A Cross Country Comparison of Banking Efficiency: Asia Pacific Banks

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This paper attempts to estimate the efficiency of the top 300 Asia Pacific Banks, as ranked by the Asian bankers, through a cross country analysis. We use a non-parametric frontier technique called data envelopment analysis (DEA) to derive technical and scale efficiency measures for these banks in 2006. The sensitivity of DEA efficiency of various input-output variables combination is investigated followed by the test of robustness on the DEA model. Our efficiency estimates indicate that a wide dispersion in efficiency exist among these top 300 banks from one country to another. The empirical findings indicate that only 22 of the 300 banks are operating at an efficient level. In general, the overall technical efficiency and scale efficiency are higher for banking groups in New Zealand and Australia, while the Philippines banking group has the lowest estimates. The result also show that the Singapore banking group has a low technical efficiency estimates but in terms of scale it is almost fully efficient. The main source of inefficiency amongst the 300 banks is dominated by ineffective utilization of resources rather than economies of scale. The results, which provide the sources of inefficiency, may provide useful insights for bankers, government regulators and policy makers to enhance decision-making and policy formulation.

Keywords: Technical Efficiency, DEA

I. Introduction

During last two decades, an increasing pace of financial market liberalization has been observed in the developing countries. This resulted in banking markets of different countries becoming highly integrated. This opportunity has allowed foreign banks to set up branches in other countries, and broaden its competitive edge. Such increased competitive pressures would indirectly force the local banks to adapt and operate efficiently in the new environment. Banks that fail to do so will be driven off the market by the highly efficient ones. Therefore, information on bank efficiency when compared across nations is important, as this will enable policy-makers to formulate appropriate and sound policies to direct their banking industry.

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This cross-country comparison of bank efficiency in developing countries is relatively lacking in the literature and there hasn't been any intensive work being done on cross-country efficiency comparisons for banks in the developing countries. This paper aims to analyse the technical efficiency of the top 300 Asia Pacific Banks through a non parametric linear programming method called Data Envelopment Analysis (DEA) and compare the relative efficiency of banks across countries. These banks are from 16 different countries representing the top 300 Asia Pacific Banks according to the 2006 ranking carried out by the Asia Bankers. They include banks from Australia, Bangladesh, China, Hong Kong, India, Indonesia, Japan, Malaysia, New Zealand, Pakistan, Philippines, Singapore, South Korea, Taiwan, Thailand and Vietnam.

The rest of the paper is organized as follows. Section II describes the concept and measurement of efficiency. Section III reviews the existing literature on the comparison of bank efficiency across countries. Section IV presents the data used, variable selection and the efficiency measures for the banks in this study. Section V explains the empirical results and Section VI concludes.

II. Concept and Measurement of Efficiency

Debreu (1951) and Farrell (1957) first developed the concept of efficiency by introducing the radial measure of technical efficiency (TE). There are two types of technical efficiency based on the orientation; input-orientation and output-orientation. Input-orientated technical efficiency measures the maximum proportionate reduction of current input usage to maintain a given output level. It is a ratio of the minimum inputs required which results in the proportional reduction from the current level as compared to the actual usage level. For a Decision Making Unit (DMU) using a vector of *x* observed inputs to produce a vector of *y* observed outputs where $(x, y) \in T$, its' technical input efficiency can be expressed as:

$$\min\{\alpha : (\alpha x, y) \in T\} \text{ or } \min\{\alpha : \alpha x \in L(y)\} \qquad (2.1)$$

The technical efficiency represents the minimum proportionate contraction of the current input while producing the current outputs. It is the ratio of the minimum input to its current input level after the proportionate contraction.

While the output orientation technical output efficiency is the maximum proportionate increase of the current outputs while using the same inputs. It is a ratio of current output level to the maximum output after the proportionate increase. For a DMU with $(x, y) \in T$, it is written as:

$$[\max\{\beta : (x, \beta y) \in T\}]^{-1} \text{ or } [\max\{\beta : \beta y \in P(x)\}]^{-1} \qquad (2.2)$$

T is the production possibility set which denotes all the input-output feasible combinations corresponding to a certain production process. *L(y)* and *P(x)* is the input and output possibility set, which contains all combinations of inputs and outputs respectively, that, can be used to produce the vector *y* and *x*. While α and β represents the radial measurement.

The idea of return to scale, incorporated in the technical efficiency measure refers to the relationship between an increase/reduction in inputs and the corresponding increase/reduction in outputs. If $y \in \partial O(x)$, (proportional increase in output) i.e. (x,y) is on the boundary of a production possibility set, then the returns to scale, $RS(x,y,\alpha)$, can be expressed as;

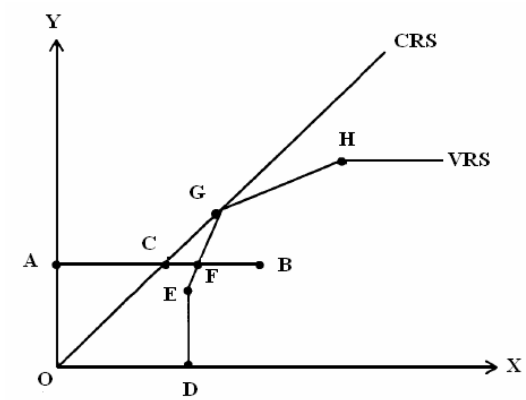
$$RS(x,y,\alpha) \equiv \frac{\max\{\beta : (\alpha x, \beta y) \in T\}}{\alpha} \tag{2.3}$$

$RS(x,y,\alpha) = 1$ implies constant returns to scale. In this case, when input changes, output scale change in the same direction and has the same rate as the input scale change, i.e., output grows by a α when input increases by α. If $RS(x,y,\alpha) > 1$, the production set is said to exhibit increasing returns to scale, i.e., the output increase more than input. The last case $RS(x,y,\alpha) < 1$, is decreasing return to scale, i.e., when input increases, output grows slower than input.

Classically, the concept of efficiency measurement is based on the definition of a frontier that envelops the observed production bundle. The efficiency score is based on the distance of an observed production bundle from this frontier which is referred as technical efficiency. It measures how well the individual transforms inputs into a set of outputs based on a given set of technology and economic factors (Aigner *et al.,* 1977 and Kumbhakar and Lovell, 2000). So, through the concept of relative efficiency, two different DMUs using the same set of inputs and technology may produce considerably different levels of output which represents the technical efficiency.

