Chapter 1. Introduction

In a recent decade, cost efficiency and *x*-efficiency have been the central focus of international- and Australian banking efficiency studies. Profit efficiency, on the other hand, has been relatively less focused, due to technical difficulties associated to measure profit efficiency by using conventional econometric approaches, such as input- and output-orientated distance functions. However, profit efficiency has been suggested as a more appropriate efficiency concept in evaluating overall bank performances, because it takes account of both cost- and revenue sides of bank operations into account. Therefore, it can be claimed that profit efficiency reflects banks' profit maximising behaviours more closely than the other types of efficiency concept.

In Australia, it was Kirkwood and Nahm (2006) who attempted to analyse profit efficiency of Australian banks for the first time, by using input-orientated distance function. Except Kirkwood and Nahm (2006), other previous Australian studies were focused on *x*-efficiency and/or cost efficiency as well as productivity changes.

This study aims to provide an analysis on profit efficiency of Australian banks in the period from 2000 to 2008. The directional (technology) distance function and Data Envelopment Analysis (DEA) are utilised to compute profit efficiency. DEA is a non-parametric approach of the frontier analysis and it has been widely used in international and Australian studies. However, the number of international studies, which utilised DEA to compute the directional distance function to measure efficiency, is quite limited. Particularly in Australia, there is no study that has attempted to measure efficiency by utilising DEA and the directional distance function.

The directional distance function is introduced by Fried, Lovell and Schmidt (1993), and applied to measure profit efficiency by Chambers, Chung and Färe (1998), because it resolved the technical difficulties associated to measure profit efficiency by using the conventional approaches. In addition, the application of the directional distance function by Grosskopf and Weber (2004) showed that the directional distance function is more suitable to measure profit efficiency than other conventional approaches.

In addition to the directional distance function, this study utilises a newly developed norm-based profit index approach. It is introduced by Nahm and Vu (2008), and provides profit efficiency scores based on Euclidean distances. To the author's knowledge, this is the first study using the directional distance function and the norm-based profit index approach to measure the profit efficiency of Australian banks.

This thesis is structured as follows. Chapter 2 provides a review of concepts of efficiency – cost, revenue and profit – and measurement techniques for frontier analyses, including DEA. It is followed by Chapter 3 and 4, which provide literature reviews of international studies (Chapter 3) and Australian studies (Chapter 4). Chapter 3 covers only selected international studies, which include profit efficiency in their analyses, where Chapter 4 covers the previous Australian banking efficiency studies more comprehensively.

The econometric model specification of this study is provided in Chapter 5. The directional distance function is introduced in conjunction with the Nerlovian profit efficiency. The reason that the Nerlovian profit efficiency is included is twofold. Firstly, it is widely used in the previous profit efficiency analyses with the directional distance function. Secondly, it is described in order to compare it to the norm-based profit index approach. This chapter also provides mathematical presentations of the linear programming as well as the data specification.

The empirical result analysis is provided in Chapter 6, which can be summarised as follows. Firstly, the overall profit efficiency of Australian banks has not been improved on average in the period of study. Secondly, allocative inefficiency is found to be the major component of the overall profit inefficiency of Australian banks, particularly for the regional banks. Thirdly, the major banks are price efficient, while the regional banks are extremely price inefficient, which appears to be consistent to the highly concentrated market structure of the Australian banking sector.

Spearman Rank Correlation (SRC) analysis is conducted in order to observe correlation between profit efficiency and accounting measures of profitability. In contrast to the previous studies, this study has found a negative correlation between the profit efficiency of Australian banks and return on assets (ROA), while return on equity (ROE) is found to be positively correlated to the profit efficiency. The size factors of the banks, such as total assets and total equity are found to be positively correlated to profit efficiency, which is consistent to the previous studies.

Chapter 2.
A Review of Concepts of Efficiency and associated Measurement Techniques

2.1 Introduction

This chapter provides a review of the concepts of efficiency and associated measurement techniques. The concepts of efficiency include cost-, revenue- and profit efficiencies. The associated measurement techniques include parametric and non-parametric approaches, where the parametric approaches include Distribution-Free Approach (DFA), Thick Frontier Approach (TFA) and Stochastic Frontier Approach (SFA), and the non-parametric approaches include Free Disposal Hull Approach (FDH) and Data Envelopment Analysis (DEA).

This study aims to estimate profit efficiency of Australian banks by using the directional (technology) distance function and DEA. Therefore, this chapter focuses on comparing the concepts of efficiency as well as the measurement techniques in order to provide rationales for choosing profit efficiency and for choosing the directional distance function and DEA over other concepts of efficiency and measurement techniques.

This chapter is structured as follows. Section 2.2 provides a review of the concepts of efficiency, and it is followed by Section 2.3 which provides a review of the measurement techniques. The summary of this chapter is provided in Section 2.4.

2.2 The concepts of efficiency

Farrell (1957)'s economic efficiency

The fundamental concept of efficiency and its decomposition is provided by Farrell (1957), who showed that the economic (productive) efficiency of production can be decomposed into technical- and allocative efficiency components (Färe, Grosskopf and Lovell, 1983).

According to Farrell (1957), a decision-making production unit (DMU), or a firm hereafter, with multiple inputs and outputs is technically efficient, if the firm produces the maximum amount of output by using given amount of inputs at given level of production technology. It means that, the technically efficient firm is not able to produce more of one output without reducing at least one of other outputs or employing at least one more of other inputs. Equivalently, the technically efficient firm cannot reduce one of inputs without reducing the production of at least one of outputs (Farrell, 1957)[1].

Allocative efficiency of a firm measures the firm's ability to choose a set of inputs at given input prices to maximise the firm's profit. The firm would be allocatively efficient, if the firm maximises its profit at given production technology by using a set of inputs at given input prices. Otherwise, the firm is allocatively inefficient.

Debreu (1951) and Farrell (1957) pioneered the measurement of output (input)-orientated technical efficiency by the maximum radial expansion (contraction) of outputs (inputs) at given level of production technology and inputs (outputs). The Debreu-Farrell measure of output (input)-orientated technical efficiency is computed by Shephard's output (input) distance functions, which are developed by Shephard in 1970 and 1953, respectively.

Cost- and revenue efficiencies

Cost- and revenue efficiencies have been popular production performance indicators (Fried, Lovell and Schmidt, 2008). Cost efficiency is defined by the ratio of the minimum cost and the actual cost of production, which is computed by a cost function with given input prices, given output quantities, and random errors (Berger and Mester, 1997). Because it is defined by the ratio,

[1] Farrell (1957)'s definition of technical efficiency as well as the motivation of his paper are based on Koopmans (1951) and Debreu (1951).

the range of cost efficiency scores is between 0 and 1. For instance, if a cost efficiency score of a firm is 0.8 then it means the firm is 80 per cent cost efficient and wasting 20 per cent of costs, relative to the best-practice (cost efficient) firm. Cost efficiency can be decomposed into technical- and allocative efficiencies, because it measures both the deviation of actual use of input(s) from the optimal use of input(s) (technical efficiency) and the deviation of the current set of input(s) and output(s) from the optimal set (allocative efficiency).

Similarly to cost efficiency, revenue efficiency is defined by the ratio between the maximum revenue and the actual revenue. Therefore, it requires information about output prices. In particular, revenue efficiency can be used to measure the differences in the quality of output(s) produced by two different firms, when two firms have identical set of input(s) and output(s) with identical input and output prices (Rogers, 1998). Revenue efficiency also can be decomposed into technical- and allocative efficiencies, similarly to the decomposition of cost efficiency. There are two types of revenue efficiency, which are the standard revenue- and the alternative revenue efficiencies.

The standard revenue efficiency assumes output price(s) is exogenous. Therefore, any revenue inefficiency is attributed to the suboptimal choice of input-output combinations. On the other hand, the alternative revenue efficiency assumes the quantity of output(s) is exogenous. Therefore, it reflects the price-setting ability of firms to maximise their profits (Berger and Mester, 1997; Rogers, 1998).

In the previous banking efficiency studies, the alternative concept has been preferred, due to the following reasons. Firstly, the standard revenue efficiency is sensitive to the integrity of output price information. It means that the standard revenue efficiency would be inaccurate if output price information is not completely accurate. Secondly, banking sectors are generally characterised as a market with imperfect competition (Berger and Mester, 1997; Lozano-Vivas, 1997). Therefore, it is necessary to take account of the price-setting ability of banks to measure the efficiency of banks, when the imperfect competition in the market is evident (Rogers, 1998).

Profit efficiency

Similarly to the above efficiency concepts, profit efficiency is defined by the ratio of the actual (observed) profit to the maximum possible profit. However, it is suggested that profit efficiency is superior to its counterparts as a performance indicator, due to the following characteristics.

Firstly, profit efficiency is an integrated concept of both cost- and revenue efficiencies. Therefore, it provides more balanced measure of efficiency than cost- and revenue efficiency measures (Berger and Mester, 1997; Maudos and Pastor, 2003). Secondly, profit efficiency can be thought of as 'total efficiency'[2], because it includes both technical and allocative efficiencies as well as scale efficiency of production. It means that, if a firm is profit efficient, then the firm is both technically and allocatively efficient at an appropriate scale (Fitzpatrick and McQuinn, 2008). Thirdly, profit efficiency is more consistent to the economic goal of profit maximisation than other types of efficiency (Berger and Mester, 1997).

In addition, a possible bias in cost efficiency measures can be avoided by measuring profit efficiency, because it takes account of cost efficiency and the difference in the quality of outputs at the same time. The biasedness of cost efficiency can be explained by follows. Suppose that there is a firm which produces a better quality output and sells it at a higher price than its competitors' prices by utilising more inputs. Then, the firm is maximising its revenue at given production technology and would be identified as revenue efficient. However, the firm can be identified as cost inefficient, because it uses more inputs to produce same quantity of outputs to its competitors (Berger, Hancock and Humphrey, 1993; Berger and Mester, 1997).

The concept of profit efficiency has been less focused than cost- or revenue efficiencies in the previous banking efficiency studies (Fried, Lovell and Schmidt, 2008). It can be attributed to the technical difficulties to measure profit efficiency by using Shephard's distance functions to compute profit function. The technical difficulties arise as profit function has an additive nature, while Shephard's distance functions are based on Farrell (1957)'s radial concepts (Berger, Hancock and Humphrey, 1993).

Nerlove (1965) attempted to measure profit efficiency by taking the difference between the maximum possible profit and the actual profit, rather than taking a ratio to avoid the technical difficulties. However, Nerlove (1965)'s measure of profit efficiency is subject to the unit of measurement. The initial attempt by Nerlove (1965) is followed by several attempts to compute profit efficiency by using parametric approaches[3]. Note that, Nerlove (1965)'s approach is later redefined to 'Nerlovian profit efficiency', which is defined by the directional distance function, by Chambers, Chung and Färe (1998).

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[2] Fitzpatrick and McQuinn, 2008, pp.2

[3] Parametric and non-parametric approaches are discussed in Section 2.3.

Berger, Hancock and Humphrey (1993) pioneered a use of profit function to measure technical-, allocative- and profit efficiencies of US banks. They utilised the Fuss normalised quadratic form of profit function and defined technical- and allocative inefficiencies differently to Farrell (1957) in order to overcome the inconsistency between Farrell's radial concepts and the additive nature of profit function.

They defined allocative inefficiency as the amount of suboptimal profit due to an inefficient choice of a production plan, and technical inefficiency is the suboptimal profit due to the failure to realise the production plan. Profit efficiency is measured by computing the ratio of the loss of potential profit to the maximum potential profit, in contrast to Farrell (1957)'s concept of profit efficiency, which is defined by the ratio of the actual profit to the maximum possible profit.

Berger and Mester (1997) calculated profit efficiency by taking the ratio of the actual profit and the maximum possible profit, by utilising a Fourier-flexible functional form. The Fourier-flexible functional form includes trigonometric terms (or Fourier terms), which enables to approximate the functional form of cost- and/or profit function from a given set of data (DeYoung and Hasan, 1998). Berger and Mester (1997) used the Fourier-flexible functional form due to its flexibility to accommodate any type of cost- and profit functions as well as the limited ability of the translog functional form to measure the efficiency of banks with various sizes.

In their analysis on US banking efficiency, Berger and Mester (1997) introduced a concept of the alternative profit efficiency to overcome a possible measurement problem associated with the standard profit efficiency. The standard profit efficiency assumes perfectly competitive markets of inputs and outputs. Therefore, it assumes banks as price-takers (Berger, Hancock and Humphrey, 1997). However, the standard profit efficiency is subject to the output price specifications, which is a source of a possible biasedness of efficiency measures, as it is observed with the standard revenue efficiency.

On the other hand, the alternative profit efficiency takes the output quantities as given and allows output price to vary. Therefore, it is free from misspecification of output prices, and discriminates the quality of outputs, similarly to the alternative revenue efficiency. By estimating the alternative profit efficiency, the scale bias in the standard profit efficiency also can be avoided. The standard profit efficiency is subject to the scale bias, because it does not discriminate the differences in the size and assets of banks (Berger and Mester, 1997).

Fried, Lovell and Schmidt (1993) introduced the directional distance function[4] to measure profit efficiency by calculating the optimal input and output quantities and, taking their deviations from the actual input and output quantities at given production technology, by computing the directional distance with the directional (technology) distance function.

The directional distance function is computed by linear programming (LP) mathematical techniques, such as DEA. The directional distance function is consistent to profit function, because of the duality between the directional distance function and profit function (Devaney and Weber, 2002). In addition, the directional distance function is a generalised functional form of Shephard's input- and output-orientated distance functions. The profit efficiency computed by the directional distance function also can be decomposed into technical efficiency and allocative efficiency (Chambers, Chung and Färe, 1998).

This study utilises the directional distance function, because of its duality to profit function and its consistency to the economic objective of profit maximisation. In this study, the directional distance function is preferred to a Fourier-flexible functional form, which requires a large number of parameters to be calculated (Maudos and Pastor, 2003). Therefore, it is inappropriate to use a Fourier-flexible functional form for a small-sized sample, such as the Australian banking sector. To the author's knowledge, this is the first study using the directional distance function to measure profit efficiency of Australian banks.

2.3 Measurement techniques

The frontier-based approaches are widely used to measure the efficiency of various organisations due to following reasons. Firstly, it can be used to measure efficiency of firms without in-depth knowledge about structural characteristics of the firms. Secondly, if it is used with knowing specific characteristics of firms, then the results of efficiency measures would be useful for the firms to identify their current efficiency positions, and how to improve their efficiencies, if they are inefficient (Berger and Humphrey, 1997). In the previous banking efficiency studies, two types of the frontier-based approach have been widely used, which are parametric approaches and non-parametric approaches.

[4] The directional distance function and its duality with profit function are discussed in Chapter 5.

Parametric approaches

For the parametric approaches, it is important to define an appropriate functional form (such as the translog and a Fourier-flexible functional form) for cost-, revenue- and/or profit function (Maudos and Pastor, 2003). It means that, the goodness of fit for the functional form is important for the parametric approaches in determining the shape of an efficiency frontier, which implies a limited flexibility of the parametric approaches. The parametric approaches include Distribution-Free Approach (DFA), Thick Frontier Approach (TFA) and Stochastic Frontier Approach (SFA).

Stochastic Frontier Approach (SFA) is introduced by Aigner, Lovell and Schmidt (1977) and is widely used to measure cost and/or profit efficiency. SFA assumes that, firstly, a production frontier can be affected by exogenous input, output and/or environmental factors. Secondly, the distribution of inefficiency is assumed to be strictly asymmetric or a half-normal, while the distribution of random errors is assumed to be symmetric (Allen and Rai, 1996; Fried, Lovell and Schmidt, 2008). However, the assumption requirements for the distributions of inefficiency and random errors imply some measurement problems associated to SFA. Firstly, it may have a low discriminatory power, because the measured inefficiency is based on the conditional mean of the distribution of inefficiency within the sample. To overcome the problem, it is suggested, firstly, to relax the assumptions for the distributions, and secondly, to use different types of the distribution of inefficiency, rather than a half-normal distribution (Berger and Humphrey, 1997). However, the second problem remains, because SFA is difficult to use when the distribution of residuals is inconsistent to the imposed distributional assumption (Berger and Mester, 1997).

Thick Frontier Approach (TFA) does not require the distributional assumptions like SFA. TFA is characterised by its treatment of observations in the highest and the lowest quartiles of inefficiency measures. TFA treats the observations as random errors and, measures inefficiency of other observations by taking the difference between the predicted level of performance and the performances of the observations in the highest and the lowest quartiles. It means that, TFA assumes the upper and lower middle quartiles are dominated by market factors and inefficiency. Because of its characteristics, TFA is more appropriate to measure the overall inefficiency of a sample, rather than to obtain point estimates for inefficiency of individual observations.

Distribution-Free Approach (DFA) also does not require the distributional assumptions. It assumes each firm in given sample is subject to the persistent core efficiency. Because DFA assumes random errors have a zero mean value, it naturally distinguishes core efficiency to random errors (Akhavein, Berger and Humphrey, 1997). Then DFA computes inefficiency by taking the difference between a firm's average residuals and the average residuals of a firm which operates on the efficiency frontier. However, DFA is subject to a possible measurement problem, when the relative efficiency of firms is changed in each period. Then, DFA measures the core efficiency of the firms in each period, rather than measures inefficiency of the firms (Berger and Humphrey, 1997; Berger and Mester, 1997).

Non-parametric approaches: Data Envelopment Analysis

Data Envelopment Analysis (DEA) is one of the non-parametric approaches[5], which is introduced by Charnes, Cooper and Rhodes (1978) based on Farrell's (1957) concepts of the efficiency decomposition. DEA is initially developed to measure technical efficiency of non-for-profit organisations. However, it has been subsequently modified and applied to measure economic efficiency of for-profit organisations with complex structures and different input-output combinations (Fried, Lovell and Schmidt, 2008). It is Sherman and Gold (1985), who applied DEA to analyse the efficiency of financial institutions, and it is followed by vast amount of banking efficiency studies that utilised DEA.

DEA is a LP technique, and computes the efficiency of given set of firms by constructing a piecewise linear efficiency frontier based on observed multiple input-output combinations and the production technology for given set of firms (Chambers and Färe, 2008). DEA assigns the efficiency scores to firms between 0 and 1, where the best-practice firm in the sample is assigned the efficiency score of 1.

As a non-parametric approach, DEA does not require a pre-specified functional form. Thus, it is not required for DEA to parameterize production technology to find the best-practice firm(s). It enables a relationship between input(s) and output(s) of firms in the sample to be identified (Avkiran, 1999). However, DEA requires the assumptions of convexity and monotonicity in order to construct an efficiency frontier.

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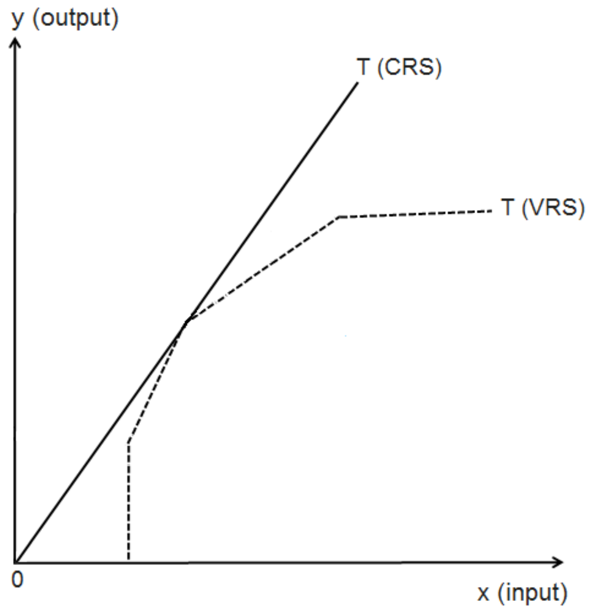
[5] The other non-parametric approach is Free-Disposal Hull (FDH) Approach, which is developed by Deprins, Simar and Tulkens (1984). FDH is not discussed in this chapter and, for a detailed discussion on FDH, see Fried, Lovell and Schmidt (2008), pp.256-258.

DEA frontier has different shapes according to different assumptions for production technology, such as constant returns to scale (CRS) and variable returns to scale (VRS), as illustrated in Figure 2.1. Note that DEA frontier under VRS has a 'kinked'-shape due to the convexity constraint λ (see (2.2)).

Figure 2.1 DEA frontiers and returns to scale



By following Charnes, Cooper and Rhodes (1978) and Fried, Lovell and Schmidt (2008), DEA frontier under CRS is constructed by linear programming, which is given by (2.1).

$$T^{CRS}(x,y) = \left\{ (x,y) \;\middle|\; \begin{array}{l} \sum_{j=1}^{n} \lambda_j y_j \geq y, j = 1, \ldots n \\ \sum_{j=1}^{n} \lambda_i x_j \leq x \\ \lambda_j \geq 0 \end{array} \right\} \tag{2.1}$$

DEA frontier under VRS is constructed by a similar linear programming, except dropping the assumption of CRS and adding the convexity constraint $\sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0$ as in (2.2), where the convexity constraint makes the shape of the frontier to be 'kinked'.

$$T^{VRS}(x, y) = \left\{ (x, y) \left| \begin{array}{l} \sum_{j=1}^{n} \lambda_j y_j \geq y, j = 1, \ldots n \\ \sum_{j=1}^{n} \lambda_i x_j \leq x \\ \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0 \end{array} \right. \right\} \tag{2.2}$$

Note that, firstly, DEA frontier is not necessarily 'true' frontier, and secondly, DEA efficiency scores should be regarded as relative rather than absolute measures. It is because of DEA frontier and efficiency scores are constructed and measured by the production technology T as well as observed input-output vectors of given set of firms. It implies DEA efficiency scores are sensitive to input-output specifications (Sturm and Williams, 2002). It should be also noted that, DEA estimations are relatively robust than other efficiency measurement techniques (Seiford and Thrall, 1990).

Despite it provides more flexible and less complicated way to measure efficiency, DEA has own drawbacks. Firstly, DEA attributes any deviation from an efficiency frontier to inefficiency, because it does not assume the distribution of random errors. However, the deterministic characteristic of DEA frontier makes the efficiency scores to be sensitive to random errors or measurement errors (Berger and Humphrey, 1997). Therefore, it is important to acknowledge a possible biasedness of DEA efficiency scores when the random errors are expected to be significant due to a low integrity of data and/or the presence of extreme outliers (Avkiran, 1999; Wu, 2008).

Secondly, the inherent incompleteness of DEA frontier leads some observations not to be 'naturally enveloped', which cause a problem of 'slacks' (Tofallis, 2001). The slacks imply that DEA efficiency scores cannot be used to rank firms in accordance with the scores. It has been attempted to overcome the problem of slacks, by Bessent, Bessent, Elam and Clark (1988) and Lovell and Eeckaut (1993), to complete an efficiency frontier by extending efficient points which are positioned within the DEA frontier. However, it inevitably fixes input(s) or output(s) for such extensions. Therefore, it is not a complete solution for the problem of slacks.

Thirdly, DEA may have a lower discriminatory power when it is applied to a model with a small-sized sample (Paul and Kourouche, 2008) and/or when the product of the number of inputs and outputs is greater than the sample size (Neal, 2004), due to the 'relative' nature of DEA efficiency scores. However, it is noted earlier by Drake (2001) that, applying DEA to a model with a small-sized sample does not necessarily reduce the discriminatory power of DEA, where it is still important to interpret the result from DEA with a small-sized sample carefully.

2.4 Summary

This chapter has provided reviews of the concepts of efficiency – economic-, cost-, revenue- and profit efficiencies – and measurement techniques - parametric and non-parametric approaches. This study aims to measure profit efficiency of Australian banks, because profit efficiency combines cost- and revenue efficiencies. Therefore, it would provide more comprehensive overview on Australian banking efficiency. In addition, profit efficiency is consistent to the economic objective of profit maximisation, because it includes cost minimisation and revenue maximisation.

The directional distance function and DEA are observed to be the most appropriate combination of measurement techniques for profit efficiency analyses due to the following reasons. Firstly, the directional distance function measures the efficiency of firms based on the firms' profit maximising behaviours with allowing the firms to make simultaneous adjustments of inputs and outputs. Secondly, the directional distance function is consistent to profit function. Thirdly, the decomposition of profit efficiency into technical- and allocative efficiencies is also possible when profit efficiency is computed by the directional distance function.

