to be highly inefficient using the SBM measure. At a more general level, however, while the SBM efficiency scores will always be equal to or lower than the BCC scores, the differences in the two sets of results are somewhat more modest. The mean and minimum scores under SBM, for example, are 51.82 and 10.65 respectively, while under BCC they are 61.39 and 17.59 respectively. Furthermore, the rank correlation between the two sets of results is relatively high. The Spearmans rank correlation between the BCC and SBM non-parametric efficiency programs is equal to 0.962 (significant at the 1% critical level).

These results contrast with the very significant differences which are often found between non-parametric and parametric efficiency estimates. Bauer et al (1998), for example, using the standard BCC program found that the mean DEA bank efficiency score for US banks was 38.50 (minimum equal to 10.30), whereas the parametric approach yielded much higher mean scores (stochastic frontier approach: 87.50; thick frontier approach: 67.40; and the distribution free approach: 85.50.)

Regardless of whether the SBM or BCC measure is utilised, however, these results reveal that Hong Kong banks, on average, exhibited a relatively-high degree of inefficiency (mean PTE scores: SBM 51.82, BCC 61.39). These figures are somewhat higher than the mean X-efficiency scores of 32% found by Kwan utilising the stochastic cost frontier approach. It is not uncommon, however, to find higher mean inefficiency scores in non-parametric as opposed to parametric studies. Furthermore, as noted in Section 3 there are differences in the approach to specifying inputs and outputs as well as in the efficiency estimation methodology.

The finding of relatively high levels of inefficiency is also not uncommon in bank efficiency studies which do not incorporate environmental factors. Lozano-Vivas et al (2002), for example, find that, in a 10-country European bank efficiency study, mean efficiency scores range from lows of 15.99 (Portugal) and 18.91 (Spain) to a high of 49.49 (Luxembourg). These latter results contrast with a mean level of inefficiency for Hong Kong banks ranging from around 39% to around 48% depending upon whether the BCC or SBM measure is used.

An interesting issue, however, given the various external factors which have impacted on Hong Kong banks (discussed previously) is to examine how this mean efficiency level has varied over time. Hence, Table 2 indicates the Stage 1 mean efficiency levels (SBM and BCC) in each year for the full sample and for different asset size groups and banking sectors within Hong Kong. The first point of note to emerge from Table 2 is that there is no evidence of any marked improvement in mean efficiency levels over the sample period as a whole. Indeed, with respect to the overall mean efficiency scores, there is evidence of a modest deterioration in performance. For example, the mean BCC score in 1995 is 67.99, while the corresponding figure in 2001 is 59.24. This is confirmed by the SBM results, which are 60.43 and 48.86 respectively.

This trend decline in relative efficiency is clearly in line with the observation made in Section 2 that the profitability of the Hong Kong banking system had traditionally been protected by the absence of foreign competition and the presence of favourable interest rate controls, etc. In the absence of such protection, therefore, it would be expected that profitability would come under increasing pressure. Nevertheless, it is significant that the mean level of inefficiency is surprisingly high, even in the base period, 1995, prior to the major phase of deregulation and adverse external factors. This suggests that the protected environment may have engendered a considerable degree of X-inefficiency in the context of the failure to minimise costs.

It is also clear from Table 2 that Hong Kong banks appear to have been considerably exposed to the impact of external (environmental) factors, such as the economic problems associated with the South East Asian financial crisis after 1997/98, and the uncertainty surrounding the aftermath of the accession to the PRC in 1997. Again, as a comparison between the BCC and SBM results, the former model shows that the mean efficiency score for Hong Kong banks declined to only 53.40 in 1998, while the corresponding SBM measure declined to only 41.46. Hence, this initial analysis of the results does suggest that it may be important to investigate more fully the impact of environmental factors on the efficiency of the Hong Kong banking sector.

Having examined the contrasts between the SBM and BCC results, we now focus on the SBM results in more detail and elect to analyse these results by asset size group and by banking sector. With respect to the former, it is evident that a very strong size efficiency relationship exists in the Hong Kong banking system in respect of pure technical efficiency. This is illustrated very clearly in Figure 1. In the earlier years of the sample period, the mean efficiency scores tend to increase monotonically with asset size. In 1996, for example, the mean efficiency level for the smallest Group D banks was 37.14, while the corresponding scores for the larger Group C, B and A banks were 56.75, 58.29 and 74.92 respectively. Although this pattern is not as evident in the later years of the sample, it is quite clear that the largest asset group banks generally exhibit much higher pure technical efficiency than the smaller banks. In 2000, for example, the mean efficiency level for the largest Group A banks was 74.20 in contrast to the mean scores for the Group B, C and D banks of 50.46, 49.19 and 47.75 respectively. This type of result corresponds well with research in the US which suggests that the larger banks tend to be more X-efficient (see Berger and Mester, 2003). As noted previously, however, this result contrasts with the finding of Kwan (2002a) that X-efficiency declines with bank size.

