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Foreign bank entry, deregulation and bank efficiency: Lessons from the Australian experience

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Abstract

This study considers the impact of foreign bank entry on banking efficiency in Australia during the post-deregulation period 1988–2001. Using Data Envelopment Analysis, Malmquist Indices and stochastic frontier analysis, we find foreign banks more efficient than domestic banks, which however did not result in superior profits. Major Australian banks have used size as a barrier to entry to new entrants. Furthermore, bank efficiency has increased post-deregulation and the competition resulting from diversity in bank types was important to prompt efficiency improvements. Finally, the recession of the early 1990s resulted in a distinct shift in the process of efficiency changes.

JEL classification: G21; G28
Keywords: Foreign banks; Deregulation; Data envelopment analysis; Malmquist indices; Stochastic frontier analysis

1. Introduction

This study compares the efficiency of foreign-owned banks operating in Australia with Australian domestic banks after deregulation of the Australian banking system

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during the early and mid 1980s. The objective is to determine if foreign banks were more efficient than domestic banks during our estimation period of 1988–2001. Deregulation of banking systems frequently includes increased openness to foreign-owned banks, with the intention of improving the competitiveness and efficiency of the financial system. The Australian experience of deregulation provides a natural experiment to determine the impact of foreign bank entry upon bank efficiency within a deregulated environment. In a relatively short period Australia moved from a regulated banking system with limited foreign participation to a deregulated banking system with 15 foreign-owned banks. This feature provides the Australian case with valuable features that allow the determination of the efficiency impact of foreign bank entry. The results of this study provide valuable insights into the impact of deregulation and foreign bank entry that can be applied to other national circumstances.

This paper will employ Data Envelopment Analysis (DEA) and Malmquist Indices to consider the efficiency of both foreign and domestic banks and the dynamics of efficiency changes in Australia post-deregulation. Stochastic frontier analysis based on parametric distance functions will be used as a robustness check on the results from the DEA analysis. The Australian banking system is dominated by four large banks, as well as having a number of smaller domestic banks, which are mainly regional retail banks. Thus, the domestic banks in this study will be categorised as either Big Four or Other Domestic. This categorisation will aid in consideration of the impact of different operational types upon observed efficiency. Further, the paper will consider several different definitions of inputs and outputs to determine if these differences have any impact upon differences in measured efficiency. This approach will have the benefit of considering the multiproduct nature of bank inputs and outputs.

The DEA results show that foreign banks were, on average, more input efficient than the domestic banks, mainly due to superior scale efficiency, which is opposite to findings of other studies (Berger et al., 2000). We argue that these results tend to support the limited form of the global advantage hypothesis as proposed by Berger et al. (2000). The major (Big Four) banks used size as a barrier to entry to the new entrants. However, the major banks did display superior pure technical efficiency. The superior input efficiency of foreign banks did not necessarily result in higher profits, consistent with DeYoung and Nolle's (1996) findings of lower foreign bank profits in the USA. Similarly, Claessens et al. (2001) found foreign banks in developed nations to be less profitable than domestic banks, but the reverse for developing nations. Williams (2003) found for the Australian case that the concentration of the Australian banking market reduced foreign bank profits. Malmquist Indices indicate that bank productivity increased post-deregulation, and that the diversity in types of banks operating in Australia was an important source of the dynamic in efficiency changes. As a result of this dynamic, the overall differences in productivity changes between the bank categories were generally found to be relatively small. The recession of the early 1990s resulted in firms on the estimated best practice frontier becoming less efficient relative to the true technological frontier, as compared to the period immediately following deregulation, which saw high levels of technolog-

ical innovation, consistent with Claessens et al. (2001). We also conclude that the choice of inputs and outputs impacts upon the finding of relative efficiency and productivity, consistent with Berger et al. (1993).

The outline of this paper is as follows. Section 2 will provide an overview of previous studies that have considered, (i) the efficiency of foreign banks, (ii) the efficiency effects of financial system deregulation, and (iii) the efficiency of the Australian banking system. Section 3 will provide some background to the process of deregulation in Australia. The fourth section will discuss the data and methodology employed, while the fifth section will discuss the results. The final section will provide conclusions and directions for further research.

2. Literature review

There are three streams of literature that are relevant to this study, (i) those comparing foreign bank efficiency with domestic bank efficiency, (ii) those considering the impact of deregulation upon bank efficiency, and (iii) those dealing with bank efficiency in Australia.

2.1. International studies of foreign bank efficiency

The empirical evidence to date, as surveyed by Berger et al. (2000), has found foreign-owned financial institutions to be less efficient than domestic institutions. [1] In the case of the United States, Hasan and Hunter (1996), Mahajan et al. (1996), and Chang et al. (1998) concluded that foreign banks are less cost efficient than domestic banks, while DeYoung and Nolle (1996) found foreign banks to have lower profit efficiency. A broader study by Miller and Parkhe (2002) considered profit efficiency in fourteen different nations, and found domestic banks to be more efficient than foreign banks.

Berger et al. (2000) proposed two alternative hypotheses to explain these results, the home field advantage hypothesis and the global advantage hypothesis. According to the first, the domestic institutions' efficiency advantage is sourced in costs borne by the foreign institution; these costs are often called the liability of foreignness. [2] The alternative global advantage hypothesis as suggested by Berger et al. (2000) has two forms: the general and the limited form. Under the general form, efficient foreign banks from a range of nations are able to offer superior efficiency compared to domestic banks, which has been rejected by the literature to date. Under the limited form, foreign banks from a particular set of nations are more efficient than domestic banks. It proposes that some efficient foreign banks are able to master

[1] See also Berger et al. (1999).

[2] See for example Miller and Parkhe (2002). These costs include monitoring from a distance, staff turnover in overseas postings, diseconomies of operation in the retail sector, and barriers to entry such as language, culture, market structure and regulations.

the disadvantages presented by the liability of foreignness. This nation-specific advantage could be sourced from factors such as home market structure and regulation. Berger et al. (2000) considered both profit and cost efficiency and concluded that, while on average domestic banks have higher cost and profit efficiency, for three of the five host nations studied, foreign banks from the United States were on average more efficient than domestic banks. It was argued that these results were due to actual advantages rather than transfer pricing, supporting the limited global advantage hypothesis (Berger et al., 2000, pp. 59–60).

2.2. International studies of the efficiency effects of deregulation

An important aspect of deregulation is its impact upon the efficiency of the financial system, as a key objective of deregulation is to improve efficiency (Berger and Humphrey, 1997). In the case of the United States, deregulation has generally been followed by a decline in cost productivity, with this decline being attributed to depositors gaining from deregulation via higher deposit interest rates (Berger et al., 2000). Deregulation of the financial system has occurred in a number of nations. Studies of its impact upon efficiency come up with mixed results. Improvements in efficiency have been reported for Taiwan (Shyu, 1998), Korea (Gilbert and Wilson, 1998), Norway (Berg et al., 1992), Turkey (Zaim, 1995), Portugal (Canhoto and Dermine, 2003) and Thailand (Leightner and Lovell, 1998). In the case of Spain (Grifell-Tatjé and Lovell, 1996) deregulation was found to have a negative impact upon efficiency.