Furthermore, DEA does not require any specific assumptions on the distributions of inefficiency and random errors, which means that DEA provides more flexibility. In particular, DEA works for a model with a small-sized sample, which is an important characteristic of DEA for this study.

Chapter 3. International Literature Review

3.1 Introduction

Berger and Humphrey (1997) provided an extensive survey of international studies of the efficiency of financial institutions. The implications of the survey are, firstly, there is no 'standard' approach to analyse the efficiency of financial institutions. The parametric and non-parametric approaches are used in a similar number of studies, where DEA was the most widely used non-parametric approach, particularly after 2002. Secondly, there is no consensus on the selection of input and output variables to estimate the efficiency. Thirdly, only a small proportion of studies have analysed profit efficiency of financial institutions, where the majority of the studies focused on economic- and cost efficiencies. However, because the focus of this study is on profit efficiency, this chapter reviews only the relevant selection of international studies.

Table 3.1 presents a list of international studies reviewed in this chapter. They analysed profit efficiency of banks exclusively, or in conjunction with cost efficiency and productivity since 1996. It appears parametric approaches, such as DFA, TFA and SFA, were widely used to analyse profit and cost efficiencies in the period prior to 2002. Non-parametric approaches, mostly DEA, became the dominant efficiency measurement technique after 2002.

This chapter reviews the studies in accordance with the efficiency measurement techniques. The studies that used parametric approaches are discussed in Section 3.2, and the studies that used DEA are reviewed in Section 3.3. The summary of this chapter is provided in Section 3.4.

Table 3.1 International studies of profit efficiency

Methodology	Author(s) (year)	Other efficiency measured	Country (period)
Distribution-Free Approach (DFA)	DeYoung and Nolle (1996)	Cost	US (1985 – 1990)
	Akhavein, Berger and Humphrey (1997)	–	US (1985 – 1989)
	Berger and Mester (1997)	Cost	US (1990 – 1995)
	Rogers (1998)	Cost, Revenue	US (1991 – 1995)
Thick Frontier Approach (TFA)	Lozano-Vivas (1997)	–	Spain (1986 – 1991)
Stochastic Frontier Approach (SFA)	Isik and Hassan (2002)	Cost	Turkey (1988 – 1996)
	Mamatzakis, Staikouras and Koutsomanoli-Filippaki (2008)	Cost	EU (1998 – 2003)
	Fitzpatrick and McQuinn (2008)	–	Ireland, UK, Canada, Australia (1996 – 2002)
Data Envelopment Analysis (DEA)	Devaney and Weber (2002)	–	US (1994 – 1999)
	Maudos and Pastor (2003)	Cost	Spain (1985 – 1996)
	Färe, Grosskopf and Weber (2004)	–	US (1990, 1992, 1994)
	Resende and Silva (2007)	–	Portugal (2000 – 2004)
	Ariff and Can (2008)	Cost	China (1995 – 2004)
	Nahm and Vu (2008)	–	Vietnam (2000 – 2006)

NOTE: Berger and Mester (1997) used both DFA and SFA.

3.2 Parametric approaches to profit efficiency

Distribution-Free Approach

DeYoung and Nolle (1996) used Distribution-Free Approach (DFA) to measure cost- and the relative profit efficiency of 302 US banks, in order to compare the overall operating efficiency of 240 US-owned and 62 foreign-owned commercial banks. They were sceptical about cost efficiency, because it may describe a profit-efficient bank to be cost inefficient[1]. Thus, they measured cost efficiency and the relative profit efficiency of the banks at the same time, by using a quadratic variable profit function. It is a modified form of Berger, Hancock and Humphrey (1993), where the original functional form assumes output prices are exogenous. However, it is inappropriate for DeYoung and Nolle (1996), because they aimed to compare relative profit efficiencies of two types of banks. They selected four variable inputs and two outputs by following the intermediation approach (see Table 3.2). Three fixed netputs are also included in order to reflect banks' non-traditional activities as well as banks' ability to control financial risks.

DeYoung and Nolle (1996) found foreign-owned banks are less profit efficient as well as less profitable than US-owned banks, in spite of the substantial increase in their market share in US between 1980s and 1990s. Cost efficiency of foreign-owned banks also appears to be relatively lower than US-owned banks. The lower profit- and cost efficiencies of foreign-owned banks are explained by the difference in operational directions, where foreign-owned banks had tried to increase their market share, rather than increased profits. On the other hand, US-owned banks focused on maximising their profits during the period. In addition, a positive relationship is observed between a bank's size and its profit, which is consistent to the results of the previous US banking studies (DeYoung and Nolle, 1996).

Akhavein, Berger and Humphrey (1997) analysed a relationship between bank mergers and profit efficiency in US. They used DFA to compute a Fuss normalised quadratic variable form of profit function, by following Berger, Hancock and Humphrey (1993). Therefore, the profit function of Akhavein, Berger and Humphrey (1997) shares the basic functional form with DeYoung and Nolle (1996), except its explicit inclusion of an allocative efficiency parameter in the profit

[1] DeYoung and Nolle (1996) pointed out that cost efficiency measures from a cost function-based model is based on the excess use of input or lower level of outputs, and non-optimal input (output)-mix, which poses a possibility of misinterpretation of the efficiency measures. In Chapter 2, the possible biasness of cost efficiency measures are discussed in detail.

function. Akhavein, Berger and Humphrey (1997) emphasized the importance of allocative efficiency parameter, because it represents a suboptimal profit due to inefficient choice of a set of netputs. They noted allocative efficiency parameters are generally considered to be less important than technical efficiency in previous studies, due to the smaller variability of allocative efficiency than technical efficiency.

Akhavein, Berger and Humphrey (1997) found a positive relationship between bank mergers and profit efficiency. The relationship is presented by the performance rank of profit efficiency changes of merging banks, which indicates that bank mergers improve profit efficiency of merging banks approximately by 10 per cent. Meanwhile, merging banks are observed to have increased the average loan-to-asset ratio almost by 7 per cent, which is higher than non-merging banks. It can be explained by the increase in size as well as market base for merging banks allows them to spread risks by diversifying their loan portfolios. Note that, they were unable to find any implication for the relationship between cost efficiency and bank mergers.

Table 3.2 Input-output and additional variables used with DFA

Author(s) (country, year)	Variable inputs (Prices)	Outputs (Amounts)	Additional variables (Fixed Netputs)
DeYoung and Nolle (US, 1996)	Purchased fund Labour Core deposits* Physical capital	Total loans Securities	Non-interest income Equity capital Risk-weighted assets
Akhavein, Berger and Humphrey (US, 1997)	Total deposit funds (incl. purchased funds) Labour	Total loans Total securities	Equity capital
Berger and Mester (US, 1997)	Purchased funds Core deposits* Labour	Consumer and Business loans Securities	Risk-weighted off-balance-sheet items Physical capital Financial equity capital
Rogers (US, 1998)	Labour Physical capital Time and Saving deposits Purchased funds	Core deposits* Real estate loans Other loans Net non-interest income**	N/A

NOTE: *Core (Produced) deposit: the sum of saving, demand and time deposits (Berger and Mester, 1997, pp.914); **Net non-interest income is included as a proxy for non-traditional activities (Rogers, 1998, pp.470)

Berger and Mester (1997) attempted to find sources that cause differences in the efficiency measures in different studies. They argued that it is practically impossible to find the sources by comparing the efficiency measures from different studies directly to each other. They suggested three possible sources of the differences, including different definitions of efficiency, measurement techniques and environmental factors. In order to observe whether the differences in the efficiency measures can be explained by different definitions of efficiency, they defined two types of profit efficiency – the standard profit and the alternative profit[2] – as well as cost efficiency. In addition, they used both DFA and SFA to observe how a choice of measurement techniques affects the efficiency measures.

Berger and Mester (1997) measured the efficiency of approximately 6,000 US banks in the period from 1990 to 1995, with three input and three output variables (see Table 3.2). They also included three types of fixed netputs[3] to minimise the problem of output price specifications, where the problem is associated to the standard profit function. In addition, they included environmental variables to take account of possible exogenous factors that may affect the banking efficiency.

The results of Berger and Mester (1997) suggested that, firstly, each efficiency concept – cost-, the standard profit- and the alternative profit efficiencies - carries own implications. It means that the efficiency concepts are not necessarily related to each other. Second, DFA and SFA techniques provided similar efficiency measures, which means that different measurement techniques do not necessary provide significantly different results. Third, the standard profit- and alternative profit efficiencies are observed to be consistent to the results of the previous US banking efficiency studies, with suggesting that the profit inefficiency reduces approximately 50 per cent of maximum possible profits for US banks (Berger and Mester, 1997).

Rogers (1998) studies the significance of banks' non-traditional activities in the banks' profit-, cost- and revenue efficiencies. Since 1960s, the proportion of non-traditional activities had been substantially increased in US banks' overall activities as well as their total revenues. However, Rogers (1998) found that non-traditional activities had been widely neglected in the majority of

[2] The alternative profit efficiency is different to the standard profit efficiency because it takes output quantities as an exogenous factor. See Chapter 2 for the differences between the standard profit and the alternative revenue efficiencies, which is applicable to the standard profit and the alternative profit efficiencies as well.
[3] The fixed netputs includes risk-weighted off-balance-sheet items, which is defined to a sum of bank's commitments, letter of credit and financial derivatives by Berger and Mester (1997). Bank's commitments, letter of credit and financial derivatives are calculated in accordance to the Basel I Accord, and are included in banks' financial statements.

banking efficiency studies, which would have resulted in underestimating the banking efficiency. Thus, he suggested that it is necessary to include a proxy for non-traditional activities in banking efficiency analyses (Rogers, 1998).

Three types of efficiency – profit-, cost- and revenue efficiencies – are measured for approximately 10,000 US commercial banks operated in the period from 1991 to 1995. The input-output specification, including the specification of a proxy variable for non-traditional activities, is presented in Table 3.2. To compare the significance of non-traditional activities in the banking efficiency, Rogers (1998) specified a restricted model (excluding non-traditional activities) and an unrestricted model (including non-traditional activities).

In Table 3.3, it is apparent that the restricted model underestimated profit- and cost efficiencies relative to the unrestricted model. On the other hand, revenue efficiency appears to be overestimated relative to the unrestricted model. Rogers (1998) suggested that the observed lower revenue efficiency in the unrestricted model can be attributed to the inclusion of non-traditional activities in the model estimation, which would have affected banks' total revenues.

Table 3.3 US banking efficiency with and without non-traditional activities[4]

	Limited Branching		State-wide Branching	
	Unrestricted model	Restricted model	Unrestricted model	Restricted model
Cost efficiency	0.756	0.659	0.710	0.654
Revenue efficiency	0.437	0.507	0.413	0.500
Profit efficiency	0.692	0.650	0.705	0.681
Sample size	2126	2126	8386	8386

Thick Frontier Approach

Lozano-Vivas (1997) applied TFA to measure profit efficiency changes in the Spanish banking sector during the period from 1986 to 1991, which is the period characterised by subsequent financial deregulations in Spain. The sample is composed by 54 Spanish saving banks operated in the period from 1986 to 1991. She defined input and output variables by following the value-added approach (see Table 3.4).

[4] Rogers (1998), pp.477

The empirical results found the difference in profit efficiency of the most profitable bank and the least profitable bank is approximately 40 per cent. The decomposition of profit efficiency revealed that, firstly, about 35 per cent of the profit efficiency difference can be explained by market factors, such as the intensity of branch networks, input mix and output prices and economies of scale. Secondly, about 65 per cent of the difference is due to the persistent technical inefficiency of Spanish banks.

Stochastic Frontier Approach

Isik and Hassan (2002) utilised SFA, cost function and the alternative profit function to measure profit- and cost efficiencies of Turkish commercial banks in the period from 1988 to 1996. They conducted a two-stage analysis in order to find implications for, firstly, a relationship between profit- and cost efficiencies and banks' structural characteristics (the first-stage analysis), and secondly, the effect of deregulations in the Turkish banking sector on banking efficiencies during the period of study (the second-stage analysis). The specifications of input and output variables are presented in Table 3.4.

The first-stage analysis revealed cost efficiency is higher than profit efficiency during the period. Meanwhile, profit efficiency of Turkish banks is observed to be higher than its counterparts in other countries, such as US and Spain, which can be attributed to the structural characteristics of the Turkish banking sector[5]. The results of profit- and cost efficiencies in the first-stage analysis indicated the deregulations in the Turkish banking sector in 1980s had increased the dispersion in profit efficiency between 'best-practice' and 'worst-practice' banks. It implies that the deregulations worked in favour of efficient banks, rather than to improve the efficiency of less-efficient banks.

In the second-stage analysis, they found, firstly, a positive relationship between the size of banks and profit- and cost efficiencies. Secondly, private-owned banks are observed to be more efficient than state-owned banks. It can be explained by different operational directions of two types of banks, where state-owned banks values social services more than profit maximisation, and vice versa. Thirdly, foreign-owned banks are more profit- and cost efficient than domestic banks. It can be attributed to the size of operations of foreign-owned banks in Turkey, which are generally larger than domestic banks.

[5] The Turkish banking sector is characterised with relatively small-sized capital and credit markets, and a small number of non-bank financial institutions which are directly controlled by parent banks. Therefore, Turkish banks are under less competitive pressure than its counterparts in other countries (Isik and Hassan, 2002).

Table 3.4 Input-output and additional variables used with TFA and SFA

Author(s) (country, year)	Variable inputs (Prices)	Outputs (Amounts)	Additional variables (Fixed Netputs)
Lozano-Vivas (Spain, 1997)	Labour Materials Deposit[6]	Loans Interbank loans Produced deposits	Physical capital
Isik and Hassan (Turkey, 2002)	Labour Capital Interest rate on loanable funds	Short-term commercial loans Long-term commercial loans Risk-adjusted off-balance-sheet items Other earning assets*	N/A
Mamatzakis, Staikouras and Koutsomanoli-Filippaki (2008)	Labour Borrowed funds	Loans Other earning assets*	N/A
Fitzpatrick and McQuinn (2008)	Labour Physical capital Financial capital	Loans Other earning assets	Financial equity capital**

NOTE: * include interbank-, specialised- and directed loans as well as investment securities (Isik and Hassan, 2002, pp.267); **a control variable

Mamatzakis, Staikouras and Koutsomanoli-Filippaki (2008) utilised the alternative profit function and SFA to measure the alternative profit- and cost efficiency of banks in new European Union (EU) member countries[7] in the periods from 1998 to 2003. They aimed, firstly, to examine the effects of regulatory and operational changes to the banks in new EU member countries, and secondly, to provide implications for the financial integrations in EU and how to achieve successful expansion of the Euro-zone in near-future. Input and output variables are defined by following the intermediation approach, as presented in Table 3.4.

They discriminated the banks in terms of ownership, operational directions and sizes in order to compare profit efficiency of the banks with different types of operation, ownership and size. They also discriminated listed and non-listed banks to find the difference in profit efficiency between listed and non-listed banks.

[6] As Lozano-Vivas (1997) noted, deposits have a dual characteristic as an input as well as an output, because deposits constitute a bank's capital and cover certain expenses of banks as an input. Meanwhile, deposits generate transaction-related services therefore can be considered as an output as well. (Lozano-Vivas, 1997, pp.384-835)

[7] The new EU member countries are Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Republic and Slovenia, as at 2008 (Mamatzakis, Staikouras and Koutsomanoli-Filippaki, 2008, pp.1162)

Mamatzakis, Staikouras and Koutsomanoli-Filippaki (2008) found profit inefficiency prevails with smaller variation than cost inefficiency. The higher profit inefficiency implies the banks in new EU member countries focus more on the cost side of operation (cost minimisation), rather than the revenue side (revenue maximisation). It is also found that the ranking of profit and cost inefficiencies are not necessarily same. For instance, Latvian banks exhibit lower-than-average profit inefficiency and higher-than-average cost inefficiency, while the banks in Malta and Cyprus exhibit the opposites. The result indicates Latvian banks generate extra revenue by providing higher quality services, while the case of Malta and Cyprus is the opposite.

Table 3.5 Profit inefficiency of the banks in new EU member countries[8]

Categories		Mean	Standard Deviation	Min.	Max.	Observations
Type	Commercial	0.443	0.075	0.243	0.939	720
	Savings	0.400	0.009	0.388	0.408	18
	Cooperative	0.401	0.066	0.243	0.481	28
Size	Large	0.474	0.107	0.367	0.939	159
	Medium	0.436	0.058	0.285	0.591	290
	Small	0.427	0.062	0.243	0.600	317
Ownership	Government	0.465	0.064	0.328	0.591	52
	Domestic private	0.442	0.054	0.243	0.600	223
	Foreign strategic	0.439	0.084	0.243	0.939	465
	Other foreign	0.393	0.038	0.305	0.425	26
Governance	Listed	0.465	0.099	0.318	0.939	202
	Unlisted	0.431	0.061	0.243	0.600	564

Table 3.5 presents profit inefficiency of the banks in the sample countries in four categories, which indicates, firstly, saving banks are the most profit efficient, while commercial banks are the most profit inefficient. Secondly, there is a negative relationship between size and profit efficiency of the banks. Third, government-owned banks are the most profit inefficient, while foreign-owned banks are more profit efficient than both government-owned and domestic-owned banks. The relatively high profit efficiency of foreign-owned banks is explained by, firstly, foreign investors' investment strategies that purchasing shares of relatively profitable domestic banks, and secondly, the introduction of advanced management techniques and strategies to banking industries in new EU member countries (Mamatzakis, Staikouras and Koutsomanoli-Filippaki, 2008).

[8] Mamatzakis, Staikouras and Koutsomanoli-Filippaki, 2008, pp.1166

However, the results of cost inefficiency indicated government-owned banks are the most cost efficient and the foreign-owned banks are relatively cost inefficient. It is explained by the recent financial reforms in new EU member countries in addition to privatisations of pre-government-owned banks. In the comparison of profit efficiency of listed and non-listed banks, unlisted banks are observed to be more profit efficient than listed banks, which is inconsistence to the market discipline hypothesis[9] (Mamatzakis, Staikouras and Koutsomanoli-Filippaki, 2008).

Fitzpatrick and McQuinn (2008) used the Battese and Coelli inefficiency model and SFA to measure profit efficiency of banks in United Kingdom (UK) and non-UK countries including Ireland, Canada and Australia, to observe the effects of institutional and environmental factors to profit efficiency.

They chose the countries because they have similar financial market structures and banking operations, which make them to be suitable for the purpose of Fitzpatrick and McQuinn (2008). They selected 55 banks in UK, Ireland, Canada and Australia in the period from 1996 to 2002, where the banks involved in mergers are excluded to avoid the scale bias. The specification of input and output variables followed Berger and Mester (1997), as listed in Table 3.4.

The results of Fitzpatrick and McQuinn (2008) can be summarised as follows. Firstly, there is a positive relationship between the growth of Gross Domestic Product (GDP) and profit efficiency of the banks. Secondly, the rate of unemployment and the size appear to have a negative relationship with profit efficiency. In terms of size, big banks are observed to be the most profit efficient, while small banks are observed to be the least profit efficient group, due to inferior technical, allocative and scale efficiencies of small banks (see Table 3.6).

The international comparison of profit efficiency indicated UK banks are relatively inefficient than Australian banks, due to relatively higher labour costs in UK than in other countries. However, the profits of UK banks are higher than its counterparts, which can be explained by the well-developed UK financial market that provides more opportunities for banks to make higher profits (Fitzpatrick and McQuinn, 2008).

[9] The market discipline hypothesis states that listed banks are generally more profit efficient than unlisted banks (Mamatzakis, Staikouras and Koutsomanoli-Filippaki, 2008, pp.1167-1168).

Table 3.6 Profit inefficiency and bank size[10]

	Big	Medium	Small
Maximum	0.593	0.715	0.744
Minimum	0.019	0.016	0.017
Mean	0.204	0.890	0.333
Range	0.574	0.699	0.727
Standard Deviation	0.196	0.253	0.290

3.3 Non-parametric approach to profit efficiency (Data Envelopment Analysis)

Profit efficiency and small-business lending

Devaney and Weber (2002) analysed a relationship between small-business lending (SBL) and profit efficiency of US banks in the periods from 1994 to 1998. They aim to find implications for, firstly, a relationship between profit efficiency and banks' resource allocation towards SBL, and secondly, if SBL reduces profit efficiency, then whether it is due to technical- or allocative inefficiency associated to SBL. In addition, they attempt to observe the effect of the FDIC Improvement Act of 1991 (FDICIA) [11] to the provision of SBL and banks' profit efficiency.

The sample used by Devaney and Weber (2002) is constituted by randomly selected 1,000 US banks in the period from 1994 to 1998, and the banks are distinguished to small-sized and large-sized banks. They used the user-cost approach, which is introduced by Hancock (1985), to define three input and eight output variables. Table 3.7 presents the input and output variables, while the calculation of input and output prices is presented in Table 3.8.

The results of Devaney and Weber (2002) can be summarised as follows. Firstly, the existence of SBL-related profit inefficiency is observed, which is explained by insufficient provision of SBL to the US credit market. Secondly, SBL-related inefficiency disappeared in 1998, which is the

[10] Fitzpatrick and McQuinn, 2008, pp.6, Profit inefficiency estimates: statistical summary
[11] The FDICIA requires banks to satisfy the equity-assets ratio of 4 per cent and the equity-risk weighted assets ratio of 8 per cent. Devaney and Weber (2002) found that the FDICIA directed US banks to increase SBL and profit efficiency in 1990s by forcing them to be efficient and imposing penalties otherwise.

period that SBL was sufficiently provided to the US credit market. It means that SBL does not necessarily reduce profit efficiency of the banks. In other words, SBL does not violate banks' objective of profit maximisation. Thirdly, SBL-related inefficiency is mostly observed from small-sized banks. It indicates a relatively large allocative inefficiency in small-sized banks, due to ineffective monitoring activities and geographically-restricted operations (Devaney and Weber, 2002).

The policy implication from Devaney and Weber (2002) is twofold. Firstly, US credit control policy should be designed in a way to motivate large US banks to make more SBL, because it does not violate banks' objective of profit maximisation. Rather, it would improve profit efficiency of banks. Secondly, policy guidance is recommended for small-sized banks to improve their allocative efficiency, which would increase the provision of SBL to the US credit market as well as will stimulate the growth of small-sized businesses in US as well (Devaney and Weber, 2002).

Table 3.7 Input-output and additional variables used with DEA (A)

Author(s) (country, year)	Variable inputs	Fixed inputs (Quasi-fixed inputs)	Outputs
Devaney and Weber (US, 2002)	Labour Physical capital Non-transaction account deposits	Off-balance-sheet activities Equity capital	Real estate loans Commercial and industrial loans* Personal loans Securities Transaction account deposits
Färe, Grosskopf and Weber (US, 2004)	Labour Capital Non-transaction account deposits	Off-balance-sheet activities Equity capital	Securities Real estate loans Commercial and industrial loans Personal loans Transaction account deposits

NOTE: *Devaney and Weber (2002) divided 'commercial and industrial loans' into four categories according to the volume of loans; 1) the loans value greater than US$ 1 million, 2) the loans value less than US$ 100,000, 3) the loans value in between US$ 100,000 – US$ 250,000, 4) the loans value in between US$ 250,000 – US$ 1 million.

Table 3.8 Calculation of input-output prices (A)

Author(s) (country, year)	Derivation of prices	
Devaney and Weber (US, 2002)	Input	Labour = total staff expenses / the number of FTEE* Physical capital = the sum of expenses on premises and other fixed assets / the total nominal value of premises and fixed assets NTAD** = the sum of interest expenses on NTAD / the total value of NTAD
	Output	Loans = interest income earned by loans / the total amount of loans Transaction account deposits = the charges for the services on deposits / the total amount of deposits
Färe, Grosskopf and Weber (US, 2004)	Input	Labour = total staff expenses / the number of FTEE* Physical capital = the sum of expenses on premises and other fixed assets / the total nominal value of premises and fixed assets NTAD** = the sum of interest expenses on NTAD / the total value of NTAD
	Output	Loans and securities = interest income earned by loans and securities / the total amount of loans and securities Transaction account deposits = the charges for the services on deposits / the total amount of deposits

NOTE: *FTEE: Full-Time Equivalent Employee; **NTAD: Non-transaction account deposits

Profit efficiency and regulatory requirements

Färe, Grosskopf and Weber (2004) analysed the effect of risk-based capital requirements[12] to profit efficiency of US banks. They computed the Nerlovian profit efficiency[13] by utilising the directional distance function and DEA. The Nerlovian profit efficiency is decomposed into technical and allocative efficiency components in order to identify sources of inefficiency.