In terms of banking, technical efficiency measures the ability of a bank to produce a given set of outputs with minimal inputs under the assumption of constant or variable returns to scale. Scale efficiency measures whether a bank produces at an optimal size of scale. The measure of technical efficiency could be further broken down into pure technical efficiency and scale efficiency if the assumption of constant returns to scale is relaxed. Figure 1.1 below provides a graphical illustration of the Constant Return to Scale (CRS) and Variable Return to Scale (VRS) frontiers. The CRS line represents the constant returns to scale frontier, while the VRS curve is the variable returns to scale frontier. VRS envelops the data more closely than the CRS, and consequently calculates technical efficiency scores greater than or equal to CRS.

Figure 1.1:
Constant and Variable Returns to Scale Frontiers



Consider a set of banks each producing a single output using a single input in varying quantities. A bank operating at point B as in the Figure 1.1 above is technically inefficient. TE is measured by AC/AB ratio in an input orientation with reference to the CRS frontier. By relaxing the constant returns to scale assumption and applying the variable returns to scale assumption the inefficiency can be decomposed into pure technical inefficiency (PTE) and scale inefficiency (SE). The new measures are calculated as PTE = AF/AB and SE = AC/AF. Thus, technical efficiency (TE) can be defined as the product of pure technical efficiency (how close the bank is to the production frontier) and scale efficiency (how close the bank is to producing at optimal scale).

The VRS assumption is applied in this paper, because the sample size consists of small to very large banks. The VRS assumption also allows banks to deviate from the CRS line which is viewed as the optimal scale of operation. The deviation may be due to factors like imperfect competition, regulatory requirements, credit and loan restrictions and even macroeconomic effects which may differ across the Asia Pacific countries. Another preference for the VRS assumption over the CRS is the more developed banking system is, the more likely it is that the banks face non-constant returns to scale (McAllister and McManus, 1993 and Wheelock and Wilson, 1995).

As more and more number of inputs and outputs are added its computation gets complicated (Farell *et al.,* 1957). Hence a general mathematical formulation is needed to handle the case of multiple inputs and multiple outputs. This mathematical formulation was provided by Charnes *et al.* (1978) who referred to it as Data Envelopment Analysis (DEA). It provided the fundamentals of mathematical aspects of frontier analysis.To present the mathematical model, consider a set of n DMUs each consuming m inputs to produce s outputs. For an input orientated assessment under CRS, the technical efficiency of a DMU is obtained from the following model:

$$\text{Max} \sum_{i=1}^{M} v_i x_{i,j} \qquad (2.4)$$

Subject to

$$\sum_{i=1}^{M} v_r x_{i,j} - \sum_{r=1}^{S} u_r y_{r,j} \geq 0 \quad (j = 1,2,.....,n)$$

$$\sum_{r=1}^{S} u_r x_{i,j} = 1$$

$$v_i > 0 \quad (i = 1,2,....,m)$$

$$u_r > 0 \quad (r = 1,2,....,s)$$

Where: $x_{ij} =$ the amount of the i^{th} input to unit j

$v_i =$ the weight given to the i^{th} input

$y_{rj} =$ the amount of the r^{th} output from unit j

$u_r =$ the weight given to the r^{th} output

Next, simplifying equation 2.4 above the technical efficiency is measured as ratio of virtual output produced to virtual input used and expressed as below;

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

Subject to

$$-y_i + Y\lambda \geq 0$$

$$\theta x_i - X\lambda \geq 0$$

$$\lambda \geq 0$$

Where, θ is a scalar and λ is a $N \times 1$ vector of constants.

III. Literature Review

Previous studies utilising cross border efficiency among countries generally differ in terms of approach, methodology, the type of efficiency measured and the variables used. The common two approach discussed in most banking literature is the production approach and the intermediation approach. In the production approach, banking activities are described as the production of services to depositors and borrowers. While the intermediation approach, which is a complementary to the production approach, describes the banking activities as transforming the money borrowed from depositors into the money lent to borrowers (Berger and Mester, 1997).The common methods are DEA, stochastic production frontier, the stochastic cost frontier and regression analysis. The various types of efficiency measures are the technical efficiency, cost efficiency, x-efficiency and scale efficiency. However most of these studies focused on more developed countries and hardly any reference was made towards developing nations.

Using the DEA technique, Berg *et al.* (1993) studied bank technical efficiency in Norway, Sweden, and Finland followed with the productivity differences across banks in the Nordic region. Results show that larger Swedish banks were being the most efficient, and were in the best position to expand in a future Common Nordic banking market. Using the same approach, Pastor, Perez, and Quesada (1997) analysed the productivity, efficiency, and differences in technology of different European and U.S. banking systems. They used loans, deposits, and both short-term and equity investments as outputs and non-interest expenses, other than personnel expenses, as inputs. The findings suggested that France, Spain, and Belgium have the most efficient banking systems, whereas the United Kingdom, Austria, and Germany have the least efficient banking system.

On the other hand, Fecher and Pestieu (1993) applied a stochastic production frontier method to evaluate technical efficiency of the financial services sectors of eleven OECD (Organization for Economic Co-operation and Development) countries. Employing aggregate value-added, net of indirect taxes, as a measure of a country's financial services sector output, employment in the financial services sector and capital (estimated by the perpetual inventory model) as inputs, they found that Japan has the most efficient financial services, while Denmark has been the least efficient.

Allen and Rai (1996) applied a stochastic cost frontier method to compare cost inefficiency across fifteen developed countries grouped into either universal (Australia, Austria, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, Italy, United Kingdom and Sweden) or separated banking countries (Belgium, Japan and US). The estimated inefficiency levels of these groups of banks were measured, and then regressed against various bank and market characteristics. Results indicated that large banks in separated banking countries exhibit the largest measure of cost inefficiency and financial institutions in Japan, Australia, Austria, Germany, Sweden, and Canada were being the most efficient.