While most banks appear to have been affected by adverse external factors between 1997 and 1998, and 2000 and 2001, it is clear from Figure 1 that the Group B banks appear to have been the most adversely affected. Table 2 and Figure 1 also offer a further perspective on the general deterioration in performance over the whole sample period. It is once again quite clear that, while there was a deterioration in the performance of all size bands over this period, the deterioration was much more pronounced for the Group B banks. The mean efficiency level for this size group of banks declined from 59.41 in 1995 to only 38.76 by 2001. While the reasons behind the relatively poor performance of the Group B banks clearly merits further future research, this type of result does support the frequently espoused view that, in a rapidly changing and increasingly competitive environment such as banking, it is the mid-sized institutions which may be most vulnerable. Such institutions are typically not large enough to benefit from scale and diversification effects to the same extent as the largest banks. Conversely, they are often too large to successfully adopt the strategy of highly efficient but narrowly focused or niche market institutions.

Turning now to the comparative efficiency levels and trends across the Hong Kong banking system, it is clear from Table 2 that there has been something of a transformation in the relative performances (based on unadjusted scores) of both the Bank Holding and Holding Company (BHHC) and the Non-Bank Credit Institution (NBCI) sectors. In the base year, 1995, for example, these sectors exhibited by far the worst mean efficiency scores of 47.02 and 46.70 respectively, in contrast to the scores of 60.74 and 62.22 for the Commercial Banks (CB) and Investment Banks (IB). By 2001, however, the BHHC and NBCI sectors were clearly outperforming the other two sectors. Furthermore, both sectors exhibited a remarkable recovery in relative efficiency levels following the low point experienced during 1998. In the case of BHHCs, for example, the mean efficiency score increased from 30.43 to 67.25 between 1998 and 2000, before declining back to 60.48 in 2001.

In contrast to the improvement in the relative performance of the BHHC and NBCI sectors over the sample period, the performance of the Commercial Banks and Investment Banks actually declined over the sample period, both relative to BHHCs and NBCIs and relative to their mean efficiency scores in the base year. Furthermore, whereas all sectors appear to have been affected by the external factors prevalent during 1998, the IB and CB sectors do not seem to have made any sustained recovery in relative efficiency levels, in contrast to the experience of the BHHC and NBCI sectors.

Finally, it is interesting to note that, while there appears to have been a general recovery in mean efficiency levels after the declines of 1998, most sectors exhibited a further decline in mean efficiency levels between 2000 and 2001. This deterioration in performance may be attributable to factors such as the aftermath of the September 11th terrorist attacks on New York and Washington in 2001, the impact of the ENRON scandal, and the general deterioration in the World economy. Significantly, however, this downturn in relative efficiency is not shared by the smallest Group D institutions (Figure 1) nor by the NBCI sector (Figure 2).

6.2 Stage 2: Tobit Regression Results

In the previous section, both the BCC and SBM Stage 1 results suggested quite strongly that the Hong Kong banking system might have been substantially affected by external (environmental) factors, and particularly the confluence of events which occurred during 1997/1998 and 2001. Furthermore, the results also suggested that such environmental factors may have a differential impact across different sectors and size groups. In recognition of these factors, therefore, we follow Fried, Schmidt and Yaisawarng (1999) in testing for possible environmental influences using a slacks-based, second stage Tobit regression. Although we report both the BCC and SBM Tobit regression results, having previously demonstrated the contrasts that can emerge between the BCC and SBM results, we will focus on the latter in the context of the subsequent analysis. This can also be justified on the basis of the relatively high rank correlation coefficient (0.962) which was alluded to previously.

These Stage 2 Tobit regression results are reported in Table 3. Although a wide range of potential variables was utilised (as discussed previously), a large number proved to be insignificant. These insignificant variables included interactive dummies relating the various macro factors to the individual bank sectors. Somewhat surprisingly, a wide range of dummies for episodes such as de-regulation were also found to be generally insignificant. This issue is discussed further below. Hence, Table 3 reports the preferred specification which includes those variables which maximised the Log-Likelihood.

These results indicate very clearly that the dominant external influence on efficiency in the Hong Kong banking system is the macro-economic cycle. Specifically, the individual components of domestic GDP, together with expenditure on housing, are generally significant in one or more of the slacks-based Tobit regressions. Furthermore, it is also evident that the sectoral dummies for the CB and BHHC sectors are also significant in all the slacks-based regressions.