They randomly selected 938 US banks in the periods from 1990 to 1994. The specification of input- and output variables and the derivation of prices are presented in Table 3.7 and 3.8, respectively, where fee incomes are included as a proxy of off-balance-sheet activities. They specified two types of model with and without equity capital as an additional quasi-fixed input, in order to observe the effect of the inclusion of equity capital as a quasi-fixed input to profit efficiency of banks and the effectiveness of the regulatory requirements. Similarly, they developed two types of model – with and without regulatory requirements – in order to observe the effect of the regulatory requirements on profit efficiency.

[12] US risk-based capital requirements include the leverage ratio and the risk-weighted capital constraints.
[13] The Nerlovian profit efficiency is discussed in detail in Chapter 5.

They found, firstly, allocative efficiency is smaller than technical efficiency by decomposing profit efficiency, while technical efficiency is found to be positively related to the regulatory requirements. Secondly, profit efficiency appears to be higher when equity capital and off-balance-sheet activities are included as quasi-fixed inputs. However, the effect of regulatory requirements to profit efficiency appears to depend on the composition of quasi-fixed inputs.

The Kolmogorov-Smirnov test result indicated the effect of the inclusion of equity capital to profit efficiency is not significant as expected. The test also suggested that the regulatory constraints have its effect mainly on allocative efficiency. It means that, the positive effect of the regulatory constraints to banks' profit efficiency is because the regulatory constraints improve banks' allocative efficiency. In addition, the test indicated a positive relationship between the size of banks and profit efficiency (Färe, Grosskopf and Weber, 2004).

Profit efficiency of Spanish banks

Maudos and Pastor (2003) analysed the effects of structural changes in Spanish banking industry in the period from 1985 to 1996 on profit- and cost efficiencies of Spanish commercial and saving banks. They estimated the standard profit- and the alternative profit efficiencies separately in order to take account of the imperfect competition in the Spanish banking sector as well as to find own implications of two types of profit efficiency.

Three variable inputs and two variable outputs are defined by following the intermediation approach, as presented in Table 3.9, while Table 3.10 presents the derivation of the prices. They also defined a variable for bank profitability, by using the operating profit in banks' balance sheets as a proxy, to find a relationship between profit efficiency and profitability. The number of banks included in the sample varies from 75 to 98 due to bank mergers in Spain during the period of study.

The result of the standard profit efficiency indicated the commercial banks are relatively profit efficient than the savings banks. However, profit efficiency of both types of bank declined during the period of study, where the commercial banks' profit efficiency declined more than the saving banks in the period from 1994 to 1996. It implies higher standard deviation of the standard profit efficiency of the commercial banks than the saving banks, where it can be explained by diversified operations, products and profitability of the commercial banks.

The result of the alternative profit efficiency is similar to the standard profit efficiency. The commercial banks are found to be more profit efficient than the saving banks, while a decline in the alternative profit efficiency of both types of bank is observed in the latter parts of 1980s. However, the overall alternative profit efficiency is lower than the overall standard profit efficiency, which means that the imperfect competition in the Spanish banking sector negatively influences on profit efficiency of Spanish banks (Maudos and Pastor, 2003).

In addition, a linear relationship is found between profitability and the alternative profit efficiency. It implies, firstly, the most profitable bank is also the most profit efficient, and secondly, banks' price-setting ability and/or product-quality differentiations are related to the banks' profitability (Maudos and Pastor, 2003).

Table 3.9 Input-output and additional variables used with DEA (B)

Author(s) (country, year)	Variable inputs	Outputs
Maudos and Pastor (Spain, 2003)	Labour Deposits and other fundings Physical capital	Loans and other earning assets Securities
Resende and Silva (Portugal, 2007)	Labour Fixed assets Customer accounts and deposits*	Loans Received commissions Equity capital**
Ariff and Can (China, 2008)	Labour Loanable funds Physical capital	Loans Investments
Nahm and Vu (Vietnam, 2008)	Labour Fixed assets Deposits and borrowed funds	Customer Loans Other income-earning assets Off-balance-sheet items***

NOTE: *The sum of customer accounts, deposits from other financial institutions, debt securities and other liabilities; **The sum of reserves held in central banks, bond holdings, fixed income securities and shares, other income-earning securities; ***Off-balance-sheet items are measured by incidental liabilities (Nahm and Vu, 2008, pp.15)

Table 3.10 Calculation of input-output prices (B)

Author(s) (country, year)	Derivation of prices	
Maudos and Pastor (Spain, 2003)	Input	Deposits and other fundings= interest paid / the total value of deposits and other fundings Labour = total staff expenses / the number of FTEE Physical capital = the sum of other expenses / physical capital
	Output	Loans and other earning assets = interest income and other operating income earned by each Output / Loans and other earning assets Securities = the sum of profits from financial operations / securities
Resende and Silva (Portugal, 2007)	Input	Labour = total staff expenses / the number of FTEE Fixed assets = the sum of other operating expenses / physical capital Customer accounts and deposits = the sum of interest-payable-related expenses / funds
	Output	Loans = the sum of interest-receivable-related income / the total value of loans Received commissions = the sum of commissions / customer accounts, loans and advances Equity capital = the sum of income from securities, profits from financial transactions less the sum of losses from financial transactions and other operating income / the total value of equity capital
Ariff and Can (China, 2008)	Input	Deposits and other fundings = the sum of interest paid / the total value of loanable funds Labour = total staff expenses / the number of FTEE Physical capital = the sum of other expenses / physical capital
	Output	Loans = interest income earned by loans / the total value of loans Securities = the sum of investment incomes / the total amount of investments
Nahm and Vu (Vietnam, 2008)	Input	Labour = total staff expenses / the number of FTEE Fixed assets = the sum of other mom-interest expenses / the total value of fixed assets Deposits and borrowed funds = the sum of interest expenses paid for deposits and borrowed funds / the total amount of deposits and borrowed funds
	Output	Customer loans = the total amount of interest income from customer loans / the total amount of customer loans Other income-earning assets = the total amount of other interest and investment income / the amount of other income-earning assets Off-balance-sheet items = the total amount of mom-interest income / the value of off-balance-sheet items

NOTE: *FTEE: Full-Time Equivalent Employee

Profit efficiency of Portuguese banks

Resende and Silva (2007) analysed the effects of regulatory and structural changes in the Portuguese banking sector to profit efficiency of Portuguese banks. They estimated the Nerlovian profit efficiency and the alternative profit efficiency by utilising DEA and the directional distance function. The alternative profit efficiency is estimated, because the Nerlovian profit efficiency may be inadequate when imperfect competition is apparent. In particular, they proposed the decomposition of the alternative profit efficiency into technical-, input allocative- and output price inefficiencies, which is different to the previous banking efficiency studies.

They defined three inputs and three outputs by following the asset approach (see Table 3.9), which is similar to the intermediation approach, except its treatment of deposits only as an input. They acknowledged the importance of taking account of banks' non-traditional activities. However, they were unable to obtain direct measures for non-traditional activities and defined banks' received commissions and equity capital as proxy variables of non-traditional activities. The sample includes 19 Portuguese banks in the period from 2000 to 2004.

The result of the Nerlovian profit efficiency revealed profit efficiency of Portuguese banks had declined since 2000. It is explained by, firstly, a problem of data specification with non-balanced panel data, and secondly, a change in operational directions of Portuguese commercial banks during the period of study. They pointed out Portuguese banks are recently focusing more on non-traditional activities, which involve medium- and long-term investment activities as well as wide-range of financial services, to generate medium- or long-term flow of profits. Thus, it may lead profit efficiency of the banks to be underestimated, where profit efficiency is based on the banks' short-term profits (Resende and Silva, 2007).

The decomposition of the Nerlovian profit efficiency indicated a large proportion of profit inefficiency is due to allocative inefficiency. The significance of allocative inefficiency is explained by, firstly, suboptimal use of inputs, mainly labour and physical capital, and secondly, an increase in the proportion of non-traditional activities in the banks' overall activities as well as total revenues (Resende and Silva, 2007).

The result the alternative profit efficiency of banks is similar to the result of Nerlovian profit efficiency, with suggesting that the banks are technically efficient. The alternative profit efficiency is lower than the Nerlovian profit efficiency, which is consistent to the result of

Maudos and Pastor (2003). It means that relatively low profit efficiency of Portuguese banks is not only due to allocative inefficiency, but also due to the negligence of the banks' ability of price-setting and product quality differentiations in the estimation of profit efficiency (Resende and Silva, 2007).

Profit efficiency of Chinese banks

Ariff and Can (2008) analysed the changes in cost, the standard profit and alternative profit efficiencies of Chinese banks in the period from 1995 to 2004. Similarly to the previous European studies, they attempt to find implications of the following four factors for profit efficiency of Chinese banks, where the factors are Chinese financial market deregulations, Chinese banking industry reform in 1994, substantial growth of Chinese economy and joining World Trade Organisation (WTO). They also compare the efficiency of four major state-owned banks against private-owned (joint-stock and city) banks, where four major state-owned banks are dominant in Chinese banking industry. They analysed the effects of environmental factors by conducting Tobit regression analysis.

Ariff and Can (2008) used non-balanced panel data of 28 Chinese banks, where input and output variables are defined by adopting the intermediation approach (see Table 3.9). In contrast to the previous banking efficiency studies, Ariff and Can (2008) excluded non-traditional activities of banks because of the following reasons. Firstly, non-traditional activities are not significant in Chinese banking operations. Secondly, they were unable to obtain reliable measures of non-traditional activities.

The results of the standard profit- and the alternative profit efficiencies are similar to the previous European studies, as the standard profit efficiency is found to be higher than the alternative profit efficiency. Ariff and Can (2008) observed that the standard profit efficiency of Chinese banks had been improved by 6.6% in the period of study, while the alternative profit efficiency had not been improved significantly. The analysis on a relationship between cost- and profit efficiencies revealed, firstly, cost efficiency is higher than profit efficiency, and secondly, if a bank is cost efficient, then the bank is also profit efficient. It also means that it is revenue inefficiency, rather than cost inefficiency, that takes a considerable part in the overall inefficiency of Chinese banks (Ariff and Can, 2008).

The result of the Tobit regression analysis[14] can be summarised to the following five points. Firstly, by the type of ownerships, the private-owned banks are more profit efficient than the state-owned banks. Secondly, they found the medium-sized banks are the most profit efficient, the large banks are the least profit efficient, and the small-sized banks are positioned in between. Thirdly, if a bank is relatively inefficient the bank is exposed to higher credit risks, which is mostly observed from the major state-owned banks. Fourthly, profit efficiency and profitability are correlated. Finally, the regulatory reforms have positive effects on the banking efficiency as it increases competitive pressures on Chinese banks and force them to be more efficient (Ariff and Can, 2008).

Profit efficiency of Vietnamese banks

The motivation for Nahm and Vu (2008) is similar to the previous banking efficiency studies, because Vietnamese banking industry has experienced significant structural and regulatory reforms since 1980s, which are accelerated after the Asian Financial Crisis in 1999. They utilised the directional distance function and DEA in order to analyse the performance of Vietnamese banks in the period from 2000 to 2006. They introduced a norm-based profit index approach and its decomposition, which are used in this study and explained in detail in Chapter 5. They defined three variable inputs, three outputs and one fixed input (see Table 3.9) by adopting the intermediation approach. The value of incidental liabilities is included as a proxy of non-traditional activities. The derivation of prices is presented in Table 3.10.

Nahm and Vu (2008) found 19 of the 273 observations do not satisfy the regulatory requirement, while they are found to be technically and allocatively efficient. In addition, 4 of the 19 observations are observed to have achieved higher profits than the maximum possible profit at given level of prices.

The decomposition of profit efficiency revealed a large proportion of profit inefficiency is due to allocative inefficiency. Meanwhile, the Kolmogorov-Smirnov test indicated profit- and allocative efficiencies are not much affected by regulatory requirement constraints. Note that, they excluded regulatory requirement constraints in the estimation of the directional distance function in order to avoid the scale bias (Nahm and Vu, 2008).

[14] For the detailed specifications of the environmental variables, see Ariff and Can (2008), pp.269

In regards to the size of banks, five state-owned banks with significant financial market shares are found to be the most profit efficient as well as technically and allocatively efficient. On the other hand, rural banks are the most inefficient in all three accounts. In particular, profit efficiency of rural banks appears to be sharply declined, which is attributed to the rapid decline in allocative efficiency. It is explained by operational and structural characteristics of rural banks, which made them to be slower to get involve in non-traditional activities and provision of diversified financial services as well as to adopt innovative technologies (Nahm and Vu, 2008).

3.4 Summary of the international studies

This chapter has discussed international studies that are focused on profit efficiency of banks in the countries other than Australia. This chapter can be summarised by the following points. Firstly, profit efficiency is highlighted in banking efficiency studies only in recent years. It is preferred to cost- and revenue efficiencies because it combines both cost- and revenue sides of bank operations (see Chapter 2). In addition, it is observed that a large proportion of overall banking inefficiency is due to profit inefficiency, rather than cost inefficiency. It implies the important of profit efficiency as a determinant of the overall banking efficiency.

Secondly, DEA has become a preferred efficiency measurement technique to its counterparts, such as SFA and DFA due to its flexibility as well as the motivations of banking efficiency studies, where the studies generally attempted to analyse the effects of regulatory and structural changes to profit efficiency, and DEA is the chosen technique as it captures those effects. Note that, the directional distance function is widely adopted in recent profit efficiency studies, because it reflects the bank behaviour of profit maximisation more closely than input- and/or output orientated distance functions.

Thirdly, it appears that the inclusion of banks' non-traditional activities, or off-balance-sheet activities, is important to banking efficiency analyses. However, there is no standard approach to define a variable for non-traditional activities, where different studies used different proxy variables. The institutional and environmental factors, such as size, ownership, operational types and governance types, are observed to important determinants of cost- and profit efficiencies of banks. Therefore, it needs to consider the institutional and environmental factors in efficiency analyses when they are apparent.

Chapter 4. Australian Literature Review

4.1 Introduction

This chapter provides a review of Australian banking efficiency studies, which are listed in Table 4.1, where the majority of the Australian studies analysed *x*-efficiency [1] and/or technical efficiency of Australian banks. In the previous Australian studies, profit efficiency has not been the central focus. However, it is worth to review the previous studies due to the following reasons.

Firstly, they provide practical implications for the application of DEA, particularly to the Australian banking sector. Secondly, as it is pointed out several times in the previous chapter, profit efficiency can be decomposed into the technical and allocative efficiencies, which are also the components of *x*-efficiency. It means that, the previous Australian studies are relevant at some degree in spite of they are not primarily focused on profit efficiency.

This chapter is structured as follows. Section 4.2 provides a general overview of the Australian banking sector, and Section 4.3 providing a review of the Australian studies of *x*-efficiency or technical efficiency of Australian banks. Section 4.4 discusses the Australian studies analysed profit efficiency, which is followed by Section 4.5 that provides the summary of this chapter.

[1] *x*-efficiency is defined by the product of technical- and the allocative efficiencies.

Table 4.1 Australian banking efficiency studies

Author(s) (year)	Methodology	Efficiency measured	Sample size (Period)
Walker (1998)	DVM*	Scale	12 (1978 – 1990)
Avkiran (1999)	DEA	*x*-efficiency	16 – 19 (1986 – 1995)
Sathye (2001)	DEA	*x*-efficiency	29 (1996)
Sturm and Williams (2002)	DEA	Technical	25 (1988 – 2001)
Neal (2004)	DEA	*x*-efficiency	26 (1995 – 1999)
Kirkwood and Nahm (2006)	DEA	Technical, Cost, Profit	10 (1995 – 2002)
Paul and Kourouche (2008)	DEA	Technical	10 (1997 – 2005)
Wu (2008)	DEA	Technical	36 (1982 – 2001)

NOTE: *Cost function-based dummy variable model.

4.2 An overview of the Australian banking sector

The Campbell Report (1981)

The period of deregulation in the Australian banking sector begins with the Australian Financial System Inquiry report (1981). It is prepared by the Campbell and Martin Committee and recommended regulatory as well as structural changes in the Australian banking sector in 1980s.

The deregulations in 1980s involved, firstly, the abolition of exchange rate controls and floating Australian dollar (December, 1983), and secondly, the elimination of government's direct controls on market interest rates, bank deposits and compositions of portfolio of banks, and thirdly, regulatory changes to improve the banking system stability. In addition, it also included some structural changes to facilitate the operations of foreign-owned banks (1985) and domestic non-bank financial institutions (NBFIs), to promote the provision of broader range of financial services in Australia. Because it also had increased the degree of market competition in the Australian banking sector, it is considered that the deregulations in 1980s made positive effects on Australian banking efficiency by forcing Australian banks to operate more efficiently.

However, the deregulations in 1980s induced the excess supply of credit, which created the asset market bubble in late 1980s (Neal, 2004). The asset bubble eventually busted due to tight monetary policies in that period, conducted by the Reserve Bank of Australia (RBA). Consequently, it undermined the stability of Australian banking system and reduced profits for the banks dramatically. It was resulted in several mergers between four major banks and small regional banks in early 1990s. Despite the mergers evidently stabilised the banking system at some degree, it deepened the market concentration in the banking sector by strengthening the dominance of four major banks, which are Australia and New Zealand Banking Group, Commonwealth Bank of Australia, National Australia Bank and Westpac Banking Corporation.

The Wallis Report (1997)

The Financial System Inquiry final report (1997), which is also known as 'The Wallis Report' (the Report hereafter), is completed by the Committee headed by Stan Wallis. It aimed to evaluate the results of deregulations in 1980s and provided 115 policy recommendations to enhance the degree of market competition and, to improve the efficiency of the Australian banking sector (Viney, 2004).

The report recognised the deregulations in 1980s had enhanced the competition and the efficiency of Australian banks and NBFIs. However, the report found a lack of consistency in the regulations of the Australian banking sector, which is one of the reasons that the banks and NBFIs had not reached at the fully efficient level (Gup, Avram, Beal, Lambert and Kolari, 2007). The report estimated that, more than 4 billion dollar gains[2] for the Australian economy are expected if banks can improve the efficiency by 10 per cent with appropriate regulatory reforms.

The report also claimed the concentrated market structure of the Australian banking sector had adversely affected Australian banking efficiency, particularly allocative efficiency. The report suggested technical- and allocative efficiencies of Australian banking sector are relatively lower than its counterparts in other developed countries. In regards to the low efficiencies, the report suggested, firstly, the banks are required to reduce the number of branches as well as the number of employees. Secondly, it is necessary for the banks to restructure their output mixes in order to improve allocative efficiency (Valentine, Ford, Edwards, Sundmacher and Copp, 2006).

Despite it is claimed that the highly concentrated market structure undermines Australian banking efficiency, the report advocated the abolition of 'six-pillar policy' with suggesting that, the size of a financial institution is not necessarily related to the efficiency as much as the market structure. In addition, it is necessary for Australian banks to be larger in order to compete against major foreign banks. The Australian government took the advice from the report and, later modified 'six-pillar policy' to 'four-pillar policy' in 1997 in spite of concerns from the Treasury, the RBA and consumer unions.

The report has motivated academics and researchers to analyse the efficiency of Australian banks, such as Avkiran (1999), Sathye (2001), Kirkwood and Nahm (2006), and more recently, Paul and Kourouche (2008) and Wu (2008). It reflects the importance of the results from the report for the Australian banking efficiency.

[2] Worthington (1999) rejected the estimation figures from the report, because the efficiency gains in the report are calculated based on accounting measures. It means that the figures from the report may not reflect the full aspects of the efficiency changes related to the deregulations.

Table 4.2 Input-output variables used in Australian banking efficiency studies

Author(s) (year)	Variable inputs	Outputs
Walker (1998)	Labour Deposits and other borrowed funds All other material inputs	Commercial loans Housing loans Investments
Avkiran (1999)	**Model A** Interest expenses Non-interest expenses	 Net interest income Non-interest income
	Model B Deposits Labour	 Net loans Non-interest income
Sathye (2001)	Labour Capital Loanable funds*	Loans Demand deposits
Sturm and Williams (2002)	**Model 1** Labour Deposits Equity capital	 Loans Off-balance-sheet items Loans less housing loans Housing loans Investments
	Model 2 Interest expenses Non-interest expenses	 Net interest income Non-interest income
Neal (2004)	The number of branches** Loanable funds*	Loans and advances Demand deposits Other operating income***
Kirkwood and Nahm (2006)	**Model A & B** Labour Physical capital Interest-bearing liabilities	**Model A** Interest-bearing assets Non-interest income*** **Model B** Profit before tax Abnormal items
Paul and Kourouche (2008)	Interest expenses Non-interest expenses	Net interest income Non-interest income
Wu (2008)	Labour Physical capital Loanable funds*	Net loans Investment Number of branches

NOTE: *Loanable funds include time deposits, saving deposits and other borrowed funds (Sathye, 2001, pp.619); ** The number of branches is a proxy variable for the number of employees and the amount of physical capital account; *** Non-interest income is a proxy variable for off-balance-sheet activities and fee incomes

4.3 x-efficiency of Australian banks

Economies of scale in Australian banks

Walker (1998) analysed the scale economies and x-efficiency of 12 Australian banks in the period from 1978 to 1990 by using SFA to compute a translog functional form. He classified the banks into three groups in terms of size, such as the largest-size group, the mid-size group and the smallest-size group, in order to observe a relationship between the size and x-efficiency of banks. By adopting the intermediation approach, he specified three types of input and output variables, as presented in Table 4.2. He did not include a proxy variable of the banks' non-traditional activities, because it is not explicitly presented in banks' annual financial statements.

Walker (1998) found that, firstly, the economies of scale in Australian banks vary throughout the period of study. However, the results are observed to be different depending on model assumptions imposed, such as the assumptions for allocative efficiency and/or differences in cost structures of individual banks. In addition, he was unable to find any evidence of the existence of diseconomies of scale in Australian banks. Secondly, it is found that an inverse relationship between the size factor and x-efficiency of banks, where smaller banks exhibited higher x-efficiency than larger banks.

Note that, Avkiran (1999) suggested the problems of measuring economies of scale and scope with a translog functional form as in Walker (1998). The problems are, firstly, a translog functional form cannot estimate a sample composed by banks with different sizes, which is acknowledged by Walker (1998). Secondly, a translog functional form may not be able to measure economies of scope for banks correctly if they are not on the efficiency frontier (Avkiran, 1999).

x-efficiency in the pre-Wallis period

Avkiran (1999) analysed the effects of deregulations in 1980s and bank mergers to x-efficiency of Australian banks in the period from 1986 to 1995. In addition, he attempted to observe whether there would be any potential benefit for the public, if the efficiency of Australian banks is improved. The analysis by Avkiran (1999) is the first DEA analysis of Australian banking efficiency, where he chose DEA mainly due to the applicability of DEA to a model with a small-sized sample, such as the Australian banking sector. In particular, he specified two types of DEA model with different input-output specifications by following the intermediation approach (see Table 4.2), in order to capture the sensitivity of efficiency scores to the data specification.

The results of Avkiran (1999) are twofold. Firstly, Australian banking efficiency had improved until 1991. The average efficiency scores are observed in the range between 0.80 (1991) and 0.91 (1986). The inefficiency is mostly due to technical inefficiency rather than allocative inefficiency, which contradicts to the Wallis Report (1997). It indicates the deregulations in 1980s had positive effects on the banking efficiency, while it had weakened after 1991, due to the problem of bad debt provisions of Australian banks in late 1980s.

Secondly, the effect of bank mergers on the efficiency appears to be inconclusive. In the observed four cases of bank mergers, the efficiency of acquiring banks is found to be generally higher than the merged banks. However, the efficiency of acquiring banks is not necessarily improved after mergers. In addition, he was unable to find any potential benefit for the public from bank efficiency gains from mergers in four cases. He also found no clear connection between the market share and the efficiency of the banks in the period (Avkiran, 1999).

