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The Impact of Macroeconomic and Regulatory Factors on Bank Efficiency: A Non-Parametric Analysis of Hong Kong’s Financial Services Sector.

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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 sector. 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 that both adjustments can have a significant impact on relative efficiency measures, ranks and trends, which is an important issue if such relative efficiency measures are to be used in policy analysis. The results also indicate: high levels of technical inefficiency for many institutions; considerable variations in efficiency levels and trends across size groups and financial sectors; and also differential impacts of environmental factors on different size groups and financial sectors.

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

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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. This is especially true, for example in the
case of Eastern European bank sectors, where there has been recent relaxation in banking regulation, and also in those countries that have seen considerable external factors impacting on banks.

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 Chinese takeover. Section 3 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 4 discusses the profit-oriented approach to the data set utilised. Section 5 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 5 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 6 concludes.
2. **RECENT DEVELOPMENTS AFFECTING THE HONG KONG BANKING INDUSTRY**

2.1. Financial Liberalisation and Reform

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 four decades or so.

As far as **structural reform** is concerned, Hong Kong has moved from a monolithic system (of "licensed banks") to a two-tier banking system. Initially this distinguished "licensed banks" from "finance companies" (1970) but later differentiated between "licensed banks" and "deposit-taking companies" (1976). This evolved further into a three-tier system, but even the last-mentioned has been the subject of frequent reform (Hall (1985); Jao (2003)). Under the changes introduced in 1981, three types of deposit-taking intermediaries were recognised: “licensed banks”; “licensed deposit-taking companies” (DTCs); and “registered DTCs”. The licensed banks were subject to a higher minimum paid-up capital requirement (HK$100 million) but faced no restrictions on the scope of their deposit taking nor controls on the minimum denomination and term to maturity of deposits taken. Licensed DTCs, in contrast, were restricted to the taking of time deposits with a minimum denomination of HK$5000,000; while registered DTCs were restricted to the taking of time deposits with a minimum denomination of HK$100,000 and a minimum term of three months. In this way, each category of institution became subject to formal “authorisation” procedures – which was not the case pre-1976 – although the stabilising effect of this was offset by the competitive distortions introduced. Exclusion of the DTCs from demand and savings deposits and the controls imposed on some of the terms they could offer on time deposits obviously favoured the licensed banks, although the former's exclusion from the banks' interest rate cartel (*see* below) ameliorated the competitive disadvantages they faced somewhat. The rationale for favouring the licensed banks in this way was that, given the tighter prudential regulation they were forced to endure, they should enjoy greater business freedom. This philosophy persisted with the introduction of the new three-tier system.
in 1990, which now distinguished “licensed banks” from “restricted license banks” and “DTCs”. The last two categories of institution remained confined to the taking of time deposits; and restricted license banks were subject to a minimum denomination requirement of HK$100 million, with DTCs also being subject to a minimum maturity restriction of three months. The relative business freedom enjoyed by the licensed banks was seen as a quid pro quo for the higher minimum paid-up capital requirements they were forced to observe (HK$150 million compared with figures of HK$100 million and HK$25 million for the restricted license banks and DTCs respectively) and the stricter regulation to which they are generally subject (Jao (2003)). Note, however, that each category of institution is now subject to the same minimum 'risk asset ratio' introduced by the Basle Committee for Banking Supervisors in 1992 under the famous Basle Capital Accord – although the maximum that can be imposed on the last two categories of institution, at 16%, is higher than the comparable figure (12%) which licensed banks may be asked to observe. Moreover, no new DTCs will be allowed to operate unless they are majority-owned by licensed banks. Further structural reform, as called for by KPMG Barents in a consultancy report produced for the Hong Kong Monetary Authority (HKMA), Hong Kong's de facto central bank, in 1998 (KPMG Barents (1998)), will entail simplification (probably a phasing out of third-tier DTCs) of the current three-tier structure as a means of enhancing competitiveness in the Hong Kong banking industry.

With respect to financial liberalisation, a number of moves have been made over the years, both to enhance the relative attractiveness of Hong Kong as a financial centre and to stimulate competition in the banking industry. In respect of the former goal, the abolition of an interest-withholding tax on foreign currency deposits in 1982 is worth noting; while, with regard to the latter goal, interest rate liberalisation and the easing of restrictions on new entry, for both domestic and foreign concerns, are perhaps the most significant policy developments. Whereas deposit rate deregulation has already been completed – see below – the government has yet to announce when it will adopt KPMG Barents' recommendations for relaxing the new entry criteria and branching restrictions applicable to foreign banks.