Goldberg and Rai (1996) latter measured the X-inefficiency and scale-inefficiency for a sample of eleven European countries by looking at the bank profitability, interest margin and the bank structure. It was found that banks in Germany, Denmark, Belgium, and Spain were operating with the smallest deviation from the efficient cost frontier (X-efficient), while banks in Italy and France are operating the furthest from the optimal scale (scale-inefficient). The results also show that banks in Germany, Switzerland, and Belgium are very competitive while banks in Spain and France are the least competitive. A similar study was carried out using DFA to compare efficiency measures across 11 European countries and show that nation-wide efficiency frontiers understate cost and profit efficiency in comparison to specific frontiers for each specialization (Maudos et al., 2001).

Later Lozano et al. (2001) analyzed the bank performances of several European Union member countries. The study was based on 1993 data on 10 European countries by incorporating environmental factors directly into the model. Findings indicated that the Italian banks were the least efficient while banks from Spain, Portugal and Denmark, seem to show the highest levels of mean efficiency. From the review of the literature on cross country efficiency studies are rather scarce and focused on developed nations. Hardly any studies focused on the efficiency across developing countries in the Asia Pacific region. This study is an attempt to fill the gap by investigating the banking efficiency of the top 300 banks ranked by The Asian Banker in the Asia Pacific region. This will aid banks to make decision regarding their direction and adapt to gain a competitive edge.

IV. Methodology

Data

The data set used in this study was obtained from the Asia Bankers Database of 2006. It consists of records of the top 300 Asia Pacific Banks, ranked according its performance in year 2006. This comprehensive ranking was based on several balance sheet measures which includes the asset size, deposits, loans, net interest income, total operating income, operating expenses, operating profits, net profits, shareholders' equity, and efficiency measures including operational ratios, liquidity ratios, capital ratios, capital adequacy ratios and gross non-performing loan (NPL) ratio. The top 300 banks of the Asia Pacific region consist of banks from Australia, Bangladesh, China, Hong Kong India, Indonesia, Japan, Malaysia, New Zealand, Pakistan, Philippines, Singapore, South Korea, Taiwan, Thailand and Vietnam.

Method

In this study the DEA technique described in Section 2 will be used to measure the efficiency of the 300 banks in the study. The method is suitable in the banking sector because it can easily handle multiple inputs-outputs producers such as banks and it does not require the specification of an explicit functional form for the production frontier or an explicit statistical distribution for the inefficiency terms unlike the econometric methods.

Variable Selection

The selection of variables is extremely important in the process of measuring efficiency. . It’s commonly acknowledged that the choice of variables in efficiency studies significantly affects the results. (Favero and Pappi, 1995; Hunter and Timme, 1995). This is further amplified when unnecessary variables clutters the analysis and makes it even difficult to interpret. Due to the nature of DEA modeling, adding more variables not only inflates DEA efficiency scores but it also potentially conceals the actual magnitude of inefficiency. So the burden is on the study to tediously justify the selection process. During recent years, the issue of the sensitivity and stability of Data Envelopment Analysis results on the combination of variables has been extensively studied. The first DEA sensitivity analysis paper by Charnes *et. al.,* (1985), examined the change in a single output. This was followed by a series of sensitivity analysis articles by Charnes and Neralic (1990).

The variable selection for most DEA banking efficiency study relied mainly on the classical banking theory which depends on the approach selected i.e. intermediation or production. In this paper the input output combination utilised are based on Mester (1996), applying the intermediation approach where deposit and asset are treated as inputs while loans and interest income will represent the outputs. Three different input-output models are derived from the combination of the variables as indicated in table 4.1 below.

Table 4.1:

Model Selection

Model	Inputs		Outputs	
	Deposit	**Assets**	**Loans**	**Interest Income**
1	√	√	√	
2	√	√		√
3	√	√	√	√

In justification of the input-output variable selection, a sensitivity analysis is carried out with these three alternative input-output models. The initial model selection process was done through Spearman Rank Correlation and its robustness was further tested through the methodology introduced by Resti (1997). The result of the Spearman Rank Correlation is presented in Table 4.2 below:

Table 4.2:

Correlations of Models

			Model 1	**Model 2**	**Model 3**
Spearman's rho	**Model 1**	Correlation Coefficient	1.000	**-.199(**)**	**.924(**)**
		Sig. (2-tailed)	.	.001	.000
	Model 2	Correlation Coefficient	**-.199(**)**	1.000	.056
		Sig. (2-tailed)	.001	.	.335
	Model 3	Correlation Coefficient	**.924(**)**	.056	1.000
		Sig. (2-tailed)	.000	.335	.

** Correlation is significant at the 0.01 level (2-tailed).

From the results above, it's found that the efficiency score for model 3's combination of inputs and outputs are highly correlated with those of model 1 as compared to model 2 and its combinations. This indicates that the choice of deposit and asset as inputs and loan and interest income would best represent the efficiency scores of the sample set. This selection of model is further tested for its robustness based on the Resti's (1997) approach. This is done by initially solving the DEA problem (model 3) and all banks presenting an efficiency score equal to 1 was deleted and followed by solving again for the DEA score. Next the correlation between these two set of efficiency scores are observed. The results obtained are as shown in Table 4.3 below.

Table 4.3:

Robustness of Model 3

			Original Model	Second Model
Spearman's rho	**Original Model**	Correlation Coefficient	1	**0.980****
		Sig. (2-tailed)	.	0.001
		N	295	295
	Second Model	Correlation Coefficient	**0.980****	1
		Sig. (2-tailed)	0.001	.
		N	295	295

** Correlation is significant at the 0.01 level (2-tailed).

It's noticed that both these scores showed a significant (at 0.01 probability level) correlation between both models which indicates that the scores obtained in model 3 are relatively stable and acceptable. This do confirms the choice of input-output variables selected in the DEA analysis.