Although dummy variables were incorporated to account for the impact of the South East Asian financial crisis, the accession of Hong Kong to the PRC, and episodes of deregulation, such as the announcement of the phasing out of interest rate controls (1999) and the actual phasing out of these controls (2001), none of these proved to be statistically significant. While these results are perhaps surprising, particularly with respect to the South East Asian financial crisis, it may well be that the impact of this major shock on the Hong Kong banking system, is being picked up via the components of domestic expenditure. It is well established, for example, that the crisis produced a general and fairly dramatic decline in GDP growth in the South East Asian economies, and often coincided with a housing market crisis

6.3 Stage 3: Efficiency Results

Having established that the performance/efficiency of the Hong Kong banking system is significantly affected by external (environmental) factors, we follow Fried, Schmidt and Yaisawarng (1999) in repeating the DEA analysis on the basis of input-adjusted data. As detailed in Section 3, the input data are adjusted to reflect the slacks-based regression results prior to the Stage 3 DEA analysis. Table 4 reports the Stage 3 mean efficiency results and the mean scores across the asset size groups described previously. The most striking feature of these results is that the incorporation of environmental factors can have a substantial impact on the mean efficiency scores. The mean efficiency score of the Group D institutions, for example, increases from 49.56 to 78.48 in 2001 according to the SBM measure. It is also clear that the different size groups of institutions are differentially affected by the various environmental factors and this is reflected in the differential adjustments between the Stage 1 and Stage 3 DEA results. Over the period 1995 - 1997, for example, the largest Group A banks appear to have been relatively unaffected by environmental factors as there is little difference between the Stage 1 and 3 SBM results. In contrast, the mean efficiency scores are increased for the Group B banks, but reduced for the Group C and D institutions (see Tables 2 and 4).

As might be expected, given the upheavals that occurred during 1998, the mean efficiency levels of all size groups are increased in this year as a result of the incorporation of the impact of environmental factors. Furthermore, this impact is most evident in the case of the larger banks, and especially the Group B institutions whose mean efficiency level increases from 38.83 to 69.19.

The Stage 3 adjustment for environmental factors also provides a very different perspective on the trends in efficiency over the sample period. Whereas the Stage 1 results suggested that mean efficiency levels had declined for all asset size groups, Table 4 reveals that mean efficiency levels have generally improved. It is very evident, however, that it is the smallest institutions that have exhibited the most remarkable improvement. These Group D institutions increased their mean efficiency level from 36.87 to 78.48 between 1995 and 2001. It is clear from Figure 3, however, that much of this improvement occurred during the last year of the sample.

The Stage 3 SBM results also reinforce the previous observation that the largest banks are clearly the most efficient institutions in the Hong Kong banking system (Table 4 and Figure 3). The mean efficiency level of 80.86 in 2001, for example, compares very favourably with the mean efficiency scores of 65.71 and 56.72 exhibited by the Group B and C banks. These results also reinforce the view that there is, in general, a monotonic size efficiency relationship operating in Hong Kong banking. The exception to this, however, occurs in 2001 when, as alluded to previously, the smallest Group D banks recorded a substantial increase in mean efficiency from 43.68 to 78.48.

It was emphasised previously that US studies have tended to find that X-efficiency tends to be higher in the larger banks. Hence, the fact that the appropriate incorporation of environmental factors can produce a very substantial change in the size – technical efficiency relationship is a very significant result. It is particularly important in respect of merger policy, both from a regulatory and bank management perspective, since it cannot be presumed that bank mergers will necessarily improve technical/X-efficiency. Indeed, the mergers of the smallest institutions may well reduce mean levels of technical efficiency according to the 2001 SBM results presented in Table 4 and Figure 3. It is clear, however, that this 2001 result does itself represent something of an anomaly in terms of the relative performance of these smallest banks. Hence, the causes of their significant improvement in relative efficiency between 2000 and 2001 merits further investigation. Leaving aside the performance of the smallest Group D institutions, however, the Stage 3 results do suggest that significant gains in technical efficiency could potentially be realised via mergers between the Group B and Group C banks.

Table 4 also presents the Stage 3 mean efficiency scores across the different banking sectors. Once again, accounting specifically for environmental influences does produce considerable changes in the rank orderings of mean efficiency levels. Whereas the Stage 1 results suggested that the BHHCs and NBCIs were the best performing institutions, at least by the end of the sample period, the Stage 3 results indicate very clearly that it is the CB and BHHC sectors which have tended to exhibit the highest mean efficiency levels. Furthermore, the superior performance of these two sectors has been sustained over the whole of the sample period. This is shown very clearly in Figure 4 which reveals something of a gulf between the relative efficiency of these two sectors and the IB and NBCI sectors, the latter of which was generally the poorest performing sector.

While all sectors show some improvement in mean efficiency levels over the sample period, the BHHC sector increased mean efficiency from 66.71 to 76.60 between 1995 and 2001, while the CB sector increased its mean efficiency score from 65.64 to 78.50. In contrast, the IB and NBCI sectors showed much more modest improvements in mean efficiency scores, from 44.83 to 49.06 and 41.68 to 49.05 respectively. The fact that the BHHC and CB sectors exhibited the biggest improvements in relatively efficiency scores after 1997/98 may suggest that, after controlling for the adverse impact of environmental factors, these sectors have been the most successful in terms of responding to the new deregulated and more competitive market environment by improving cost efficiency and by raising revenues by diversifying into other, fee-generating, business lines and possibly via increases in service quality.