Returning briefly to the issue of interest rate liberalisation, it is also worth noting that interest rate controls, of one form or another, operated in Hong Kong throughout the period 1964-July 2001. Originally designed to prevent “destructive” interest rate competition between banks, the controls were enforced by the Hong Kong Association of Banks (HKAB) through its Ordinance, which affected all
"licensed banks" in Hong Kong. Under the Ordinance, licensed banks were restricted in the maximum rates of interest they could pay on specified Hong Kong dollar-denominated deposits and the minimum commissions and charges they could levy on certain types of business operation (Hall, 1985). These limits had first to be agreed with the Financial Secretary (later, the HKMA), however. The cartel meant that, in practice, zero interest was paid on demand deposits by licensed banks, a uniform rate was paid on savings deposits, and interest rate ceilings applied to time deposits (although, after March 1982, deposits of over HK$500,000 were exempt to enable licensed banks to compete with (licensed) DTCs, not bound by the agreement). Not surprisingly, given the induced allocative inefficiency, the competitive distortions created and the distributive injustice involved (Jao (2003); Hall (1985)), the government eventually came under pressure to reform the system (Hong Kong Consumer Council (1994)). A partial deregulation of interest rates on time deposits of more than seven days was duly agreed by the HKAB in 1994, although further deregulation was postponed in 1995 following the Mexican crisis and pending the handover of the colony to the PRC. Following KPMG Barents' calls for further staged deregulation – initially involving time deposits of up to six days, but later to embrace current accounts and culminating in the removal of all interest rate caps – however, the HKMA agreed to the phasing out of all interest rate controls within two years from 1 July 1999.

The final area of reform worth mentioning is the proposed introduction of a deposit protection scheme in Hong Kong (it was approved in principle by Hong Kong's Executive Council in April 2001). While this would impose additional costs on banks, in the form of the ex ante premiums to be levied to fund the scheme, the banking system as a whole would ultimately benefit from the increased investor confidence. Moreover, the proposals to keep the insurance coverage low (at HK$100,000), to limit the initial target size of the fund to 0.3% of insured deposits, to gradually build up the fund (over 5 years) and to charge risk-related (based on CAMEL ratings) premiums would serve to minimise such costs, reduce competitive inequities and minimise the induced moral hazard (Li (2002)).

Assuming that, in the past, the profitability of domestic banks in Hong Kong was boosted by the application of controls – especially the caps imposed on deposit rates and the restrictions maintained on new bank entry and branching – it is to be expected that reforms, actual and prospective, adopted in these areas will serve to dampen the future prospects of such (especially small retail) banks, ceteris paribus.
Moreover, to the extent that the controls obviated the need for local banks to develop strategies to maximise economic efficiency, one can expect to find renewed interest in recent years in strategic planning and operational efficiency, the more so in the light of the external pressures faced by the industry since 1997 (see immediately below).

2.2. Environmental Factors

The main ‘environmental’ factors to impact upon the Hong Kong banking industry during the period relevant to this empirical study (1995-2001) are the handover of the former colony to the PRC in July 1997 and the effects of the Asian Financial Crisis (AFC) of 1997/8. Each will now be covered in turn.

In line with the Sino-British Joint Declaration of 1984 and the Basic Law of 1990, the Hong Kong dollar has continued to circulate as a convertible and separate currency since 1 July 1997, the date of the handover. As for the post-reunification financial relationship between Hong Kong and Mainland China, a number of "guiding principles" have been applied (Jao (2003)). Firstly, the currencies and monetary systems of the two regions are to remain mutually independent of each other. Secondly, the two monetary authorities, the HKMA and the People's Bank of China (PBC) respectively, are also to remain mutually independent, but should work closely together. Thirdly, financial institutions from either region opening up branches in the other region are to be treated as foreign entities. Fourthly, the PBC will assist in maintaining currency stability in Hong Kong. Fifthly, financial transactions between the two regions are to be conducted in accordance with international rules and best practice. Sixthly, Mainland financial institutions operating in Hong Kong must abide by the laws of Hong Kong and be supervised by the HKMA. And, lastly, Shanghai and Hong Kong are to act as complementary and mutually-reinforcing financial centres. In this way, the continuing independence of Hong Kong as an international financial centre should be safeguarded although, clearly, the fortunes of institutions domiciled in the Mainland and in Hong Kong will become more closely entwined.