V. Empirical Results

The descriptive statistics of the financial variables of the banks in the countries studied is as table 4.4 below:

Table 4.4:

Descriptive Statistics of Top 300 Asia Pacific Banks

Commercial Bank	No of Banks among top 300	Average Assets ($m)	Average Loan ($m)	Average Deposits ($m)	Average Interest Income ($m)
Australia	12	99250.24	69710.23	63006.85	1138.32
Bangladesh	1	5102.45	3430.11	4320.49	3.14
China	24	139914.93	74695.88	122449.68	738.27
Hong Kong	15	47576.20	20408.42	39712.13	687.59
India	26	20860.98	11347.84	17296.68	179.19
Indonesia	8	11191.40	4783.79	9199.24	171.52
Japan	114	67104.06	34962.26	56226.57	352.90
Malaysia	16	14799.47	8881.92	12017.74	144.96
New Zealand	4	36915.38	31396.96	29971.73	395.57
Pakistan	5	6734.16	3666.36	5834.69	130.58
Philippines	7	6929.04	2955.44	5248.71	68.64
Singapore	3	91388.08	40379.84	55206.39	823.43
South Korea	15	59666.28	40712.94	45246.61	679.49
Taiwan	38	20960.53	12924.86	17950.93	41.36
Thailand	9	17600.44	11823.36	15072.22	239.05
Vietnam	3	57338.29	31339.22	39467.98	514.76

Among the top 300 banks, Banks from Japan has the biggest number of banks that form the top 300 banks in Asia Pacific while Bangladesh has one bank included in the Asian bankers top 300 ranking. In terms of average bank assets, banking group from China, Australia and Singapore has the largest asset base. The same scenario is also present for average deposits and loans. Meanwhile banks with smaller asset base are from Bangladesh, Philippines and Pakistan.

Utilizing Model 3, the technical efficiency and the pure technical efficiency levels of these 300 top Asia Pacific banks are computed. Due to lack of space the focus of the analysis will be on the banking groups in each country at an overall industry level rather than the individual banks. The aggregated results are presented as in Table 4.4 below. (The individual result of each bank is presented in Appendix 1).

Table 4.4:

VRS and CRS Efficiency Score of the 300 top Asia Pacific Banks

Banks of	Technical Efficiency Score (CRS)				Technical Efficiency Score (VRS)				No of Efficient Banks	% of Efficient Bank
	Geometric Average	Min	Max	Spread	Geometric Average	Min	Max	Spread		
Australia	0.85	0.47	1.00	0.53	0.91	0.49	1.00	0.51	5	25
Bangladesh	0.75	0.75	0.75	0.00	0.88	0.88	0.88	0.00	-	
China	0.62	0.48	0.77	0.29	0.77	0.56	1.00	0.44	1	4.5
Hong Kong	0.63	0.49	0.73	0.24	0.71	0.60	1.00	0.40	1	4.5
India	0.62	0.49	0.71	0.22	0.70	0.58	1.00	0.41	-	
Indonesia	0.63	0.40	0.86	0.46	0.77	0.42	1.00	0.58	2	9.1
Japan	0.70	0.11	1.00	0.89	0.76	0.13	1.00	0.87	7	31.8
Malaysia	0.71	0.52	0.82	0.30	0.77	0.57	0.90	0.33	-	
New Zealand	0.98	0.94	1.00	0.06	0.98	0.95	1.00	0.05	2	9.1
Pakistan	0.71	0.53	0.86	0.33	0.87	0.73	1.00	0.27	1	4.5
Philippine	0.51	0.37	0.58	0.20	0.76	0.62	0.91	0.29	-	
Singapore	0.57	0.52	0.62	0.10	0.58	0.52	0.63	0.11	-	
South Korea	0.77	0.68	0.92	0.24	0.81	0.70	1.00	0.30	1	4.5
Taiwan	0.73	0.48	1.00	0.52	0.78	0.59	1.00	0.41	1	4.5
Thailand	0.78	0.49	0.91	0.42	0.83	0.60	1.00	0.40	1	4.5
Vietnam	0.72	0.49	0.89	0.40	0.81	0.59	0.94	0.35	-	
Geometric Average	**0.71**	**0.51**	**0.84**	**0.33**	**0.79**	**0.60**	**0.95**	**0.36**	**Total = 22**	**100**

From Table 4.4 above, Japan seems to dominate the frontier with the highest number of efficient banks followed by Australia which represent 31.8 and 25 percent of the banks within the country respectively. From the overall total number of banks only 22 were efficient which consists of 7 percent of the included in the analysis.

In terms of overall technical efficiency measures defined by CRS frontier, the results indicate that banking groups from New Zealand followed by Australia had the highest average score while the banking group from Philippine and Singapore had the lowest scores. Similar results were also found when the frontier was defined by VRS. In terms of the range of the efficiency scores obtained by the banking groups of each country, Japan appears to have the widest disparity, suggesting that some of its banks could be extremely efficient in allocating its resources while others are not that efficient in doing so.

The finding also indicates that the overall technical efficiency of the top 300 Asia-Pacific banks is around 70 percent with a level of 30 percent room for improvement on average. Besides that, the spread of the efficiency score is be found to have a huge disparity among these 300 top banks (approximate 33 percent). This explains that some banks are at frontier while other are lagging far behind.

The nature of technical inefficiencies may be due to the ineffective implementation of the production plan in converting inputs to outputs (pure technical inefficiency) and/or to the divergence of the DMU from the most productive scale size (scale inefficiency). Decomposing technical efficiency (TE) into pure technical efficiency (PTE) and scale efficiency (SE) allows an insight into the source of inefficiencies. The VRS model scores are regarded as the pure technical efficiency scores while the scale efficiency is computed by dividing the VRS scores with the CRS scores. When the efficiency derived from the case of VRS equals to the efficiencies derived for the Non Increasing Return to Scale (NIRS) then scale inefficiency exists due to DRS and if they are not equal then scale inefficiency is due to IRS. The results of the decomposition are as in Table 4.5 below.

Table 4.5:

Decomposition of Technical Efficiency Score

Banks of	Technical Efficiency (TE) Geometric Average	Pure Technical Efficiency (PTE) Geometric Average	Scale Efficiency (SE) Geometric Average
Australia	0.85	0.91	0.93
Bangladesh	0.75	0.88	0.85
China	0.62	0.77	0.81
Hong Kong	0.62	0.71	0.88
India	0.62	0.70	0.90
Indonesia	0.63	0.77	0.82
Japan	0.70	0.76	0.92
Malaysia	0.71	0.77	0.92
New Zealand	0.98	0.98	1.00
Pakistan	0.71	0.87	0.82
Philippine	0.51	0.76	0.68
Singapore	0.57	0.58	0.98
South Korea	0.77	0.81	0.96
Taiwan	0.73	0.78	0.93
Thailand	0.78	0.83	0.95
Vietnam	0.72	0.81	0.89
Geometric Average	**0.71**	**0.79**	**0.89**

Table 4.5 presents the overall technical efficiency scores (TE) and its components i.e. the pure technical efficiency (PTE) and scale efficiency scores (SE) of banks based on its country of operation (refer to Appendix 1 for the complete list). Technical inefficiency refers to the extent to which a bank fails to produce maximum output from its chosen combination of factor inputs, while the scale inefficiency refers to sub-optimal bank size.