The significant impact of environmental factors on relative efficiency scores detailed above is consistent with previous studies. Lozano-Vivas et al (2002), for example, found that including environmental variables in a non-controllable DEA model increased mean Spanish bank efficiency from 18.91 to 82.14, increased mean UK bank efficiency from 22.08 to 58.65 and increased the mean efficiency level of Portuguese banks from 15.99 to 79.87. In addition, Dietsch and Lozano-Vivas (2000), using a parametric stochastic frontier specification, showed that mean French bank efficiency increased from 0.48 to 0.78 (relative to a maximum of 1.0) and Spanish bank efficiency from 0.07 to 0.65 (using a common frontier). They conclude that “neglecting these [environmental] variables leads to an important misspecification of the common frontier and overestimates inefficiency.” (page 1002)

6.4 An Alternative Intermediation-Based Approach

As alluded to above, the main aim of this paper is to analyse the impact of environmental factors on the efficiency of Hong Kong's banking system utilising a "profit approach" specification, as advocated by Berger and Mester (2003). For the reasons advanced previously, this profit approach is likely to provide a more complete perspective of the impact of environmental factors on banking firm efficiency. Nevertheless, as already acknowledged, this represents a departure from the usual specification of inputs and outputs in DEA banking studies. Such studies typically follow the spirit of the intermediation approach first advanced by Sealey and Lindley (1976). Hence, it is interesting to ascertain the extent to which the results obtained in this paper are attributable to the use of a profit approach specification, rather than the more traditional intermediation-based specification.

In order to do this we re-estimate the stage 3 approach, utilising SBM Data Envelopment Analysis in conjunction with the intermediation approach.[4] Furthermore, in order to facilitate comparisons with previous studies we adopt a fairly standard intermediation approach as utilised in recent years by, inter alia, Drake and Simper (2002), and Kulasekaran and Shaffer(2002). Specifically, we posit an intermediation model that has four inputs and three outputs. The inputs (X_i) are; X1 (total deposits + total money market funds + total other funding); X2 (personnel expenses); X3 (total fixed assets); and X4 (loan loss provisions and other provisions). In relation to the three outputs (Y_i) we have; Y1 (total customer loans + total other lending); Y2 (total other earning assets); and Y3 (other, non-interest, income).

Table 5 provides details of the Stage 1 and Stage 3 SBM results. However, in the interests of brevity, we will only comment on the most salient aspects of the contrast between these results and the previous profit approach results.

With respect to the unadjusted Stage 1 results, it is clear that technical efficiency is generally higher under the intermediation approach than under the profit approach. In the base year (1995), for example, the former provides a mean level of efficiency for the sample of 74.72, as opposed to 60.43 for the latter. Nevertheless, the intermediation results do show a marked decline in efficiency levels during 1997 / 98, although this decline is not as dramatic as that recorded under the profit approach. This is to be expected, however, as the profit approach will capture the full impact of any adverse environmental factors on revenues as well as costs, while the intermediation approach tends to focus on the technical efficiency of the financial intermediation process.

Interestingly, while the size efficiency relationship in Table 5 appears to echo the previous results, in the sense that the largest Group A banks are considerably more efficient (according to the Stage 1 results) than their smaller competitors (with the exception of 1995), this relationship does not persist in the Stage 3 results. In fact, in contrast to the profit-based results, the Stage 3 adjustment for environmental factors results in a general increase in, and a convergence of, the technical efficiency scores, with all bank size groups recording efficiency scores reasonably close to the sample mean.

[4] We are grateful to an anonymous referee who suggested that we carry out this check on our results.

With respect to the different banking sectors, there are again some similarities between the results in Table 5 and the earlier profit-based results. Most significantly, all sectors show a marked decline in relative efficiency during 1998, which reinforces the argument that, even when utilising the more traditional intermediation approach, there is still a need to control for environmental factors. Furthermore, all sectors exhibited a strong recovery in efficiency levels after 1998 and, as with the profit-based results, this recovery was especially marked for the BHHC sector.

Turning to the Stage 3 adjusted results, however, it is again clear that, once environmental factors are taken into account, the intermediation approach offers little scope for discriminating between sectors on the basis of relative technical efficiency scores, as these are all closely grouped around the 10% inefficiency level. In contrast, as we have seen, the use of the profit approach produces a much greater diversity in relative efficiency scores, both across different asset size groups and different sectors, and in both the unadjusted and adjusted efficiency scores. This probably reflects the fact that, in a dynamic and increasingly competitive financial services marketplace which is also affected by periodic environmental or external "shocks", the participants can respond with strategies which modify costs but also impact on revenue streams. As emphasised by Berger and Mester (2003), the latter may reflect, for example, changes in product quality (which may increase revenues by more than costs) and also product range via diversification strategies. The fact that these strategic responses will only be partially captured by the intermediation approach may therefore provide a justification for the use of the profit-based approach, at least in the context of this particular study.