It is generally found that deregulation has different effects upon different bank types within a nation. In the Indian case, Bhattacharyya et al. (1997) conclude that foreign banks experienced the greatest improvements in efficiency. According to Berg et al. (1992), Norwegian banks created idle capacity (excess inputs) pre-deregulation and post-deregulation improvements in efficiency were mainly the result of the Norwegian banks catching up to efficient output levels. [3] Overall, the impact of deregulation seems to be determined by the nature of deregulation adopted and the structure of the financial system prior to deregulation. Canhoto and Dermine (2003) found for the Portuguese case that new banks (including some foreign banks), were more efficient than the incumbent banks.

2.3. Australian studies

The Australian banking system has been subject to considerable changes, which brought with them expectations of improved efficiency; however, the literature to date has been relatively sparse. A survey by Berger and Humphrey (1997) did not include any studies of Australian bank efficiency. Allen and Rai (1996) conducted

[3] This situation has some parallels to the Australian situation, where the major Australian banks merged amongst themselves and increased spending (especially upon branch infrastructure) in order to increase the barriers to entry for the foreign banks (Ferguson, 1990).

a cross-border study of bank efficiency between 1988 and 1992 and concluded that Australia had a relatively efficient banking system. More recently, Walker (1998) applied a translog cost function to twelve Australian banks from 1978 to 1990. This study did not include foreign banks and concluded that there was no evidence of diseconomies of scale and some evidence of constant returns to scale. Avkiran (1999) considered the effects of Australian bank mergers. Considering 23 banks from 1986 to 1995, it was concluded that bank efficiency increased until 1991 and then declined due to bad debt problems. Furthermore, acquiring banks were more efficient than target banks pre-merger. However, post-merger efficiency changes could not be conclusively discerned. Avkiran (2000) studied ten domestic Australian banks from 1986 to 1995, considering post-deregulation changes in bank productivity. [4] Total productivity was found to have increased over the study period, but this increase was mainly due to technological progress rather than technical efficiency. Sathye (2002) applied Malmquist indices to 17 Australian banks (1995–1999) and concluded that there had been a decline in productivity over the study period, but did not consider foreign banks. [5] To date, one Australian study has considered the efficiency of foreign as well as domestic banks, Sathye (2001). He studied 29 banks in 1996 (12 foreign, 17 domestic) and concluded that Australian banks are, on average, less efficient than world mean bank efficiency. Sathye (2001) did not find significant differences between foreign bank and domestic bank efficiency, but did not consider the issue of economies of scale.

3. Deregulation in Australia

Australian Financial System Inquiry (1981) (Campbell Committee) recommended deregulation of the Australian Financial System. Swan and Harper (1982) emphasised the economy-wide benefits that would result from deregulation increasing the efficiency of the banking system, which was found persuasive by the Campbell Committee. Symptoms of inefficiencies resulting from the system of regulations in place prior to deregulation included internal cross-subsidies and over-provision of branch networks. [6] For our purpose, the main consequence of deregulation was the access of foreign banks into Australia. [7]

[4] Avkiran (1999, 2000) included a foreign-owned bank in both studies (The Bank of Scotland acquired 51% ownership of BankWest in 1995). Avkiran (1999) included a second foreign bank (National Mutual Royal Bank, a joint venture bank). The foreign ownership issue was not considered in either study.

[5] It should be noted that the discussion in Sathye (2002, p. 53) is somewhat inconsistent with the results presented in Table 3 on page 54.

[6] For further detail on the arguments for deregulation in Australia, see also Perkins (1989) and Harper (1986).

[7] Other key aspects of deregulation included (i) the removal of qualitative and quantitative controls upon bank balance sheets, (ii) the floating of the Australian dollar in 1983, and (iii) the use of market based operations for the implementation of monetary policy.

As a defensive reaction to the threat of foreign bank entry, there were mergers among the major six domestic banks during the deregulation period to create four major domestic banks (Stearn and Tress, 1983; Hall, 1987). [8] In 1985, 16 foreign banks were granted licences to operate in Australia as subsidiary banks, of these, 15 eventually established operations. [9] It was originally anticipated that these sixteen licences would be the entire ration of such licences. [10] All of the foreign banks that elected to take up their licences were operating by May 1986.

The Reserve Bank of Australia (RBA) considered that foreign bank entry would provide a competitive stimulus to the banking system (Davis and Lewis, 1982, p. 539). Foreign banks were also considered to innately possess economies of scale and so were capable of immediately competing with the incumbent banks (RBA, 1994). [11] Subject to some restrictions, branch operations are permitted since 1992. However, some tax-related issues delayed conversion of subsidiaries to branches until 1994 (East, 1993). [12]

The entrance of foreign banks into Australia has been regarded as a failure. This is particularly due to their inability to reach their target market share within five years of entry (Standing Committee of Finance and Public Administration (SCOFPA), 1991). Contributing to this perception is also the lack of impact the foreign banks have made upon the retail market (Ackland and Harper, 1992), and poor profits (Ferguson, 1990). This has been attributed to the high entry barriers the foreign banks faced upon entry (SCOFPA, 1991, p. 151). It has been argued that the foreign banks were never likely to succeed, given the creation of four dominant banks by the mergers of 1981, and the increased spending of these four banks to increase these barriers to entry (Ferguson, 1990). The newly licenced banks operating in Australia, [13] including the foreign banks, have also been regarded as less efficient and productive than the existing banks (Hogan, 1991).

[8] Detailed timelines of financial deregulation in Australia are available in Lewis and Wallace (1997) and Carew (1998).

[9] J.P. Morgan did not take up its licence. The announcement of sixteen licences was in excess of industry expectations, which were in the range of six to eight.

[10] In 1992 this ration was removed.

[11] This view regarded the foreign bank's Australian operations as a direct extension of their international operations.

[12] A subsidiary is an Australian incorporated bank that has foreign ownership of over 50% of the equity; the majority of foreign bank subsidiaries in Australia have 100% foreign ownership. A foreign bank branch is not legally separate from its parent and as such has the full support of the parent's capital base and carries the parent's credit rating. In Australia foreign bank branches are restricted to wholesale banking only. As foreign bank branches are not legally separate from the parent they do not report many of the variables necessary for this study. Davis and Lewis (1982) found that foreign banks have an active preference for branch operations.

[13] During the process of deregulation a number of non-bank financial institutions (NBFIs) converted to bank status, these were mainly building societies with a regional focus upon retail finance. One foreign-owned merchant bank (Hill Samuel Australia) listed on the Australian Stock Exchange as Macquarie Bank and became largely Australian-owned with a wholesale focus.

4. Method and data

There are a number of alternative methods available to measure bank efficiency, with Berger et al. (1993), Berger and Humphrey (1997) and Berger and Mester (1997) providing key surveys of the alternative methods. [14] This study will employ Data Envelopment Analysis (DEA), Malmquist Indices [15] and stochastic frontier analysis based on parametric distance functions (Coelli and Perelman, 1999). DEA is a non-parametric linear programming method, which does not require input or output prices in order for a best practice production frontier to be identified. A separate production frontier will be estimated for each year of this study.

