ELSEVIER Journal of Banking & Finance 25 (2001) 613–630

Journal of BANKING & FINANCE

www.elsevier.com/locate/econbase

X-efficiency in Australian banking: An empirical investigation

Milind Sathye *

The University of Southern Queensland, Department of Finance and Banking, Toowoomba, QLD 4350, Australia

Received 18 July 1999; accepted 15 June 2000

Abstract

This paper empirically investigates the *x*-efficiency (technical and allocative) in Australian banks. A non-parametric method of Data Envelopment Analysis (DEA) has been used to arrive at the efficiency scores. Banks in this sample were found to have low levels of overall efficiency compared with the banks in the European countries and in the US. The results indicate that, as a source of overall inefficiency, the technical component was more important than the allocative component. Thus, the inefficiency in Australian banks can be attributed to wasting of inputs (technical inefficiency) rather than choosing the incorrect input combinations (allocative inefficiency). Domestic banks were found to be more efficient than foreign owned banks. The study has important implications such as guiding the government policy regarding deregulation and mergers. Since the study pinpoints the sources of inefficiency, it would also help banks with strategic planning.

JEL classification: D61; G21; G34

Keywords: Bank efficiency; Mergers; DEA analysis

* Tel.: +61-7-4631-2789; fax: +61-7-4631-2625.
E-mail address: sathye@usq.edu.au (M. Sathye).

0378-4266/01/$ - see front matter
PII: S0378-4266(00)00156-4

1. Introduction

The three objectives of this paper are (1) to investigate the overall (economic), technical and allocative efficiency (also called *x*-efficiency) of Australian banks and compare it with the banks from other countries, (2) to investigate whether domestic banks are more or less efficient than foreign owned banks in Australia and (3) to determine which factors influence the above three types of efficiencies. The overall, technical and allocative efficiency was measured using Data Envelopment Analysis (DEA), ANOVA was performed to find the difference in efficiency of domestic and foreign banks, and least square regression was used to determine the factors influencing efficiency.

The examination of *x*-efficiency in banking has important public policy implications in the Australian context. Firstly, the principal aim of the Wallis Inquiry Report (1997) itself was to achieve a more competitive and efficient financial system. The banking industry is a vital part of the financial system in any country. Hence, the assessment of its efficiency is important. In particular, a study of *x*-efficiency is important since Berger et al. (1993), found that *x*-inefficiencies account for around 20% or more of costs in banking. However, scale and product mix inefficiencies, when accurately estimated, are usually found to account for less than 5% of the costs. The Wallis Inquiry Report (1997) has estimated that even a 10% improvement in efficiency of the financial system would translate into cost savings for the economy in excess of $4 billion per annum. Secondly, after the Wallis Inquiry Report (1997) recommended the removal of the six-pillar policy (which banned the merger of the "Big Four" banks in Australia), the efficiency effects of bank mergers, which may create still bigger size banks, are being debated. The Wallis Inquiry states that there is room for the Australian banking industry to become more efficient and in this context states that size alone does not determine the levels of efficiency. It will be interesting to study which other factors determine efficiency, as it could help banks with strategic planning and also help the policy-making bodies create, if needed, an appropriate regulatory environment. Thirdly, in the context of executive salary increases, the performance of corporations (which includes banks) is being increasingly examined. A statement by the Governor of the Reserve Bank of Australia (RBA) that "executive salary increases has not related to company performance" (McKinnon and Riggert, 1999) recently made headlines in Australian newspapers. In addition, a pay-out of $13 million to an outgoing CEO of an under-performing financial institution has further brought this issue in focus. Hence, the assessment of *x*-efficiency (managerial efficiency) becomes important in the Australian banking context. Lastly, despite the importance of efficiency studies, the literature on efficiency in Australian banking is limited (discussed in a subsequent section of this paper) in comparison to that of US banking. A recent review of 130 studies across 21 countries by Berger and Humphrey (1997) does not contain any Australian

study. Berger et al. (1993) state "much more research is needed measuring and comparing the efficiency of banks". Molyneux et al. (1996, p. 273) also support this view when they state that "a great deal more work is needed on *x*-efficiency research in banking". In comparison to scale and scope economies, "managerial efficiency, the concept of *x*-efficiency, appears to be a much more important strategic and policy consideration". In view of the above, a study of *x*-efficiency in Australian banks will be useful to various interest groups such as the Commonwealth Government, Reserve Bank of Australia, and the community. Hence, the present study proposes to address the issue of *x*-efficiency in Australian banks.

To measure *x*-efficiency, the institutions that perform better relative to a particular standard are separated from those that perform poorly. Such separation is done either by applying a non-parametric or parametric frontier analysis to firms within the financial services industry. The parametric approach includes stochastic frontier analysis, the free disposal hull, thick frontier and the Distribution Free Approaches (DFA), while the non-parametric approach is DEA (Molyneux et al., 1996). In this paper, the DEA approach has been used. This approach has been used since "recent research has suggested that the kind of mathematical programming procedure used by DEA for efficient frontier estimation is comparatively robust" (Seiford and Thrall, 1990). Furthermore, according to Charnes et al. (1978) who coined the term DEA, a "large number of papers have extended and applied the DEA methodology" (Coelli, 1996). Again, DEA was the chosen methodology in preference to stochastic frontier estimation, since it has been applied in prior studies when the sample size was small.

The rest of the paper has been organised as follows. Section 2 reviews various international and Australian studies on efficiency of financial institutions, Section 3 briefly introduces the non-parametric methodology of DEA, Section 4 specifies bank costs, outputs and inputs, Section 5 concerns the data and results, and Section 6 provides concluding comments.

