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ARTICLES

The Role of Governance, ICT and Bad Loans in Australian Bank Efficiency: An Empirical Study*

RUHUL SALIM, MOHAMMAD ZIAUL HOQUE AND SUYANTO

This paper analyzes the impact of governance, information and communications technology (ICT) and bad loans on bank efficiency over the period 1997–2007. Using linear programming–based data envelopment analysis, the study shows that the overall efficiency of Australian banks is influenced by a consistent growth of technical efficiency since 1997, with major banks showing relatively higher levels of technical efficiency than regional banks. The results from the Malmquist productivity index reveal that technological progress contributes substantially to banks' productivity growth. Furthermore, the results from the common effect panel data model show that bad loans and poor governance have negative effects while ICT has a positive impact on banks' technical efficiency.

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INTRODUCTION

Banking constitutes a vital part of the financial system of any economy. Despite the changing circumstances that have occurred in recent years as a result of the technological revolution, the development of various financial intermediaries and the globalization of financial markets, banks continue to play a dominant role in the economy. Hence, evaluating banks' performance in terms of productive efficiency is of critical importance not only to bank managers or banks' shareholders, but to policymakers as well. The inquiry into the efficiency measurement in the banking industry has attracted a lot of attention from researchers in Australia and elsewhere for the past two decades. Such attention is not surprising because the efficiency of banks is an important aspect of financial intermediation functions. This study throws light on the efficiency of the existing financial system and assesses whether financial resources are being used efficiently. The issue has become more pronounced, however, in the wake of the financial crises experienced by the developed and developing economies in the world.

The aims of this study are two-fold: one is to examine the productive efficiency of Australian banks; and the other is to analyze the impact of corporate governance, information and communications technology (ICT), and non-performing loans on banking efficiency using data over the period 1997–2007.

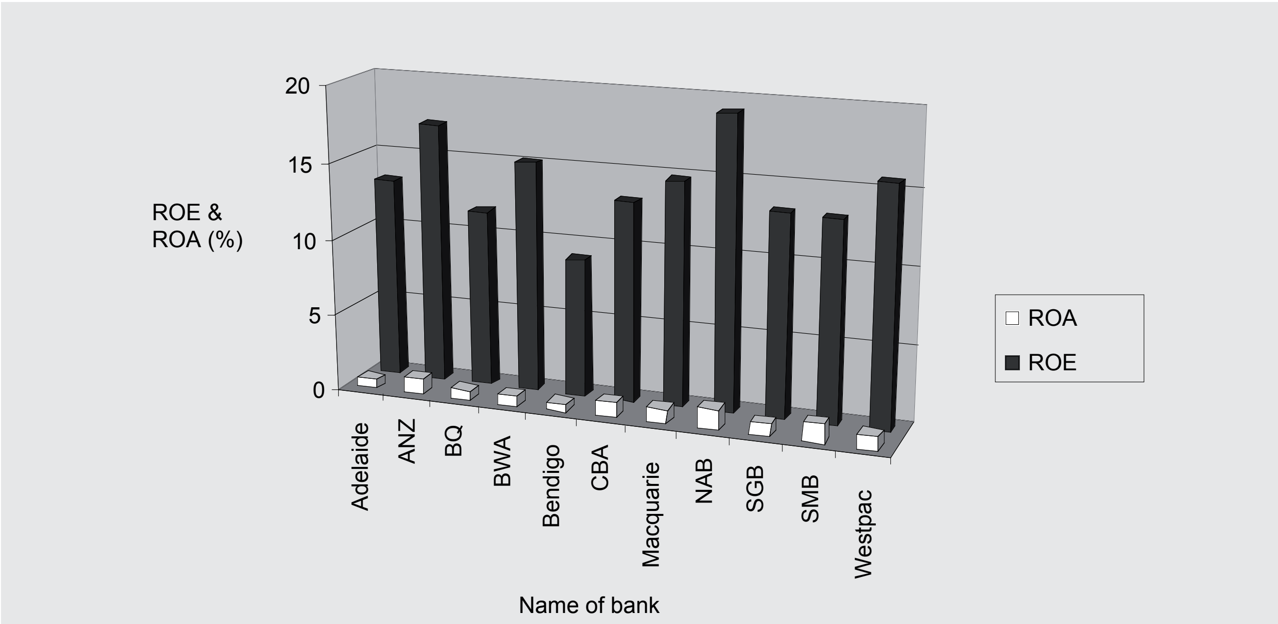
Good loans and good corporate governance provide sound resource allocation and ensure efficient performance in the banking sector. Several earlier studies confirm this proposition. Berg, Forsund and Jansen (1992), Kwan and Eisenbeis (1996), Resti (1996) and, more recently, Dongili and Zago (2005) report that there is a negative relationship between problem loans and the efficiency of banking institutions. These studies further argue that the institution with problem loans incurs high costs and generates low profits relative to the institution with the 'best practice' efficient frontier. Pi and Timme (1993), Berger and Mester (1997), Berger *et al.* (2005) and Gup (2007) argue that corporate governance affects the behavior and performance of banks, innovative activity, and the development and functioning of capital markets; and exerts a strong influence on resource allocation. It is also argued that the current financial crises, credit crunch and the collapse of some of the renowned financial institutions in the United States (US) and Europe are attributed to persistent default loans, bad governance and poor regulatory response from the banks. In addition, the whole banking landscape has been changing since the mid-1990s with the use of ICT, which has been transforming banks both quantitatively and qualitatively. Moreover, improvements in information technology continue at a high rate and are expected to have a significant impact on future banking methods and structures. Yet there is little empirical evidence on the effects of ICT adoption on banking efficiency gains. Furthermore, none of the previous studies focused on analysis of the sources of bank (in-)efficiency, Australian banks in particular, after incorporating the above three important determinants. This study attempts to close this gap and provides an important addition to the body of knowledge relating to bank efficiency.