The Malmquist Index approach is a chained index approach, which measures changes in productivity relative to a base year. [16] Changes in productivity can be decomposed into components due to changes in technical efficiency (catching up) and movements due to changes in technology (technological change). Changes in a firm's technical efficiency can be decomposed into change due to pure technical efficiency change and changes due to scale efficiency. The DEA, stochastic frontier and Malmquist Index estimation used in this study are input oriented, addressing the issue of reducing input quantities proportionally while keeping output quantities unchanged. As input prices and cost data are not available for some of the banks in the sample employed, particularly the foreign banks, these methods are ideally suited to the available data.

DEA and Malmquist indices have the further advantage that they do not require the researcher to specify a functional form for the production frontier. However these advantages are accompanied by some disadvantages in that no random error is assumed and so the efficiency scores do not distinguish between noise and inefficiency (Canhoto and Dermine, 2003), thus tending to result in lower efficiency scores for DEA based methods. Further, DEA and Malmquist indices lacking an assumption of a distributional form, do not allow conventional hypothesis testing (Coelli et al., 1998).

Given these limitations, a stochastic frontier methodology will also be employed as a robustness check upon the DEA results. As this data set does not contain input or output prices, the parametric input-distance function proposed by Coelli and Perelman (1999) will be applied. This approach allows maximum likelihood estimation of a translog function using multiple outputs and inputs. We allow a time trend to influence the efficiency of the banks to reflect the impact of technology shifts and other time-dependent effects.

This study will consider banks operating in Australia between 1988 and 2001. While foreign banks commenced operations in 1986, their annual reports for 1987 in many cases reflected results for a portion of the year. The primary data source for this study is the banks annual reports. These were individually obtained from

[14] A valuable reference is also Coelli et al. (1998).

[15] Berger and Humphrey (1997) identified over 60 studies that have applied DEA to the banking industry.

[16] Relevant studies include Berg et al. (1992) and Färe et al. (1994).

each bank. [17] Details regarding housing loans were obtained from the Reserve Bank of Australia *Bulletin* and the earlier Australian Government *Gazette*. Sufficient data was available for 39 banks to be included in the sample. The banks are categorised as Big Four, Other Domestic and Foreign. The Big Four banks are the dominant banks in the Australian banking industry, with 67.8% of total bank assets in 1988 and 65.7% of total bank assets in 1998. [18] The Other Domestic banks consist primarily of regional banks with a retail focus, with the exception of Macquarie Bank, which focuses upon wholesale banking. The Other Domestic banks were mainly state-owned banks in the early years of the sample, with converted building societies increasing in importance in the later years of the sample period. There are a total of 16 Other Domestic banks in this study. The foreign banks are all those banks with more than 50% foreign ownership, the majority of the foreign banks are wholly-owned subsidiaries of foreign banks. [19] Due to their wholly-owned status, the annual reports produced by the foreign banks, in many cases, had a lower level of disclosure. [20] There are a total of 19 foreign banks in this study. [21] Restrictions resulting from data availability dictated the research method chosen. Mergers, changes of ownership and data availability meant that some banks were not included in every year of the sample period. [22] The impact of mergers amongst the banks as well as conversion by foreign banks to branch status resulted in a decline in the sample size for each year across the sample period.

In order to conduct efficiency analysis, inputs and outputs must be specified. This study will employ the intermediation approach, viewing banks as financial intermediaries employing inputs such as labour, capital and deposits to produce outputs such as loans and off-balance sheet items. [23] Four alternative specifications of inputs and outputs are employed in this study. The most parsimonious model

[17] Annual reports were not available from foreign bank branches and so they are excluded from this study.

[18] Reserve Bank of Australia *Bulletin*, various issues.

[19] Of the foreign banks in this study, BankWest, Bank of America, Bank of Singapore, Chase AMP, National Mutual Royal operated as joint venture banks with majority foreign ownership. With the exception of BankWest, these joint ventures were relatively short lived, with the banks either exiting (National Mutual Royal) or converting to 100% foreign ownership.

[20] These banks are not listed on the stock exchange and so are subject to less onerous disclosure requirements.

[21] This is more than the 15 foreign banks mentioned in Section 3. As a bank was restructured it was counted as a new bank. This applied in three cases: (i) Chase AMP dissolved its joint venture and re-established Australian operations as Chase Manhattan; (ii) Bank of Tokyo and Mitsubishi Bank merged their operations at home, and as a result Bank of Tokyo/Mitsubishi Australia was formed; (iii) the regional domestic R&I Bank was sold to Bank of Scotland and restructured as BankWest. In each of these cases the restructured bank was treated as a new bank. The other case is a new foreign bank (Arab Bank) that was established after restrictions on new foreign bank entry were removed in 1992.

[22] In each case of a re-structure the new entity was treated as a new bank, as discussed above. As a separate production frontier was estimated for each year, this process does not create any bias.

[23] There is some controversy regarding the specification of inputs and outputs in banking; see for example Berger and Humphrey (1992). Favero and Papi (1995) found that their results were not sensitive to respecifying deposits as an output rather than as an input.

(Model 1) has as inputs (i) employee numbers, (ii) deposits and borrowed funds, and (iii) equity capital. Outputs are (i) loans advances and other receivables, and (ii) off-balance sheet activity measured as commitments and contingent liabilities. [24] Model 1a decomposes outputs in Model 1 by dividing loans into two categories, (i) loans advances and other receivables less housing loans, and (ii) housing loans. Model 1a acknowledges that some banks have a greater focus upon retail activity (with a different cost structure), but brings with it a disadvantage that housing loans are not available for all banks for the entire study period. [25] Model 1b is identical to Model 1, but includes investments (liquid assets, trading securities, bill acceptances and other investments) as an additional output. Model 1b acknowledges the impact of an increased wholesale activity. Model 2 provides a mechanism to compare the results of this study with the previous studies by Avkiran (1999, 2000), which excluded foreign banks. In Model 2, inputs are (i) interest expenses, and (ii) non-interest expenses, while outputs are (i) net interest income and, (ii) non-interest income. These measures of inputs and outputs are revenue focussed, and as efficiency estimates are sensitive to specification of inputs and outputs (Berger et al., 1993), it is expected that this revenue focussed model will yield some differences.

Table 1 (Panel A) details the characteristics of the sample used in Model 1 for DEA estimation, which had the largest sample size. [26] The sample composition for the Malmquist Index estimation is detailed in Panel B. Given the available data, the maximum sample size for each Malmquist Index Model was selected, resulting in different sample sizes, with Models 1 and 1b having the largest sample, 15 banks over six years; and Model 2 having the smallest sample, 13 banks over six years. Stochastic frontier estimation allows the use of the entire sample in an unbalanced panel covering 1988–2001, which implies a total of 273 observations for Model 1.