2. Overview of the efficiency studies

2.1. Efficiency studies: International

Many studies examining the scale and scope efficiencies in banking markets have been undertaken in the last 30 years. These studies stem from the works of Benston (1965) and Bell and Murphy (1967). Clark (1988) reviews 13 studies-which, inter alia, include those by Gilligan et al. (1984), Kolari and Zardkoohi (1987), and Berger et al. (1987). These early studies measured economies of scale using the Cobb–Douglas production form. The studies also made assumptions regarding the lack of interdependence among outputs and the lack

the flexibility necessary if the data estimates a U-shaped cost curve. Some of the studies, for example, Benston et al. (1982), Lawrence and Shay (1986) and Hunter and Timme (1986) use the more flexible quadratic functional form, that is, the translog cost function. Some of the scope efficiency studies that followed the above studies include those by Dietsch (1993) on French banking, Fanjul and Marvall (1985) on Spanish banking, Baldini and Landi (1990) on Italian banking and Sheldon and Haegler (1993) on Swiss banking.

The second stream of studies investigates the technical and allocative efficiencies. These studies use Farrell's (1957) approach to analyze efficiency. This stream, inter alia, includes studies by Sherman and Gold (1985), Parkan (1987), Vassiloglou and Giolias (1990), Tulkens (1990), Elysiani and Mehdian (1990), Field (1990), Drake and Weyman Jones (1992), and Berg et al. (1993). A comprehensive review of efficiency studies of financial institutions in 21 countries has been provided by Berger and Humphrey (1997).

2.2. Australian studies

Turning to the Australian scene, one finds limited research on the scale/scope efficiencies of financial institutions. Garden (1998) states that "to date there have been 12 studies of which six relate to banking – Edgar, Hatch and Lewis (1971), Burgess and Walker (1978), Valentine and Williamson (1982) and Walker (1994), Swan and Harper (1982) and Swan and Summonds (1988). Four studies relate to building societies – Bartlett and Crapp (1977), Elstone (1980), Crapp (1982) and Esho and Sharp (1993) and three to credit unions – Crapp (1983), Brown and O'Connor (1995)". These studies have used either the Cobb–Douglas production function or the translog functional form.

Only a few studies have examined the *x*-efficiency of financial institutions. Garden and Ralston (1999) have studied the efficiency effects of credit union mergers using DEA. Worthington (1996) compares efficiency measures using DEA with respect to 63 credit unions. Brown and O'Connor (1996) use DEA to measure the relative efficiency of Victorian credit unions. Esho and Sharpe (1996) have completed a detailed study of *x*-efficiency in Australian Building Societies. With regard to *x*-efficiency in Australian banks, only two studies were found. Walker's (1998) paper focuses on measuring the scale economies in Australian banks for the period 1978–1990 and thereafter uses the fixed effect version of the stochastic frontier approach to measure *x*-efficiency. Walker concedes that the fixed effect approach possesses limitations, one of which is that it imposes a constant level of efficiency for each bank across the sample time period. Molyneux et al. (1996) have also emphasized the limitations of this approach. Avkiran (1999b) measures operating efficiencies, employee productivity, profit performance and average relative efficiency of Australian trading banks for the period from 1986 to 1995 using DEA. The

stress in his study was on determining the extent to which efficiency gains are passed on to the public and whether mergers should be promoted for efficiency gains.

This paper uses DEA to study efficiency in Australian banks in the period subsequent to that studied by Walker and Avkiran. Additionally, it compares the efficiency of Australian banks with banking efficiency indices in other countries and the efficiency of two groups of banks, that is, domestic and foreign. Berger and Humphrey (1997, p. 17) state that "cross-country studies can provide valuable information regarding the competitiveness of banks in different countries, a concern of particular importance in the increasingly ... globalised financial markets of the future". A comparison of domestic and foreign banks is important since Berger and Humphrey (1997, p. 34) state that efficiency differences associated with foreign versus domestic ownership are of concern and to date four studies in US and one in India have compared such differences. Molyneux et al. (1996, p. 274) support the view that such comparison is a key area requiring more research. More importantly, by regression, this paper provides an in-depth analysis of the sources of Australian bank efficiency by studying the factors that may influence the overall (economic), technical and allocative efficiency. A regression of efficiency vis-à-vis possible factors influencing it has been constructed. Among others, the independent variables used are size and market power. Berger and Humphrey (1997, p. 25) state that the evidence concerning "market power and efficiency" is limited. The regression results will have implications for the policy on mergers and deregulation in Australia which is indicated in subsequent paragraphs of this paper.

3. The DEA methodology

DEA is a linear programming technique initially developed by Charnes et al. (1978) to evaluate the efficiency of public sector non-profit organisations. "Sherman and Gold (1985) were the first to apply DEA to banking" (Molyneux et al., 1996). DEA calculates the relative efficiency scores of various Decision-Making Units (DMUs) in the particular sample. The DMUs could be banks or branches of banks. The DEA measure compares each of the banks/branches in that sample with the best practice in the sample. It tells the user which of the DMUs in the sample are efficient and which are not. The ability of the DEA to identify possible peers or role models as well as simple efficiency scores gives it an edge over other methods. Fried and Lovell (1994) have given a list of questions that DEA can help to answer. Readers interested in the details of the various frontier measurement techniques are encouraged to consult the works of Banker et al. (1989), Bauer (1990), Seiford and Thrall (1990), Aly and Seiford (1993), etc. There are a number of software options for running DEA. This study uses the software (DEAP) developed by Coelli (1996)

to calculate the technical, allocative and cost efficiency scores of Australian banks in the sample.