Sathye (2001) analysed x-efficiency of 17 domestic- and 12 foreign banks in Australia operated in 1996. He decomposed x-efficiency into technical- and allocative efficiencies in order to determine which type of efficiency has more influence on the overall banking efficiency. He followed the intermediation approach to define input and output variables (see Table 4.2), because it is thought of as an appropriate approach to reflect the characteristics of Australian bank operations (Sathye, 2001).

Table 4.3 presents the results of technical-, allocative- and overall efficiencies[3] of banks. In 1996, the overall efficiency of both domestic and foreign banks is estimated to 0.58, which is lower than the world average banking efficiency of 0.86 (Berger and Humphrey, 1997), due to low technical efficiency relative to allocative efficiency. In the comparison of the efficiency of domestic- and foreign banks, Sathye (2001) found foreign banks are relatively inefficient than domestic banks (see Table 4.4). The lower efficiency of foreign banks is explained by the highly concentrated market structure of the Australian banking sector, which would have prevented foreign banks to penetrate into the Australian market and make profits (Sathye, 2001).

[3] In Sathye (2001), the overall efficiency is given by the multiplication of technical- and allocative efficiencies.

According to Sathye (2001), it is possible for foreign- and domestic Australian banks to improve their overall efficiency, which can be reinforced by appropriate regulatory changes. In addition, the Australian banking sector may require structural reform, because the highly concentrated market structure of the Australian banking sector evidently undermines x-efficiency of Australian banks (Sathye, 2001). Note that, the low technical efficiency of Australian banks in Sathye (2001) may be due to the period of his study, because the year 1996 is the period before of the widespread of electronic banking facilities in Australia (Kirkwood and Nahm, 2006).

Table 4.3 x-efficiency of domestic- and foreign banks (1996)[4]

	Minimum	Maximum	Mean	Standard Deviation
Technical efficiency	0.39	1.00	0.67	0.17
Allocative efficiency	0.57	1.00	0.85	0.11
Overall efficiency	0.22	1.00	0.58	0.18

Table 4.4 Comparison of efficiency: domestic- and foreign banks (1996)[5]

	Domestic Banks	Foreign Banks
Number of banks	17	12
Overall efficiency	0.83	0.62
Allocative efficiency	0.92	0.86
Technical efficiency	0.90	0.71

x-efficiency in the post-Wallis period

Sturm and Williams (2002) compared technical efficiency of domestic- and foreign banks in Australia in the period of 1988 to 2001, in order to observe the effect of deregulations in 1980s to the changes in Australian banking efficiency in the post-deregulation periods. They utilised input-orientated DEA and SFA, in order to find correlation between two different approaches. They adopted the intermediation approach to specify input and output variables (see Table 4.2). Note that 'off-balance-sheet items' in Model A is given by the sum of bank's commitment and contingent liabilities, where bank's derivatives are excluded due to limited data availability.

[4] Sathye (2001), pp.620
[5] Sathye (2001), pp.625

Table 4.5 x-efficiency of Australian domestic and foreign banks (1988 – 2001)[6, 7]

Year	Technical efficiency	Pure technical efficiency	Scale efficiency
1988	0.74	0.89	0.93
1989	0.76	0.89	0.94
1990	0.75	0.89	0.94
1991	0.73	0.86	0.93
1992	0.79	0.91	0.94
1993	0.78	0.90	0.90
1994	0.75	0.93	0.84
1995	0.78	0.92	0.87
1996	0.84	0.96	0.93
1997	0.79	0.93	0.89
1998	0.87	0.96	0.96
1999	0.86	0.95	0.97
2000	0.94	0.99	0.95
2001	0.93	0.96	0.98

The result of technical efficiency analysis revealed the average efficiency score (see Table 4.5) is similar to Avkiran (1999) and the world average from Berger and Humphrey (1997), while it is higher than Sathye (2001). In Table 4.5, it is indicated that, technical efficiency was reached at the lowest level in 1991, which implies the deregulations in 1980s had positive effects on the banking efficiency. However, it is weakened since 1991 due to the problem of bad debts in late 1980, as it is suggested by Avkiran (1999).

The decomposition of the technical efficiency reveals scale efficiency of domestic banks had slightly improved in the period of study, where the scale efficiency of four major banks appears to be lower than the banks' pure technical efficiency. It means that technical efficiency is largely influenced by scale efficiency, rather than pure technical efficiency (Sturm and Williams, 2002).

[6] Sturm and Williams (2002), pp.13-14
[7] Table 4.5 is constructed based on Table 4 in Sturm and Williams (2002), which presented the average efficiency scores measured by DEA in separate tables for each year, and presented technical, pure technical and scale efficiencies according to types of banks. Table 4.5 collectively presents the measured efficiencies of all banks.

The comparison of the efficiency of domestic- and foreign banks indicates foreign banks are more efficient than domestic banks due to higher scale efficiency, which is also different to Sathye (2001). However, Sturm and Williams (2002) suggested that higher efficiency scores do not necessarily mean higher profitability, because they found foreign banks are less profitable than domestic banks in the period of study. In addition, they found the existence of a correlation between the results from DEA and SFA, by obtaining similar results from two different approaches (Sturm and Williams, 2002).

Neal (2004) utilised DEA to measure scale- and x-efficiencies of domestic- and foreign banks in Australia during the period from 1995 to 1999. He assumed variable returns to scale (VRS) production technology. It is different to Avkiran (1999) and Sathye (2001) who assumed constant returns to scale (CRS)[8]. He also adopted the intermediation approach, and defined 'other operating income' as a proxy output variable for banks' off-balance-sheet activities.

Table 4.6 x-efficiency of Australian domestic and foreign banks (1995 – 1999)[9]

Year	Technical efficiency	Allocative efficiency	Overall efficiency	Scale efficiency
1995	0.861	0.914	0.791	0.867
1996	0.816	0.900	0.740	0.866
1997	0.753	0.937	0.712	0.891
1998	0.812	0.938	0.769	0.794
1999	0.866	0.947	0.826	0.808

Neal (2004) found x-efficiency of Australian banks is found to be within the range from 0.71 (1997) to 0.82 (1999). Table 4.6 presents average efficiency scores of four different types of efficiency. The average technical efficiency scores are within a range from 0.75 to 0.87, which is similar to Sturm and Williams (2002). Meanwhile, allocative and scale efficiencies are observed to be higher than in the previous studies by Avkiran (1999) and Sathye (2001). Neal (2004) suggested the different results can be explained by different production technology assumptions as well as differences sample sizes (Neal, 2004).

[8] Detailed discussion on DEA with different returns to scale production technology is provided in Chapter 2.
[9] Neal (2004), pp.182

Kirkwood and Nahm (2006) analysed production efficiency of 10 Australian domestic banks in the period from 1995 to 2002. They used conventional input-orientated DEA and the intermediation approach, and defined banks' non-interest income as a proxy of banks' off-balance-sheet activities by following Clark and Siems (2002)[10]. In order to observe the overall production efficiency, they developed two types of model to measure banking service efficiency and profit efficiency. Banking service efficiency is estimated to measure the efficiency of banks in generating revenue and, it is decomposed into the technical and allocative efficiencies. Profit efficiency is obviously to measure the efficiency of banks in generating profit, as discussed in Chapter 2.

In contrast to the previous studies (Sathye, 2001; Sturm and Williams, 2002; Neal, 2004), Kirkwood and Nahm (2006) found technical efficiency is higher than allocative efficiency throughout the period of study, where the range of differences between technical and allocative efficiencies is from 0.004 (2002) to 0.065 (1995). The higher technical efficiency is explained by stable economic growth and the widespread of electronic banking facilities during the period. They suggested technical and allocative efficiency scores, which are different to the previous studies, can be explained by the differences in sample sizes as well as different specifications for input and output variables, which is also suggested by Neal (2004) (Kirkwood and Nahm, 2006).

Table 4.7 Banking service efficiency of Australian banks (1995 – 2002)[11]

Year	Technical efficiency		Allocative efficiency		Banking service efficiency	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1995	0.965	0.033	0.900	0.083	0.869	0.087
1996	0.970	0.028	0.911	0.071	0.885	0.076
1997	0.965	0.023	0.916	0.056	0.883	0.054
1998	0.961	0.024	0.942	0.044	0.905	0.045
1999	0.969	0.026	0.950	0.033	0.920	0.031
2000	0.978	0.023	0.967	0.033	0.946	0.039
2001	0.977	0.029	0.976	0.021	0.953	0.040
2002	0.983	0.030	0.979	0.036	0.963	0.061

[10] Kirkwood and Nahm (2006) followed Clark and Siems (2002), while it is suggested by Rogers (1998) in early, as discussed in Chapter 3. It is important to note that only three studies has attempted to include a proxy variable for off-balance-sheet activities to analyse Australian banking efficiency, which are Sturm and Williams (2002), Neal (2004) and Kirkwood and Nahm (2006).
[11] Kirkwood and Nahm (2006), pp.260

Paul and Kourouche (2008) analysed technical efficiency of 10 Australian domestic banks in the period from 1997 to 2005. They also utilised input-orientated DEA and decomposed technical efficiency into scale and pure technical efficiencies. They adopted the intermediation approach for input and output variable specifications by following Avkiran (1999), and categorised the banks into three different asset sizes of banks (large, medium-sized and small banks) to find a relationship between the size factor and banking efficiencies (see Table 4.8).

Table 4.8 Australian bank by asset size[12]

Bank Category	Name of Bank	Asset Size ($ billion)
Large	National Australia Bank	222.7
	Commonwealth Bank of Australia	222.4
	Westpac Banking Corporation	193.1
	Australia and New Zealand Banking Group	165.5
Medium-sized	St George Bank	71.7
	Suncorp-Metway	34.9
	Macquarie Bank	24.7
Small	Bendigo Bank	11.7
	Adelaide Bank	11.1
	Bank of Queensland	9.8

Table 4.9 Australian banking efficiency changes (1997 – 2005)[13]

Year	Large banks			Medium-sized banks			Small banks			All banks		
	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE
1997	0.972	1.000	0.972	0.928	0.938	0.989	0.955	1.000	0.995	0.967	0.994	0.973
1998	0.982	1.000	0.982	0.873	0.887	0.984	0.938	1.000	0.938	0.967	0.986	0.981
1999	0.950	0.951	0.999	0.955	0.957	0.998	0.941	1.000	0.941	0.950	0.953	0.997
2000	0.971	0.979	0.992	0.981	1.000	0.981	0.944	1.000	0.944	0.972	0.981	0.991
2001	0.988	0.993	0.995	0.996	1.000	0.996	0.889	1.000	0.889	0.987	0.994	0.993
2002	0.969	0.970	0.999	0.969	0.983	0.986	0.828	0.998	0.830	0.966	0.972	0.994
2003	0.982	0.985	0.997	0.952	0.957	0.995	0.837	1.000	0.837	0.975	0.982	0.993
2004	0.979	1.000	0.979	0.990	0.996	0.994	0.846	0.992	0.853	0.977	0.999	0.978
2005	0.954	0.990	0.964	1.000	1.000	1.000	0.849	0.993	0.855	0.959	0.992	0.967

NOTE: TE (Technical efficiency); PE (Pure technical efficiency); SE (Scale efficiency)

[12] Paul and Kourouche (2008), pp.264
[13] Paul and Kourouche (2008), pp.266

Paul and Kourouche (2008) found pure technical- and scale efficiencies had been improved after the period covered by Avkiran (1999). The improvement in pure technical efficiency is explained by the widespread of electronic banking facilities in Australia, which is after the period covered by Avkiran (1999). The improvement in scale efficiency is attributed to structural reforms of Australian banks, including branch closures and staff layoffs. However, it is found that the improvement in pure technical- and scale efficiency are insignificant for all banks.

They also found a positive relationship between a bank's size and the pace of the bank's efficiency improvement (see Table 4.9). According to Paul and Kourouche (2008), the major banks are more actively adopt innovative technologies because they can make more capital investments, which would lead the banks to improve their services and the flow of revenues. On the other hand, the small regional banks would be relatively slower in the adoption of advanced technology than the major banks, due to the limited ability of capital investment (Paul and Kourouche, 2008).

Wu (2008) analysed a relationship between bank mergers and the banking efficiency in Australia by utilising with input-orientated DEA and the intermediation approach. Wu (2008) focused on 17 bank merger cases between 1987 and 2000 in Australia and analysed five pre-mergers characteristics of the banks, which are size, growth rate, profitability, capital adequacy ratio and technical efficiency.

In contrast to Avkiran (1999), Wu (2008) found acquiring banks exhibit lower technical and scale efficiencies than merged banks, while acquiring banks are observed to be larger and had higher growth rates than merged banks. In terms of profitability and capital adequacy ratio, he found no significant difference between acquiring banks and target banks. It is also revealed that post-merger efficiency of banks is correlated to pre-merger efficiency, while the effects of mergers to the bank efficiency is observed to depend on the types of merger, rather than the types of banks involved in mergers (Wu, 2008).

4.4 Profit efficiency

Kirkwood and Nahm (2006) analysed profit efficiency of Australian banks in the period from 1995 to 2002, which is the first and the only study that analysed profit efficiency of Australian banks so far. The measurement techniques are equivalent to the techniques used for banking service efficiency (see Section 4.3), except 'profit before tax and abnormal items' is specified to a single output variable in order to measure profit efficiency (see Table 4.2). The revenue efficiency is also measured by incorporating banking service efficiency scores estimated by Model A to profit efficiency scores from Model B.

Table 4.10 Profit efficiency and decomposition (1995 – 2002)[14]

Year	TE		AE		BSE		TE		AE		PE	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1995	0.965	0.033	0.900	0.083	0.869	0.087	0.786	0.180	0.908	0.087	0.715	0.194
1996	0.970	0.028	0.911	0.071	0.885	0.076	0.797	0.162	0.904	0.098	0.720	0.168
1997	0.965	0.023	0.916	0.056	0.883	0.054	0.747	0.172	0.907	0.084	0.673	0.150
1998	0.961	0.024	0.942	0.044	0.905	0.045	0.759	0.149	0.881	0.106	0.662	0.116
1999	0.969	0.026	0.950	0.033	0.920	0.031	0.799	0.134	0.858	0.127	0.680	0.119
2000	0.978	0.023	0.967	0.033	0.946	0.039	0.865	0.129	0.844	0.154	0.732	0.187
2001	0.977	0.029	0.976	0.021	0.953	0.040	0.825	0.155	0.833	0.148	0.687	0.187
2002	0.983	0.030	0.979	0.036	0.963	0.061	0.812	0.178	0.825	0.133	0.668	0.191

NOTE: TE (Technical efficiency); AE (Allocative efficiency); BSE (Banking service efficiency);
PE (Profit efficiency); SD (Standard deviation)

Table 4.10 presents profit efficiency estimated by Model B. The results suggest that, firstly, the change in profit efficiency exhibited a decreasing trend, in contrast to banking service efficiency. It can be explained a decline in interest spreads in the late 1990s, which had reduced banks' traditional interest revenues. Secondly, technical- and allocative efficiencies, which are decomposed from the profit efficiency, are found to be lower than technical- and allocative efficiencies decomposed from banking service efficiency. The decomposition of the profit efficiency also revealed that the technical efficiency is lower than the allocative efficiency, which is also different to the results of the decomposition of banking service efficiency. Finally, it is

[14] Kirkwood and Nahm (2006), pp.262

observed that profit efficiency is more deviated across the banks, where the standard deviation of profit efficiency is greater than the standard deviations of the banking service efficiency (Kirkwood and Nahm, 2006).

The comparison of the profit efficiency of the banks with different sizes indicated the four major banks have been more profit efficient than smaller banks. It is also found that there is a difference in the trend of profit efficiency changes between the major banks and smaller banks. The profit efficiency of the major banks had been improved continuously since 1997, while the profit efficiency of smaller banks had been declined since 1997.

The higher profit efficiency of the major banks than smaller banks implies the significance of non-traditional activities in the major banks' activities and revenues. In other words, the major banks are more actively involved in non-traditional activities, such as fund management, insurance and superannuation, and are able to generate more revenues as well as less affected by the decline in interest spreads than smaller banks. In addition, they suggested that the differences in profit efficiency of the major banks and smaller banks can be explained by other factors as well, such as geographical constraints, different customer bases and access to the international financial markets (Kirkwood and Nahm, 2006).

The results of Kirkwood and Nahm (2006) provide important implications for profit efficiency studies for Australian banks, which are twofold. Firstly, the inclusion of non-traditional activities is important in profit efficiency analyses, with considering the increasing significance of non-traditional activities in banks' activities and total revenues. Secondly, the size factor appears to be correlated to profit efficiency of the banks, which implies the impact of the highly concentrated market structure of the Australian banking sector on profit efficiency of Australian banks.

4.5 Summary of the Australian studies

This chapter provides a review of Australian banking efficiency studies in the pre- and the post-Wallis period, which can be summarised as follows.

Firstly, Australian banking efficiency has been improved during the last two decades. In spite of the differences in detail, the trend of improvement in Australian banking efficiency appears to be consistent across the studies. It means that, the subsequent deregulations after the Campbell Report (1981) and the Wallis Report (1997) have led Australian banks to improve their efficiency. Meanwhile, the highly concentrated market structure of the Australian banking sector is suggested as a source of inefficiency, as well as the reason for the lower profitability of foreign banks in Australia.

Secondly, it is observed that DEA is the most favourable measurement technique to analyse Australian banking efficiency at this stage. The most of studies reviewed in this chapter utilised DEA, with an exception of Walker (1998), mainly due to small number of banks in the Australian banking sector as well as limited data availability, particularly for foreign banks. However, DEA efficiency scores are found to be case-sensitive, which means that efficiency scores obtained by different studies utilised DEA are not directly comparable, due to different model- and variable specifications as well as production technology assumptions.

Thirdly, the intermediation approach is preferred by Australian banking efficiency studies, because it reflects the characteristics of the recent Australian bank operations, such as non-traditional activities and diversified financial services (Paul and Kourouche, 2008). Meanwhile, it is observed to be difficult to specify a variable for non-traditional activities of banks, due to limited data availability (Sturm and Williams, 2002; Neal, 2004).

Lastly, it is important to note that Australia had not experienced severe economic recessions during the last two decades. It means that, the efficiency of Australian banks may be explained by other external factors, which are not yet considered, such as stable economic growth, widespread of sophisticated investment and management strategies and introductions of innovative technologies from other industries. Therefore, it would not be appropriate to make a decisive conclusion about Australian banking efficiency solely based on the frontier-based econometric analyses.

Chapter 5. Econometric Model Development

5.1 Introduction

This chapter provides an introduction to the measurement techniques and outlines econometric model specification and data specification of this study. This study utilises DEA and the directional distance function to compute the norm-based profit index approach, which makes this study unique to Australian banking efficiency studies.

This chapter is structured as follows. Section 5.2 presents the measurement techniques used in this study, including the directional distance function and the norm-based profit index approach. DEA is discussed in Chapter 2, and is extensively covered in the previous Australian studies. Therefore, it is not included in this chapter.

The norm-based profit index approach is utilised in this study to obtain four types of efficiency scores, including profit-, technical-, allocative- and price efficiencies. The introduction of the index approach is provided in Section 5.2, which is followed by the description of linear programming for the model, and data specifications are provided in Section 5.3.

5.2 The measurement techniques

Nerlovian profit efficiency and the directional distance function

It is discussed in Chapter 2 that ratio-based approaches define profit efficiency to the ratio of the actual profit to the maximum possible profit for a firm at given level of production technology T (Cooper, Seiford and Tone, 2000). Therefore, it is necessary to define the maximum possible profit to measure profit efficiency of a firm. By following Fried, Lovell and Schmidt (2008), the maximum possible profit[1] that can be calculated by DEA is given by,

$$Max\ y_r x_i \lambda_j \left\{ \Pi = \sum_{r=1}^{s} P_{ro} y_r - \sum_{i=1}^{m} w_{io} x_i \;\middle|\; \begin{array}{l} \sum_{j=1}^{n} \lambda_j y_{rj} \geq y_r,\ r = 1, \ldots s \\ \sum_{j=1}^{n} \lambda_i x_{ij} \leq x_i,\ r = 1, \ldots s \\ \sum_{j=1}^{n} \lambda_j = 1,\ \lambda_j \geq 0 \end{array} \right\} \tag{5.1}$$

where w = the vector of input price(s), p = the vector of output price(s), x = the vector of input(s), y = the vector of output(s) and λ = the convexity constraint.

Note that (5.1) assumes variable returns to scale (VRS) production technology. Constant returns to scale (CRS) production technology implies zero profit in the long run therefore computing the maximum possible profit to derive profit efficiency is not possible (Fried, Lovell and Schmidt, 2008).

On the other hand, the directional approach provides normalised profit efficiency by taking the difference between the maximum possible profit and the actual (observed) profit, and the difference is normalised by the directional vector measured by the directional distance function (Chambers, Chung and Färe, 1998).

The directional approach to measure profit efficiency, which is called to 'the Nerlovian profit efficiency', is based on the additive nature of profit function and the directional distance function. The Nerlovian profit efficiency is developed to resolve the measurement problems associated to

[1] Fried, Lovell and Schmidt (2008), pp.279

the ratio-based approaches. The problems are, firstly, profit efficiency measured by ratio-based approaches can be negative, and secondly, it does not provide an implication for simultaneous input- and output adjustments (Fried, Lovell and Schmidt, 2008).

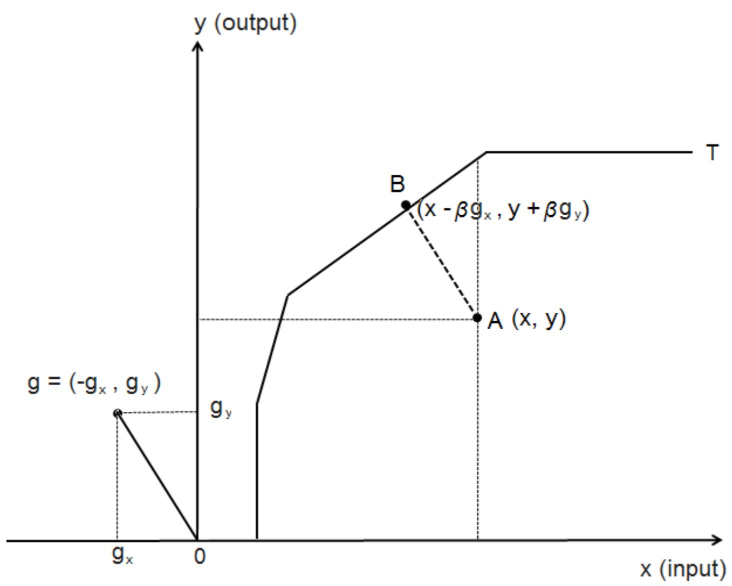
The Nerlovian profit efficiency (NE) is defined in (5.2), which shows that NE is an additive profit efficiency normalised by the non-zero direction vector $(wg_x + pg_y)$, where $(g_x, g_y) \in R^+_N \times R^+_M$ and computed by the directional distance function in (5.3).

$$NE = \frac{\left[\pi^*(py^* - wx^*) - (py - wx)\right]}{(wg_x + pg_y)} \tag{5.2}$$

$$\beta^* = \vec{D}_T\,(x, y; g_x, g_y) = max\,[\beta \in R^+ : (x - \beta g_x, y + \beta g_y) \in T] \tag{5.3}$$

The normalisation in (5.2) is possible due to the duality between profit function and the directional distance function (Chambers, Chung and Färe, 1998), which is similar to the duality between Farrell's cost- and revenue-based efficiency and the Shephard distance function and the McFadden gauge function.

Figure 5.1 The directional distance function



The directional distance function in (5.3) radially takes given combination of inputs and outputs (x, y) to the production frontier at $(x - \beta g_x, y + \beta g_y)$ proportionally to β. The signs indicate contraction of input(s) and expansion of output(s) due to efficiency improvement (Figure 5.1). If $\beta^* = 0$, then the firm is operating at technically efficient point. If $\beta^* > 0$, then this firm is at technically inefficient point (Färe, Grosskopf and Weber, 2004).