Table 2 shows the descriptive statistics for the sample used. All values except employee numbers are in thousands of Australian dollars. Table 2 (Panel A) shows the overall descriptive statistics, while Panels B, C and D, show respectively the segmented descriptive statistics for the Big Four, Other Domestic and Foreign banks. The Other Domestic banks tend to have higher levels of housing loans, while the Foreign banks tend to have higher levels of off-balance sheet activity and non-interest income, while unsurprisingly, the Big Four banks are the largest.

[24] This definition of off-balance sheet activity excludes market-related activity such as derivatives due to lack of data availability for the entire sample period. Off-balance sheet items are measured as face value, as risk weighted values were not reported for the entire sample period.

[25] This problem particularly relates to the early part of the study period when housing loans were reported in the Australian Government *Gazette*. In the case of trading banks (pre 1989) housing loans were not reported. In most cases foreign banks operated in Australia as a trading bank. The distinction between trading banks and savings banks was removed during the deregulation process.

[26] The sample details and results for Models 1a, 1b and 2 are available from the authors.

Table 1
Sample characteristics

Year	Big4	Other domestic	Foreign	Total		
Panel A: DEA sample characteristics of model 1						
1988	2	3	13	18		
1989	3	8	15	26		
1990	3	7	13	23		
1991	4	9	13	26		
1992	4	9	12	25		
1993	4	9	11	24		
1994	4	10	11	25		
1995	4	10	9	23		
1996	4	10	6	20		
1997	4	7	6	17		
1998	4	5	4	13		
1999	4	5	4	13		
2000	4	4	2	10		
2001	4	5	1	10		
Panel B: Malmquist index sample characteristics						
Model				Total banks	Years	Total observations
Model 1	3	5	7	15	1989–1995	105
Model 1a	3	6	7	16	1990–1995	96
Model 1b	3	5	7	15	1989–1995	105
Model 2	4	6	3	13	1989–1995	91

Model 1: Inputs: (i) employees, (ii) deposits, (iii) equity capital. Outputs: (i) loans, (ii) off-balance sheet items.
Model 1a: Inputs: (i) employees, (ii) deposits, (iii) equity capital. Outputs: (i) loans less housing loans, (ii) housing loans (iii) off balance sheet items.
Model 1b: Inputs: (i) employees, (ii) deposits, (iii) equity capital. Outputs: (i) loans, (ii) investments, (iii) off-balance sheet items.
Model 2: Inputs: (i) interest expenses, (ii) non-interest expenses. Outputs: (i) net interest income, (ii) non-interest income.
The maximum sample size was selected for each model.

5. Results

5.1. DEA results

DEA efficiency scores for Model 1 for each year in the sample period are shown in Table 3. Average Technical Efficiency ranges from 0.73 (1991) to 0.94 (2000). These values are higher than those found by Sathye (2001), but similar to model A of Avkiran (1999). As stated by Berger et al. (1993), results of efficiency estimations are sensitive to the specification of inputs and outputs, even when the same method of estimation is applied. With average input efficiency in this study of around 80%, this indicates that the Australian banking system could reduce inputs by approximately 25% without changing output levels.

Table 2
Descriptive statistics: 1988–2001 ($A 000s, except employees)

Variable	Obs.	Mean	SD	Minimum	Maximum
Panel A: All banks					
Deposits	274	17,126,535.08	31,253,061.67	95,779.00	185,097,000.00
Employees	255	8,528.18	15,013.89	45.00	50,367.00
Equity capital	274	1,871,828.74	3,440,163.65	25,234.00	21,407,000.00
Housing loans	261	4,610,771.29	7,795,707.82	0.00	34,155,000.00
Interest expense	273	1,316,116.87	2,228,427.77	6,151.00	11,146,000.00
Investments	274	3,655,175.87	5,944,115.20	2,701.00	32,614,000.00
Loans	274	17,576,890.57	32,399,683.17	300,490.00	195,492,000.00
Non-interest income	264	497,183.29	923,551.05	1,686.00	6,523,000.00
Non-interest expense	238	876,810.12	1,407,196.58	8,431.00	7,229,000.00
Net interest income	273	724,001.63	1,329,037.16	−856.00	6,371,000.00
Off-balance sheet activity	262	774,202.81	16,401,153.85	0.00	93,611,000.00
Panel B: Big four banks					
Deposits	48	77,896,052.08	30,563,418.44	33,036,300.00	185,097,000.00
Employees	48	38,943.06	6,318.81	23,134.00	50,367.00
Equity capital	48	8,428,083.33	3,658,608.87	3,766,100.00	21,407,000.00
Housing loans	48	18,262,241.25	8,340,088.53	5,053,000.00	34,155,000.00
Interest expense	48	5,758,618.75	1,847,994.75	3,103,400.00	11,146,000.00
Investments	48	14,452,445.83	5,253,018.62	7,705,100.00	32,614,000.00
Loans	48	79,860,500.00	33,476,104.11	35,339,800.00	195,492,000.00
Non-interest income	48	2,056,968.75	950,570.09	813,000.00	6,523,000.00
Non-interest expense	48	3,416,660.42	933,116.91	2,061,200.00	7,229,000.00
Net interest income	48	3,435,612.50	954,508.62	2,072,100.00	6,371,000.00
Off-balance sheet activity	46	39,364,732.61	17,623,005.26	5,510,000.00	93,611,000.00

Table 2 (*continued*)

Variable	Obs.	Mean	SD	Minimum	Maximum
Panel C: Other domestic banks					
Deposits	115	6,727,316.49	7,232,348.04	540,753.00	37,853,919.00
Employees	100	2,360.45	2,137.28	530.00	11,253.00
Equity capital	115	667,640.06	835,025.08	62,388.00	3,859,000.00
Housing loans	105	2,682,914.35	3,322,930.44	7,000.00	18,199,000.00
Interest expense	115	515,467.42	525,111.54	6,151.00	2,145,500.00
Investments	115	1,888,121.76	3,492,263.96	54,485.00	29,247,000.00
Loans	115	6,516,643.14	7,479,304.29	485,509.00	39,454,000.00
Non-interest income	115	221,516.38	565,354.27	1,686.00	4,332,000.00
Non-interest expense	114	321,169.96	574,754.92	22,323.00	4,261,000.00
Net interest income	115	222,917.22	249,575.88	13,119.00	1,172,000.00
Off-balance sheet activity	106	1,349,120.02	1,777,397.44	0.00	8,320,000.00
Panel D: Foreign banks					
Deposits	111	1,621,790.23	1,920,254.21	95,779.00	10,029,900.00
Employees	107	648.35	825.43	45.00	2,997.00
Equity capital	111	284,274.48	337,204.36	25,234.00	1,576,769.00
Housing loans	108	417,756.67	1,180,123.85	0.00	6,441,200.00
Interest expense	110	214,613.20	198,050.22	21,495.00	942,920.00
Investments	111	816,817.88	996,728.55	2,701.00	5,051,666.00
Loans	111	2,102,252.76	2,484,295.35	300,490.00	14,256,200.00
Non-interest income	101	69,777.28	120,381.35	2,122.00	580,546.00
Non-interest expense	76	106,154.38	120,140.24	8,431.00	568,218.00
Net interest income	110	64,614.22	90,084.32	−856.00	369,000.00
Off-balance sheet activity	110	678,409.36	860,514.50	5,772.00	5,086,258.00