4. Specification of inputs, outputs and prices

The definition and measurement of bank outputs has been a matter of long-standing debate among researchers. For defining inputs and outputs, prior research studies adopt either the intermediation or production approach. Under the production approach, a financial institution is defined as a producer of services for account holders, that is, they perform transactions on deposit accounts and process documents such as loans. Hence, according to this approach, the number of accounts or their related transactions best measures output. Sherman and Gold (1985), Ferrier and Lovell (1990), and Fried et al. (1993) follow this approach. The inputs include the number of employees and physical capital. Under the intermediation approach, financial intermediaries are institutions that convert and transfer financial assets between surplus units and deficit units. For this approach, output is defined as the dollar value of deposits and loans while inputs include labour, fixed assets and equipment and loanable funds. This study uses the intermediation approach. This approach has been found to be more relevant for financial institutions as it is inclusive of interest expenses which often account for one-half to two-thirds of total costs (Berger and Humphrey, 1997).

In this study, the inputs used in the calculation of the various efficiency measures are labour ($X1$), capital ($X2$) and loanable funds ($X3$). The outputs used in this study are loans ($Y1$) and demand deposits ($Y2$). This selection of inputs and outputs follows the studies by Aly et al. (1990) and Hancock (1986), wherein the author develops a methodology based on user costs to determine the outputs and inputs of a banking firm. However, Aly et al. (1990) have classified one of the outputs, that is, loans, into four groups, for example, real estate loans, commercial and industrial loans, consumer loans and all other loans. In this study, such classification has not been done and all the loans are grouped as one output. This has been done so that the number of outputs and inputs are in proportion to the sample size.

The sample size in this study (29 banks) is larger than that used in some of the studies in the DEA literature. Avkiran (1999b) has given a table of small sample size studies in DEA literature. The sample size used in this study exceeds all of those. Further, the sample size also exceeds the rule of thumb given by Soteriou and Zenios (1998) and Dyson et al. (1998) who state that it should be larger than the product of the number of inputs and outputs. Nunamaker (1985) holds the view that the sample size should be at least three times larger than the sum of the number of inputs and outputs. Evanoff and Israilevich (1991) quoted in Avkiran (1999a) state that DEA can be used with small sample sizes.

Turning to the inputs and outputs, the number of full-time staff has been used as a measure of labour. Capital represents the book value of premises and fixed assets the net of depreciation and has been measured in millions of dollars. Loanable funds include time deposits, savings deposits and other borrowed funds and have been measured in million of dollars. $P1$, the price of labour, was arrived at by dividing the total dollar expenditure on employees by the total number of employees ($X1$). $P2$, a proxy for the price of capital, was derived by taking total expenditures on premises and fixed assets divided by book value ($X2$). $P3$, the price of loanable funds, was derived by taking the sum of interest expenses on deposits and other loanable funds divided by loanable funds ($X3$). The two outputs used in this study are measured in millions of dollars.

5. Data and empirical results

As of 30 June 1996, Australia had 32 locally incorporated banks (20 domestic and 12 foreign) and 19 branches of foreign banks (RBA, 1996). As the locally incorporated banks were subject to similar regulatory requirements, the sample was drawn from these banks. Availability of data dictated the selection of year and inclusion of banks in the sample. A sample of 29 out of the total 32 locally incorporated banks has been used. Three banks (Primary Industries Bank of Australia, St George Partnership Banking Ltd, and Bank of South Australia) had to be excluded from the sample, as their financial data was not available from any source. The sample includes the Big Four banks, which together controlled about 66% of the total banking assets in Australia in 1996. The data on inputs and outputs were collected from the banks, their annual reports, the KPMG Financial Institution Performance Survey (KPMG, 1996) and the Reserve Bank of Australia Bulletin for the year of 1996.

5.1. Efficiency estimates of pooled sample

Some sample statistics have been presented in Table 1. Summary statistics of calculated values of the various efficiency measures have been presented in Table 2.

The overall efficiency score of Australian banks was found to be 0.58 in the year of 1996. This comes closer to Avkiran's (1999b) study of Australian banking efficiency. As per his Model B, the scores range between 37.23% (1986) and 79.43% (1994) and to about 40% in 1995. Avkiran uses a 2×2 set of inputs and outputs, while in this study a 3×2 set has been used and the year of reference is also different. Further, DEA is sensitive to the variables included in the analysis. Avkiran uses staff numbers and deposits as inputs while in this study, the additional input is capital, and in addition to deposits, borrowings

Table 1
Descriptive statistics: Sample[a]

	N	Minimum	Maximum	Mean	S.D.
*Y*1	29	172	57,709	10,954	17,955
*Y*2	29	13	31,845	4175	7860
*X*1	29	59	47,178	6458	13,522
*X*2	29	3	2330	286	515
*X*3	29	85	61,298	10,299	16,919
*P*1	29	0.03	0.6	0.09	0.11
*P*2	29	0.01	1.17	0.42	0.35
*P*3	29	0.04	0.42	0.10	0.07

[a] Loans (*Y*1), demand deposits (*Y*2), labour (*X*1), capital (*X*2), loanable funds (*X*3), price of labour (*P*1), price of capital (*P*2) and the price of loanable funds (*P*3). All variables are measured in millions of Australian dollars except *X*1, which is measured in terms of number of employees.