7. Conclusions

This paper assesses the relative technical efficiency of institutions in the Hong Kong banking system using both the BCC and the SBM approaches, and an innovative profit-based DEA specification. The results indicate quite clearly that the failure to incorporate slacks formally and directly into the efficiency analysis (as in the BCC approach) can sometimes produce inflated and misleading indications of relative efficiency, even though the rank correlation between the two sets of results is relatively high.

Both approaches, however, suggested that banks in Hong Kong may have been affected by a range of external / environmental factors outside the control of the institutions' management. In order to incorporate the possible impact of these factors in the efficiency analysis, therefore, the second stage Tobit approach advocated by Fried et al (1999) was adopted and a subsequent Stage 3 DEA efficiency analysis conducted using the transformed input data.

This Stage 3 efficiency analysis generally supported the hypothesis that the Hong Kong banking system had indeed been affected by external factors (mainly macroeconomic and housing market factors), but indicated that different sized banks and different institutional sectors had been differentially affected. Interestingly, the accession of Hong Kong to the PRC, episodes of financial deregulation, and the 1997/98 South East Asian crisis were found not to have had a significant independent influence on relative efficiency levels in the Hong Kong banking system. In the case of the last mentioned, however, it would appear that the impact of the crisis was manifested via adverse developments in the macro economy and in the housing market.

One of the most striking results to emerge from the Stage 3 analysis was the finding of a very strong size-efficiency relationship, with the largest institutions clearly outperforming their smaller competitors. This result clearly has important implications for future merger policies, although it has been stressed that the recent marked improvement in the relative performance of the smallest Group D institutions merits further investigation. The Stage 3 results also indicated that the CB and BHHC sectors have consistently outperformed the IB and NBCI sectors in terms of technical efficiency. Furthermore, the fact that the former sectors have performed particularly well after 1997/98 (once external factors are controlled for) may suggest that these sectors have adapted most successfully to the deregulated and post-PRC accession environment.

The use of a more conventional intermediation-based DEA specification confirmed the potential impact of environmental factors on the relative efficiency of the Hong Kong banking systemtor. However, in line with ex-ante expectations, the intermediation-based approach generally produced less discrimination across different asset size groups and different banking sectors, particularly in the case of the Stage 3 (adjusted) results. This result tends to support the assertion of Berger and Mester (2003) that a profit-based approach is better able to capture the diversity of strategic responses by financial firms in the face of dynamic changes in competitive and environmental conditions.

The key message to emerge from this paper, however, is that the failure to account for the impact of external factors can have a marked impact on relative efficiency scores and ranks and on trends in efficiency levels over time, both across the sector as a whole, and across differential size and institutional groupings. This is a particularly significant issue if such results are to be used to inform policy analysis, in the area of mergers and consolidation, for example. An important issue for future research in this respect will be to investigate the size-efficiency relationship in respect of scale efficiency in order to establish whether the superior technical efficiency of the larger Hong Kong banks is offset by scale inefficiencies.

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Table 1. Summary Data Descriptions

	Minimum	Maximum	Mean	Medium	S.D
Outputs					
Net Interest Revenue	170.23	5164040	165394.8	19615.7	583559.8
Net Commission Revenue	18.37	1498786	39317.3	5598.2	160933.8
Other Income	11.48	836857	20713.3	2273.2	89011.23
Inputs					
Personal Expenses	88.00	1659987	47001.3	7409.9	178906.0
Other Operating Expenses	2.31	1221489	35341.1	7792.1	132497.2
Loan Loss Provisions	12.20	1454415	29967.1	3771.7	126955.1

Figures deflated using Hong Kong GDP deflator and in US $ millions.

Table 2. Hong Kong Banking System - Profit Approach Efficiency Scores

Asset Group - Efficiency Scores

DEA - BCC Stage 1 Efficiency Scores

	1995	1996	1997	1998	1999	2000	2001
Asset Grp A	84.75	85.61	88.07	76.19	78.64	83.70	72.28
Asset Grp B	65.98	68.14	69.29	50.45	54.79	59.24	47.23
Asset Grp C	63.91	64.35	55.37	54.18	53.66	60.17	55.01
Asset Grp D	65.95	47.19	47.86	45.86	49.72	59.75	61.25
Mean	67.99	66.35	64.14	53.40	57.92	64.81	59.24

DEA - SBM Stage 1 Efficiency Scores

	1995	1996	1997	1998	1999	2000	2001
Asset Grp A	77.45	74.92	76.52	62.07	63.77	74.20	63.14
Asset Grp B	59.41	58.29	61.56	38.83	42.49	50.46	38.76
Asset Grp C	55.35	56.75	46.36	37.58	41.24	49.15	43.96
Asset Grp D	59.23	37.14	40.03	35.67	40.91	47.75	49.56
Mean	60.43	57.22	55.25	41.46	45.81	54.34	48.86