Table 3
Average DEA efficiency scores: Model 1 (standard deviations in parentheses)

	TE	PTE	Scale
1988			
All	0.74*	0.89**	0.93*
	(0.22)	(0.14)	(0.24)
Big 4	0.62	**1.00***	0.62
	(0.10)	(0.00)	(0.10)
ODOM	**0.76***	0.88*	**1.15***
	(0.28)	(0.13)	(0.21)
Foreign	0.75	0.88*	0.92*
	(0.23)	(0.16)	(0.21)
1989			
All	0.76*	0.89*	0.94*
	(0.21)	(0.18)	(0.20)
Big 4	0.65	**0.97***	0.67
	(0.07)	(0.06)	(0.08)
ODOM	0.75*	0.87*	0.96*
	(0.22)	(0.20)	(0.19)
Foreign	**0.79***	0.89*	**0.98***
	(0.22)	(0.19)	(0.18)
1990			
All	0.75*	0.89*	0.94*
	(0.21)	(0.19)	(0.21)
Big 4	0.61	**0.96***	0.64
	(0.09)	(0.06)	(0.08)
ODOM	0.73*	0.82*	0.92*
	(0.16)	(0.18)	(0.16)
Foreign	**0.80***	0.92*	**1.03***
	(0.24)	(0.21)	(0.20)
1991			
All	0.73*	0.86*	0.93*
	(0.21)	(0.22)	(0.20)
Big 4	0.71	**0.96***	0.73
	(0.09)	(0.07)	(0.06)
ODOM	0.66*	0.80*	0.86*
	(0.18)	(0.23)	(0.18)
Foreign	**0.78***	0.88*	**1.03***
	(0.25)	(0.24)	(0.18)
1992			
All	0.79*	0.91*	0.94*
	(0.18)	(0.16)	(0.18)
Big 4	0.79	**0.98***	0.81
	(0.14)	(0.04)	(0.12)
ODOM	0.74*	0.89*	0.88*
	(0.18)	(0.13)	(0.20)
Foreign	**0.82***	0.89*	**1.03***
	(0.21)	(0.20)	(0.13)

(*continued on next page*)

Table 3 (*continued*)

	TE	PTE	Scale
1993			
All	0.78*	0.90*	0.90*
	(0.19)	(0.17)	(0.18)
Big 4	0.71	**0.96***	0.74
	(0.08)	(0.09)	(0.03)
ODOM	0.77*	0.92*	0.85*
	(0.19)	(0.13)	(0.20)
Foreign	**0.81***	0.86*	**1.00***
	(0.23)	(0.22)	(0.13)
1994			
All	0.75*	0.93*	0.84*
	(0.22)	(0.16)	(0.21)
Big 4	0.67	**0.99***	0.68
	(0.07)	(0.02)	(0.07)
ODOM	**0.80***	0.93*	**0.87***
	(0.12)	(0.11)	(0.11)
Foreign	0.74*	0.90*	0.86*
	(0.31)	(0.22)	(0.28)
1995			
All	0.78*	0.92*	0.87*
	(0.21)	(0.11)	(0.20)
Big 4	**0.81***	**0.99***	0.82*
	(0.13)	(0.03)	(0.12)
ODOM	0.76	0.88*	0.87
	(0.13)	(0.13)	(0.10)
Foreign	0.79*	0.93*	**0.88***
	(0.30)	(0.10)	(0.30)
1996			
All	0.84*	0.96*	0.93*
	(0.12)	(0.06)	(0.17)
Big 4	0.78	0.98*	0.79
	(0.14)	(0.04)	(0.13)
ODOM	0.81	0.94*	0.94*
	(0.11)	(0.08)	(0.17)
Foreign	**0.92***	**0.99***	**1.02***
	(0.12)	(0.03)	(0.13)
1997			
All	0.79*	0.93*	0.89*
	(0.21)	(0.15)	(0.19)
Big 4	0.81*	**1.00***	0.81*
	(0.13)	(0.00)	(0.13)
ODOM	0.77	0.93*	**0.93**
	(0.18)	(0.14)	(0.21)
Foreign	**0.80***	0.89*	0.90*
	(0.29)	(0.20)	(0.20)

Table 3 (*continued*)

	TE	PTE	Scale
1998			
All	0.87*	0.96*	0.96*
	(0.15)	(0.12)	(0.13)
Big 4	0.87*	**1.00***	0.87*
	(0.09)	(0.00)	(0.09)
ODOM	0.80	0.91*	0.97
	(0.21)	(0.20)	(0.16)
Foreign	**0.95***	1.00*	**1.05***
	(0.10)	(0.01)	(0.09)
1999			
All	0.86*	0.95*	0.97*
	(0.16)	(0.10)	(0.16)
Big 4	0.90	**1.00***	0.90
	(0.14)	(0.00)	(0.14)
ODOM	0.76*	0.88*	0.94*
	(0.17)	(0.14)	(0.17)
Foreign	**0.93***	**1.00***	**1.07***
	(0.14)	(0.00)	(0.14)
2000			
All	0.94*	0.99*	0.95*
	(0.08)	(0.03)	(0.07)
Big 4	0.92*	**1.00***	0.92*
	(0.09)	(0.00)	(0.09)
ODOM	0.93*	0.98*	0.95*
	(0.09)	(0.04)	(0.06)
Foreign	**1.00***	**1.00***	1.00*
	(0.00)	(0.00)	(0.00)
2001			
All	0.93*	0.96*	0.98*
	(0.09)	(0.06)	(0.06)
Big 4	0.94*	0.99*	0.95*
	(0.07)	(0.03)	(0.06)
ODOM	0.91*	0.94*	**1.00***
	(0.11)	(0.08)	(0.06)
Foreign	**1.00***	**1.00***	1.00*
	(0.00)	(0.00)	(0.00)

Model 1: Inputs: (i) employees, (ii) deposits, (iii) equity capital. Outputs: (i) loans, (ii) off-balance sheet items. TE: Technical Efficiency, PTE: Pure Technical Efficiency, Scale: Scale Efficiency, ODOM: Other Domestic.

The largest value for each measure in each year is depicted in bold.

Scale Efficiency is calculated by transforming increasing returns to scale values by (2 – original score) and leaving decreasing and constant returns to scale scores unchanged. Thus, an average scale efficiency score above 1 indicates increasing returns to scale on average, below one indicates decreasing returns to scale on average and a score of one indicates constant returns to scale on average.

* Indicates that the maximum value of 1 is observed within that group.