Table 2
Descriptive statistics: Efficiency measures[a]

	Minimum	Maximum	Mean	S.D.
TE	0.39	1.00	0.67	0.17
AE	0.57	1.00	0.85	0.11
OE	0.22	1.00	0.58	0.18

[a] TE – Technical efficiency, AE – Allocative efficiency, OE – Overall efficiency such that $OE = TE * AE$.

are also included in loanable funds. A further improvement is the inclusion of weights represented by price of labour, capital and loanable funds. Thus, the effect of interest expenses has also been captured.

A sharp decline in efficiency from about 80% in 1994 to about 40% in 1995, as per his Model B, has not been explained by Avkiran. A possible explanation can be offered by the study of the inputs and outputs used by Avkiran. Staff costs have increased as the staff numbers have gone up from 179,648 (1994) to 182,140 (1995). The interest costs have increased because the proportion of non-interest bearing deposits has declined from 10 (1994) to 8 (1995) and fixed deposits increased from 61 (1994) to 66 (1995). On the other hand, the outputs in his study (net loans and net interest income) did not show an increase. The growth rate of loans has declined from 0.085 (1994) to 0.066 (1995). Hence, the overall effect appears to be a sharp decline in the efficiency score. In 1996 (the year of this study), while the staff numbers increased, banks have held the deposit proportion at the 1995 level. Importantly, on the output side, loans exhibited a substantial increase. These factors may, to some extent, explain an upward swing in the efficiency score in 1996.

The overall efficiency score fits within the range of the scores found in other overseas studies but is lower than the world mean efficiency. "The mean efficiency value was 0.86 with a range of 0.55 (UK)–0.95 (France)" (Berger and Humphrey, 1997, p. 17). A mean efficiency score that is lower than the world

mean implies two things. Firstly, that there is a need for Australian banks to further improve efficiency so as to achieve world best practice. The government also needs to help banks by creating an appropriate policy environment that promotes efficiency. Studies show that there is room for further opening of financial services. "Hong Kong has more open financial services trade than Australia" (Claessens and Glaessner, 1998). Secondly, that the Australian banking market is more concentrated than the banking markets overseas. Berger and Hannan's (1989) study found that banks in more concentrated markets exhibited poorer efficiency. For example, the figures of the concentration ratio and DEA efficiency scores were 0.27 and 0.84 (Spain), 0.28 and 0.98 (Italy), 0.57 and 0.56 (Swiss) and 0.63 and 0.58 (Australia), respectively. Regression results presented in the next paragraph support the view that market concentration actually reduces efficiency. This has important implications for the removal of the six-pillar (now known as the four-pillar) policy as discussed later in this paper.

The cross-country comparison of efficiency scores needs to be read with caution. Firstly, as Berger and Humphrey (1997, p. 17) state:

> cross-country comparisons are difficult to interpret because the regulatory and economic environments faced by financial institutions are likely to differ importantly across nations and because the level and quality of service associated with deposits and loans in different countries may differ in ways that are difficult to measure.

Secondly, as Berger et al. (1993, p. 228) suggest, even where the same technique is used, results can be sensitive to the specification and measurement of input and output variables. Thirdly, the data of concentration ratios and efficiency scores have been taken from two different sources and as such may not be directly comparable. The concentration ratio data were taken from Goldberg and Rai (1996) and DEA efficiency scores from Berger and Humphrey (1997, p. 17). For Australia, the scores have been calculated.

The technical efficiency of Australian banks in the sample was lower than their allocative efficiency. Technical efficiency relates to the productivity of inputs. Australian banks need to improve the productivity of the three inputs (capital, labour and loanable funds) included in this study. The banks are already reducing their capital asset ratio and shedding excess staff, as evidenced by the decline in staff numbers in 1997 and further in 1998. The banks may like to continue with these policies so as to optimize the inputs. With regard to the loanable funds input, garnering increasingly low cost deposits and deploying these in more remunerative channels could help. However, in both these areas, banks are likely to face stiff competition. The banks need to reduce the ratio of operating expenses to both total assets and operating income. This has already happened and the ratio has shown a decline in the last few years. Banks could

further reduce this ratio by encouraging customers to migrate to telephone banking and Internet banking which have been found to be cost effective ways for the delivery of financial services. However, by June 1996, only one bank in Australia was providing transactional Internet banking and to date only nine banks provide such service.

The allocative efficiency of Australian banks was found to be very high. This could be ascribed to a judicious combination of inputs (capital, deposits and staff) and outputs (loans) achieved by the Australian banks. To further improve allocative efficiency, banks need to rationalize their fee structure so as to fully reflect underlying costs. The Wallis Inquiry Report advocates banks to rationalize their fee structure and to date the banks have implemented this change. The Reserve Bank of Australia found that the fee income of banks grew by 21% in 1998 alone (RBA, 1999). But banks also need to pass on the benefits of increased efficiency to customers if they want to avoid the wrath of consumer organizations, something that was recently experienced in Queensland. This does not appear to be happening. Avkiran's (1999b) study showed mixed evidence regarding the extent to which the benefits of efficiency gains are passed on to the public.

5.2. Regression analysis of pooled sample

5.2.1. Dependent variable: Overall efficiency

Regression analysis was used to determine whether the overall efficiency indices derived from the pooled sample are related to the size of the bank (measured by total assets), market power (measured by log of deposits), ownership (dummy variable 0 = domestic banks and 1 = foreign banks), use of technology (proxied by number of bank owned ATMs) and cost per employee (Stfcost). Size, market power, ownership of ATMs and cost per employee were expected to have a positive relationship to efficiency while no sign was postulated for the ownership variable. Efficiency is postulated to have a positive relationship to the two variables viz. ownership of ATMs and per staff cost, because as Berger (1995) suggests, "firms with superior management or production technologies have lower costs" and thus increased efficiency. It is possible that superior managerial staff will demand higher pay thus creating a higher per staff cost, though the overall staff cost may be lower due to redundancies. The annual reports of banks actually reveal a reduction in number of staff on one hand and a rise in total staff cost on the other hand, thus indicating higher per staff cost. The results are shown in Table 3.