The inappropriate size of a bank (too large or too small) may sometimes be a cause for technical inefficiency. This is referred to as scale inefficiency and takes two forms, decreasing returns to scale and increasing returns to scale. Decreasing returns to scale (also known as diseconomies of scale) implies that a bank is too large for the volume of activities that it conducts. Unit costs increase as outputs increases. In contrast, a bank with increasing returns to scale (economies of scale) is too small for its scale of operation. Unit costs decrease as outputs increase while a bank that is scale-efficient is said to operate under constant returns to scale.

For these top 300 Asia Pacific banks, the pure technical inefficiency scores are much higher as compared to the scale inefficiency. This means technically inefficient banks use a relatively excessive quantity of inputs when compared with it peers operating with the same size and outputs. An inefficiency of around 20 percent exists as compared to only around 10 percent in terms of scale inefficiency. Thus, there is a huge room for improvement in utilising bank resources.From Table 4.5, it's also found that only the banking group from New Zealand was operating at optimal scale followed by Australia. The banking groups from countries such as India, Japan, Malaysia and Thailand indicate signs of pure technical inefficiency. The banking groups from Singapore are almost scale efficient but are technically inefficient while the Philippine banking group show both technical and scale inefficiency.

The next step is to look into this scale inefficiency and its nature. The number and percentage of banks with their nature of scale inefficiency is given in Table 4.6 below. From the table it is apparent that there is a mixed combination of return to scale among countries. Most of the banks from Pakistan, Philippines, Bangladesh, Australia, Indonesia and Vietnam in this study are relatively small as compared with its peer. Meanwhile, banks from New Zealand, Singapore, India, Malaysia, Thailand, Hong Kong, Taiwan and South Korea show a high sign of diseconomies of scale which implies that the banks from these countries are too large for the volume of activities that are carried out by these banks. So, this would be a very important indicator to help bank formulate its long term plans to stay efficient and effective bank in the Asia Pacific region. Furthermore steps could also be taken either to merge or to downsize its operation in staying competitive.

Table 4.6:

Return to Scale of Top 300 Asia Pacific Banks

Banks	Number of Banks on top 300	IRS		DRS	
		No.	%	No.	%
Australia	12	7	58	5	42
Bangladesh	1	1	100	-	0
China	24	8	33	16	67
Hong Kong	15	2	13	13	87
India	26	1	4	25	96
Indonesia	8	3	38	5	63
Japan	115	18	16	96	83
Malaysia	16	1	6	15	94
New Zealand	4	4	100	0	0
Pakistan	5	3	60	2	40
Philippines	6	3	50	3	50
Singapore	3	0	0	3	100
South Korea	15	3	20	12	80
Taiwan	38	6	16	32	84
Thailand	9	1	11	8	89
Vietnam	3	1	33	2	67

V. Conclusion

An input-oriented DEA model was used for estimating overall technical, scale and pure technical, efficiencies of the top 300 Asia Pacific Banks in 2006. The variables used in this study are deposit and asset as inputs while loans and interest income as outputs. This selection of variables was done through a sensitivity analysis followed by the testing of the robustness of the model.

A comprehensive analysis of efficiency among the cross country found that on average of 20 percent of inefficiency exist among these banks which signals ineffective utilization of its resources in the most productive manner. Banking groups from New Zealand show the highest level of overall and pure technical efficiency while banking groups from Philippines and Singapore indicate the lowest level of technical and scale efficiency. There were also some elements of scale inefficiency for banking groups in Pakistan, Philippines, Bangladesh, Indonesia and Vietnam; however the figure was relatively very low. So these smaller banks should take steps in ensuring they are relatively large enough to stay competitive among the other top Asia Pacific banks.

In total, this findings signals that banking efficiency has becomes critically important and it should be constantly compared with their counterparts in other countries to help bankers make better decisions regarding the direction of their banking industry and adapt to gain a competitive edge. The findings also may provide useful insights to government regulators and policy makers to enhance decision-making and policy formulation.

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Appendix 1

No.	Countries	Technical Efficiency		Scale Efficiency
		CRS	VRS	
	Australia	**TE**	**PTE**	**EFF**
1	National Australia Bank	0.83	1.00	0.83
2	Commonwealth Bank of Australia	0.85	1.00	0.85
3	ANZ Banking Group	0.97	1.00	0.97
4	Westpac Banking Corporation	0.92	0.95	0.97
5	Macquarie Bank	0.47	0.49	0.96
6	St. George Bank	1.00	1.00	1.00
7	Suncorp Metway	0.90	0.90	1.00
8	Bank of Western Australia	0.96	0.97	1.00
9	Citibank (Australia)	0.66	0.69	0.95
10	Adelaide Bank	0.91	0.96	0.95
11	Bendigo Bank	0.91	0.96	0.95
12	Bank of Queensland	0.92	1.00	0.92
	Geometric Average	***0.86***	***0.91***	***0.94***
	Bangladesh	**TE**	**PTE**	**EFF**
1	Sonali Bank	0.75	0.88	0.85
	Geometric Average	***0.75***	***0.88***	***0.85***
	China	**TE**	**PTE**	**EFF**
1	Industrial and Commercial Bank	0.56	0.87	0.65
2	Agricultural Bank of China	0.64	0.96	0.67
3	Bank of China	0.52	0.72	0.72
4	China Construction Bank	0.61	1.00	0.61
5	Bank of Communications	0.60	0.64	0.95
6	China Merchants Bank	0.70	0.73	0.95
7	China CITIC Bank	0.71	0.71	0.99
8	Shanghai Pudong Development	0.72	0.74	0.97
9	China Minsheng Banking Corporation	0.74	0.78	0.95
10	Industrial Bank	0.56	0.57	1.00
11	China Everbright Bank	0.68	0.69	0.98
12	Hua Xia Bank	0.72	0.72	1.00
13	Guangdong Development Bank	0.67	0.68	1.00
14	Bank of Shanghai	0.55	0.56	0.98
15	Bank of Beijing	0.57	0.58	0.98
16	Shenzhen Development Bank	0.77	0.78	0.99
17	Tianjin City Commercial Bank	0.48	0.57	0.84
18	Shenzhen Commercial Bank	0.64	0.72	0.89
19	Nanjing City Commercial Bank	0.51	0.72	0.71