The main source of technical inefficiency is scale inefficiency, with scale efficiency ranging between 0.84 (1994) and 0.98 (2001). This is in contrast to the results of Allen and Rai (1996) who found—in a global context—that input X-inefficiencies dominated output inefficiencies when determining overall efficiency. The Big Four banks are found to have consistently lower scale efficiency, but they also have consistently higher *pure* technical efficiency. Thus, the Big Four banks are operating at a scale exceeding that required for technical efficiency. [27] Stearn and Tress (1983) and Hall (1987) argued that the mergers amongst the major banks during the deregulation period were defensive reactions to foreign bank entry, with the major banks seeking to use size as a barrier to entry to the new entrants, which is found here. This would indicate that the use of size as a barrier to entry was most reflected in the branch networks employed in retail banking (as also argued by Ferguson, 1990). It is interesting to note that in the later years of this study, one of the Big Four banks (ANZ) has adjusted its size to that of constant returns to scale (or most efficient scale size), for all DEA models. [28] It should be noted that Model 1a, with a retail focus, tends to favour the Other Domestic banks, which are mainly retail banks.

Overall, the foreign banks generally display superior technical efficiency due to superior scale efficiency. This confirms the argument of the Reserve Bank of Australia (1994) that the foreign banks innately possess economies of scale and were able to offer an immediate competitive stimulus to the Australian banking system, and is consistent with the global study of Claessens et al. (2001). In their first full year of operations, the foreign banks were, on average, more efficient than the Big Four banks. However, given the sample size and standard deviations, these differences are not significant. In the fourteen years considered here the foreign banks displayed superior average technical efficiency in eleven years. This is in contrast to the results surveyed by Berger et al. (2000) that foreign banks are on average less efficient than domestic banks. This can be explained by the limited form of the global advantage hypothesis proposed by Berger et al. (2000), which argues that multinational banks from a subset of nations are able to operate in the host nation at superior efficiency. The number of foreign banks considered in this study is relatively small, thus statistical testing of nation effects is not possible. However, selection of these banks by Federal Cabinet did have a bias toward large established multinational banks from Australia's major trading partners (Pauly, 1987). It is possible that this bias has selected those banks that possess advantages reflecting the limited global advantage hypothesis. [29] Interestingly, Canhoto and Dermine (2003) also found for the Portuguese case that new entrants (including a few foreign banks) to a deregulated market were more efficient than incumbent banks, arguing that the new banks were able to choose best practice techniques without being hampered by overheads of less efficient historical investments.

Consistent with Avkiran (1999), 1991 was the year of lowest average efficiency. In 1991 increased provisions for bad debts were experienced by the Australian banking

[27] The Big Four banks were found to consistently display decreasing returns to scale until 2000.

[28] Sathye (2002) also found ANZ to show consistently high efficiency.

[29] Suggestive of this conclusion is that IBJ and Mitsubishi Bank (later Bank of Tokyo/Mitsubishi) are consistently found to have technical efficiency of 1 in each of Models 1, 1a, and 1b.

system. Model 1a, which has a retail focus, does not show 1991 to be the year of lowest average efficiency, indicating that those banks with a retail focus were able to reduce the negative impact of the losses of the early 1990s. It is also worth noting that Model 2, which has a revenue focus, shows 1993 as the year of lowest efficiency, indicating there are some delays in these losses being reflected in the revenue measures used. [30]

Over the study period, the number of foreign subsidiary banks declined due to mergers of parents as well as conversion to branch status. [31] It is likely that those foreign banks that have made a strategic choice to operate in Australia as subsidiary banks rather than branches are the more efficient. The decline in sample size is an alternative explanation, but it is notable that the foreign banks consistently exhibit the best practice efficiency in the last two years of the sample, with the exception of Model 2.

Model 2 measures the efficiency of banks in turning costs into revenue, while Model 1 and its variations measure the efficiency of banks turning quantities of inputs into quantities of outputs. Model 2 generally finds the foreign banks to be less efficient than the Big Four and Other Domestic banks. [32] Thus, while the foreign banks were more efficient in transforming quantities of inputs into quantities of outputs than domestic banks, this was not reflected in revenue efficiency. The revenue-focussed model further demonstrates the impact of the economic downturn of the early 1990s on the foreign banks and the barriers to entry caused by the dominance of the Big Four. Williams (2003) found that the domination of the Australian market by the four major banks resulted in a reduction in foreign bank and foreign merchant bank return on assets, consistent with these results.

The cross-border study of Claessens et al. (2001) found foreign banks to be less profitable than domestic banks in developed nations, and they also argued that foreign bank entry is associated with increased efficiency of the domestic banking system, as reflected in lower profits of domestic banks. [33] According to DeYoung and Nolle (1996), foreign banks were willing to accept lower profits (hence the lower revenue efficiency found in Model 2) in return for growth, (potentially reflected in the superior efficiency found in Model 1).

Of the four DEA models of bank efficiency presented in this paper, Models 1, 1a and 1b are relatively highly correlated, with the exception of Model 1a in 1988, and Model 1b in 1998. The low correlation for Model 1a in 1988 is due to sample availability issues. Model 2 has low or negative correlations with the other models except for 2001. This change (for 2001 only) is also most likely due to the impact of reduction in sample size.

[30] As the revenue measures employed excluded an asset quality measure.

[31] Some foreign banks operate in Australia as both subsidiary banks and branches.

[32] In the case of Model 2, the lower scale efficiency of the Big Four banks does not persist across the entire sample period.

[33] The Malmquist Index results found a reduction in efficiency for the revenue focussed Model 2 for all banks. This could reflect the arguments of Claessens et al. (2001).

5.2. Malmquist index results

The Malmquist Index estimation results are in Table 4. They show the post-deregulation period was generally one of overall productivity improvement, with Models 1 and 1b finding productivity improvements of around 10%. Thus, the competitive impact of foreign bank entry in Australia seems to be particularly apparent in the wholesale markets, as argued by Milbourne and Cumberworth (1991). The rate of technological change was lower in the retail focussed model (Model 1a), at 8%. However, the sample period for Model 1a differs from that of Models 1 and 1b. The Model 1a results indicate that the recession of the early 1990s considerably reduced the pace of technological change. It is highly likely that some of the foreign banks were adjusting their operations after 1993 to reflect the process of conversion to branch status, causing a shift in the input–output mix employed by the foreign subsidiary banks and a resulting reduction in observed productivity.

Model 2 found productivity regress of 3% over the sample period, while Avkiran (2000) found productivity improvement of 3.5%. The inclusion of foreign banks in this study is the most likely source of this difference, with the foreign banks in Australia most impacted by the recession of the early 1990s in terms of profit reductions (Ferguson, 1990; Williams, 2003). [34] Model 1 and its variations confirm Avkiran's (2000) result of productivity improvements being mainly sourced in technological progress. However, Model 2 found banks on the estimated best-practice frontier becoming less efficient relative to the unobserved true technological frontier, [35] and any small productivity improvements were sourced in scale efficiency changes, mainly for the Other Domestic banks. Models 1, 1a and 1b show foreign bank productivity improving, mainly due to technological change. However, Model 2 finds productivity regress for the foreign banks. This confirms that Model 2 measures different aspects of productivity.