The duality between the profit function in (5.4) and the directional distance function in (5.3) is given by (5.5) and (5.6), with knowing that the feasibility condition for the duality is satisfied by the translation property of the directional distance function. Note that (5.5) is an unconstrained profit maximisation problem, which implies the maximum possible profit is the sum of the actual profit and the additional profit gains due to the improvement of technical efficiency. Note that it is not subject to input- or output constraints (Chambers, Chung and Färe, 1998; Färe, Grosskopf and Weber, 2004).

$$\pi(p, w) = max_{(x,y) \geq 0} \, [py - wx : (x, y) \in T] \tag{5.4}$$

$$\pi(p, w) = max_{(x,y) \geq 0} \, [py - wx + \vec{\mathrm{D}}_{\mathrm{T}} \, (x, y; g_x, g_y)(wg_x + pg_y)] \tag{5.5}$$

$$\vec{\mathrm{D}}_{\mathrm{T}} \, (x, y; g_x, g_y) = inf_{(p,\, w) \geq 0} \left[\frac{\left[\pi^*(py^* - wx^*) - (py - wx)\right]}{(wg_x + pg_y)} \right] \tag{5.6}$$

The additive decomposition of the Nerlovian profit efficiency into technical- and allocative efficiencies (Färe, Grosskopf and Weber, 2004) is based on the duality above. Technical efficiency (TE) is defined by a chosen input-output directional vector (g_x, g_y) such that,

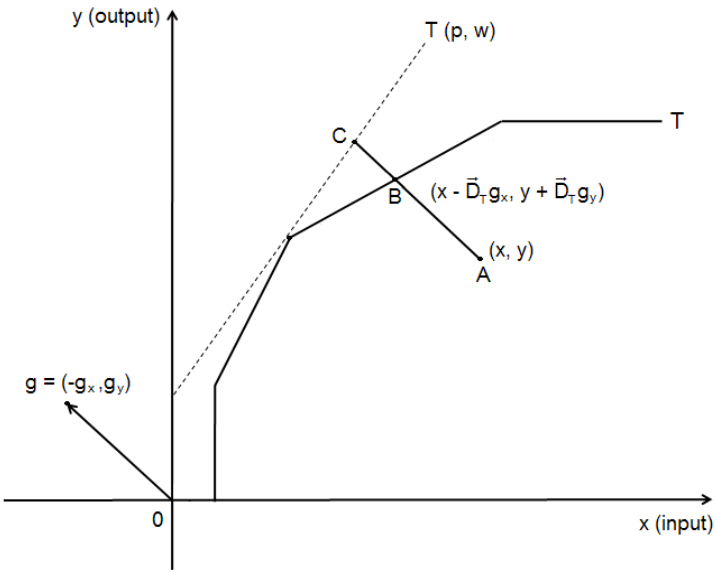
$$TE = \vec{\mathrm{D}}_{\mathrm{T}} \, (x, y; g_x, g_y) \tag{5.7}$$

However, allocative efficiency is not explicitly derived from the Nerlovian profit efficiency. Färe and Grosskopf (2003) define allocative efficiency (AE) as the difference between the Nerlovian profit efficiency and the directional distance function, or a residual which includes both input- and output-allocative efficiencies, which is given by (5.8).

$$AE = \left[\frac{\left[\pi^{*}(py^{*} - wx^{*}) - (py - wx)\right]}{(wg_x + pg_y)}\right] - \vec{D}_{T}(x, y; g_x, g_y) \tag{5.8}$$

In Figure 5.2, the Nerlovian profit efficiency (NE), technical efficiency (TE) and allocative efficiency (AE) are represented by points A, B and C, where $NE = \hat{\vec{D}}_{T(p,w)}(x, y; g_x, g_y) = C - A$, $TE = \vec{D}_{T}(x, y; g_x, g_y) = B - A$ and, $AE = C - B$.

Figure 5.2 The Nerlovian profit efficiency



The Nerlovian profit efficiency poses a couple of important drawbacks. Firstly, it may not be consistent to the traditional efficiency index concept, because the efficiency measures may not be within a range from 0 to 1. In addition, it derives allocative efficiency by taking a residual between the Nerlovian profit efficiency and the directional distance function, rather than explicitly calculate. The drawbacks of the Nerlovian profit efficiency, particularly its inconsistency with the traditional efficiency index concept, motivated Nahm and Vu (2008) to develop a new profit efficiency index approach based on Euclidean distance.

The norm-based profit efficiency index approach

Nahm and Vu (2008) introduced a new profit efficiency index approach and decomposition based on the ratio of the Euclidean distances, which is measured by the directional distance function and DEA. The norm-based index approach by Nahm and Vu (2008) is different to the Nerlovian profit efficiency, because it explicitly computes technical, allocative and profit efficiencies by taking the ratio of the Euclidean distances.

Figure 5.3 The norm-based profit efficiency index approach

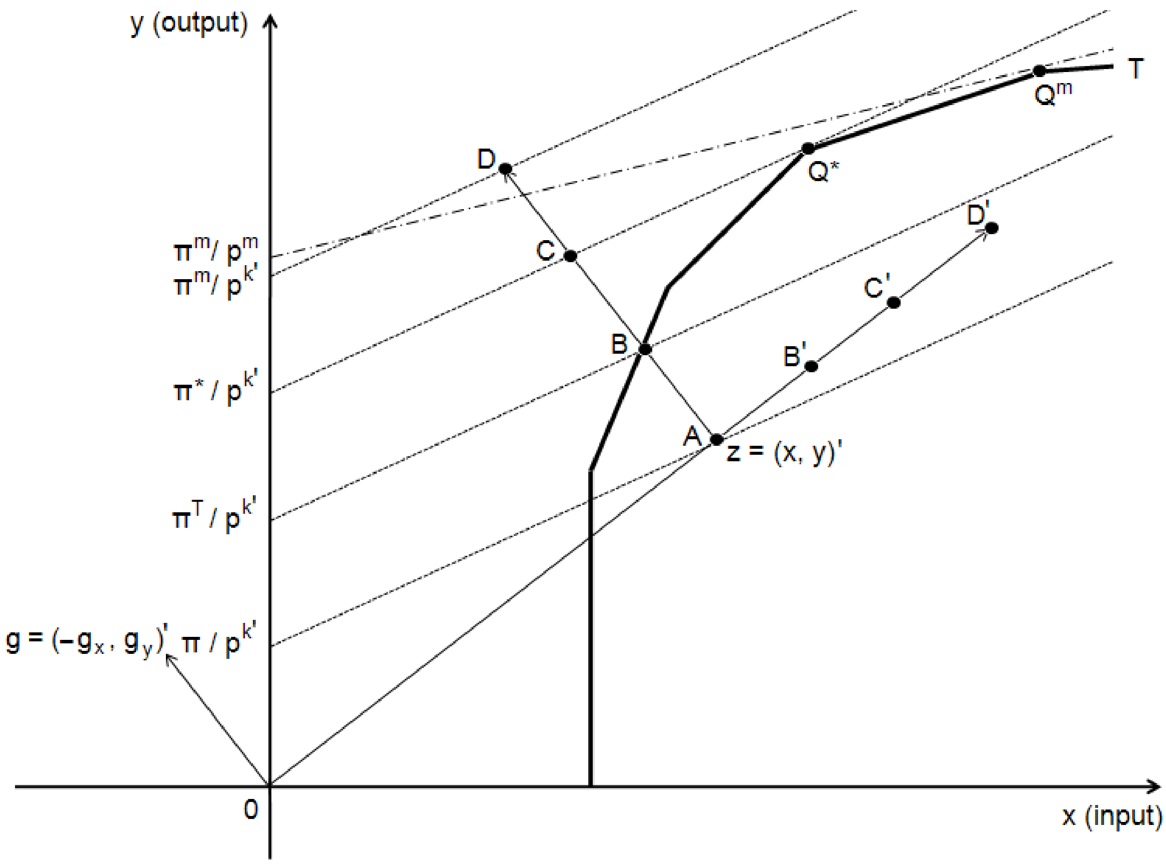


Figure 5.3[2] illustrates a simple one input x and one output y case for a firm k, where $z = (x, y)'$ in the production frontier represents the firm's current input and output level. There are five price lines in the figure, based on different levels of profit π, which are normalised by different output prices, p. The different profit levels π, π^T and π^* represent the actual (observed) profit, the profit available when the firm becomes technically efficient and the maximum possible profit at given

[2] Nahm and Vu (2008), pp.5

input-output price vector $(w^{k'}, p^{k'})$, respectively. The superscript m with profit π^m and output prices p^m indicates the output prices are at the level which allows the firm to maximise its profit at given level of production technology T.

Suppose the firm is currently operating at $z = (x, y)'$, which is an inefficient point. Then, the distance between the current point A and an efficiency point B needs to be measured by the directional vector $g = (-g_x, g_y)$ to reflect the firm's profit maximising behaviour, which requires the firm to reduce input(s) and increase output(s) simultaneously. It means that technical inefficiency index of this firm will be a ratio of $|AB|$ to $|OA| + |OB|$. With considering B', where $|AB| = |AB'|$, technical inefficiency index also can be defined to $|AB'| / |OB'|$. It indicates technical efficiency index TE is equivalent to $|OA| / |OB'|$.

To define allocative efficiency index AE, observe the price lines correspond to the points A, B, C and D, where the slopes of the price lines are given by $w^{k'} / p^{k'}$. If this firm can choose any input-output combination for profit maximisation at given level of technology, then Q^* represents the profit maximising point for this firm, which is tangent to the line passing through the point C at profit π^*. Therefore, $|AB|$ equals to $(\pi^T - \pi)$, which means that $|AB|$ is the additional profit gains for the firm when it becomes technically efficient.

Similarly, $|AC|$ is equivalent to $(\pi^* - \pi)$, which means that $|AC|$ is equivalent to the additional profit when the firm is able to choose profit-maximising input-output vector to achieve Q^*. If $|AB'|$ is an additional profit for this firm at a technically efficient point, allocative efficiency index can be defined by $|OB'| / |OC'|$, where allocative inefficiency index is $|BC|$. Therefore, profit efficiency index, which is the product of technical and allocative efficiencies, is given by $|OA| / |OC'|$.

Note that, the actual profit may be negative, which poses a possible measurement problem. However, three different profit levels are used in this approach in order to calculate the profit indices, which are π, π^T and π^*. They are equal to each other at the minimum in this context. Therefore, a negative profit would not cause a significant measurement problem. Note that, if $\pi = \pi^*$, then the firm's technical, allocative and profit efficiency scores are all equal to 1.

To define the efficiency indices mathematically, recall the unconstrained profit maximisation problem given by (5.5).

$$\pi\,(p,\,w) = max_{(x,y)\,\geq\,0}\;[py - wx + \vec{\mathrm{D}}_{\mathrm{T}}\;(x,y;g_x,g_y)(wg_x + pg_y)] \tag{5.5}$$

In Figure 5.3, the maximum possible profit, which can be achieved when the firm is technically efficient, is represented as π^T. Therefore (5.5) can be redefined to,

$$\pi^T = py - wx + \vec{\mathrm{D}}_{\mathrm{T}}\;(x,y;g_x,g_y)(wg_x + pg_y) = \pi + \vec{\mathrm{D}}_{\mathrm{T}}\;(x,y;g_x,g_y)\delta \tag{5.9}$$

where π = the actual profit, and $\vec{\mathrm{D}}_{\mathrm{T}}\;(x,y;g_x,g_y)\delta$ = the additional profit when the firm becomes technically efficient. Rearranging (5.9) yields,

$$\vec{\mathrm{D}}_{\mathrm{T}}\;(x,y;g_x,g_y) = \frac{\pi^T - \pi}{\delta} \tag{5.10}$$

The maximum profit with allowing an unrestricted choice of input-output vector also can be written as below.

$$\pi^* = py - wx + \lambda_1(wg_x + pg_y) = \pi + \lambda_1\delta \tag{5.11}$$

where λ_1 is non-negative constant to make (5.11) holds. Therefore λ_1 should exist, but may not be feasible. However, rearranging (5.11) provides a derivation of λ_1.

$$\lambda_1 = \frac{\pi^* - \pi}{\delta} \tag{5.12}$$

For the simplicity of mathematical expression of efficiencies, let $\beta^* = \vec{\mathrm{D}}_{\mathrm{T}}\;(x,y;g_x,g_y)$, the directional vector $g = (-g_x{'}, g_y{'}) \in \mathrm{R}^{+}_{\mathrm{N+M}}$, the actual input-output vector $z = (x{'}, y{'}) \in \mathrm{R}^{+}_{\mathrm{N+M}}$ and the input-output price vector $p = (-w{'}, p{'}) \in \mathrm{R}^{--}_{\mathrm{N+M}} \times \mathrm{R}^{++}_{\mathrm{N+M}}$.

Recall that technical inefficiency of this firm is a ratio of $|AB|$ to $|OA| + |OB|$, which is $\beta^*|g|$, therefore $|AB| = \lambda_1|g|$. Similarly, allocative inefficiency, $|BC|$, is defined by $\lambda_1|g| - \beta^*|g|$ where $\lambda_1|g| - \beta^*|g| > 0$ because $\pi^* > \pi$ and $\delta > 0$. As a result, the efficiencies can be expressed as below (Nahm and Vu, 2008).

$$TE = \frac{1 - \beta^*|g|}{|z| + \beta^*|g|} = \frac{|z|}{|z| + \beta^*|g|} \tag{5.13}$$

$$AE = \frac{1 - (\lambda_1|g| - \beta^*|g|)}{|z| + \lambda_1|g|} = \frac{|z| + \beta^*|g|}{|z| + \lambda_1|g|} \tag{5.14}$$

$$PE = \frac{|z|}{|z| + \lambda_1|g|} \tag{5.15}$$

This study also provides the measure of price efficiency of the banks, which is given by (5.17) by following Nahm and Vu (2008), where it has not been provided in the previous Australian studies. Price efficiency (PRE) gives the efficiency of the banks to secure profit maximising input- and output price ratios. This study computed price efficiency by solving each bank's profit maximisation problem to each bank's input- and output price vectors in each year. Then the maximum profit obtained for each bank is used to compute λ_2 by (5.16),

$$\pi^m = p(z + \lambda_2 g) = pz + \lambda_2 pg = \pi + \lambda_2\delta \tag{5.16}$$

Thus, price efficiency (PRE) is computed by (5.17) by using λ_2 obtained from (5.16)

$$PRE = \frac{|z| + \lambda_1|g|}{|z| + \lambda_2|g|} \tag{5.17}$$

5.3 Model specification

Linear programming

This study adopted the norm-based index approach to estimate profit efficiency by following Nahm and Vu (2008). The corresponding LP to compute the maximum unregulated profit for the k-th bank, $k = 1 \cdots K$ with input and output prices w^k and p^k and inputs and outputs x_n and y_m, $n = 1 \ldots N$ and $m = 1 \ldots M$ is specified in (5.18). e^k indicates the equity capital, which is included as a fixed input. Note that (5.18) assumes CRS production technology.

$$\pi^* = Max_{y,\,x,\,v}\left\{ p^{k\prime}\cdot y - w^{k\prime}\cdot x : \left| \begin{array}{l} \sum_{k=1}^{K} v_k y_m^k \geq y_m,\ m = 1, \ldots, M \\ \sum_{k=1}^{K} v_k x_n^k \leq x_n,\ n = 1, \ldots, N \\ \sum_{k=1}^{K} v_k e^k \leq e^{k\prime} \\ \sum_{k=1}^{K} v_k = 1 \\ x \geq 0_N,\ y \geq 0_M \text{ and } v_k \geq 0 \text{ for } k = 1, \ldots, K \end{array} \right. \right\} \tag{5.18}$$

The distance between the VRS production frontier and the current input-output vector of the k-th bank is computed by (5.19).

$$\beta^* = Max_{\beta}\left\{ \beta : \left| \begin{array}{l} \sum_{k=1}^{K} v_k y_m^k \geq y_m^k + \beta g_{ym},\ m = 1, \ldots, M \\ \sum_{k=1}^{K} v_k x_n^k \leq x_n^k - \beta g_{xn},\ n = 1, \ldots, N \\ \sum_{k=1}^{K} v_k e^k \leq e^{k\prime} \\ \sum_{k=1}^{K} v_k = 1 \\ \beta \geq 0 \text{ and } v_k \geq 0 \text{ for } k = 1, \ldots, K \end{array} \right. \right\} \tag{5.19}$$

where g_{xn} and g_{ym} are n-th and m-th element of the directional vector (g_x, g_y). Note that the distance for the CRS production frontier can be computed by excluding the VRS convexity constraint $\sum_{k=1}^{K} v_k = 1$ (Nahm and Vu, 2008).

Data specification

This study includes 9 Australian domestic banks operated in the period from 2000 to 2008. The number of banks becomes 8 in 2008 due to the merger between Bendigo Bank Limited and Adelaide Bank Limited in November 2007 (see Table 5.1). The selection of banks is limited by the availability of data and the level of disclosure, which made other domestic banks and foreign bank branches and subsidies to be excluded from the sample. The classification of the banks in two groups – major banks and regional banks – follows Valentine, Ford, Edwards, Sundmacher and Copp (2006).

Table 5.1 Australian domestic banks included in the sample

	Name	Abbreviation
Major banks	Australia and New Zealand Banking Group Limited	*ANZ*
	Commonwealth Bank of Australia Limited	*CBA*
	National Australia Bank Limited	*NAB*
	Westpac Banking Corporation	*WBC*
Regional banks	Suncorp Bank Limited**	*SUN*
	Bank of Queensland Limited	*QLD*
	Adelaide Bank Limited*	*ADL*
	Bendigo Bank Limited*	*BEN*
	St George Bank Limited	*SGB*

NOTE: *Bendigo Bank Limited and Adelaide Bank Limited merged in 30 November 2007 and became Bendigo and Adelaide Bank Limited; **Suncorp-Metway Limited changed its name to Suncorp Bank Limited in April 2009.

The data used in this study are obtained from banks' annual financial statements and annual reports for the financial year-end in the period from 2000 to 2008. It gives the total number of observation is 80[3].

[3] The number of observations used in this study meets the criteria suggested by Nunamaker (1985). He suggested the number of observations used in DEA should be greater than the product of input and output variables by three times. For a detailed discussion, see Nunamaker (1985).

It is discussed in Chapter 3 and 4 that, there is no consensus to define input and output variables to measure the banking efficiency. In the previous banking efficiency studies, the production approach, the value-added approach and the intermediation approaches are widely adopted to specify input and output variables, where these three types of approach are different to each other in terms of its definition of the banks' activities (Pasiouras, 2008).

Firstly, the production approach defines a bank as a producer of financial services, such as loans, deposit accounts, by using labour and capital inputs, where it is suggested that the production approach is more appropriate to measure the efficiency of bank at the branch level (Pasiouras, 2008). Secondly, the value-added approach defines the value-added services as outputs, which includes loans, deposits and securities, and labour, fixed assets and physical capital are generally defined as inputs (Devaney and Weber, 2002).

Thirdly, the intermediation approach, which is widely adopted by Australian studies (see Chapter 4), views a bank as a financial intermediary between depositors and borrowers, and produces loans and securities by using labour, capital and deposits (Resende and Silva, 2007). This study adopts the intermediation approach, because it is consistent to banks' behaviours of cost minimisation and revenue maximisation. Therefore, it is more appropriate to use to measure banks' profit efficiency[4].

In particular, this study defines a bank as a financial intermediary, which produces outputs of loans, securities and non-traditional activities, by using variable inputs of labour, deposits, physical capital and a fixed input of equity capital. The input and output variables are fairly conventional in the intermediation approach, and are used in the previous Australian studies (see Table 4.2 in Chapter 4).

In contrast to Kirkwood and Nahm (2006), who defined 'profit before tax and abnormal items' as an output to measure profit efficiency, this study does not define a profit-based output variable. Rather, profits are directly computed by subtracting the total amount of expenses on variable inputs from the total amount of revenues from outputs.

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[4] In this study, the intermediation approach is used to define input and output variables for DEA estimation. However, Fortin and Leclerc (2007) found DEA cannot provide reliable measures of productivity change if variables are defined by the intermediation approach, due to its limited coverage of banks' balance sheets. Therefore, this study focuses on profit efficiency and does not provide measures of productivity changes of Australian banks due to the possible biasness of measures of productivity changes. For a detailed discussion, see Fortin and Leclerc (2007).

Note that the accounting standard of Australian banks has been changed from the Australian Accounting Standards (AGAAP) to the Australian equivalent to International Financial Reporting Standards (AIFRS), and applied since 2005. The transition has changed recognition and measurement of balance sheet items, while the changes in the balance sheet components concerned by this study are found to be minor.

The list of input- and output variables and their components are presented in Table 5.2, and the calculations of the prices and the summary statistics are provided in Table 5.3 and 5.4, respectively. All the financial values used are deflated to the year 2000 based on the Consumer Price Index (CPI).

Table 5.2 Input and output variables and its components

Variables		Financial statement components
Variable inputs	Labour (x_1)	Full-time equivalent employees
	Deposits and other borrowings (x_2)	Certificate of deposits Savings, investment and transaction deposits Non-interest-bearing deposits Other demand deposits Securities sold under agreement to repurchase
	Physical capital (x_3)	Property, Plant and Equipment Fixed assets
Fixed inputs	Equity Capital (e)	Shareholders' equity attributable to Equity holders of the bank Shareholders' equity attributable to minority interests
Outputs	Loans (y_1)	Home loans Credit card and other personal lending Term loans Bill financing Overdrafts Redeemable preference shares Financial leases
	Securities (y_2)	Australian public securities Foreign government securities Bills of exchange Certificates of deposits Medium term notes Other securities Equity and Debt security investments Property investments
	Non-traditional activities (y_3)	Contingent liabilities Direct credit substitutes Foreign-exchange, interest rate and other market-related transactions Fund under administration Life insurance assets Trade- and performance-related items

Table 5.3 Calculation of input-output prices

Prices	Calculation
Price of Labour (w_1)	= Staff expense / Labour (x_1)
Price of Deposits and other borrowings (w_2)	= Interest expenses / Deposits and other borrowings (x_2)
Price of Physical capital (w_3)	= Non-interest expense / Physical capital (x_3)
Price of Loans (p_1)	= Net-interest income / Loans (y_1)
Price of Securities (p_2)	= Securities income / Securities (y_2)
Price of Non-traditional activities (p_3)	= Fee and other incomes / Non-traditional activities (y_3)

Non-traditional activities

In Chapter 3 and 4, it is discussed that the inclusion of banks' non-traditional activities is important due to the increasing proportion of non-traditional activities in the banks' overall activities as well as their revenues. Graph 5.1 shows the volume of non-traditional activities of Australian banks in the period from 2000 to 2008.

The graph shows the total volume of non-traditional activities has increased substantially, mostly with the major banks. It implies the importance of non-traditional activities in the overall banking activities as well as in the banks' revenues. Therefore, it is necessary to include non-traditional activities to measure profit efficiency of Australian banks.

In the previous Australian studies, banks' non-interest income is generally used as a proxy variable of non-traditional activities (see Table 4.2 in Chapter 4). This study uniquely defines the nominal amount of non-traditional activities as an output (y_3), which is defined by the sum of direct credit substitutes, trade- and performance-related items, commitments, financial derivative, and fiduciary activities[5]. Non-interest income is used to compute the price of non-traditional activities (p_3), rather than used as an output as in the previous Australian studies (see Table 5.3).

[5] Non-traditional activities (y_3) is defined by following Hogan, *et al.* (2004) and Gup, *et al.* (2007).