The aggressiveness of some Mainland lenders in Hong Kong markets in recent years, however, in search of higher quality credits has served to further depress lending margins for local banks already facing the effects of deposit rate deregulation. Moreover, the resultant push of the larger Hong Kong banks into fee-generating business, particularly wealth management (i.e. sales of unit trusts and insurance
products) and credit cards, has entailed heavy expenditure on technology in the case of the former and rising delinquency rates in the case of the latter. Short-term profitability has suffered as a result.

The second major environmental factor impacting on Hong Kong's banks during the period in question was the Asian Financial Crisis (AFC) of 1997/98. Unfortunately for the banks, this coincided with a local property market crash, which increased the banks' exposure, both by virtue of direct investment but also because of the proliferation of property-related collateral in lending operations. The resultant depression of profits and increase in bad debts was further exacerbated by the 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) p.116-118). 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. Whilst the banks’ financial positions have improved since, largely due to falls in provisions made and, for some, to increases in net income and fee income, the full effects of deposit rate deregulation have yet to be felt. Moreover, the downturn in the local economy continues to exert a drag on loan demand, by both corporates and individuals.

3. 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), 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,

\[
\begin{align*}
\min_{\theta, \lambda} \theta \\
\text{subject to:} \quad & X\lambda \leq x_0 \\
& Y\lambda \geq \theta y_0 \\
& \sum \lambda = 1
\end{align*}
\]

(1)

where, \( \lambda \geq 0 \). Recently, however, 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 \( X = \left(x_{ij}\right) \in \mathbb{R}^{m \times n} \) and outputs \( Y = \left(y_{ij}\right) \in \mathbb{R}^{s \times n} \), the slacks from a DEA-based program can be written as, \( x_\theta = X\lambda + s^- \) and \( y_\theta = Y\lambda + s^+ \), 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 \( \lambda \), \( s^- \) and \( s^+ \) is given by the following expression;

\[
\begin{align*}
\min \tau = t - \frac{1}{m} \sum_{i=1}^{m} S^-_i / x_{io} \\
\text{subject to:} \quad & 1 = t + \frac{1}{s} \sum_{r=1}^{s} S^+_r / y_{ro} \\
& tx_o = X\lambda + S^- \\
& ty_o = Y\lambda - S^+
\end{align*}
\]

(2)
where, \( \Lambda = t\lambda \geq 0 \), \( S^- = ts^- \geq 0 \), and \( S^+ = ts^+ \geq 0 \). The optimal solution is when \( \tau = 1 \) and 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). 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 are examined utilising a second stage Tobit model which regressed efficiency on a vector of explanatory factors including age, size of caseload, etc. In the second stage model many of the external factors 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, also utilising a second stage Tobit approach, 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.

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.

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

\[ IS^k_j = f_j(Z^k_j, \beta_j, \epsilon_j) \]  

where: \( IS^k_j \) is the input slack \( j \) for bank \( k \); \( Z^k_j \) is a vector of \( j \) external factors that are likely to affect the efficiency of bank \( k \) and hence its input slack \( IS^k_j \); \( \beta_j \) is a vector of parameters to be estimated; and finally, \( \epsilon_j \) is the disturbance term. It is important to note that, in the original Fried et al (1999) procedure, only the BCC program was utilised (for an example of the Fried technique applied to the relative efficiency of police forces, see Drake and Simper (2003)).

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.

- **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 \( \hat{IS}^k_j \) and the predicted slack \( \hat{IS}^k_j \). That is,

\[ x^k_{j \text{ adjusted}} = x^k_j + [\hat{IS}^k_j \text{ Maximum} - \hat{IS}^k_j] \]  

(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, which has undergone substantial changes over the last decade or so (see Section 2).

4. 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.
Coherently 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 in US $ and deflated with respect to the Hong Kong GDP deflator. 
Input and output data were obtained from the Bankscope resource package produced 
by Bureau Van Dijk (BVD) over the period 1995-2001

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. Furthermore, in the context of a study which incorporates the four main “banking” sectors of the Hong Kong financial services 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.

5. RESULTS


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 Spearman rank correlation between the BCC and SBM non-parametric efficiency programs is equal to 0.962 (significant at the 1% critical level). The relationship between the BCC and SBM results is illustrated in Figure 1.

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). This is not uncommon, however, 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). Similarly, Bauer et al (1998),
estimating a sample of large US banks, found a DEA mean efficiency score equal to 39.00 (minimum equal to 10.00).