The paper is organized in the following way. Firstly, an overview of Australian banking is presented, which is followed by a critical review of theoretical and empirical literature. The next section outlines the analytical framework, after which the data sources and variables construction are described. The empirical results are then presented along with a discussion about links between productive efficiency and corporate governance, ICT and non-performing loans (NPLs). Finally, there is a concluding section in which some policy implications are discussed.

OVERVIEW OF AUSTRALIAN BANKING

During the 1990s, the Australian government implemented a number of deregulatory measures in order to provide support for an efficient, responsive and innovative banking system. Central to the deregulation was legislation granting the banks the freedom to set their own pricing and product policies. In addition, the government allowed foreign banks to enter the domestic banking market for wholesale banking and such changes culminated in the rapid growth of the banking sector. Despite the existence of foreign entrants, the increased competition from non-bank financial institutions and the onslaught of technological innovation, the Australian banking sector remains highly concentrated and behaves in an oligopolistic manner. As of April 2009 the Australian banking system comprised fifty-eight authorized banks of which forty-two were foreign- owned. The largest four banks are the Australia and New Zealand Banking Group (ANZ), Commonwealth Bank of Australia (CBA),

FIGURE 1
Average ROE and ROA of Australian banks (1999–2005)

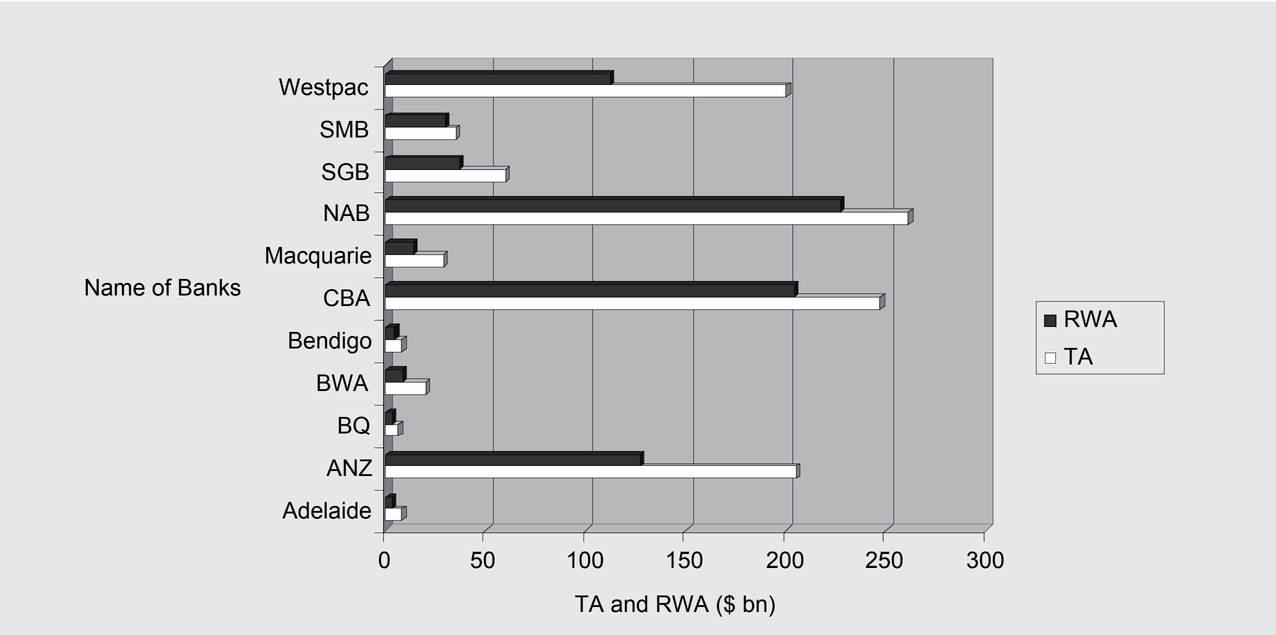


National Australia Bank (NAB) and Westpac Banking Corporation. These banks are highly diversified, both geographically and in their income. The most prominent regional banks are the Adelaide Bank, Bendigo Bank, Bank of Queensland (BQ), St.George Bank (SGB), Bank of Western Australia (BWA) and Suncorp-Metway Corporation (SMB). The market is highly dominated by the four largest banks which together control 67.5% of total banking assets and 32% of the assets of all financial institutions in Australia. Figure 1 shows that the National Australia Bank (NAB) was the largest bank in Australia during 1999–2005, with average total assets over the period of A$261 billion. It is also evident that it was the most profitable and efficient bank in Australia during this period, with 1.35% average return on assets (ROA) and 19.15% average return on equity (ROE).