Graph 5.1 The volume of non-traditional activities (2000 – 2008)

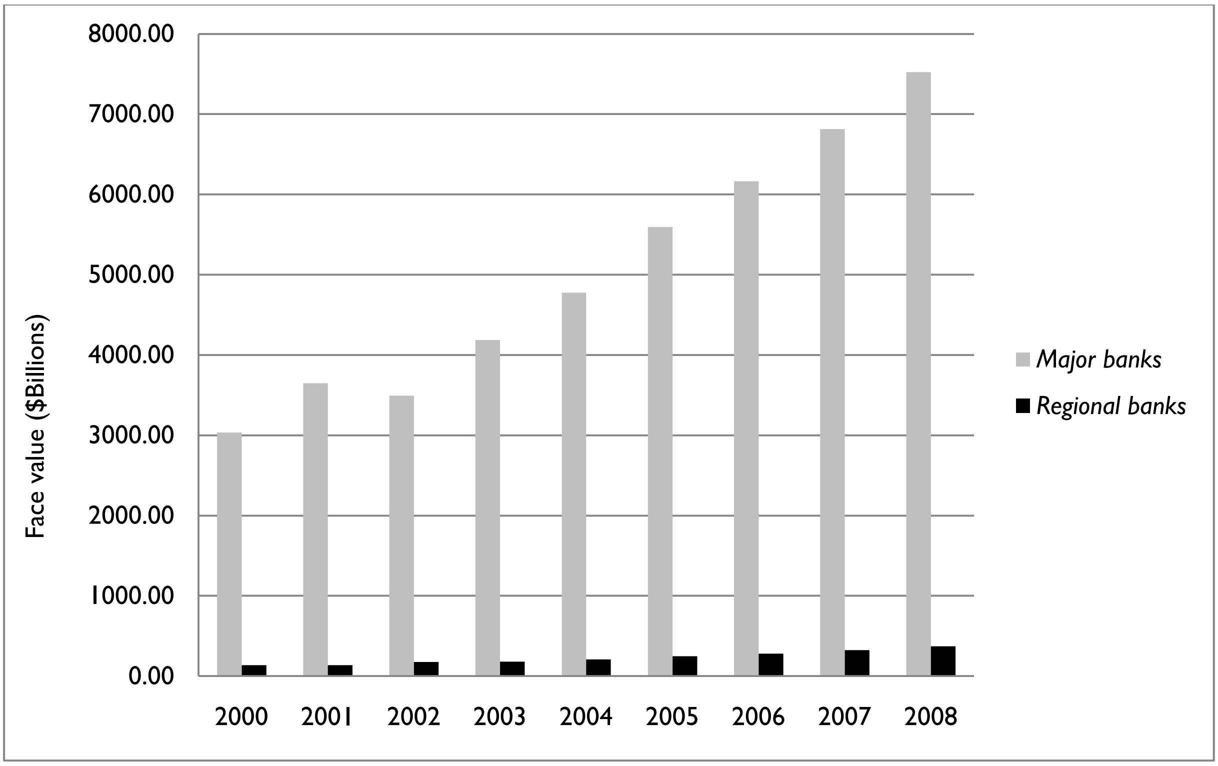


Table 5.4 Descriptive statistics

Groups	Types	Description	Mean	Standard Deviation	Minimum	Maximum
All banks	Variable inputs	Labour(x_1)	17540.93	15846.28	664.00	49514.00
		Deposits (x_2, \$mil)	78550.54	73134.67	3176.82	255096.01
		Physical capital (x_3, \$mil)	655.26	731.88	15.84	3296.77
	Fixed input	Equity Capital (e, \$mil)	8782.67	8197.58	179.66	25543.41
	Input prices	w_1	0.0668	0.0104	0.0430	0.0903
		w_2	0.0540	0.0141	0.0312	0.0980
		w_3	0.3500	0.2707	0.0171	1.3806
	Outputs	Loans (y_1, \$mil)	97684.76	91415.40	3042.60	281438.68
		Securities (y_2, \$mil)	11808.10	13528.76	115.97	58620.53
		Non-traditional activities (y_3, \$mil)	591139.55	745714.16	1022.40	3277471.90
	Output prices	p_2	0.0689	0.0096	0.0487	0.0943
		p_2	0.0529	0.0496	0.0002	0.3047
		p_3	0.0142	0.0214	0.0014	0.0985
Major banks	Variable inputs	Labour(x_1)	33732.44	7416.97	22482.00	49514.00
		Deposits (x_2, \$mil)	151727.46	41777.96	89994.00	255096.01
		Physical capital (x_3, \$mil)	1280.30	669.68	326.32	3296.77
	Fixed input	Equity Capital (x_3, \$mil)	16862.10	4762.94	9262.00	25543.41
	Input prices	w_1	0.0704	0.0085	0.0430	0.0886
		w_2	0.0558	0.0135	0.0403	0.0980
		w_3	0.4439	0.3263	0.1212	1.3806
	Outputs	Loans (y_1, \$mil)	189222.78	51940.22	107533.00	281438.68
		Securities (y_2, \$mil)	20979.45	14990.81	7132.00	58620.53
		Non-traditional activities (y_3, \$mil)	1256633.29	650083.65	539557.17	3277471.90
	Output prices	p_2	0.0705	0.0103	0.0594	0.0943
		p_2	0.0491	0.0215	0.0176	0.1144
		p_3	0.0036	0.0014	0.0014	0.0080
Regional banks	Variable inputs	Labour(x_1)	4293.32	4181.75	664.00	18000.00
		Deposits (x_2, \$mil)	18678.51	15962.66	3176.82	70266.58
		Physical capital (x_3, \$mil)	143.86	156.13	15.84	564.00
	Fixed input	Equity Capital (x_3, \$mil)	2172.22	2373.03	179.66	10073.07
	Input prices	w_1	0.0639	0.0110	0.0462	0.0903
		w_2	0.0525	0.0145	0.0312	0.0857
		w_3	0.2732	0.1858	0.0171	0.8118
	Outputs	Loans (y_1, \$mil)	22790.02	20061.20	3042.60	76124.66
		Securities (y_2, \$mil)	4304.26	5030.55	115.97	20496.54
		Non-traditional activities (y_3, \$mil)	46644.67	59286.14	1022.40	221709.63
	Output prices	p_2	0.0676	0.0088	0.0487	0.0847
		p_2	0.0560	0.0642	0.0002	0.3047
		p_3	0.0229	0.0258	0.0027	0.0985

Chapter 6. Empirical Result Analysis

6.1 Introduction

This chapter provides the empirical result analysis of profit efficiency and its decomposition to technical- and allocative efficiencies as well as price efficiency. The profit efficiency scores of Australian banks are obtained by, firstly, computing directional distances using DEA, and secondly, calculating profit efficiency by following the norm-based profit index approach based on the estimated directional distances for each bank.

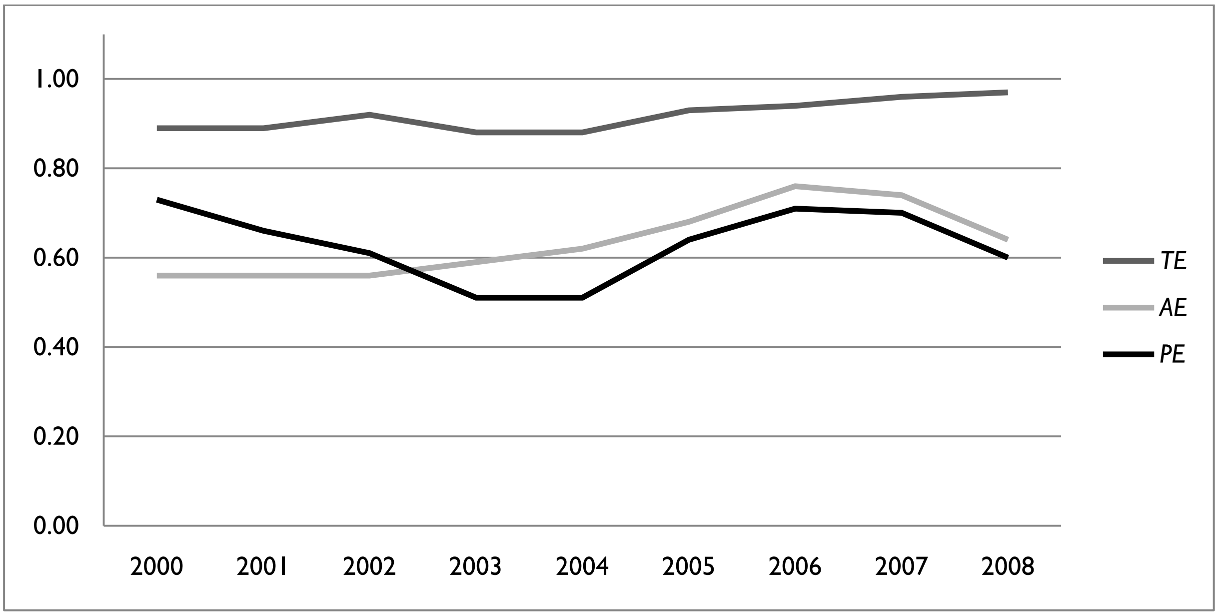
Technical- and allocative efficiency scores are given by the decomposition of profit efficiency, while price efficiency scores are given by (5.16) and (5.17) in Chapter 5. Table 6.1 presents the yearly statistics of four types of efficiency scores of all banks in the sample. Note that, this study used a pooled set of observations to construct DEA efficiency frontier, in order to minimise any possible measurement error associated to DEA with a small-sized sample (see Footnote 3 in Chapter 5).

This chapter is composed as follows. Firstly, Section 6.2 discusses the result of profit efficiency, which is followed by Section 6.3 that presents the result of decomposition of profit efficiency into technical- and allocative efficiencies. Section 6.4 is devoted to discuss the result of price efficiency, and it is followed by Section 6.5, which presents the result of Spearman Rank Coefficient (SRC) analysis of profit efficiency and accounting measures of profitability as well as banks' size factors.

Table 6.1 DEA efficiency scores: all banks (2000 – 2008)

	Technical efficiency	Allocative efficiency	Price efficiency	Profit efficiency
2000	0.89	0.56	0.61	0.73
2001	0.89	0.56	0.61	0.66
2002	0.92	0.56	0.61	0.61
2003	0.88	0.59	0.62	0.51
2004	0.88	0.62	0.64	0.51
2005	0.93	0.68	0.66	0.64
2006	0.94	0.76	0.67	0.71
2007	0.96	0.74	0.73	0.70
2008	0.97	0.64	0.80	0.60
Mean	0.92	0.63	0.66	0.63
Standard Deviation	0.0346	0.0773	0.0653	0.0809

Graph 6.1 DEA efficiency scores: all banks (2000 – 2008)



NOTE: TE (Technical efficiency), AE (Allocative efficiency), PE (Profit efficiency)

6.2 Profit efficiency

In Table 6.1 (Graph 6.1), it appears that profit efficiency of Australian banks had declined from 2000 and, reached at the minimum of 51 per cent in 2004. After 2004, it had rapidly improved and reached at the maximum of 71 per cent in 2006. However, it is still lower than the profit efficiency in 2000. Therefore, it can be suggested that the profit efficiency of Australian banks has been stable as it is not much changed since 2000, rather than improved or declined. Note that the profit efficiency has declined by 10 per cent in 2008 from the previous year, which can be attributed to the global financial crisis of 2007.

Table 6.2 (Graph 6.2) presents the profit efficiency of the banks in two groups; the major banks and the regional banks. The table and graph indicate the major banks have managed to improve their profit efficiency across the period, particularly from 2004, and have maintained higher profit efficiency relative to the regional banks (22 per cent on average). In contrast, the regional banks had experienced a decline in their profit efficiency, and reached at the lowest 48 per cent in 2004. Despite the profit efficiency of the regional banks had recovered since then, it started to decline from 2006 and reached at 54 per cent in 2008.

The dispersion between the profit efficiency of the major banks and the regional banks can be explained by different degree of income stream diversifications of two groups, as suggested by Kirkwood and Nahm (2006). In Chapter 5, Graph 5.1 has shown the volume of non-traditional activities of the major banks have been increased significantly after 2000, while the volume of non-traditional activities of the regional banks has been almost unchanged. It means that the major banks have more diversified income streams the regional banks. Therefore, the major banks are less sensitive to the change of net interest margins than the regional banks.

The pattern of profit efficiency changes of the regional banks supports the above conjecture. The period when the profit efficiency of the regional banks sharply declined, it is also the period of the decline in the net interest margins in Australia (RBA, 2003). The regional banks' sensitivity is observed to have had increased further, due to the increasing proportion of residential mortgages in the regional banks' loan portfolios during that period, which in turn further reduced the profit efficiency of the banks. In contrast to the regional banks, the major banks are almost unaffected by the decline in the net interest margins due to their diversified income streams.

Table 6.3 (Graph 6.3) provides more detailed result for the profit efficiency of individual banks. In the group of the regional banks, Suncorp Bank (SUN) is observed to be the least profit efficient, with significantly low profit efficiency scores. However, it should be attributed to the data specification of this study. Suncorp Bank generates a large proportion of its profits from non-banking activities. However, they are not fully covered in this study, as the intermediation approach is adopted to define input- and output variables as well as to select data components. Consequently, it has resulted in the underestimations of the bank's profit- and allocative efficiencies (see Table 6.7). Therefore, the case of Suncorp Bank implies the significance of data specification in the banking efficiency analyses.

With an exception of Suncorp Bank, Bendigo Bank (BEN) is the least profit efficient with the average of 49 per cent of efficiency, which can be explained by the structural characteristic of the bank's branch network. In the network[1], the majority of bank branches are not under the direct control of the bank (e.g. Community Bank branches), or located in remote rural areas with low profitability (e.g. Elders Rural Bank branches). Therefore, the low profit efficiency of Bendigo Bank can be attributed to, firstly, a lower profit efficiency of individually-owned branches than company-owned branches, and secondly, low profitability (therefore profit efficiency) of local branches located in the remote rural areas with low profitability.

In the group of the major banks, National Australia Bank (NAB) and Westpac Banking Corporation (WBC) have reached at the fully profit efficient level in 2008, after continuous improvements of their profit efficiency in the period by 22 per cent and 28 per cent, respectively. Commonwealth Bank of Australia (CBA) and Westpac Banking Corporation in particular have achieved noticeable improvements in their profit efficiency from 60 per cent in 2000 to 88 per cent in 2008 (CBA), and from 78 per cent in 2000 to the maximum of 1 in 2008 (WBC).

In Chapter 4, Kirkwood and Nahm (2006) found a positive relationship between a bank's size and its profit efficiency as well as an increasing trend of the major banks' profit efficiency and the opposite trend for the regional banks in the Australian banking sector. This study found that the profit efficiency of the major banks has been consistently higher than the regional banks, which is similar to the results of Färe, Grosskopf and Weber (2004), Fitzpatrick and McQuinn

[1] Bendigo and Adelaide Bank branch network is composed by 160 company-owned branches, 220 Community Bank branches, 400 Elders Rural Bank branches and 100 authorised representative agencies. Community Bank branches are owned and operated individually, while it shares its profit with Bendigo Bank, which provides infrastructure and resources. Elders Rural Bank branches are located in remote rural areas in order to provide financial services in remote areas. (Bendigo and Adelaide Bank Financial Report, 2008)

(2008), and Kirkwood and Nahm (2006), as it is also observed that the major banks are more profit efficient than the regional banks as well as have improved their profit efficiency in contrast to its counterparts. Note that the relationship between the size factor and profit efficiency will be discussed in detail in Section 6.5.

Table 6.2 Profit efficiency scores: by groups (2000 – 2008)

Year	Major banks	Regional banks	Mean	SD
2000	0.71	0.67	0.69	0.0283
2001	0.71	0.61	0.66	0.0707
2002	0.71	0.55	0.61	0.1768
2003	0.73	0.48	0.62	0.1980
2004	0.76	0.48	0.71	0.1697
2005	0.83	0.59	0.77	0.1697
2006	0.89	0.65	0.79	0.2051
2007	0.93	0.64	0.74	0.2758
2008	0.93	0.54	0.69	0.1563
Mean	0.80	0.58		
SD	0.0959	0.0708		

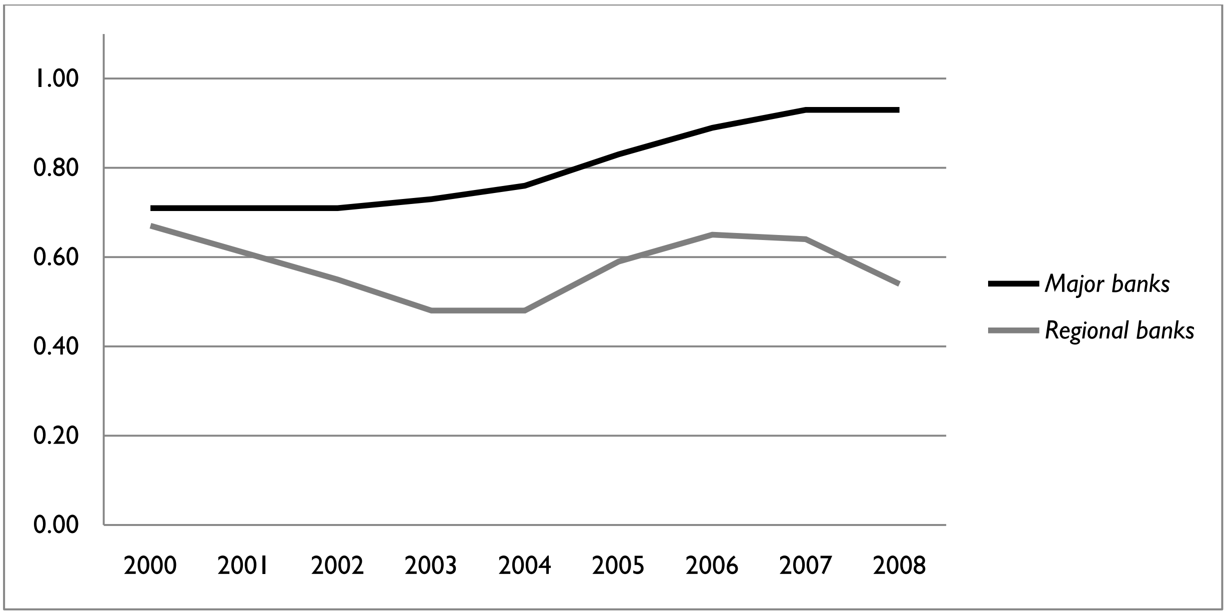
NOTE: SD (Standard Deviation)

Table 6.3 Profit efficiency scores: by individual banks (2000 – 2008)

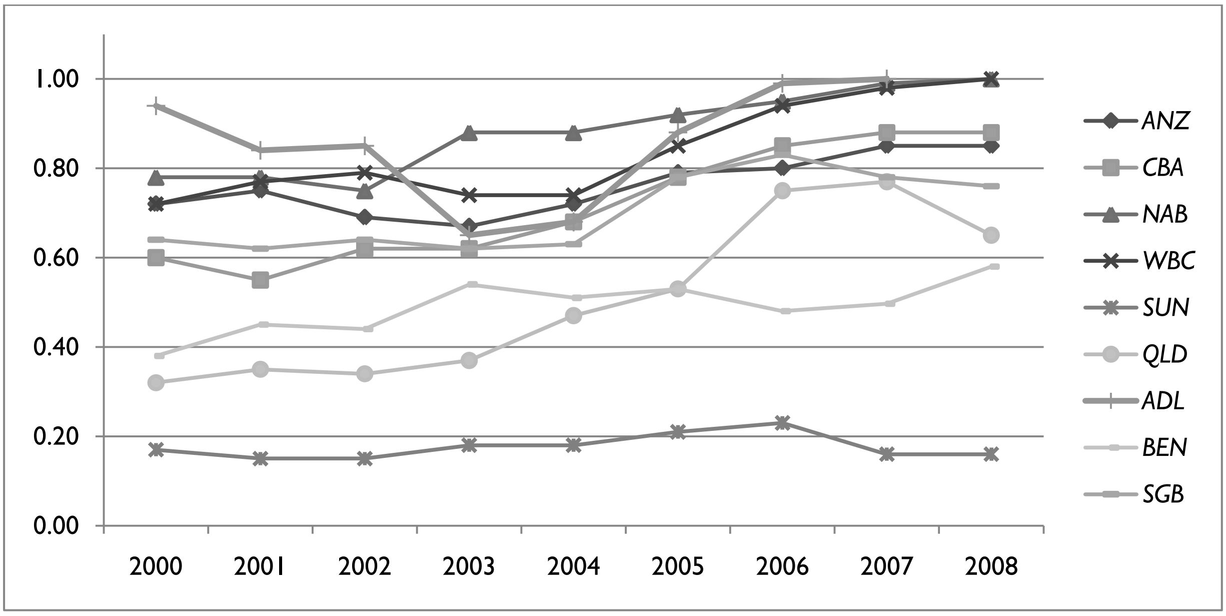
Year	Major banks				Regional banks					Mean	SD
	ANZ	*CBA*	*NAB*	*WBC*	*SUN*	*QLD*	*ADL*	*BEN*	*SGB*		
2000	0.72	0.60	0.78	0.72	0.17	0.32	0.94	0.38	0.64	0.59	0.2329
2001	0.75	0.55	0.78	0.77	0.15	0.35	0.84	0.45	0.62	0.58	0.2185
2002	0.69	0.62	0.75	0.79	0.15	0.34	0.85	0.44	0.64	0.59	0.2173
2003	0.67	0.62	0.88	0.74	0.18	0.37	0.65	0.54	0.62	0.59	0.1936
2004	0.72	0.68	0.88	0.74	0.18	0.47	0.68	0.51	0.63	0.61	0.1905
2005	0.79	0.78	0.92	0.85	0.21	0.53	0.88	0.53	0.78	0.70	0.2165
2006	0.80	0.85	0.95	0.94	0.23	0.75	0.99	0.48	0.83	0.76	0.2346
2007	0.85	0.88	0.99	0.98	0.16	0.77	1.00	0.50	0.78	0.77	0.2605
2008	0.85	0.88	1.00	1.00	0.16	0.65	-	0.58*	0.76	0.74	0.2591
Mean	0.76	0.72	0.88	0.84	0.18	0.51	0.85	0.49	0.70		
SD	0.0661	0.1307	0.0935	0.1101	0.0274	0.1792	0.1309	0.0602	0.0853		

NOTE: *indicates the profit efficiency of the Bendigo and Adelaide Bank Limited; SD (Standard Deviation)

Graph 6.2 Profit efficiency scores: by groups (2000 – 2008)



Graph 6.3 Profit efficiency scores: by individual banks (2000 – 2008)



6.3 Decomposition of profit efficiency

The norm-based profit index approach provides technical- and allocative efficiency scores from the decomposition of profit efficiency, which gives more detailed information of the banking efficiency. The technical- and allocative efficiency scores of all banks have presented in Table 6.1 in the previous section, while technical efficiency scores of the banks by groups and by individual banks are presented in Table 6.4 (Graph 6.4) and Table 6.5 (Graph 6.5), respectively.

Recall that, in Table 6.1, Australian banks are found to have managed their technical efficiency relatively higher than other types of efficiency, and have improved it across the period, except a slight decline in 2003. Table 6.5 (Graph 6.5) presents technical efficiency scores by individual banks, which indicates a similar result to the results by groups.

Table 6.4 (Graph 6.4) shows a slump of the technical efficiency of all banks in 2003, which is due to the decline in the technical efficiency of the regional banks (by 7 per cent in 2003). Initially, the regional banks' technical efficiency was higher than the major banks (96 per cent from 2000 to 2002 and 89 per cent in 2003). However, they only have managed to recover technical efficiency to 94 per cent after the slump in 2003, and have maintained the level without any further improvement. On the other hand, the major banks has been improved their technical efficiency continuously from 82 per cent (2000) to 99 per cent (2008).

In Chapter 4, Paul and Kourouche (2008) suggested the major banks are capable to improve their technical efficiency more quickly than the regional banks, because they can make sufficient capital investments towards technological improvements. However, this study suggests that it is not necessarily the case, because the regional banks are found to be technically efficient in the early 2000s and the deviation in the technical efficiency between the major banks and the regional banks are not significant. Therefore, it can be suggested that the continuous improvements in the production technology have lowered the barriers for the regional banks to take advantages of innovative technologies, such as the expansion of automotive teller machine (ATM) networks as well as the widespread of broadband access and internet banking facilities, by reducing the required amount of capital investments.

It is suggested by Neal (2004) in Chapter 4 that the dispersion in the technical efficiency between the major banks and the regional banks can be explained by the highly concentrated market structure of the Australian banking sector. However, the result of technical efficiency in this study does not have a strong implication for the relationship between technical efficiency and the market structure. However, a similar relationship is observed with the result of price efficiency, which is discussed in Section 6.4.