The regression on overall efficiency shows that the variable logdepo (market power) has a significant negative influence on efficiency. Studies by Edwards and Heggestad (1973) show that in highly concentrated markets, uncertainty avoidance or risk aversion rather than profitability and efficiency become the objectives of some banks. Market power (concentrated market) can thus lead

Table 3
Dependent variable: Overall efficiency[a]

Variable	Coefficient	S.E.	*t*-value	Sig of *t*
Constant	1.097	0.261	4.207	0.000
Owner	−7.14E−02	0.076	−0.939	0.557
Stfcost	0.668	0.286	2.337	0.029
Assets	−1.84E−06	0.000	−0.314	0.756
Logdepo	−7.07E−02	0.033	−2.145	0.043
ATM	1.703E−04	0.000	0.811	0.426

[a] *R*-squared 0.36, *F* 2.626, Sig of *F* 0.05 (Owner – dummy variable 0 for domestic ownership and 1 if otherwise, Stfcost – per staff cost, Assets – amount of total assets, Logdepo – log of deposits, ATM – number of bank owned automated teller machines).

to reduced efficiency. The Wallis Inquiry Report (1997, p. 199) recognized the fact that lack of competition (market concentration) in the Australian financial services market is adversely affecting efficiency. Walker (1998) states that Australian banking is a highly concentrated industry, dominated by four major banks and that bank mergers between the major banks might raise costs if a decline in their *x*-efficiency, flowing from reduced competition, were to outweigh the scale cost efficiencies flowing from their increased size. Mergers could further strengthen the market power. With high degree of concentration it is possible that, in Australia, the "quiet life" hypothesis may have come into play. This hypothesis predicts a reverse causation, that is, as firms enjoy greater market power and concentration, inefficiency follows not because of non-competitive pricing but more so because of a relaxed environment with no incentives to minimize costs. The RBA Governor's statement on executive pay and managerial performance is a pointer to this possibility of a quiet life. If market concentration is leading to lower efficiency, then the merger of the Big Four banks (abolishing of the four-pillar policy) may need to be approached with caution. Another significant variable is per employee cost, which shows a positive relationship to overall efficiency as postulated.

5.2.2. Dependent variable: Technical efficiency

A regression model of technical efficiency and three independent variables, that is, ATMs, size and market power, yielded the following results (see Table 4).

The variable logdepo (market power) has again a significant negative relationship to the dependent variable, indicating that further concentration will reduce this type of efficiency.

5.2.3. Dependent variable: Allocative efficiency

To explain allocative efficiency – which is concerned with the mix of inputs and outputs – five independent variables, that is, number of branches, number

Table 4
Dependent variable: Technical efficiency[a]

Variable	Coefficient	S.E.	*t*-value	Sig of *t*
Constant	1.219	0.206	5.911	0.000
ATMs	1.764E−04	0.000	0.867	0.394
Assets	−1.378E−06	0.000	0.244	0.809
Logdepo	−7.146E−02	0.028	−2.530	0.018

[a] *R*-squared 0.27, *F* 3.085, Sig of *F* 0.046. (ATMs – Number of Automated Teller Machines, Assets – amount of total assets, Logdepo – log of deposits).

of staff, log of deposits, log of loans and capital, were used. Branches and staff numbers have been used as independent variables in earlier studies on bank efficiency. A negative sign was postulated for these two variables, because as per the Wallis Inquiry Report (1997, p. 209) downsizing both will raise efficiency. The remainder of the variables were expected to influence allocative efficiency positively. The results obtained are shown in Table 5.

The variable logdepo (market power) has a significant negative relationship to allocative efficiency which indicates that further concentration will also reduce this type of efficiency. Log of loans has a significant positive coefficient, indicating that output mix is favourably influencing allocative efficiency.

5.3. Efficiency of domestic vis-à-vis foreign banks

The sample consisted of 17 domestic banks and 12 foreign banks incorporated in Australia. DEA was performed on both these sets of banks separately to find the comparative efficiency scores. The results are presented in Table 6.

Table 6 compares the mean relative efficiencies of foreign and domestic banks for the year of 1996. An interesting point is that the mean score of relative efficiency of domestic banks was closer to world mean efficiency score. The table also shows that, on average, domestic banks are more efficient than foreign banks. Similar results were obtained by Avkiran (1997) in his study of Australian banks for the period of 1986–1995. However, the regression at

Table 5
Dependent variable: Allocative efficiency[a]

Variable	Coefficient	S.E.	*t*-value	Sig of *t*
Constant	0.61	0.191	3.196	0.004
Branches	2.87E−04	0	1.09	0.287
StaffNo	−1.47E−05	0	−1.356	0.188
Logdepo	−0.123	0.052	−2.368	0.027
Logloans	0.154	0.067	2.314	0.03
Capital	−8.28E−05	0	−1.661	0.11

[a] *R*-squared 0.36, *F* 2.613, Sig of *F* 0.052. (Branches – number of branches, StaffNo – number of staff members, Logdep – log of deposits, Logloans – log of loans, Capital – amount of capital).