20	Hangzhou City Commercial Bank	0.67	0.91	0.74
21	Wuxi City Commercial Bank	0.61	0.87	0.70
22	Ningbo Commercial Bank	0.56	0.93	0.60
23	Dalian City Commercial Bank	0.56	0.93	0.60
24	Dongguan City Commercial Bank	0.57	0.99	0.58
	Geometric Average	***0.62***	***0.77***	***0.84***
	Hong Kong	**TE**	**PTE**	**EFF**
1	Hongkong and Shanghai Bank	0.50	1.00	0.50
2	BOC (Hong Kong) Holdings	0.56	0.60	0.93
3	Hang Seng Bank	0.62	0.64	0.97
4	Standard Chartered Bank (Hong Kong)	0.62	0.62	1.00
5	Bank of East Asia	0.70	0.70	0.99
6	DBS Bank (Hong Kong)	0.71	0.72	0.99
7	CBC (Asia)	0.71	0.75	0.95
8	Wing Hang Bank	0.64	0.68	0.94
9	Dah Sing Banking Group	0.65	0.70	0.92
10	CITIC Ka Wah Bank	0.64	0.70	0.91
11	Shanghai Commercial Bank	0.61	0.67	0.91
12	Wing Lung Bank	0.64	0.71	0.90
13	Liu Chong Hing Bank	0.56	0.68	0.82
14	Fubon Bank (Hong Kong)	0.49	0.65	0.75
15	Bank of America (Asia)	0.73	0.86	0.85
	Geometric Average	***0.62***	***0.71***	***0.89***
	India	**TE**	**PTE**	**EFF**
1	State Bank of India	0.63	0.65	0.97
2	ICICI Bank	0.66	0.66	1.00
3	Punjab National Bank	0.63	0.63	0.99
4	Canara Bank	0.69	0.70	0.99
5	Bank of Baroda	0.60	0.61	0.98
6	Bank of India	0.64	0.66	0.98
7	Union Bank of India	0.69	0.71	0.97
8	Central Bank of India	0.55	0.58	0.95
9	HDFC Bank	0.59	0.62	0.95
10	UCO Bank	0.67	0.70	0.95
11	Syndicate Bank	0.68	0.72	0.94
12	Indian Overseas Bank	0.71	0.75	0.94
13	Oriental Bank of Commerce	0.66	0.70	0.94
14	Allahabad Bank	0.64	0.69	0.93
15	UTI Bank	0.54	0.60	0.90
16	Indian Bank	0.57	0.63	0.90
17	Corporation Bank	0.70	0.77	0.91
18	Andhra Bank	0.66	0.73	0.90
19	Citibank (India)	0.70	0.79	0.89
20	Vijaya Bank	0.58	0.68	0.85

21	Bank of Maharashtra	0.58	0.68	0.86
22	United Bank of India	0.49	0.64	0.76
23	HSBC (India)	0.58	0.70	0.83
24	Dena Bank	0.59	0.71	0.84
25	Jammu and Kashmir Bank	0.61	0.75	0.82
26	Federal Bank	0.58	0.99	0.58
	Geometric Average	***0.62***	***0.70***	***0.90***
	Indonesia	**TE**	**PTE**	**EFF**
1	Bank Mandiri	0.40	0.42	0.96
2	Bank Central Asia	0.57	0.60	0.95
3	Bank Negara Indonesia	0.48	0.52	0.92
4	Bank Rakyat Indonesia	0.86	0.88	0.97
5	Bank Danamon	0.83	0.91	0.91
6	Bank Internasional Indonesia.	0.60	0.85	0.70
7	Bank Niaga	0.82	1.00	0.82
8	Panin Bank	0.52	1.00	0.52
	Geometric Average	***0.63***	***0.77***	***0.84***
	Japan	**TE**	**PTE**	**EFF**
1	Mitsubishi UFJ Financial ...	0.56	1.00	0.56
2	Mizuho Financial Group	0.52	0.91	0.57
3	Sumitomo Mitsui Financial	0.64	1.00	0.64
4	Norinchukin Bank	0.28	0.30	0.92
5	Resona Holdings	0.76	0.99	0.77
6	Shinkin Central Bank	0.31	0.32	0.95
7	Sumitomo Trust & Banking	0.59	0.61	0.95
8	Mitsui Trust Holdings	0.72	0.73	0.99
9	Shoko Chukin Bank	1.00	1.00	1.00
10	Bank of Yokohama	0.85	0.92	0.93
11	Hokuhoku Financial Group	0.79	0.84	0.93
12	Chiba Bank	0.69	0.73	0.94
13	Shinsei Bank	0.58	0.60	0.98
14	Shizuoka Bank	0.68	0.71	0.96
15	Bank of Fukuoka	0.72	0.76	0.95
16	Joyo Bank	0.65	0.68	0.96
17	Sapporo Hokuyo Holdings	0.67	0.69	0.96
18	Nishi Nippon City Bank	0.76	0.79	0.96
19	Hiroshima Bank	0.71	0.73	0.97
20	Aozora Bank	0.73	0.76	0.96
21	Hachijuni Bank	0.69	0.71	0.98
22	Gunma Bank	0.66	0.67	0.98
23	Bank of Kyoto	0.58	0.58	1.00
24	Chugoku Bank	0.58	0.58	1.00
25	77 Bank	0.60	0.60	1.00
26	Yamaguchi Bank	0.69	0.69	1.00