Table 6.4 Technical efficiency scores: by groups (2000 – 2008)

Year	Major banks	Regional banks	Mean	SD
2000	0.82	0.96	0.89	0.0990
2001	0.82	0.96	0.89	0.0990
2002	0.87	0.96	0.92	0.0636
2003	0.87	0.89	0.88	0.0141
2004	0.88	0.88	0.88	0.0000
2005	0.93	0.94	0.94	0.0071
2006	0.95	0.94	0.95	0.0071
2007	0.97	0.95	0.96	0.0141
2008	0.99	0.94	0.97	0.0354
Mean	0.90	0.94		
SD	0.0626	0.0300		

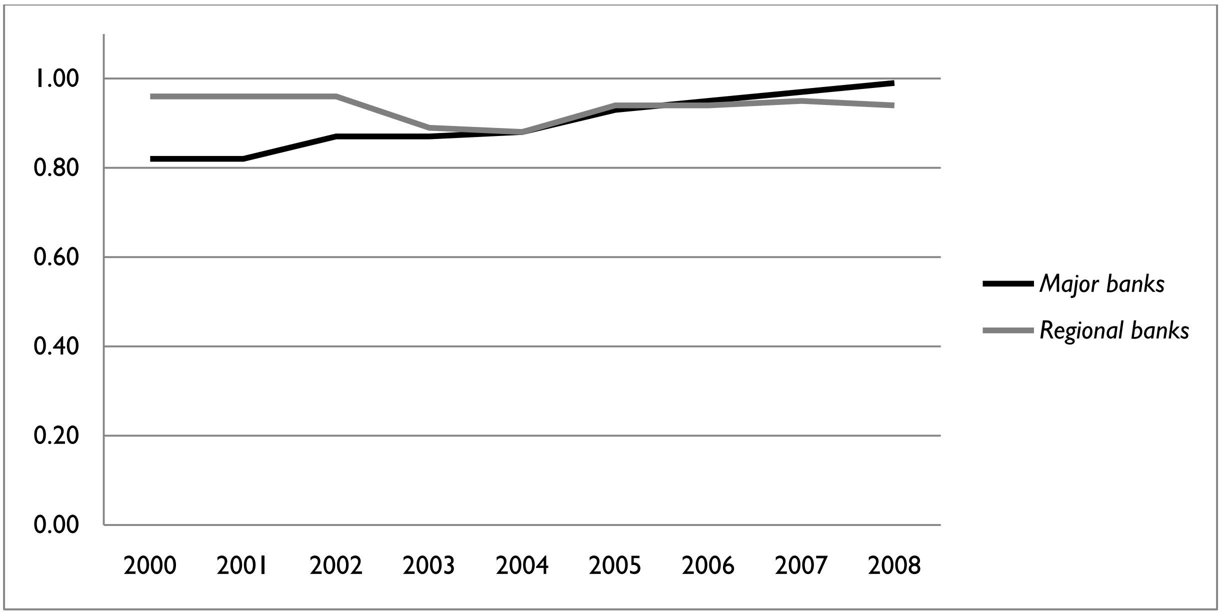
NOTE: SD (Standard Deviation)

Table 6.5 Technical efficiency scores: by individual banks (2000 – 2008)

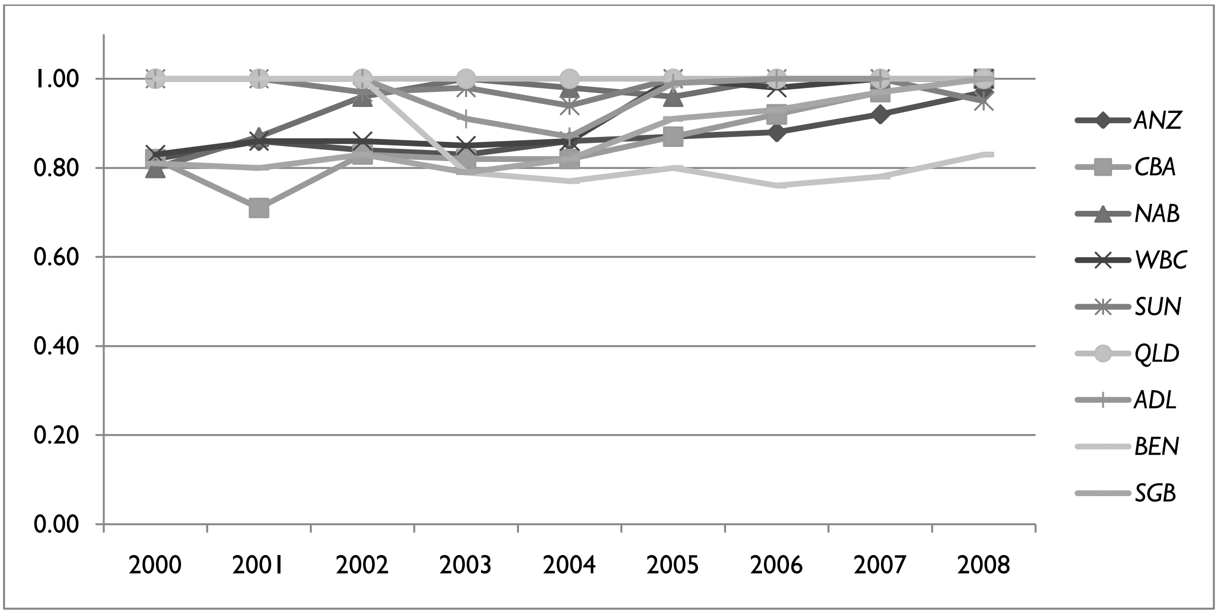
Year	Major banks				Regional banks					Mean	SD
	ANZ	*CBA*	*NAB*	*WBC*	*SUN*	*QLD*	*ADL*	*BEN*	*SGB*		
2000	0.82	0.82	0.80	0.83	1.00	1.00	1.00	1.00	0.81	0.90	0.0917
2001	0.86	0.71	0.87	0.86	1.00	1.00	1.00	1.00	0.80	0.90	0.1001
2002	0.84	0.83	0.96	0.86	0.97	1.00	1.00	1.00	0.83	0.92	0.0742
2003	0.83	0.82	1.00	0.85	0.98	1.00	0.91	0.79	0.79	0.89	0.0834
2004	0.86	0.82	0.98	0.86	0.94	1.00	0.87	0.77	0.82	0.88	0.0732
2005	0.87	0.87	0.96	1.00	1.00	1.00	0.99	0.80	0.91	0.93	0.0696
2006	0.88	0.92	1.00	0.98	1.00	1.00	1.00	0.76	0.93	0.94	0.0764
2007	0.92	0.97	1.00	1.00	1.00	1.00	1.00	0.78	0.97	0.96	0.0685
2008	0.97	1.00	1.00	1.00	0.95	1.00	-	0.83*	1.00	0.97	0.0553
Mean	0.87	0.86	0.95	0.92	0.98	1.00	0.97	0.86	0.87		
SD	0.0471	0.0891	0.0707	0.0762	0.0239	0.0000	0.0514	0.1076	0.0798		

NOTE: *indicates the technical efficiency of the Bendigo and Adelaide Bank Limited; SD (Standard Deviation)

Graph 6.4 Technical efficiency scores: by groups (2000 – 2008)



Graph 6.5 Technical efficiency scores: by individual banks (2000 – 2008)



The result of allocative efficiency is quite different to the result of technical efficiency. Recall that, in the previous Australian studies (Avkiran, 1999; Sathye, 2001; Neal, 2004), technical efficiency is found to be lower than allocative efficiency, and it is claimed that the inefficiency of Australian banks is due to the low technical efficiency. In contrast to the previous studies, this study has found the technical efficiency of Australian banks has been higher than the allocative efficiency during the period of study, which is consistent to Kirkwood and Nahm (2006) as well as the Wallis Report (1995).

Recall that, in Table 6.1, the allocative efficiency scores of the banks are observed to be lower than the technical efficiency scores across the period. In particular, Graph 6.1 shows that the technical efficiency of Australian banks has been improved and maintained close to 1, where the allocative efficiency has been lower than the technical efficiency. In addition, the allocative efficiency change in the graph exhibits a similar pattern of change with the profit efficiency. Therefore, it can be suggested that it is allocative inefficiency that reduces the overall profit efficiency of the banks, rather than technical inefficiency.

Table 6.6 (Graph 6.6) and Table 6.7 (Graph 6.7) present the allocative efficiency scores by groups and by individual banks, respectively. They suggest that, the major banks have been more allocatively efficient than the regional banks across the period (by 30 per cent on average). The regional banks appear to have had improved their allocative efficiency until 2006, and closed the allocative efficiency dispersion with the major banks to 24 per cent. However, the allocative efficiency of the regional banks has rapidly declined in 2008 and reached at 57 per cent. The low allocative efficiency of the regional banks may be attributed to geographical restrictions as well as inferior monitoring activities of the regional banks, as it is suggested by DeYoung and Nolle (1996) and Kirkwood and Nahm (2006).

In Chapter 2, it is discussed that allocative efficiency reflects a bank's ability to choose a set of inputs at given input prices in order to maximise its profit. It means that, the dispersion between the allocative efficiency of the major banks and the regional banks may imply the existence of market power for the major banks, which enables the banks to set input- and output prices in their favour. In fact, the following discussion on the result of price efficiency provides implications for possible correlation between the market structure and the banking efficiency, which supports the results of both technical- and allocative efficiency.

Table 6.6 Allocative efficiency scores: by groups (2000 – 2008)

Year	Major banks	Regional banks	Mean	SD
2000	0.86	0.52	0.69	0.2404
2001	0.86	0.51	0.69	0.2475
2002	0.81	0.51	0.66	0.2121
2003	0.83	0.55	0.69	0.1980
2004	0.85	0.57	0.71	0.1980
2005	0.90	0.63	0.77	0.1909
2006	0.94	0.70	0.82	0.1697
2007	0.95	0.68	0.82	0.1909
2008	0.94	0.57	0.76	0.2616
Mean	0.88	0.58		
SD	0.0519	0.0719		

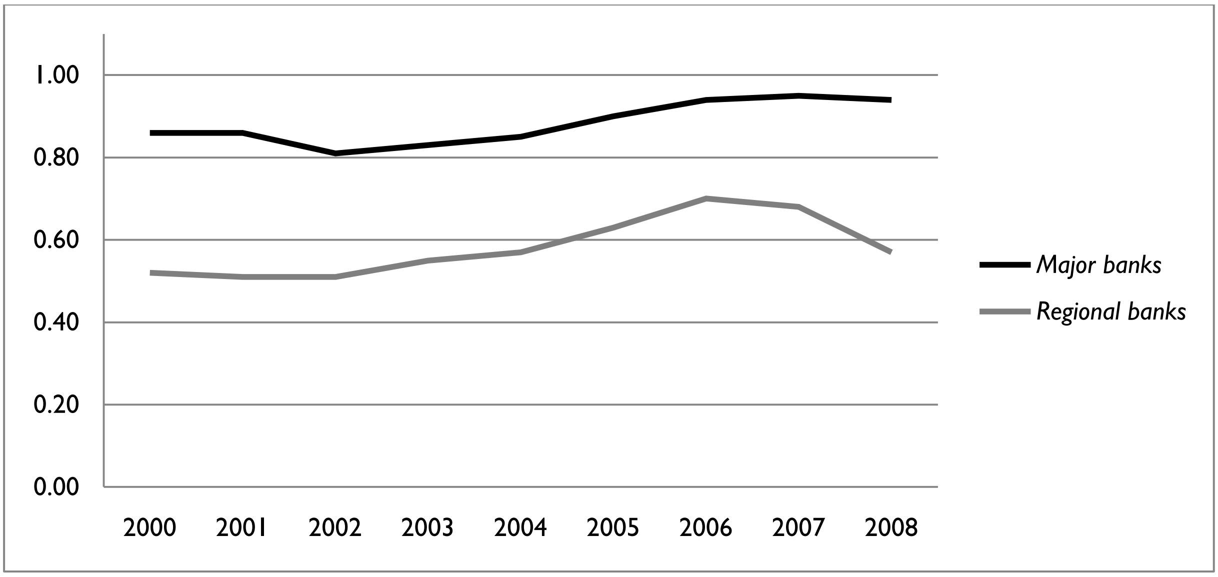
NOTE: SD (Standard Deviation)

Table 6.7 Allocative efficiency scores by individual banks (2000 – 2008)

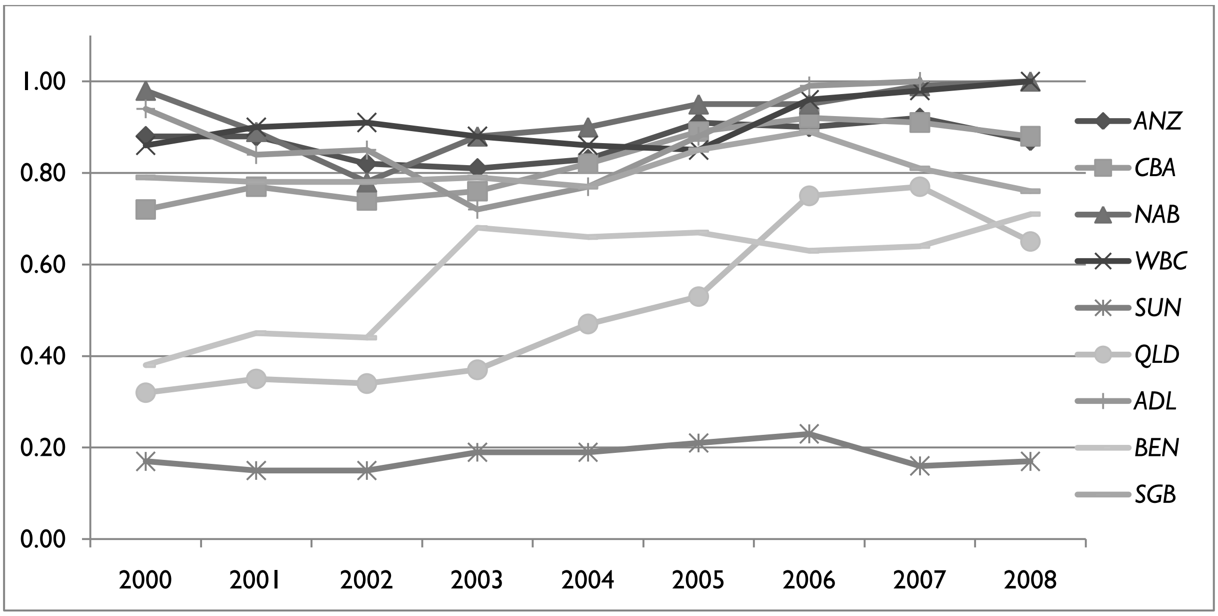
Year	Major banks				Regional banks					Mean	SD
	ANZ	*CBA*	*NAB*	*WBC*	*SUN*	*QLD*	*ADL*	*BEN*	*SGB*		
2000	0.88	0.72	0.98	0.86	0.17	0.32	0.94	0.38	0.79	0.67	0.2834
2001	0.88	0.77	0.89	0.90	0.15	0.35	0.84	0.45	0.78	0.67	0.2619
2002	0.82	0.74	0.78	0.91	0.15	0.34	0.85	0.44	0.78	0.65	0.2513
2003	0.81	0.76	0.88	0.88	0.19	0.37	0.72	0.68	0.79	0.68	0.2244
2004	0.83	0.82	0.90	0.86	0.19	0.47	0.77	0.66	0.77	0.70	0.2163
2005	0.91	0.89	0.95	0.85	0.21	0.53	0.88	0.67	0.85	0.75	0.2282
2006	0.90	0.92	0.95	0.96	0.23	0.75	0.99	0.63	0.89	0.80	0.2292
2007	0.92	0.91	0.99	0.98	0.16	0.77	1.00	0.64	0.81	0.80	0.2519
2008	0.87	0.88	1.00	1.00	0.17	0.65	-	0.71*	0.76	0.76	0.2510
Mean	0.87	0.82	0.92	0.91	0.18	0.51	0.87	0.58	0.80		
SD	0.0401	0.0783	0.0698	0.0560	0.0274	0.1792	0.1000	0.1244	0.0421		

NOTE: *indicates the technical efficiency of the Bendigo and Adelaide Bank Limited; SD (Standard Deviation)

Graph 6.6 Allocative efficiency scores: by groups (2000 – 2008)



Graph 6.7 Allocative efficiency scores: by individual banks (2000 – 2008)



6.4 Price efficiency

In Chapter 5, it is discussed that price efficiency is a measure of a bank's ability to secure the profit maximising input- and output price ratios. In Table 6.1, the price efficiency of Australian banks is found to have been improved, and reached at the maximum of 80 per cent in 2008. It means that the banks' ability of securing input- and output prices, or price-setting ability, has been improved. However, in the previous discussions on the results of technical- and allocative efficiency scores, it is suggested that the existence of market power in the Australian banking sector in favour of the major banks. Therefore, it is necessary to compare price efficiency of the major banks and the regional banks.

Table 6.8 (Graph 6.8) and Table 6.9 (Graph 6.9) present the price efficiency scores by groups and by individual banks, respectively. In Table 6.8 (Graph 6.8), a significant dispersion in price efficiency is observed between the major banks and the regional banks, as it is expected. The results suggest the major banks have maintained almost maximum price efficiency across the period. On the other hand, the regional banks have been extremely price inefficient relative to the major banks.

The extreme dispersion in the price efficiency (excluding St.George Bank) may imply the presence of the market power as well as a strong price-setting ability of the major banks. It can be attributed to the highly concentrated market structure of the Australian banking sector, with the dominance of the major banks, as it is discussed in Chapter 4.

Graph 6.10 shows the shares of the banks, by using the sum of banks' total loans and total deposits as proxy variables of the banks' market share. By combining the result of price efficiency and Graph 6.10, it can be suggested that, if a bank has more than 10 per cent of market share, then the bank would be price efficient. On the other hand, if a bank has less than 5 per cent of market share, then the bank would be pricing inefficient. In the case of St.George Bank (SGB), which is the biggest in the group of regional banks, has 7 per cent of market share and the bank's price efficiency is in between of two extremes, with 66 per cent on average.

Table 6.8 Price efficiency scores: by groups (2000 – 2008)

Year	Major banks	Regional banks	Mean	SD
2000	1.00	0.21	0.61	0.5586
2001	1.00	0.22	0.61	0.5515
2002	1.00	0.23	0.62	0.5445
2003	1.00	0.24	0.62	0.5374
2004	1.00	0.27	0.64	0.5162
2005	1.00	0.32	0.66	0.4808
2006	1.00	0.34	0.67	0.4667
2007	0.98	0.48	0.73	0.3536
2008	0.97	0.63	0.80	0.2404
Mean	0.99	0.33		
SD	0.0113	0.1418		

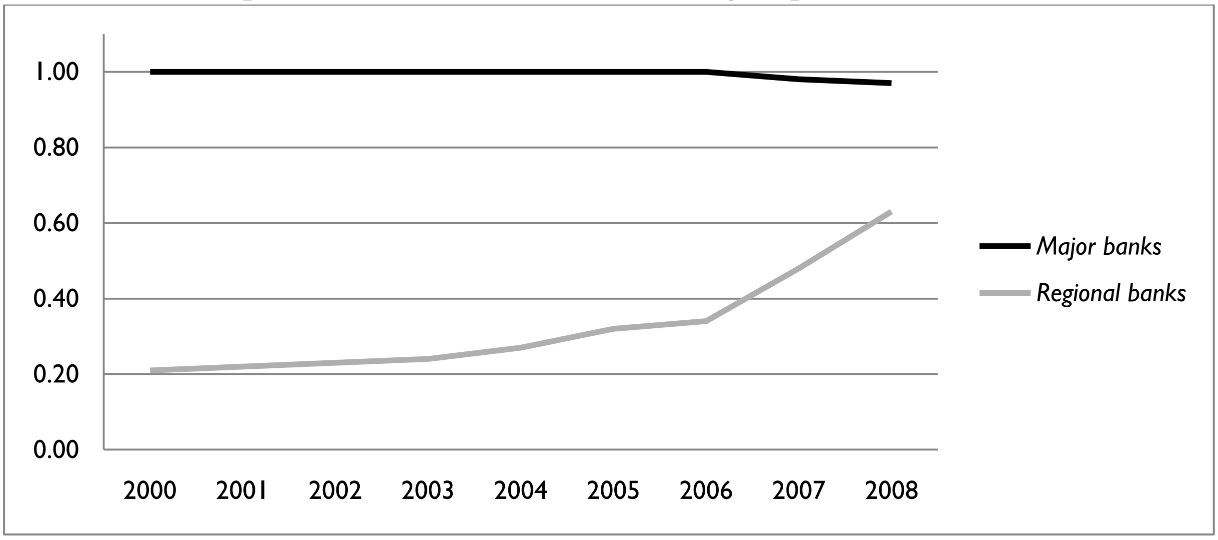
NOTE: SD (Standard Deviation)

Table 6.9 Price efficiency scores: by individual banks (2000 – 2008)

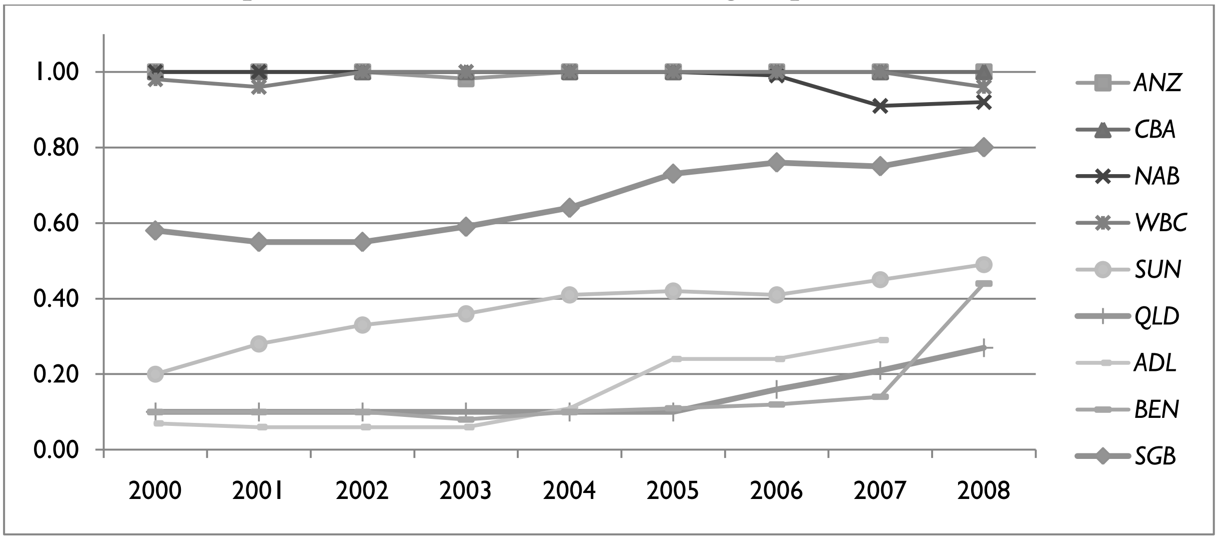
Year	Major banks				Regional banks					Mean	SD
	ANZ	*CBA*	*NAB*	*WBC*	*SUN*	*QLD*	*ADL*	*BEN*	*SGB*		
2000	1.00	1.00	1.00	0.98	0.20	0.10	0.07	0.10	0.58	0.56	0.4151
2001	1.00	1.00	1.00	0.96	0.28	0.10	0.06	0.10	0.55	0.56	0.4072
2002	1.00	1.00	1.00	1.00	0.33	0.10	0.06	0.10	0.55	0.57	0.4082
2003	0.98	1.00	1.00	1.00	0.36	0.10	0.06	0.08	0.59	0.57	0.4068
2004	1.00	1.00	1.00	1.00	0.41	0.10	0.11	0.10	0.64	0.60	0.3969
2005	1.00	1.00	1.00	1.00	0.42	0.10	0.24	0.11	0.73	0.62	0.3807
2006	1.00	1.00	0.99	1.00	0.41	0.16	0.24	0.12	0.76	0.63	0.3710
2007	1.00	1.00	0.91	1.00	0.45	0.21	0.29	0.14	0.75	0.64	0.3444
2008	1.00	1.00	0.92	0.96	0.49	0.27	-	0.44*	0.80	0.74	0.2722
Mean	1.00	1.00	0.98	0.99	0.37	0.14	0.14	0.14	0.66		
SD	0.0061	0.0000	0.0371	0.0176	0.0902	0.0630	0.0982	0.1125	0.0991		

NOTE: *indicates the technical efficiency of the Bendigo and Adelaide Bank Limited; SD (Standard Deviation)

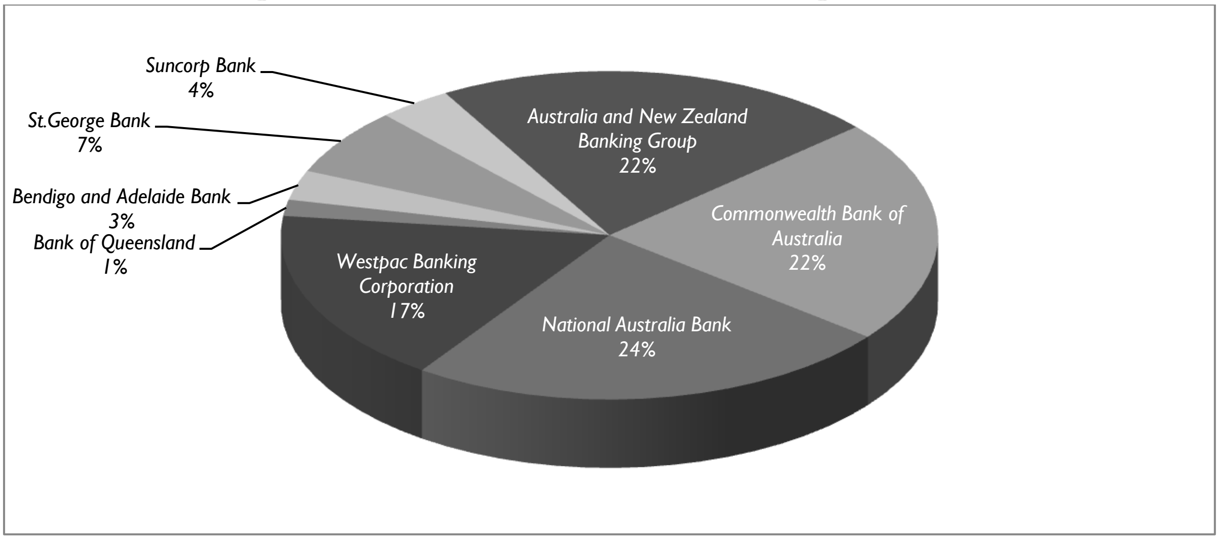
Graph 6.8 Price efficiency scores: by group (2000 – 2008)



Graph 6.9 Price efficiency scores: by group (2000 – 2008)



Graph 6.10 Market shares – Loans and Deposits (2008)



6.5 Spearman Rank Coefficient (SRC) analysis

Profit efficiency and profitability

Bauer, Berger, Ferrier and Humphrey (1998) defined the conditions of consistency between frontier efficiency measures and non-frontier performance measures, with suggesting that, if efficiency scores are measured by conventional frontier approaches, including DEA, then the scores should be correlated to accounting measures of performance, such as return on assets (ROA) or return on equity (ROE). In this regard, this study examines correlation between profit efficiency and the accounting measures of profitability, including ROA and ROE. This study utilises Spearman Rank Correlation (SRC) coefficient analysis, by following Maudos and Pastor (2003).