Table 6
Efficiency scores of domestic and foreign banks[a]

Efficiency	Domestic banks	Foreign banks
N	17	12
OE	0.83	0.62
AE	0.92	0.86
TE	0.90	0.71

[a] TE – Technical efficiency, AE – Allocative efficiency, OE – Overall efficiency such that OE = TE * AE.

Table 3 (variable: owner) shows that the difference in efficiency in these two groups of banks is not significant. Even when regression was performed using only one independent variable, that is, "owner" against OE, TE and AE, no significant difference was shown. Studies in the US, however, found that "foreign owned banks in the US were significantly less efficient than US owned banks" (Berger and Humphrey, 1997, p. 34). The higher mean relative efficiency of domestic banks vis-à-vis foreign banks could be due to the fact that foreign banks do not have a wide branch network like the domestic banks (it takes time to establish such a network) and as in the US are required to rely on purchased funds (which are more expensive than core deposits) for rapid growth (Berger and Humphrey, 1997, p. 34). Foreign banks do not have as many ATMs (a proxy for technology use) and due to stiff competition from domestic banks, have found it difficult to make inroads into the retail market, which restricts their ability to achieve both technical and allocative efficiencies. A study by Naughton and Harvie (1996) shows how the foreign banks in Australia resorted to scrambling for market share and consequently reported poor results. The KPMG Financial Institutions Performance Survey (1997) shows that in the year of 1996, the ratio of operating expenses to average total assets of foreign banks was higher (3.55) than that of major banks (2.90) and that of regional banks (2.47). In the same year their ratio of operating expenses to operating income was 62.56, while for major banks it was 62.10 and for regional banks it was 65.11. These indicators support the findings of this study. The reason for lower foreign bank efficiency could also be because in Australia the "foreign banks were willing to sacrifice profits to achieve size targets" (Williams, 1998). Avkiran (1997) states that "foreign banks are closing the gap" in their efficiency score vis-à-vis the domestic banks.

Given the above position, an interesting issue to consider is why foreign banks continue to operate in, or are willing to enter, the Australian banking market. This could be because the "interest margins in Australia are stronger than many other international financial centres" (KPMG, 1999) and thus provide opportunities for foreign banks. Further, their business strategy seems to be to move away from seeking a comparative advantage by traditional means. Instead, these banks are focussing on alliances, specialization and ac-

Table 7
Summary test of effects of ownership on efficiency: one-way ANOVA[a]

	F	Sig of *F*
TE	0.003	0.955
AE	0.31	0.862
OE	0.017	0.898

[a] TE – Technical efficiency, AE – Allocative efficiency, OE – Overall efficiency.

quisition. A recent alliance of Robo bank with credit unions for the purpose of dispensing farm credit is a pointer. In his study of foreign banks in Australia, Williams (1998) explains some of these issues by stating that firm-specific characteristics are more important than country-specific events.

The issue of interest is whether or not the two samples are drawn from the same population. The null hypothesis tested was that these two samples are from the same population or environment. This hypothesis was tested by ANOVA and Fishers's exact test. ANOVA assumes that underlying distributions are normal and compares the samples on the basis of the within-group and between-group variation in efficiency. Fisher's test is a non-parametric test. The results are presented in Table 7.

On the basis of the evidence presented in Table 7, the null hypothesis cannot be rejected. Further, the Fisher exact probability test showed that the calculated value of D was 4 against the table value of 1. As the observed value of D is more than the table value (Table 1 – Siegel) at the significance level of 0.05, the null hypothesis cannot be rejected (Seigel, 1956). This implies that the two samples have been drawn from the same population and it is appropriate to construct a combined production frontier.

6. Conclusion

This study used DEA to measure x-efficiency in Australian banks in the year of 1996. The scores of overall, technical and allocative efficiency have been calculated using a sample of 29 out of 32 locally incorporated banks. ANOVA has been performed to compare the efficiency of domestic banks and foreign banks. Lastly, the regression on efficiency shows which factors influence it.

Two important conclusions emerge from this study. Firstly, the efficiency of Australian banks is below the world mean efficiency and banks need to improve it further so as to achieve world best practice. This would call for action at individual bank and industry level. The factors that influence efficiency have been identified in this study and could aid banks in devising suitable strategies. The Australian government also needs to create an environment, which facilitates achievement of world best practice by banks. Secondly, the removal of the four-pillar policy is likely to concentrate market power even further, a

situation not conducive to increasing efficiency (an objective of the Wallis Inquiry). Hence, the removal of the policy cannot be supported on ''efficiency'' grounds.

The study has some limitations. Firstly, it uses cross-sectional data to analyse bank efficiency. A time series data on the lines of Avkiran (1999b) could have shown the recent trends in efficiency. Further, the data has been analysed for the year prior to the Wallis Inquiry Report. A post-Wallis analysis would be interesting and could capture the effects of regulatory reforms on efficiency. The technical efficiency can be analyzed into pure technical efficiency and scale efficiency to gain further insights. Further, Australian banking efficiency could be studied using the window analysis technique of DEA (Ahn et al., 1989). This could show the changes in efficiency scores over the years.

Acknowledgements

I am grateful to Neomi Avkiran, and seminar participants at the University of Southern Queensland for comments on earlier draft of the paper. I thank the anonymous referee of Journal of Banking and Finance for making very constructive comments on both occasions.

References

Ahn, T., Arnold, V., Charnes, A., Cooper, W.W., 1989. DEA and ratio efficiency analyses for public institutions of higher learning in Texas. In: Chan, J.C., Patton, J.M. (Eds.), Research in Governmental and Non-profit Accounting. JAI Press, Greenwich, CT, pp. 165–185.