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 financial services 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 financial sector 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. Due to the large panel data sample, however, we elect to analyse these results by asset size group and by financial sector. With respect to the former, it is evident that a very strong size efficiency relationship exists in the Hong Kong banking sector in respect of pure technical efficiency. This is illustrated very clearly in Figure 2. 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 with research in the US which suggests that the larger banks tend to be more X-efficient (see Berger and Mester (2003)).

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 2 that the Group B banks appear to have been the most adversely affected. Table 2 and Figure 2 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.

Turning now to the comparative efficiency levels and trends across the Hong Kong financial sector, 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 worse 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). It is interesting to note, however, that this contrast in performance is not so apparent in the
BCC results, which tend to inflate the relative efficiency of the NCBI sector considerably. With respect to the SBM scores, however, by 2001 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 NCBI 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 2) nor by the NBCI sector (Figure 3).

5.2. Stage 2: Tobit Regression Results

In the previous section, both the BCC and SBM Stage 1 results suggested quite strongly that the Hong Kong financial sector 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. As in the previous section, we utilise both the BCC and SBM approaches, but will tend to focus on the SBM-based results.

INSERT TABLE 3

These two sets of 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 financial sector 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. Indeed, to capture any business cycle effects we also included a dummy variable for each year, and again found these were insignificant. 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 financial sector 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.

Finally, although variables, such as unemployment, were included as potential regressors, these proved to be insignificant. Once again, this may be because the major macro-economic influence on Hong Kong banks came through the domestic
components of GDP, with variables such as unemployment being themselves highly influenced by the macro cycle, albeit with a lag.

5.3. Stage 3: Efficiency Results

Having established that the performance/efficiency of the Hong Kong financial sector 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.

INSERT FIGURES 4 AND 5

The contrast between the Stage 1 and Stage 3 efficiency results (across the full sample) is illustrated for both the BCC and SBM measures in Figures 4 and 5 respectively. It is quite clear that the adjustment for environmental factors can have a significant impact on bank performance, both positive and negative. With respect to the BCC measure, for example, Figure 4 illustrates that, for banks deemed efficient under Stage 1, the Stage 3 scores range from 100 to around 70. Similarly, for those institutions deemed as efficient under the Stage 3 estimation, the Stage 1 scores range from 100 to just under 30. Although similar observations can be made regarding the SBM scores, an interesting feature of Figure 5 is that there are relatively few financial institutions which are technically efficient under the Stage 3 SBM estimation. Furthermore, there is a preponderance of institutions with relatively low Stage 3 SBM scores (in the range 20 to 60). This suggests that, even when external factors are accounted for, there is still a high degree of residual technical inefficiency for the majority of banks in the Hong Kong financial sector. The much greater dispersion between the Stage 1 and Stage 3 results using the SBM approach relative to the BCC approach is evident from the rank correlation coefficient for the former of only 0.245, although this is significant at the 1% level.

INSERT TABLE 4
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 6, however, that much of this improvement occurred during the last year of the sample.

INSERT FIGURE 6

The Stage 3 SBM results also reinforce the previous observation that the largest banks are clearly the most efficient institutions in the Hong Kong financial sector (Table 4 and Figure 6). 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 6. 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 financial 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 7 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 diversifying into other, fee-generating, business lines.

Finally, Figures 8 to 11 illustrate the temporal profiles of the Stage 1 and Stage 3 SBM relative efficiency scores for all the financial sectors under consideration. The most interesting feature of these comparisons is that the BHHC and CB sectors appear to have been generally disadvantaged by the external factors under consideration and consequently their Stage 3 relative efficiency scores tend to be above the Stage 1 scores (Figures 8 and 9). Significantly, however, the two scores show some evidence of convergence, especially after 1998, for the BHHC sector, while the two scores tend to be diverging over the same time period for the CB sector. This may suggest that the nature of the holding company structure, combined with the impact of deregulation, etc, has resulted in the BHHC sector becoming more immune from the impact of environmental/external factors over time.

In contrast, it is clear from Figures 10 and 11, that the IB sector was generally positively affected by the range of environmental factors, and hence the Stage 1 efficiency scores are typically above the Stage 3 scores, while the impact on the NBCI sector was more mixed. Once again, there is some evidence of a convergence over the sample period between the two sets of efficiency scores for the IB sector.

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. CONCLUSIONS

This paper assesses the relative technical efficiency of institutions in the Hong Kong financial sector using both the BCC and the SBM approaches. This contrast indicates quite clearly that the failure to incorporate slacks formally and directly into the efficiency analysis (as in the BCC approach) can produce inflated and often misleading indications of relative efficiency.