Bank Efficiency Scores

DEA - BCC Stage 1 Efficiency Scores

	1995	1996	1997	1998	1999	2000	2001
BHHCs	54.59	58.96	69.60	41.75	52.90	73.22	68.65
CBs	68.42	69.39	68.24	58.97	58.45	67.10	56.65
IBs	70.39	68.95	69.65	54.65	61.06	67.96	62.20
NBCIs	68.48	60.05	41.61	45.16	53.25	50.84	59.14

DEA - SBM Stage 1 Efficiency Scores

	1995	1996	1997	1998	1999	2000	2001
BHHCs	47.02	46.63	60.89	30.43	38.60	67.25	60.48
CBs	60.74	58.76	57.59	45.75	44.71	56.26	46.77
IBs	62.22	61.63	63.18	44.55	52.24	59.18	49.53
NBCIs	46.70	36.20	40.00	33.25	33.56	52.82	61.69

Asset Grp A includes banks with total assets greater than US$5,000 million, Asset Grp B between US$1,000 million and US$4,999 million, Asset Grp C between US$100 million and US$999 million, and Asset Grp D below US$99 million. BHHCs, CBs, IBs and NBCIs denote; Bank Holding & Holding Companies, Commercial Banks, Investment Banks, and Non-Banking Credit Institutions respectively.

Table 3. Stage 2 Tobit Regression Results - Profit Approach

BCC Stage 1 Total Input Slacks

	Input Slacks 1	Input Slacks 2	Input Slacks 3
Constant	37505 (23462)	41027** (20846)	109267** (26168)
Private Consumption	-0.18* (0.09)	-0.19** (0.09)	-0.42** (0.11)
Expenditure on Housing	-0.05 (0.06)	-0.03 (0.05)	0.13** (0.06)
Government Consumption	0.60** (0.25)	0.63** (0.23)	1.14** (0.29)
Fixed Capital Formation	0.09 (0.06)	0.09* (0.05)	0.18** (0.06)
BHHC Dummy Variable	12268** (1814)	9337** (1612)	11239** (2023)
CB Dummy Variable	8545** (1177)	6043** (1046)	6123** (1314)
IB Dummy Variable	-225 (1294)	-659 (1149)	-1750 (1444)
Sigma	8862** (340)	7874** (302)	9871** (376)
Log Likelihood	-37961.77	-3719.58	-3794.98

SBM Stage 1 Total Input Slacks

	Input Slacks 1	Input Slacks 2	Input Slacks 3
Constant	66152* (35449)	109959* (67199)	496554** (158544)
Private Consumption	-0.32* (0.15)	-0.53* (0.27)	-1.68** (0.65)
Expenditure on Housing	-0.04 (0.09)	0.07 (0.17)	0.82* (0.04)
Government Consumption	1.06** (0.39)	1.73** (0.74)	4.25** (1.75)
Fixed Capital Formation	0.13 (0.08)	0.24 (0.16)	0.58 (0.38)
BHHC Dummy Variable	18771** (2754)	21677** (5198)	34388** (12284)
CB Dummy Variable	12897** (1784)	15176** (3371)	25590** (7955)
IB Dummy Variable	-1052 (1961)	-2557 (3701)	-9579 (8740)
sigma	13326** (527)	25347** (968)	59698** (2264)
Log Likelihood	-3744.64	-4129.14	-4426.36

* denotes significant at the 10% and ** at the 5% critical level; standard errors in parentheses, BHHC are Bank Holding and Holding Companies, CB are Commercial Banks, and IB are Investment Banks.

Table 4. Hong Kong Banking System - Profit Approach Efficiency Scores

Asset Group - Efficiency Scores

	DEA - SBM Stage 3 Efficiency Scores						
	1995	1996	1997	1998	1999	2000	2001
Asset Grp A	77.98	77.45	75.91	79.74	78.28	81.71	80.86
Asset Grp B	64.17	66.15	61.28	69.19	76.09	64.26	65.71
Asset Grp C	43.70	49.13	39.26	53.82	61.13	49.65	56.72
Asset Grp D	36.87	33.72	35.22	45.02	48.94	43.68	78.48
Mean	58.72	56.22	52.07	59.27	65.27	57.99	65.76

Bank Efficiency Scores

	DEA - SBM Stage 1 Efficiency Scores						
	1995	1996	1997	1998	1999	2000	2001
BHHCs	66.71	70.87	61.23	68.37	76.19	76.38	76.60
CBs	65.64	67.43	61.07	76.89	78.52	70.95	78.50
IBs	44.83	44.43	49.18	44.03	54.89	49.08	49.06
NBCIs	41.68	44.56	27.50	43.31	47.86	35.91	49.05

Asset Grp A includes banks with total assets greater than US$5,000 million, Asset Grp B between US$1,000 million and US$4,999 million, Asset Grp C between US$100 million and US$999 million, and Asset Grp D below US$99 million. BHHCs, CBs, IBs and NBCIs denote; Bank Holding & Holding Companies, Commercial Banks, Investment Banks, and Non-Banking Credit Institutions respectively.