Aly, H.Y., Grabowski, R., Pasurka, C., Rangan, N., 1990. Technical, scale and allocative efficiencies in US banking an empirical investigation. Review of Economics and Statistics 72, 211–218.

Aly, A.I., Seiford, L.M., 1993. The mathematical programming approach to efficiency analysis. In: Fried, H.O., Lovell, C.A.K., Schmidt, S.S. (Eds.), The Measurement of Productive Efficiency; Techniques and Applications. Oxford University Press, Oxford, pp. 120–159.

Avkiran, N.K., 1997. Performance of foreign banks in Australia. The Australian Banker, The Australian Institute of Banking and Finance, pp. 222–224.

Avkiran, N.K., 1999a. An application reference for Data Envelopment Analysis in branch banking: Helping the novice researcher. International Journal of Bank Marketing 17 (5), 206–220.

Avkiran, N.K., 1999b. The evidence of efficiency gains: The role of mergers and the benefits to the public. Journal of Banking and Finance 23, 991–1013.

Baldini, D., Landi, A., 1990. Economie di scala e complementarietà di costo nell'industria bancaria italianà. L'Industria 1, 25–45.

Banker, R.D., Charnes, A., Cooper, W.W., Swarts, J., Thomas, D.A., 1989. An introduction to Data Envelopment Analysis with some of its models and their uses. In: Chan, J.L., Patton, J.M. (Eds.), Research in Governmental and Non-Profit Accounting, Vol. 5. JAI Press, Greenwich, CT, 125–163.

Bauer, P.W., 1990. Recent developments in the econometric estimation of frontiers. Journal of Econometrics 46, 39–56.

Bell, F.W., Murphy, N.B., 1967. Economies of scale in commercial banking. Federal Reserve Bank of Boston.

Benston, G.J., 1965. Branch banking and economies of scale. Journal of Finance 312–331.

Berg, S.A., Forsund, F.R., Hjalmarsson, L., Souminen, M., 1993. Banking efficiency in the Nordic countries. Journal of Banking and Finance 17 (2–3), 371–388.

Berger, A.N., 1995. The profit-structure relationship in banking tests of market-power and efficient-structure hypothesis. Journal of Money, Credit and Banking 27 (2), 404–431.

Berger, A.N., Hancock, D., Humphrey, D.B., 1993. Banking efficiency derived from the profit function. Journal of Banking and Finance 17, 317–347.

Berger, A.N., Hannan, T.H., 1989. The price–concentration relationship in banking. The Review of Economics and Statistics 71, 291–299.

Berger, A.N., Hanweck, G.A., Humphrey, D.B., 1987. Competitive viability in banking: Scale, scope and product mix economies. Journal of Monetary Economics 20, 501–520.

Benston, G.J., Hanweck, G.A., Humphrey, D.B., 1982. Scale economies in banking: A restructuring and reassessment. Journal of Money, Credit and Banking 14, 435–456.

Berger, A.N., Humphrey, D.B., 1997. Efficiency of financial institutions: International survey and directions for future research. European Journal of Operational Research (special issue) www.http://papers.ssrn.com/paper.taf? ABSTRACT_ID = 2140.

Berger, A.N., Hunter, W.C., Timme, S.G., 1993. The efficiency of financial institutions: A review and preview of research past, present and future. Journal of Banking and Finance 17, 221–249.

Brown, R., O'Connor, I., 1996. Measurement of economies of scale in Victorian credit unions. Australian Journal of Management 20 (1), 1–24.

Charnes, A., Cooper, W.W., Rhodes, E., 1978. Measuring efficiency of decision making units. European Journal of Operational Research 2, 429–444.

Clark, J.A., 1988. Economies of scale and scope at depository financial institutions: A review of the literature. Federal Reserve Bank of Kansas City Economic Review 73, 16–33.

Claessens, S., Glaessner, T., 1998. Internationalization of financial services in Asia, World Bank, Washington, DC; Quoted in: McGuire, G. (Ed.), Australia's restrictions on trade in financial services. Productivity Commission Staff Research Paper, Ausinfo, Canberra, 26–27 November.

Coelli, T., 1996. A Guide to DEAP Version 2.1, A Data Envelopment Analysis (Computer) Program. CEPA Working paper 96/08.

Dietsch, M., 1993. Economies of scale and scope in French commercial banking industry. Journal of Productivity Analysis 1.

Drake, L., Weyman Jones, T.G., 1992. Technical and scale efficiency in UK building societies. Applied Financial Economics 2, 1–9.

Dyson, R.G., Thanassoulis, E., Boussofiane, A., 1998. Data Envelopment Analysis. Warwick Business School, www.http://www.csv.warwick.ac.uk/~bsrlu/dea/deat/deat1.htm.

Edwards, F.R., Heggestad, A.A., 1973. Uncertainty, market structure and performance: The Galbraith-Caves hypothesis and managerial motives in banking. Quarterly Journal of Economics 87, 455–473.

Elysiani, E., Mehdian, S., 1990. Efficiency in the commercial banking industry, a production frontier approach. Applied Economics 22, 539–551.

Esho, N., Sharpe, I.G., 1996. *X*-efficiency of Australian permanent building societies, 1974–1990. The Economic Record 72, 218, 246–249.

Fanjul, O., Marvall F, 1985. La eficiencia del sistema bancario espanol. Alianza University, Madrid.

Farrell, M.J., 1957. The measurement of productive efficiency. Journal of Royal Statistical Society 120 Sec A, 253–281.