The SRC analysis is a non-parametric method to examine the relationship between two variables based on the Pearson's correlation coefficient (SRC coefficient), which is given by (6.1).

$$SRC = 1 - \frac{6}{N(N^2 - 1)} \sum_{i=1}^{5} D_i \tag{6.1}$$

where D_i = the difference between the corresponding values of efficiency scores and accounting measures, and N = the number of values. ROA and ROE, which are standard accounting measures of profitability, are computed by (6.2) and (6.3)[2], respectively.

$$ROA = \frac{\text{Operating profit after tax}}{\text{Total assets}} \tag{6.2}$$

$$ROE = \frac{\text{Operating profit after tax}}{\text{Total equity}} \tag{6.3}$$

The summary statistics are provided in Table 6.10, where the statistics are presented graphically in Graph 6.11 (ROA) and 6.12 (ROE), respectively. Table 6.11 presents the estimated SRC coefficients between profit efficiency and ROA as well as ROE.

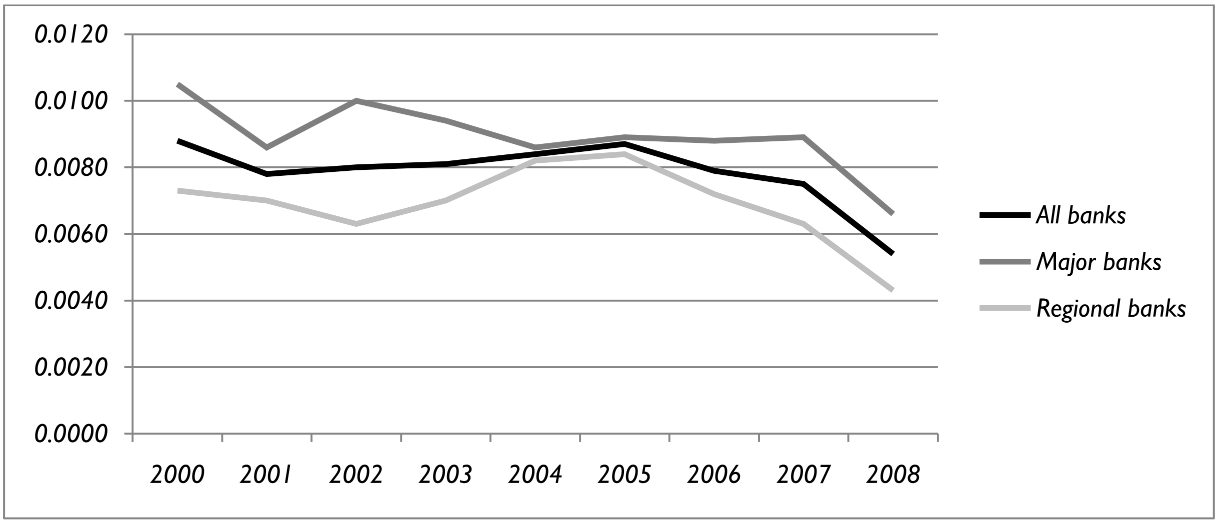
[2] The calculations of ROA and ROE is from Hogan, *et al.* (2004), pp.85

Table 6.10 The ratios of Return on Assets and Return on Equity (2000 – 2008)

Year	Return on Assets			Return on Equity		
	All banks	Major banks	Regional banks	All banks	Major banks	Regional banks
2000	0.0088	0.0105	0.0073	0.1395	0.1655	0.1188
2001	0.0078	0.0086	0.0070	0.1218	0.1397	0.1075
2002	0.0080	0.0100	0.0063	0.1300	0.1599	0.1060
2003	0.0081	0.0094	0.0070	0.1195	0.1331	0.1086
2004	0.0084	0.0086	0.0082	0.1186	0.1199	0.1176
2005	0.0087	0.0089	0.0084	0.1337	0.1418	0.1273
2006	0.0079	0.0088	0.0072	0.1453	0.1603	0.1333
2007	0.0075	0.0089	0.0063	0.1396	0.1727	0.1130
2008	0.0054	0.0066	0.0043	0.1001	0.1328	0.0673
Mean	0.0078	0.0089	0.0069	0.1276	0.1473	0.1110
SD	0.000994	0.001112	0.001218	0.014045	0.017863	0.018785

NOTE: SD (Standard Deviation)

Graph 6.11 Return on Assets (2000 – 2008)



Graph 6.12 Return on Equity (2000 – 2008)

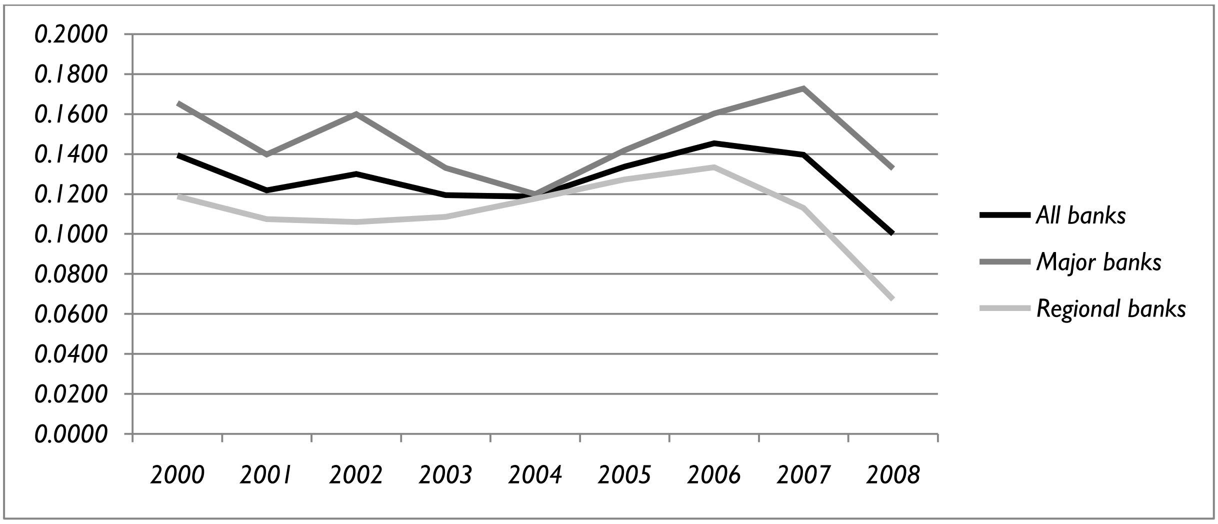


Table 6.11 SRC coefficients: profit efficiency and ROA / ROE

All banks	PE	ROA	ROE
PE	1.00		
ROA	- 0.09	1.00	
ROE	0.35	0.69	1.00
Major banks	PE	ROA	ROE
PE	1.00		
ROA	- 0.48	1.00	
ROE	0.14	0.51	1.00
Regional banks	PE	ROA	ROE
PE	1.00		
ROA	- 0.40	1.00	
ROE	0.15	0.55	1.00

NOTE: PE (Profit efficiency), ROA (Return on Assets), ROE (Return on Equity)

The SRC coefficients in Table 6.11 indicate a positive correlation between profit efficiency and ROE, which means the consistency between the profit efficiency and ROE. However, ROA is found to be negatively correlated to the profit efficiency. It may imply that the profit efficiency of Australian banks measured in this study is inconsistent to ROA, which is a contradict result to Maudos and Pastor (2003).

The inconsistency also can be found by observing the changes in the profit efficiency and ROA of Australian banks in the period of study. Recall that, Table 6.2 and 6.3 (see Section 6.2) have indicated the profit efficiency of Australian banks has been not much changed from 2000. In particular, the major banks are found to have improved their profit efficiency, while the regional banks' profit efficiency are found to be declined until 2004, and improved in 2005 and 2006, which is followed by a decline in 2008.

However, Graph 6.11 shows ROA of all banks has been declined, particularly from 2006, and reached at 0.0054 in 2008, which is the minimum of the period. In contrast to the result of the profit efficiency, the major banks also have experienced a decline in ROA since 2006, similarly to the regional banks. Note that, the decline in ROA for the major banks across the period of study may be explained by an increase in banks' non-traditional activities, which are not recorded in the banks' financial statements and, consequently, have been excluded from the calculation of ROA in this study. On the other hand, Graph 6.12 shows ROE in fact has been changed in a similar pattern to the profit efficiency, except the slump in 2004.

In summary, this study found the positive correlation between the profit efficiency and ROE, where both measures are observed to have been changed in similar pattern in the period of study. On the other hand, the negative correlation is found between the profit efficiency and ROA, which is observed to have been declined on average in contrast to the profit efficiency. Therefore, it can be suggested that the most profitable Australian bank in terms of ROE is the most profit efficient, while the relationship between the profit efficiency and ROA is inconclusive due to the inconsistency between two types of measure.

Note that, Bauer, Berger, Ferrier and Humphrey (1998) found DEA efficiency scores are weakly correlated to accounting measures of profitability[3] at the best, where this study also has found the SRC coefficients for the profit efficiency and ROE are relatively small[4].

Profit efficiency and size factors

This study also attempts to examine the correlation between the profit efficiency of Australian banks and the size factors, including banks' total assets and total equity, by following Färe, Grosskopf, and Weber (2004). They found profit- and allocative efficiencies of US banks are weakly and positively related to the banks' assets and equity, similarly to the majority of the previous studies, including DeYoung and Nolle (1996), Isik and Hassan (2002), Fitzpatrick and McQuinn (2008) as well as Kirkwood and Nahm (2006) in Australia. The SRC coefficient analysis is also utilised in this section. Table 6.13 provides summary statistics of the banks' total assets and total equity, where Graph 6.13 and 6.14 present the information graphically.

[3] Bauer, Berger, Ferrier and Humphrey (1998) found DEA efficiency scores are weakly related to the accounting measures at the best, in contrast to other frontier analysis approaches. For more detailed discussion, see Bauer, Berger, Ferrier and Humphrey (1998), pp.108-109

[4] Note that Tobit regression analysis provided same results as SRC coefficient analysis, where the results from Tobit regression indicated much higher inconsistency between DEA efficiency scores and ROA. Therefore, the results from Tobit regression analysis are not provided.

The SRC coefficients in Table 6.12 indicate strong positive correlations between the profit efficiency and the banks' total assets and total equity. In particular, the correlation between the profit efficiency and banks' total assets is found to be more significant for the major banks, which is consistent to Kirkwood and Nahm (2006). Meanwhile, the SRC coefficients for the profit efficiency and the banks' total equity are found to be similar for both the major banks and the regional banks.

Therefore, it can be suggested that, firstly, the profit efficiency and the size factors, including the banks' total assets and total equity, are positively correlated. Secondly, the SRC coefficients are found to be significant for the profit efficiency and total assets, which means that the banks' total assets may be more appropriate to use to examine a relationship between a bank's size and its profit efficiency.

Table 6.12 SRC coefficients: DEA efficiency scores and Total assets/Total equity

All banks	PE	TA	TEQ
PE	1.00		
TA	0.58	1.00	
TEQ	0.48	0.96	1.00
Major banks	PE	TA	TEQ
PE	1.00		
TA	0.77	1.00	
TEQ	0.44	0.51	1.00
Regional banks	PE	TA	TEQ
PE	1.00		
TA	0.50	1.00	
TEQ	0.42	0.55	1.00

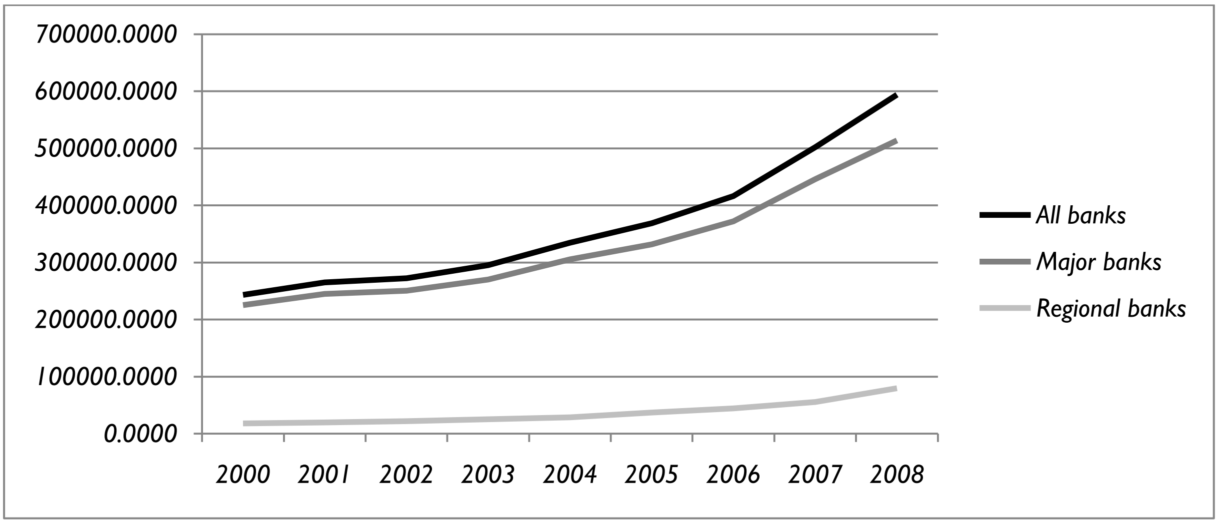
NOTE: PE (Profit efficiency), TA (Total assets), TEQ (Total equity)

Table 6.13 Total assets and Total equity (2000 – 2008)

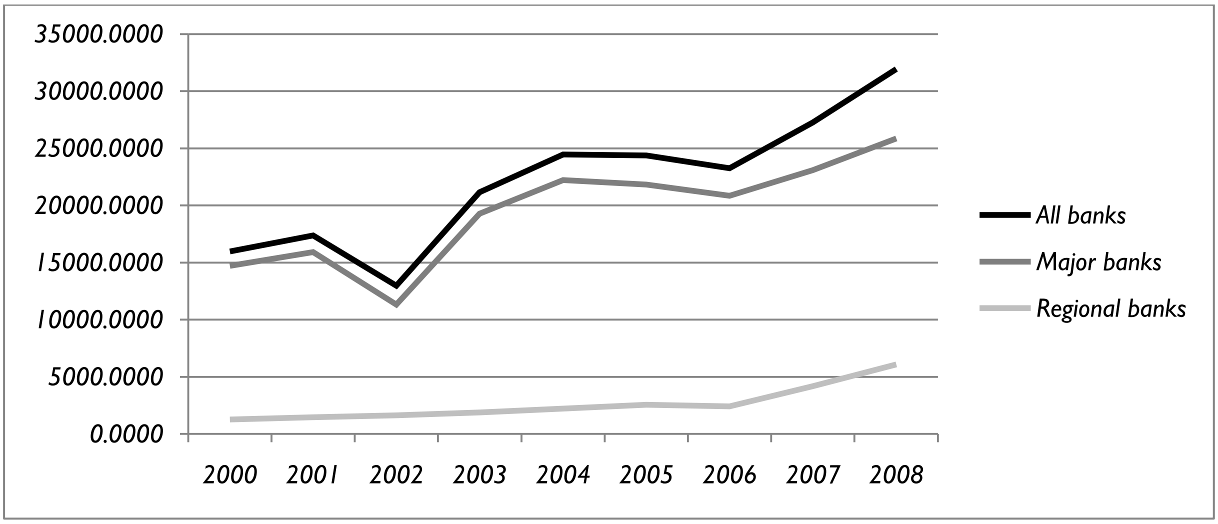
Year	Total assets ($mil)			Total equity ($mil)		
	All banks	Major banks	Regional banks	All banks	Major banks	Regional banks
2000	0.0088	0.0105	0.0073	0.1395	0.1655	0.1188
2001	0.0078	0.0086	0.0070	0.1218	0.1397	0.1075
2002	0.0080	0.0100	0.0063	0.1300	0.1599	0.1060
2003	0.0081	0.0094	0.0070	0.1195	0.1331	0.1086
2004	0.0084	0.0086	0.0082	0.1186	0.1199	0.1176
2005	0.0087	0.0089	0.0084	0.1337	0.1418	0.1273
2006	0.0079	0.0088	0.0072	0.1453	0.1603	0.1333
2007	0.0075	0.0089	0.0063	0.1396	0.1727	0.1130
2008	0.0054	0.0066	0.0043	0.1001	0.1328	0.0673
Mean	0.0078	0.0089	0.0069	0.1276	0.1473	0.1110
SD	0.000994	0.001112	0.001218	0.014045	0.017863	0.018785

NOTE: SD (Standard Deviation)

Graph 6.13 Total Assets ($mil, 2000 – 2008)



Graph 6.14 Total Equity ($mil, 2000 – 2008)



Chapter 7. Conclusion

This thesis has provided an analysis of profit efficiency of Australian banks in the period from 2000 to 2008. In spite of the importance of profit efficiency as a measure of performance and its consistency to the economic objective of profit maximisation, the technical difficulties associated to measure profit efficiency made it to be relatively understudied in Australia than its counterparts, such as cost- and/or *x*-efficiency as well as productivity changes. However, the recent developments in econometrics have enabled to take advantages of the newly developed measurement techniques to measure profit efficiency.

This study have utilised Data Envelopment Analysis (DEA), the directional distance function and the norm-based profit index approach to measure profit efficiency of Australian banks. Technical-, allocative- and price efficiencies of the banks are provided by decomposing the profit efficiency. Because the measurement techniques are recently introduced and have been utilised in only a limited number of studies, Chapter 2 and Chapter 5 are devoted to provide introductions to the techniques.

DEA has been widely used in the banking efficiency studies and has been the most preferred measurement technique in the previous Australian studies as well as this study. The popularity of DEA in Australia can be attributed to, firstly, its flexibility as a non-parametric approach, and secondly, it works reasonably well with a small-sized sample, such as the Australian banking sector. This thesis has measured profit efficiency of Australian banks by estimating the directional distance between the banks and DEA efficiency frontier, which are computed by the directional distance function and DEA.

The results from DEA then are used to compute profit efficiency, by following the norm-based profit index approach. It is different to the conventional profit efficiency measures, because it directly calculates allocative efficiency. Price efficiency of the banks, which has not been provided in any previous Australian study, is computed by following the norm-based index approach as well.

This study has found profit efficiency of Australian banks has not been improved on average in the period of study. Meanwhile, the major banks and the regional banks are observed to have experienced different patterns of change in their profit efficiency. It is explained by the different revenue compositions as well as the difference in the volume non-traditional activities of two groups of bank. In addition, the case of Suncorp Bank has showed the significance of data specification in efficiency analyses as well as the sensitivity of efficiency measures to variable specification, which is also suggested by Neal (2004).

The decomposition of profit efficiency revealed that allocative efficiency is lower than technical efficiency of the banks, with indicating that Australian banks have maintained their technical efficiency relatively higher than the allocative efficiency. The major banks are found to be more allocatively and price efficient than the regional banks, where the dispersion in the price efficiency is much greater than in the allocative efficiency. It implies that the persistent dominance of the major banks has given the market power as well as price-setting ability to the major banks. Consequently, it would have prevented the regional banks to improve their performances, which is observed with low profit-, allocative- and price efficiencies of the regional banks.

The results of this study have provided the following implications for the impact of the Wallis Report (1997) and subsequent regulatory changes on the Australian banking sector. Firstly, the regulatory changes may have been worked in favour of the major banks, rather than improving the efficiency of the Australian banking sector. Secondly, the abolition or relaxation of anti-merger policy should be carefully considered as it appears that premature abolition of anti-merger policy in the Australian banking sector would increase the degree of concentration, which would have adverse effects on the efficiency of the Australian banking sector.

This study also has provided the results of Spearman Rank Correlation (SRC) coefficient analysis, in order to observe correlation between profit efficiency and the accounting measures of profitability (ROA and ROE) as well as the banks' size factors (total assets and total equity). In contrast to the previous studies, such as Maudos and Pastor (2003), this study has failed to find consistency between profit efficiency and ROA, as it is observed that they are negatively correlated. However, profit efficiency and ROE as well as the banks' size factors are found to be positively correlated, despite the size of SRC coefficients are small. It suggests that profit efficiency and ROE as well as the size factors are weakly consistent.

This study has made some contributions by utilising newly developed measurement techniques, including the directional distance function and the norm-based profit index approach, as well as by providing profit efficiency measures for Australian banks. However, further researches for this subject are necessary, due to the following limitations of this study.

Firstly, the number of banks in the sample of this study is the smallest, in comparison to the previous Australian studies. The limited availability of data was the main constraint on data specification, since the financial data for the period of study were available for only 9 Australian domestic banks. However, it is evident that more banks in the sample would produce more reliable efficiency measures. In addition, the extended coverage of banks' financial statements would be important for further researches in order to reflect the full aspects of Australian banks' activities correctly.

Secondly, this study does not provide an index of productivity changes due to the limitations of the intermediation approach, which is adopted by this study to specify input- and output variables. As it is discussed in Chapter 5, the intermediation approach is inappropriate to use to compute conventional productivity indices, such as the Malmquist index of productivity changes, unless it covers 100 per cent of banks' financial statements. The value-added approach has been suggested as an alternative to the intermediation approach, when it is required to obtain an index of productivity changes.

Thirdly, this study has not provided implications of the global financial crisis in 2007 for the Australian banking efficiency, because of its limited period coverage up to 2008. Despite this study has found a decline in the banking efficiency after 2007, it is insufficient to discuss the implications of the financial crisis. However, it is important to take account of the global financial crisis in the banking efficiency analyses in the future, because of its significant impacts on the international financial market as well as the Australian banking sector.

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