27	Yo Bank	0.71	0.71	1.00
28	Rokinren Bank	0.11	0.13	0.85
29	Nanto Bank	0.60	0.60	1.00
30	Daishi Bank	0.57	0.58	0.99
31	Ashikaga Bank	1.00	1.00	1.00
32	Shinkumi Federation Bank	0.16	0.17	0.89
33	Juroku Bank	0.73	0.73	1.00
34	Shiga Bank	0.65	0.65	0.99
35	Hyakugo Bank	0.59	0.59	0.99
36	Ogaki Kyoritsu Bank	0.67	0.68	0.99
37	San In Godo Bank	0.64	0.64	0.99
38	Hyakujushi Bank	0.72	0.72	0.99
39	Higo Bank	0.65	0.66	0.99
40	Musashino Bank	0.78	0.79	0.99
41	Bank of Nagoya	0.68	0.69	0.99
42	Kagoshima Bank	0.70	0.71	0.99
43	Suruga Bank	0.79	0.80	0.99
44	Hokkoku Bank	0.74	0.75	0.99
45	Keiyo Bank	0.73	0.74	0.99
46	Momiji Holdings	0.68	0.70	0.98
47	Toho Bank	0.70	0.71	0.98
48	Kiyo Bank	0.68	0.69	0.98
49	Kyushu Shinwa Holdings	0.77	0.78	0.99
50	Bank of Ikeda	0.57	0.59	0.97
51	Minato Bank	0.85	0.86	0.99
52	Kansai Urban Banking Corporation	0.88	0.89	0.99
53	Oita Bank	0.66	0.68	0.98
54	Yamanashi Chuo Bank	0.62	0.64	0.97
55	Aichi Bank	0.64	0.65	0.97
56	Shikoku Bank	0.69	0.71	0.98
57	Tokyo Tomin Bank	0.72	0.74	0.98
58	Awa Bank	0.70	0.72	0.98
59	Bank of Iwate	0.57	0.59	0.96
60	Eighteenth Bank	0.64	0.66	0.97
61	Tochigi Bank	0.66	0.68	0.97
62	Akita Bank	0.59	0.62	0.96
63	Aomori Bank	0.68	0.71	0.97
64	Fukui Bank	0.79	0.81	0.97
65	Chiba Kogyo Bank	0.72	0.75	0.97
66	Hokuetsu Bank	0.63	0.65	0.96
67	Yachiyo Bank	0.73	0.75	0.97
68	Senshu Bank	0.81	0.83	0.97
69	Michinoku Bank	0.70	0.73	0.96
70	Bank of Saga	0.69	0.72	0.96

71	Yamagata Bank	0.62	0.65	0.95
72	Higashi Nippon Bank	0.83	0.86	0.97
73	Towa Bank	0.72	0.75	0.96
74	Miyazaki Bank	0.67	0.71	0.95
75	Daisan Bank	0.66	0.69	0.95
76	Chukyo Bank	0.79	0.82	0.96
77	Ehime Bank	0.82	0.85	0.96
78	Tokyo Star Bank	0.77	0.82	0.95
79	Bank of the Ryukyus	0.76	0.80	0.95
80	MIE Bank	0.71	0.75	0.94
81	Bank of Okinawa	0.79	0.84	0.94
82	Kumamoto Family Bank	0.84	0.88	0.95
83	Shimizu Bank	0.76	0.81	0.94
84	Kanto Tsukuba Bank	0.74	0.79	0.93
85	Kagawa Bank	0.82	0.87	0.94
86	Taiko Bank	0.71	0.77	0.93
87	Hokuto Bank	0.65	0.71	0.92
88	Kita Nippon Bank	0.73	0.79	0.93
89	Tokushima Bank	0.78	0.84	0.93
90	Biwako Bank	0.83	0.89	0.93
91	First Bank of Toyama	0.73	0.80	0.91
92	Bank of Kochi	0.80	0.87	0.92
93	Nagano Bank	0.75	0.83	0.90
94	Shonai Bank	0.77	0.86	0.90
95	Tomato Bank	0.76	0.85	0.89
96	Tottori Bank	0.77	0.86	0.90
97	Gifu Bank	0.74	0.83	0.88
98	Sendai Bank	0.70	0.80	0.88
99	Tajima Bank	0.83	0.93	0.90
100	Sony Bank	0.35	0.60	0.59
101	Saikyo Bank	0.77	0.86	0.89
102	Ibaraki Bank	0.75	0.85	0.88
103	Minami Nippon Bank	0.78	0.90	0.87
104	Daito Bank	0.70	0.83	0.85
105	Yamagata Shiawase Bank	0.77	0.89	0.86
106	Shokusan Bank	0.82	0.94	0.87
107	Fukushima Bank	0.80	0.92	0.87
108	Tohoku Bank	0.78	0.90	0.86
109	Chikuho Bank	0.76	0.90	0.84
110	Miyazaki Taiyo Bank	0.73	0.88	0.83
111	Howa Bank	0.72	0.87	0.82
112	Okinawa Kaiho Bank	0.70	0.91	0.77
113	Shizuoka Chuo Bank	0.83	1.00	0.83
114	Fukuho Bank	0.81	1.00	0.81