Table 5. Hong Kong Banking System - Intermediation Approach Efficiency Scores

Asset Group - Efficiency Scores

DEA - SBM Stage 1 Efficiency Scores

	1995	1996	1997	1998	1999	2000	2001
Asset Grp A	79.04	77.05	78.07	64.48	69.25	85.71	88.39
Asset Grp B	70.55	74.99	69.84	61.30	63.27	73.79	79.73
Asset Grp C	71.65	65.27	56.59	52.24	56.93	71.10	73.68
Asset Grp D	89.77	54.65	66.18	58.87	59.17	68.75	78.01
Mean	74.72	69.34	67.65	57.98	61.25	74.25	78.99

DEA - SBM Stage 3 Efficiency Scores

	1995	1996	1997	1998	1999	2000	2001
Asset Grp A	88.56	87.55	92.71	91.68	91.10	90.84	89.15
Asset Grp B	91.91	91.71	91.15	94.98	94.78	91.94	90.95
Asset Grp C	91.16	92.77	91.14	94.82	94.09	91.57	90.00
Asset Grp D	92.63	92.32	91.71	93.85	92.73	91.49	92.01
Mean	91.98	91.55	91.62	94.06	93.35	91.48	90.16

Bank Efficiency Scores

DEA - SBM Stage 1 Efficiency Scores

	1995	1996	1997	1998	1999	2000	2001
BHHCs	72.82	82.13	78.39	61.20	67.27	83.64	90.01
CBs	71.98	70.87	68.95	60.28	62.90	76.20	79.80
IBs	84.57	70.08	65.36	60.01	58.19	73.30	79.39
NBCIs	72.04	61.55	58.64	50.54	59.64	66.85	70.81

DEA - SBM Stage 3 Efficiency Scores

	1995	1996	1997	1998	1999	2000	2001
BHHCs	91.98	89.04	93.94	93.88	92.20	90.69	88.59
CBs	90.35	91.28	91.59	93.44	94.18	92.15	90.61
IBs	91.73	92.82	91.24	94.86	92.90	90.97	90.29
NBCIs	91.50	91.71	90.51	94.50	92.64	91.25	89.62

Asset Grp A includes banks with total assets greater than US$5,000 million, Asset Grp B between US$1,000 million and US$4,999 million, Asset Grp C between US$100 million and US$999 million, and Asset Grp D below US$99 million. BHHCs, CBs, IBs and NBCIs denote; Bank Holding & Holding Companies, Commercial Banks, Investment Banks, and Non-Banking Credit Institutions respectively.

Figure 1. SBM Stage 1 Profit Approach Efficiency Scores - Asset Groups.

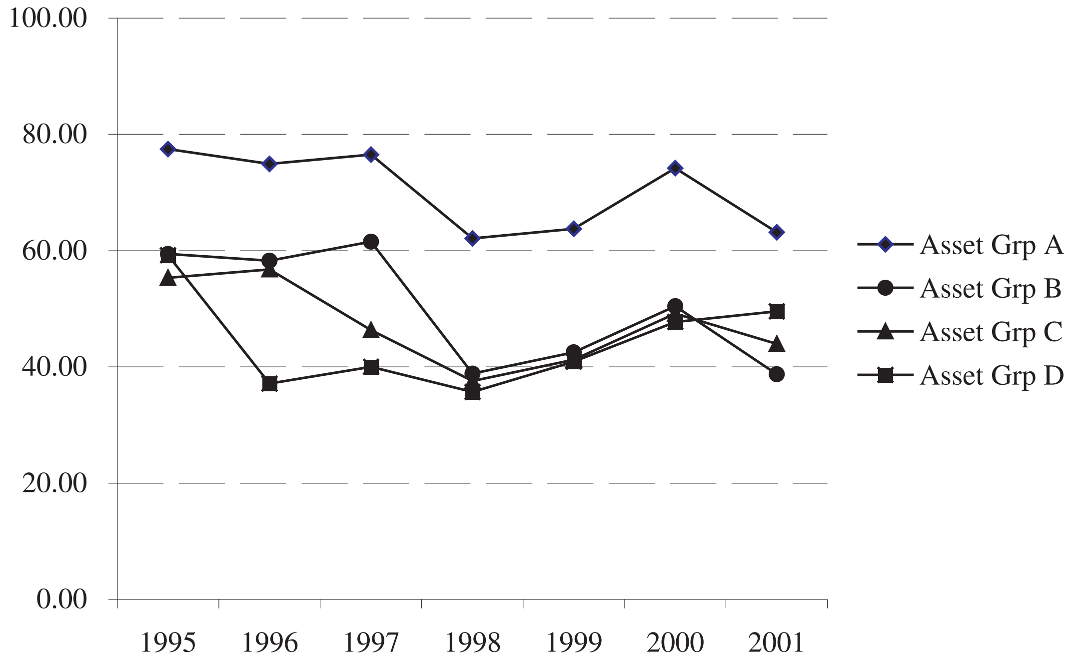

Figure 2. SBM Stage 1 Profit Approach Efficiency Scores - Bank Sectors.