The Commonwealth Bank of Australia (CBA) was the second largest bank (average assets of A$247 billion), while ANZ Banking Corporation (ANZ), the third largest bank (A$205 billion in assets), demonstrated high profitability with an average ROE of 17.0%. ANZ's efficiency, however, as measured by its average ROA (1.08%) was lower than that of Suncorp-Metway (1.25%). Similarly, Westpac Banking Corporation, the fourth largest bank (A$200 billion in assets), achieved ROE of 15%. The lowest ROE was recorded by the Bank of Bendigo with 9.02% ROE and 0.55% ROA. With the same average assets (A$8 billion), the Adelaide Bank achieved a 13.18% ROE.

The relationship between risk and return is well known, so one would expect to see a relationship between the level of risk and the financial performance of Australian banks. The per cent of risk-weighted assets (RWA) to total assets (TA) provides one indication of risk, whereby the lower the ratio, the lower the risk. The relationship between risk and returns, however, shows no conclusive results in this regard. Figure 2 (opposite) shows that with TA of A$247 billion and RWA of A$204 billion (83%),

FIGURE 2
TA and RWA of Australian banks



the CBA generated an annual average ROE of 13.14%; whereas a 17.05% ROE was earned by ANZ with 62% of RWA to TA. Much the same ROE was achieved by the Adelaide Bank with 42.50% RWA, St.George Bank with 62% RWA, and Suncorp-Metway with 84.28% RWA. All these show that the Australian banks have demonstrated a convincing and satisfactory growth of RWA and bank efficiency in terms of ROA.

LITERATURE REVIEW

Banking Efficiency: International Literature

A remarkable number of studies on the efficiency of the banking industry has been carried out over the last two decades. Some studies focus on measuring the efficiency indices and separating efficiency change from technological change, while others pay more attention to the determinants of efficiency. Aly *et al.* (1990) measure the efficiency of US banking and find that the technical component is relatively more important than the allocative component as a source of overall inefficiency. Elyasiani and Mehdian (1995) estimate the efficiency of the US banks, but they extend further to separate efficiency change and technological change. They show that the productive performance of the observed banks comes mainly from technological change. Similar types of evidence are found by Grifell-Tatje and Lovell (1997) and Casu, Girardone and Molineux (2004) for Spanish and European banks, respectively. Most of the earlier studies identify some key determinants such as size, age, market share, and loan-asset ratio that influence banking efficiency. These studies include Berger and Mester (1997) for the US; Delis and Papanikolaou (2009) for the European Union; Hassan, Al-Sharkas and Samad

(2007) for Bahrain; and Sufian (2009) for Malaysia.