115	Nomura Trust and Banking	0.33	1.00	0.33
	Geometric Average	***0.69***	***0.76***	***0.93***
	Malaysia	**TE**	**PTE**	**EFF**
1	Maybank	0.75	0.75	1.00
2	Public Bank	0.73	0.73	0.99
3	RHB Bank	0.63	0.65	0.97
4	AMMB Holdings	0.75	0.78	0.96
5	Bumiputra Commerce Bank	0.73	0.75	0.97
6	Hong Leong Bank	0.52	0.56	0.93
7	Citibank (Malaysia)	0.64	0.70	0.90
8	HSBC (Malaysia)	0.72	0.79	0.91
9	EON Bank	0.81	0.88	0.92
10	Standard Chartered Bank (Malaysia)	0.67	0.74	0.90
11	Southern Bank	0.82	0.90	0.91
12	United Overseas Bank (Malaysia)	0.67	0.75	0.89
13	OCBC Bank (Malaysia)	0.81	0.89	0.91
14	Affin Bank	0.74	0.86	0.87
15	Alliance Bank	0.68	0.80	0.85
16	BIMB Holdings	0.57	0.84	0.68
	Geometric Average	***0.70***	***0.77***	***0.91***
	New Zealand	**TE**	**PTE**	**EFF**
1	National Bank	0.94	0.95	0.99
2	Westpac Banking Corporation	0.99	0.99	1.00
3	Bank of New Zealand	1.00	1.00	1.00
4	ASB Bank	1.00	1.00	1.00
	Geometric Average	***0.98***	***0.98***	***1.00***
	Pakistan	**TE**	**PTE**	**EFF**
1	National Bank of Pakistan	0.67	0.73	0.92
2	Habib Bank	0.76	0.83	0.91
3	United Bank	0.75	0.87	0.86
4	MCB Bank	0.86	1.00	0.86
5	Bank Alfalah	0.53	0.92	0.57
	Geometric Average	***0.71***	***0.87***	***0.82***
	Philippines	**TE**	**PTE**	**EFF**
1	Metropolitan Bank & Trust	0.55	0.62	0.90
2	Bank of The Philippine	0.58	0.64	0.90
3	Equitable PCI Bank	0.56	0.75	0.75
4	Land Bank of the Philippine	0.54	0.71	0.76
5	Banco de Oro	0.47	0.91	0.52
6	Philippine National Bank	0.37	0.90	0.41
	Geometric Average	***0.51***	***0.76***	***0.71***
	Singapore	**TE**	**PTE**	**EFF**
1	DBS Group Holdings	0.52	0.52	1.00
2	United Overseas Bank	0.62	0.63	0.98
3	Oversea Chinese Banking	0.58	0.60	0.97

	Corporation			
	Geometric Average	***0.57***	***0.58***	***0.98***
	South Korea	**TE**	**PTE**	**EFF**
1	Kookmin Bank	0.87	0.94	0.93
2	Woori Bank	0.82	0.84	0.98
3	Hana Bank	0.79	0.80	0.98
4	Industrial Bank of Korea	0.87	0.89	0.98
5	Shinhan Bank	0.85	0.85	0.99
6	Chohung Bank	0.80	0.80	1.00
7	Korea Exchange Bank	0.92	1.00	0.92
8	Standard Chartered First Bank	0.72	0.73	0.99
9	Citibank (Korea)	0.70	0.70	1.00
10	Daegu Bank	0.68	0.70	0.97
11	Pusan Bank	0.72	0.75	0.97
12	Kyongnam Bank	0.69	0.73	0.95
13	Suhyup Bank	0.79	0.83	0.95
14	Kwangju Bank	0.69	0.74	0.93
15	Jeonbuk Bank	0.68	0.83	0.82
	Geometric Average	***0.77***	***0.81***	***0.96***
	Taiwan	**TE**	**PTE**	**EFF**
1	Bank of Taiwan	0.57	0.59	0.96
2	Taiwan Cooperative Bank	0.71	0.74	0.96
3	Land Bank of Taiwan	0.83	0.86	0.96
4	Chinatrust Commercial Bank	0.65	0.65	1.00
5	Hua Nan Commercial Bank	0.66	0.67	0.99
6	First Commercial Bank	0.67	0.67	1.00
7	Chang Hwa Commercial Bank	0.69	0.70	1.00
8	International Commercial Bank	0.62	0.62	0.99
9	Cathay United Bank	0.64	0.65	0.99
10	Taiwan Business Bank	0.77	0.77	1.00
11	Taipei Fubon Commercial Bank	0.63	0.64	0.98
12	Taishin International Bank	0.71	0.72	0.98
13	Shanghai Commercial & Sav Bank	0.57	0.59	0.97
14	Chiao Tung Bank	0.84	0.86	0.97
15	Farmers Bank of China	0.84	0.86	0.98
16	Bank SinoPac	0.65	0.68	0.96
17	E. Sun Commercial Bank	0.73	0.76	0.96
18	International Bank of Taiwan	0.78	0.82	0.95
19	Hsinchu International Bank	0.76	0.81	0.94
20	Ta Chong Bank	0.74	0.80	0.93
21	Taiwan Shin Kong Commercial Bank	0.67	0.73	0.92
22	Union Bank of Taiwan	0.65	0.71	0.92
23	EnTie Commercial Bank	0.77	0.83	0.93
24	Fuhwa Bank	0.82	0.87	0.93

25	Far Eastern International	0.78	0.84	0.92
26	Jih Sun International Bank	0.75	0.81	0.92
27	Bank of Overseas Chinese	0.73	0.80	0.91
28	Taichung Commercial Bank	0.76	0.83	0.91
29	Cosmos Bank	0.67	0.75	0.89
30	Sunny Bank	0.78	0.87	0.90
31	Chinese Bank	0.71	0.81	0.88
32	China Development Industrial	1.00	1.00	1.00
33	Bowa Commercial Bank	0.65	0.76	0.85
34	Bank of Panhsin	0.88	1.00	0.88
35	Chinfon Commercial Bank	0.67	0.87	0.77
36	King's Town Bank	0.80	0.94	0.85
37	Bank of Kaohsiung	0.75	0.95	0.79
38	Industrial Bank of Taiwan	0.48	0.95	0.51
	Geometric Average	***0.72***	***0.78***	***0.93***
	Thailand	**TE**	**PTE**	**EFF**
1	Bangkok Bank	0.73	0.73	1.00
2	Krung Thai Bank	0.84	0.85	1.00
3	Kasikorn Bank	0.86	0.88	0.99
4	Siam Commercial Bank	0.91	0.92	0.99
5	TMB Bank	0.85	0.88	0.97
6	Bank of Ayudhya	0.76	0.79	0.96
7	Siam City Bank	0.76	0.82	0.93
8	Bankthai	0.49	0.60	0.81
9	United Overseas Bank (Thailand)	0.85	1.00	0.85
	Geometric Average	***0.78***	***0.83***	***0.94***
	Vietnam	**TE**	**PTE**	**EFF**
1	Vietnam Bank for Agriculture	0.89	0.94	0.95
2	Bank for Foreign Trade of Vietnam	0.49	0.59	0.83
3	Industrial and Commercial Bank	0.78	0.89	0.88
	Geometric Average	***0.72***	***0.81***	***0.88***