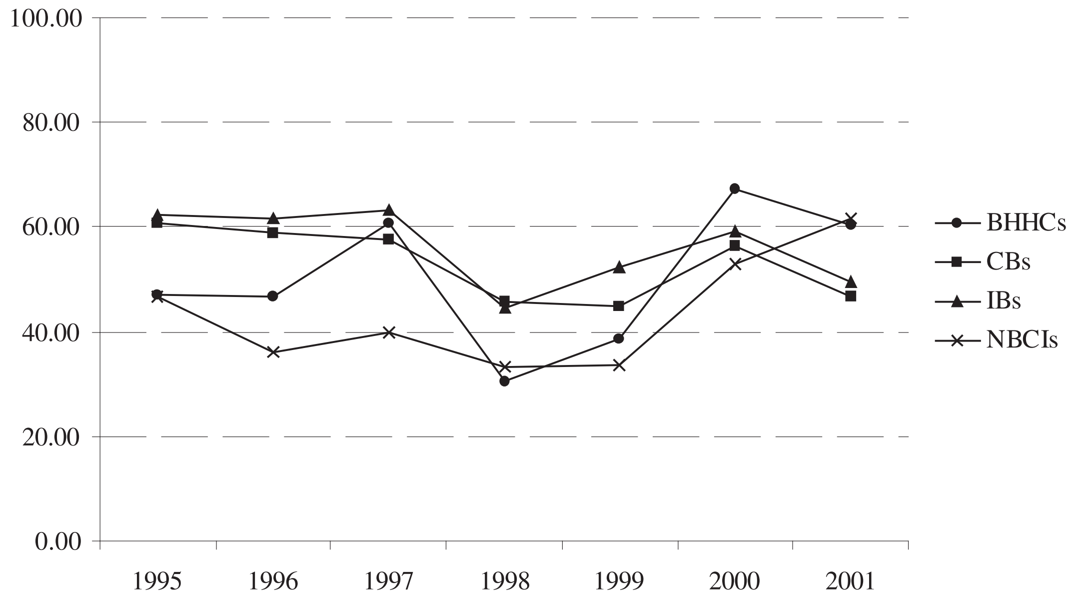

Figure 3. SBM Stage 3 Profit Approach Efficiency Scores - Asset Groups.

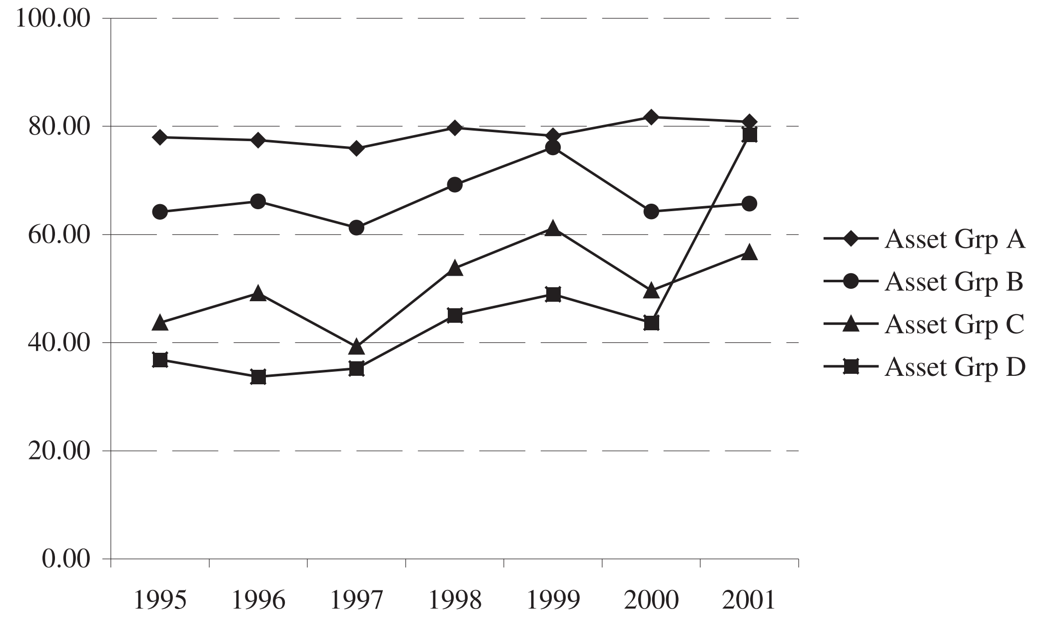

Figure 4. SBM Stage 3 Profit Approach Efficiency Scores