Consistent with the DEA results for Model 2, improvements in productivity did not necessarily translate into improvements in observed profitability. This is most likely due to the impact of the recession of 1991 and 1992. The early 1990s saw a distinct shift in efficiency changes, particularly for technological change, with the later part of the sample showing efficiency regress due mainly to banks being less efficient than implied by the unobserved true technological frontier. Consistent with Claessens et al. (2001), after deregulation, the competitive shock resulted in rapid technological innovation. The exogenous shocks of the recession of the early 1990s reversed many of these early benefits. However, the post-recession period also saw some small increases in scale efficiency changes. The Australian banking system experienced consolidation during that time, brought on by both in-market mergers and some mergers of foreign bank parents. [36] Furthermore, these mergers may have

[34] The domestic banks did not escape these effects, but they were felt disproportionately by the foreign banks, see Williams (2003).

[35] We are indebted to an anonymous referee for the valuable comments on this issue.

[36] It is possible that these mergers (both in-market and of foreign bank parents) resulted in the post-recession improvements in scale efficiency. Avkiran (1999) was unable to conclusively discern a post-merger change in efficiency for individual banks.

Table 4
Malmquist index means

	Effch	Techch	Pech	Sech	Tfpch
Model 1					
All	0.98	1.12	1.00	0.98	1.10
(SD)	(0.16)	(0.25)	(0.02)	(0.17)	(0.29)
Big 4	0.98	**1.17**	**1.00**	0.98	**1.15**
(SD)	(0.26)	(0.42)	(0.04)	(0.26)	(0.35)
Other Dom.	0.98	1.11	**1.00**	0.98	1.09
(SD)	(0.12)	(0.21)	(0.04)	(0.18)	(0.13)
Foreign	**0.99**	1.11	**1.00**	**0.99**	1.10
(SD)	(0.19)	(0.27)	(0.03)	(0.19)	(0.56)
Model 1a					
All	1.00	1.09	1.00	1.00	1.08
(SD)	(0.12)	(0.55)	(0.09)	(0.12)	(1.18)
Big 4	0.98	0.94	0.99	0.99	0.92
(SD)	(0.05)	(0.36)	(0.02)	(0.02)	(0.35)
Other Dom.	**1.00**	1.04	**1.00**	**1.00**	1.04
(SD)	(0.22)	(0.54)	(0.01)	(0.19)	(1.62)
Foreign	**1.00**	**1.20**	**1.00**	**1.00**	**1.20**
(SD)	(0.10)	(0.59)	(0.14)	(0.14)	(1.02)
Model 1b					
All	0.98	1.12	1.00	0.98	1.10
(SD)	(0.05)	(0.24)	(0.02)	(0.06)	(0.25)
Big 4	0.98	1.12	**1.00**	0.98	1.09
(SD)	(0.15)	(0.34)	(0.04)	(0.07)	(0.34)
Other Dom.	0.98	1.09	**1.00**	0.98	1.08
(SD)	(0.04)	(0.22)	(0.04)	(0.03)	(0.25)
Foreign	**0.99**	**1.14**	**1.00**	**0.99**	**1.12**
(SD)	(0.07)	(0.26)	(0.02)	(0.07)	(0.28)
Model 2					
All	0.99	0.98	0.99	1.00	0.97
(SD)	(0.09)	(0.11)	(0.04)	(0.12)	(0.28)
Big 4	**0.99**	**1.01**	**1.00**	0.99	**1.00**
(SD)	(0.17)	(0.11)	(0.06)	(0.15)	(0.31)
Other Dom.	**0.99**	0.98	0.99	**1.01**	0.97
(SD)	(0.08)	(0.14)	(0.03)	(0.09)	(0.14)
Foreign	**0.99**	0.96	0.99	1.00	0.94
(SD)	(0.18)	(0.09)	(0.13)	(0.22)	(0.52)

Model 1: Inputs: (i) employees, (ii) deposits, (iii) equity capital. Outputs: (i) loans, (ii) off-balance sheet items.
Model 1a: Inputs: (i) employees, (ii) deposits, (iii) equity capital. Outputs: (i) loans less housing loans, (ii) housing loans, (iii) off balance sheet items.
Model 1b: Inputs: (i) employees, (ii) deposits, (iii) equity capital. Outputs: (i) loans, (ii) investments, (iii) off-balance sheet items.
Model 2: Inputs: (i) interest expenses, (ii) non-interest expenses. Outputs: (i) net interest income, (ii) non-interest income.
The largest value for each measure is depicted in bold.
Effch: technical efficiency change relative to constant returns to scale technology.
Techch: technological change.
Pech: pure technical efficiency change relative to variable returns to scale technology.
Sech: scale efficiency change.
Tfpch: total factor productivity change.
Effch = Pech * Sech. Tfpch = Effch * Techch.
(There are some small differences due to rounding).

resulted in a shift of emphasis from technological change to scale efficiency, but this is less certain. Over the study period a number of foreign banks converted to branch status and this may also act as a partial explanation of these results.

Overall, no one category of bank type is found to be conclusively more productive. The Foreign banks are the most productive in Models 1a and 1b, while Models 1 and 2 favour the Big Four banks. However, given the sample sizes and standard deviations, this cannot be considered conclusive. The year-by-year indices found that as one category innovated to move the frontier outward, the other categories reacted by innovating themselves and so moving the frontier outward in following year. This explains why the averages are relatively uniform across the three bank categories across the sample periods, with the exception of Model 1a. This indicates the need for diversity in the types of banks operating in Australia in order to provide the competitive pressure to innovate and provide productivity improvements. This outcome is also consistent with the global findings of Claessens et al. (2001), who concluded that it is the number of banks rather than their size that determine competitive conditions. We find that diversity is also an important element in this process.

Little evidence of overall superior scale efficiency by the foreign banks is found overall (in contrast to the DEA results). A rapid improvement in scale efficiency was found in the early 1990s, followed by a rapid reduction, caused by the recession of the early 1990s. Following the recovery from this recession, both domestic bank categories experienced improvements in their scale efficiency, although the Big Four banks also experienced reduction in scale efficiency changes in the last sample year. This indicates that the shock of the recession of the early 1990s possibly produced a positive outcome of increased scale efficiency.

5.3. Stochastic frontier results

The correlations between the DEA results and the stochastic frontier estimates of bank efficiency are shown in Table 5 (Panel A). With the exception of 1988 and 1996, these correlations are high, and consistent with, or higher than, the range of correlations shown in Coelli and Perelman (1999). [37] The overall correlation between the DEA results and the stochastic frontier results of 0.63 demonstrates the overall consistency between the two approaches toward measuring bank efficiency. [38] The estimated average input-efficiency found by the stochastic frontier for Model 1 is 83.3%, which is slightly higher than for the DEA estimates, as expected, but not appreciably divergent from the overall DEA input-efficiency of around 80%. [39]

[37] In the case of 1996 the lower correlation appears to be due to a change in sample composition, with 20.5% of the banks either entering or leaving the sample in that year. Examination of the results for 1988 could not determine any obvious causes of the low observed correlations.

[38] The overall correlations between the DEA results and the stochastic frontier estimates for Models 1a, 1b and 2 are respectively 0.61, 0.53 and 0.68 (using respectively 223, 273 or 264 observations).

[39] For Model 1a the average efficiency estimated by the stochastic frontier is 86.4%, for Model 1b, it is 87.5% and for Model 2 it is 87.8%.