Some studies focus on the effects of bad-debts or problem loans on banking efficiency. Berg, Forsund and Jansen (1992) make the original observation by including bad-debts into a production function in their study on Norwegian banking. Their results show a negative effect of bad-debts on productivity growth, but the magnitude was very small, which indicates a non-binding constraint of bad-debts in Norwegian banking. In a similar vein, Berger and De Young (1997) examine the inter-temporal relationship between problem loans and the efficiency of US banks between 1985 and 1994. They find that the increase in problem loans is related to the decrease in overall efficiency of US banks. Resti (1996) and Matthews, Guo and Zhang (2007) also find a negative effect of bad-debts on efficiency for Italian and for Chinese banks.

Empirical literature on the relationship between banking efficiency and ICT is not plentiful. The authors of this paper found only two working papers on the issue. Suhaimi (2005) examines the effect of ICT on the overall efficiency of Malaysian banks between 1995 and 2003 and finds that expenditure on ICT significantly decreases inefficiency. More recently, Erber and Madlener (2008) made an attempt to examine the link between ICT expenditure and banking efficiency in the European financial sector. Their results suggest that expenditure on ICT might need to be complemented by learning-by-doing and learning-by-using modes of training in the new technology in order to increase the efficiency of financial institutions. Although these two studies bring a significant contribution to the literature, they suffer from some drawbacks. While Suhaimi's study is dated, Erber and Madlener's study is laced with an implicit homogeneity assumption in the observed relationship across European countries.

An extensive literature search failed to locate a significant number of studies on the relationship between corporate governance and productive efficiency of banking institutions. Only two recent studies could be located that focused on the relationship between corporate governance and banking performance. Williams and Nguyen (2005) identify corporate governance in terms of bank ownership (state-owned, private-owned, and foreign-owned) and find that privatization raises banking performance. Berger *et al.* (2005) report identical findings in the sense that privatization increases banks' performance. Although these studies do not typically examine the effects of corporate governance on banking efficiency, they may provide a foothold for furthering the study on the linkage between corporate governance and banking efficiency. Furthermore, elements of some empirical studies that examine the link between corporate governance and technical efficiency in the manufacturing sector may provide some insights for studying such a relationship in the banking sector. In a study on Ukrainian manufacturing industries, Zulenyuk and Zheka (2006) find a positive relationship between the level of corporate governance quality and the technical efficiency level. But Destefanis and Sena (2007) find otherwise in the case of Italian manufacturing firms. Since standard economic theories do not provide an explicit link between corporate governance and technical efficiency, it largely remains a matter of empirical issue.

Australian Literature

Studies on Australian banking efficiency are relatively sparse compared to the enormous numbers of those in other developed countries. Berger and Humphrey (1997) published a literature survey on 130 empirical studies on banking efficiency in twenty-one countries and none of the studies was related to Australian banks. Allen and Rai (1996) may be the first authors to have studied Australian banking efficiency. Using cross-border data they concluded that Australia had a relatively efficient banking system. Applying a *translog* cost function to twelve Australian banks, Walker (1998) shows that there is no evidence of diseconomies of scale although some evidence is found of constant returns to scale. Analyzing post-deregulation bank mergers, however, between 1986 and 1995, Avkiran (1999) finds inefficiency in the post-deregulation period, and that acquiring banks are more efficient than the target banks in the merger process. He further reports that bad loans affect banking efficiency negatively. He did not test this proposition empirically, however. Subsequently, using the same data set, Avkiran (2000) extends the analysis in respect of productivity decomposition and shows that technological progress (TP) is the main driver behind productivity growth.