Ferrier, G., Lovell, C.A.K., 1990. Measuring cost efficiency in banking: Econometric and linear programming evidence. Journal of Econometrics 46, 229–245.
Field, K., 1990. Production efficiency of British building societies. Applied Economics 22, 415–425.
Fried, H.O., Lovell, C.A.K., 1994. Measuring efficiency and evaluating performance. Quoted in: Data Envelopment Analysis: A technique for measuring the efficiency of government service delivery. Steering Committee for the Review of Commonwealth/state Service Provision. 1997, AGPS, Canberra.
Fried, H.O., Lovell, C.A.K., Eackaut, P.V., 1993. Evaluating the performance of US credit unions. Journal of Banking and Finance 17, 251–265.
Garden, K., 1998. The efficiency effects of credit union mergers. Unpublished Dissertation, University of Southern Queensland, Toowoomba, Australia, 29.
Garden, K., Ralston, D., 1999. The *X*-efficiency and allocative efficiency effects of credit unions mergers. Journal of International Financial Markets, Institutions and Money 9 (3), 285–301.
Gilligan, T., Smirlock, M., Marshall, W., 1984. Scale and scope economies in the multi-product banking firm. Journal of Monetary Economics 13, 393–405.
Goldberg, L.G., Rai, A., 1996. The structure–performance relationship for European banking. Journal of Banking and Finance 20, 745–771.
Hancock, D., 1986. A model of the financial firm with imperfect asset and deposit elasticities. Journal of Banking and Finance 10, 37–54.
Hunter, W.C., Timme, S.G., 1986. Technical change, organisational form and the structure of bank production. Journal of Money, Credit and Banking 18 (2), 152–166.
Kolari, J., Zardkoohi, A., 1987. Bank Cost, Structure and Performance. Lexington Books, Lexington, MA.
KPMG, 1996. KPMG Financial Institutions Performance Survey. KPMG, Sydney.
KPMG, 1997. KPMG Financial Institutions Performance Survey. KPMG, Sydney.
KPMG, 1999. KPMG Financial Institutions Performance Survey. KPMG, Sydney.
Lawrence, C., Shay, R., 1986. Technology and financial intermediation in a multiproduct banking firm: An econometric study of I.S.S. banks, 1979–1982. In: Lawrence, C., Shay, R. (Eds.), Technological Innovation, Regulation and the Monetary Economy. Ballinger, Cambridge, MA.
McKinnon, M., Riggert, E., 1999. Reserve Bank boss blasts executive pay. The Courier Mail, Brisbane, 30 November, p. 1.
Molyneux, P., Altunbas, Y., Gardener, E., 1996. Efficiency in European Banking. Wiley, Chichester, p. 198.
Naughton, T., Harvie, C., 1996. The performance of foreign banks in a deregulated environment: Evidence from Australia and Korea. Economic Papers 15 (1), 57–75.
Nunamaker, T.R., 1985. Using Data Envelopment Analysis to measure the efficiency of non-profit organizations: A critical evaluation. Managerial and Decision Economics 6 (1), 50–58.
Parkan, C., 1987. Measuring the efficiency of service operations: An application to bank ranches. Engineering Costs and Production Economies 12, 237–242.
RBA (Reserve Bank of Australia), 1996. Reserve Bank of Australia Bulletin. June, Reserve Bank of Australia, Sydney.
RBA (Reserve Bank of Australia), 1999. Bank Fees in Australia. Reserve Bank of Australia Bulletin, June, Reserve Bank of Australia, Sydney, 7.
Seiford, L.M., Thrall, R.M., 1990. Recent developments in DEA. The mathematical programming approach to frontier analysis. Journal of Econometrics 46, 7–38.
Seigel, S., 1956. Nonparametric Statistics for the Behaviour Sciences. McGraw-Hill, New York.
Sheldon, G., Haegler U., 1993. Economics of scale and scope and inefficiency in Swiss banking. In: Blattner, N., Genberg, H., Swoboda, A. (Eds.), Banking in Switzerland. Weidelberg, New York, pp. 103–134.
Sherman, D., Gold, F., 1985. Branch operating efficiency: Evaluation with Data Envelopment Analysis. Journal of Banking and Finance 9, 297–315.

Soteriou, A., Zenios, S., 1998. Data Envelopment Analysis: An introduction and an application to bank branch performance assessment. In: Marcoulides, G. (Ed.), Modern Methods for Business Research, Lawrence Erlbaum Associates, London, p. 136.

Tulkens., H., 1990. Non-parametric efficiency analyses in four service activities: Retail banking, municipalities, courts and urban transit. Centre for Operations Research and Econometrics. Discussion Paper No. 9050. Université Catholique de Louvain, Louvain-la-Neuve.

Vassiloglou, M., Giolias, D., 1990. A study of the relative efficiency of bank branches: An application of Data Envelopment Analysis. Journal of Operational Research Society 41, 591–597.

Walker, G., 1998. Economies of Scale in Australian Banks 1978–1990. Australian Economic Papers 37, 1, pp. 71–87.

Wallis Inquiry Report, 1997. The Financial Systems Inquiry Final Report. AGPS, Canberra.

Williams, B., 1998. Factors affecting the performance of foreign-owned banks in Australia: A cross-sectional study. Journal of Banking and Finance 22, 197–219.

Worthington, A.C., 1996. A comparison of financial ratio and DEA efficiency measures in assessing co-operative financial institutions performance: Evidence using the Australian credit union industry. Working Paper, School of Economics and Finance, Queensland University of Technology, Australia.