Table 5
Stochastic frontier results

Year	Correlation with DEA	Number of observations	Year	Correlation with DEA	Number of observations
Panel A: Correlations with DEA results for Model 1					
1988	0.0837	18	1995	0.6941	23
1989	0.7783	26	1996	0.0926	20
1990	0.8047	23	1997	0.8116	17
1991	0.7225	26	1998	0.7954	13
1992	0.6737	25	1999	0.9053	13
1993	0.6318	24	2000	0.6561	10
1994	0.6850	25	2001	0.6538	10
Overall	0.6262	273			

Panel B: Secondary regression results

Variable	Coefficient (t-statistic)	Equal coefficients for each group	Equal coefficients for each period[a]
Big 4 (88–89)	0.827 (16.02)*	$F(3,261) = 0.685$	$F(2,261) = 0.297$
Big 4 (90–91)	0.840 (19.26)*		$F(2,261) = 0.020$
Big 4 (92–96)	0.864 (33.47)*		$F(2,261) = 9.838$*
Big 4 (97–01)	0.894 (34.63)*		$F(2,261) = 0.583$
Other Domestic (88–89)	0.815 (23.43)*	$F(3,261) = 0.423$	
Other Domestic (90–91)	0.848 (29.40)*		
Other Domestic (92–96)	0.836 (50.17)*		
Other Domestic (97–01)	0.858 (37.90)*		
Foreign (88–89)	0.846 (38.79)*	$F(3,261) = 7.59$*	
Foreign (90–91)	0.850 (37.54)*		
Foreign (92–96)	0.750 (45.48)*		
Foreign (97–01)	0.864 (30.85)*		

Model 1: Inputs: (i) employees, (ii) deposits, (iii) equity capital. Outputs: (i) loans, (ii) off-balance sheet items. The stochastic frontier was estimated using the parametric input-distance function methodology of Coelli and Perelman (1999), including a time trend.

Dependent Variable: Efficiency estimates from stochastic frontier estimation, Model 1: 39 banks, 1988–2001, 273 observations.

Adjusted $R^2 = 0.085$, F-statistic (11, 261) = 3.2906*.

* Significant at a 1% level. Big 4 (88–89) is a dummy variable representing Big 4 banks in 1988 and 1989. Big 4 (90–91) is a dummy variable representing Big 4 banks in 1990 and 1991; and so forth.

[a] Equal coefficients for each period implies for instance Big 4 (88–89) = Other Domestic (88–89) = Foreign (88–89).

Efficiency scores drawn from the stochastic frontier estimation were used as dependent variables in secondary regressions to determine differences in estimated efficiency across firm types and years. Results of this regression for Model 1 are shown in Table 5 (Panel B). In this regression the sample period was divided into four blocks of time, with 1988 and 1989 representing the post-deregulation period,

1990 and 1991 representing the recession period. The remaining ten years were divided into two equal blocks of five years, the first five years, 1992–1996, for the post-recession recovery period, and 1997 to 2001 representing the post-recovery period. [40] Each of these four sets of time specific dummy variables were interacted with the three dummy variables representing the three bank types to result in a total of twelve dummy variables (and no constant) in the secondary regressions. Chow tests found a significant difference between the year blocks for the Foreign banks, with the post-recession period of 1992–1996 showing significantly lower efficiency, and an overall upward trend in Foreign bank efficiency over the sample period. It is worth noting that the revenue focussed Model 2 showed this lower efficiency occurring in 1990–1991, slightly earlier than the DEA estimates for Model 2. Thus the recession of the early 1990s resulted in a reduction of bank input-efficiency, which seemed to last about three years after the recession. While no significant time trends were found for the Big Four or Other Domestic banks, it is notable that the coefficients for the Big Four banks trended upward over the sample period. The coefficients for the Other Domestic banks show a less clear-cut trend across the four models, probably due to the restructuring this sector experienced over the sample period, with state-owned banks exiting Australian banking [41] and the converted building societies entering the sample, as well as some in-market takeovers. As shown in Table 5 (Panel B), the coefficients for the Other Domestic banks did trend upwards over the sample period for Model 1. Overall, this upward trend in bank efficiency tends to confirm the results of the Malmquist Index estimations.

6. Conclusions and directions for further research

Our DEA results show that scale inefficiency dominates technical inefficiency in the Australian case (in contrast to Allen and Rai, 1996). The Big Four Australian banks during and after deregulation used size as a barrier to entry via mergers before the entry of the foreign banks and increased spending upon branch networks post-deregulation. Williams (2003) found that this barrier to entry effect resulted in lower foreign bank and foreign merchant bank profits. Our Malmquist Index results show that bank productivity improved, on average, post-deregulation, with the exception of the revenue-focussed Model 2, which tends to be supported by the stochastic frontier results. The main source of these productivity gains post-deregulation was technological change rather than technical efficiency. It can be concluded that the foreign banks provided an important source of technological efficiency changes immediately post-deregulation, and after the shock of the recession of the early 1990s the domestic banks somewhat improved their scale of operations.

The DEA results found foreign banks experienced superior scale efficiency, which resulted in increased efficiency, on average, compared to the Big Four banks or the

[40] Use of dummy variables representing each year did not yield appreciably different outcomes. In the interests of compactness, only results for the regression using blocks of years are reported.

[41] The state-owned banks were largely privatised during the study period.

Other Domestic Banks. This is opposite to the results of other studies surveyed by Berger et al. (2000). This is most likely due to the rationing process during deregulation selecting banks possessing attributes consistent with the limited form of the global advantage hypothesis (Berger et al., 2000). An interesting direction for further research would be to determine which foreign bank attributes result in superior efficiency in the host nation. We also suggest that those foreign banks that elected to *not* convert to branch status, when the opportunity arose, are the most efficient of the foreign banks. The process of conversion to branch status seems to explain the reduction in efficiency changes observed in 1994 for the foreign banks. Again, further research into this issue would be valuable. Some improvement in scale efficiency after the recession of the early 1990s was also found. It is not clear if this scale efficiency improvement is due to the exogenous shock of the recession resulting in increased attention upon scale efficiency, or if this was due to the post-recession consolidation of the banking system.

Furthermore, those banks with a stronger retail focus were less affected by the recession-induced losses of the early 1990s in terms of reduced efficiency. Diversity in the types of banks participating in the banking system was found to be an important source of competitive improvements in productivity. Consistent with Berger et al. (1993), conclusions regarding efficiency were found to be sensitive to the specification of inputs and outputs. However, this study indicates that foreign banks were more efficient than domestic banks, on average, post-deregulation, but this higher efficiency was not found to imply higher foreign bank profits.

The policy implications resulting from this study are that regulators should encourage diversity in banks types as a source of ongoing efficiency and innovation in the banking market, that the establishment of new banks (both domestic and foreign) provide an important contribution toward efficiency gains during deregulation. Further, recessions and the accompanying increases in bad debts can result in a shift in the nature of ongoing changes in efficiency, with post-recession periods showing some lower efficiency, (but increased attention to scale efficiency), followed by a later recovery in bank efficiency.

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