Both approaches, however, suggested that financial institutions 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 financial sector 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.

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 key message to emerge from the paper is that the failure to account for both slacks (in the optimisation process), and 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 in this respect for future research 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 2.
Hong Kong Financial Services Sector - Non-Parametric Efficiency Scores

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Financial Sector Efficiency Scores

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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. BHHC, CB, IB and NCBI denote; Bank Holding & Holding Companies, Commercial Banks, Investment Banks, and Non-Banking Credit Institutions respectively.
Table 3.
Stage 2 Tobit Regression Results

**BCC Stage 1 Total Input Slacks**

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

**SBM Stage 1 Total Input Slacks**

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

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<tbody>
<tr>
<td>Asset Grp A</td>
<td>90.90</td>
<td>88.91</td>
<td>91.44</td>
<td>86.83</td>
<td>88.45</td>
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<td>86.70</td>
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<td>Asset Grp B</td>
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<td>88.46</td>
<td>84.97</td>
<td>78.17</td>
<td>79.74</td>
<td>81.19</td>
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<td>Asset Grp C</td>
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<td>81.93</td>
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<td>85.74</td>
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<td>Mean</td>
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<td>84.54</td>
<td>82.43</td>
<td>82.75</td>
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<td>82.41</td>
<td>83.96</td>
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<tr>
<td>Asset Grp A</td>
<td>77.98</td>
<td>77.45</td>
<td>75.91</td>
<td>79.74</td>
<td>78.28</td>
<td>81.71</td>
<td>80.86</td>
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<td>Asset Grp B</td>
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<td>66.15</td>
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<td>33.72</td>
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<td>56.22</td>
<td>52.07</td>
<td>59.27</td>
<td>65.27</td>
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Financial Sector Efficiency Scores

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<tbody>
<tr>
<td>BHHC</td>
<td>90.08</td>
<td>92.35</td>
<td>89.15</td>
<td>70.22</td>
<td>79.87</td>
<td>85.16</td>
<td>76.90</td>
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</tr>
<tr>
<td>CB</td>
<td>87.23</td>
<td>88.62</td>
<td>86.35</td>
<td>86.79</td>
<td>85.98</td>
<td>85.45</td>
<td>86.90</td>
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<tr>
<td>IB</td>
<td>76.49</td>
<td>80.19</td>
<td>78.16</td>
<td>82.77</td>
<td>85.17</td>
<td>79.81</td>
<td>83.89</td>
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<tr>
<td>NCBI</td>
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<td>79.52</td>
<td>74.85</td>
<td>78.80</td>
<td>90.05</td>
<td>78.81</td>
<td>83.82</td>
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<table>
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</thead>
<tbody>
<tr>
<td>BHHC</td>
<td>66.71</td>
<td>70.87</td>
<td>61.23</td>
<td>68.37</td>
<td>76.19</td>
<td>76.38</td>
<td>76.60</td>
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<tr>
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<td>67.43</td>
<td>61.07</td>
<td>76.89</td>
<td>78.52</td>
<td>70.95</td>
<td>78.50</td>
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<td>44.43</td>
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<td>54.89</td>
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<td>44.56</td>
<td>27.50</td>
<td>43.31</td>
<td>47.86</td>
<td>35.91</td>
<td>49.05</td>
</tr>
</tbody>
</table>

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. BHHC, CB, IB and NCBI denote; Bank Holding & Holding Companies, Commercial Banks, Investment Banks, and Non-Banking Credit Institutions respectively.
Figure 1
BCC and SBM Stage 1 Efficiency Scores.

Figure 2
SBM Stage 1 Efficiency Scores – Asset Groups.
Figure 3
SBM Stage 1 Efficiency Scores.

Figure 4
BCC Stage 1 and BCC Stage 3 Efficiency Scores.
Figure 5
SBM Stage 1 and SBM 3 Efficiency Scores.

Figure 6
SBM Stage 3 Efficiency Scores – Asset Groups.
Figure 7
SBM Stage 3 Efficiency Scores.

Figure 8
Bank Holding and Holding Companies (BHHC)
SBM Stage 1 and Stage 3 Efficiency Scores.
Figure 9
Commercial Banks (CB)
SBM Stage 1 and Stage 3 Efficiency Scores.

Figure 10
Investment Banks (IB)
SBM Stage 1 and Stage 3 Efficiency Scores.
Figure 11
Non-Credit Banking Institutions (NCBI)
SBM Stage 1 and Stage 3 Efficiency Scores.