Applying the data envelopment analysis (DEA) to Australian banking data for the year 1996, Sathye (2001) investigates X-efficiency and finds that average technical efficiency is lower than average allocative efficiency. In addition, he estimates the relationship between efficiency and several factors that might contribute to inefficiency. But he did not consider bad loans, ICT or corporate governance as important factors for his study. Later on, Sathye (2002) measures the productivity growth of Australian banks over the period 1995–99 using the Malmquist index, and finds that technical efficiency decreases by 3.5% during the sample period. By segmenting Australian banks into two groups (major and regional banks), he shows that there is no relationship between bank size and productivity growth. Neal (2004) imitated the same DEA technique for the same data period considered by Sathye (2002) and finds that allocative efficiency is higher than technical efficiency for the sample period and that allocative efficiency tends to increase over time. He also finds that the average annual total factor productivity (TFP) growth is 7.6%, which is 1.013% in Sathye's (2002) study, and that such change is mostly driven by technological progress. Furthermore, Neal provides evidence that the Australian banks are less efficient in 1999 compared to 1995. Dividing Australian banks into three categories: national, regional and international, he shows that regional banks are the worst performers in terms of efficiency and productivity. Also, he reports that the unproductive regional banks may become the target of the large banks. A more recent study is conducted by Kirkwood and Nahm (2006). Using data of ten Australian banks from 1995 to 2002, Kirkwood and Nahm find that technological progress is the main driver of TFP growth, which is identical to what is found by Neal (2004). Unlike Neal, however, they also find that regional banks have higher cost efficiency than large national banks during the period in question. In fact, regional banks experienced lower efficiency after 2000, since they have a fairly constant level of cost efficiency. Kirkwood and Nahm also show that the cost efficiency in Australian banks is mostly driven by allocative efficiency, which contradicts Sathye's (2001) findings.

It is now clear that past studies did not focus on the impact of bad loans, ICT and corporate governance on the efficiency of Australian banks, and the present study endeavours to close this gap. It appears from the preceding discussion that there is no consensus regarding whether allocative or technical efficiency is the major driver of cost efficiency in Australian banks. This study, by using more updated data, attempts to provide efficiency estimates for bolstering cost efficiency for Australian banks. Furthermore, debates about the contradictory findings reported by Neal (2004) and Kirkwood and Nahm (2006) provide scope to carry out further study to confirm the differences of efficiency between regional and large national banks in

Australia; to the extent that this exercise constitutes one of the objectives of the current study.

METHOD AND EMPIRICAL MODEL

Generally speaking, two approaches are used to estimate banking efficiency: the parametric approach and the non-parametric approach. The commonly used parametric technique is stochastic frontier analysis (SFA) and the non-parametric approach is data envelopment analysis (DEA). The SFA has the advantage of separating the inefficiency component from the purely random component, which represents the effect of variables beyond control of production units; whereas the DEA assumes that deviations from the efficient frontier arise due to inefficiency. Nonetheless, this study adopts the DEA, for three reasons. First, it requires no functional form when measuring efficiency. Imposition of a common functional structure on the production technology of Australian banks would be inappropriate, given the fact that there is wide variation among the banks in terms of delivery of technology-assisted financial services. Secondly, DEA accommodates multi-outputs, which is ideal for studying banking efficiency. Thirdly, DEA is suitable for analysis of small sample sizes, such as those of Australian banks. Given the existence of so few banks in Australia and the dearth of adequate data, together with restricted access to the data regime, an analysis of banking efficiency using the parametric approach might not be suitable.

This study adopts the input-oriented DEA for measuring the efficiency of Australian banks.[1] To present the formal model, consider a group of N banks transforming K inputs into M outputs. The DEA model for measuring technical efficiency (TE) of the i-th bank is expressed as

$$
\begin{aligned}
&\min_{q,\lambda} TE = q \\
&s.t. - y_i + Y\lambda \geq 0_M \\
&q x_i - X\lambda \geq 0_K \\
&1'_N \lambda = 1 \\
&\lambda \geq 0_N
\end{aligned}
\qquad (1)
$$

Where, q is a scalar value between 0 and 1, λ is a $(Nx1)$ vector of constraints, y_i is $(Mx1)$ vector of the output quantities, Y is (MxN) matrix of actual quantities of M outputs by N banks, x_i is $(Kx1)$ vector of input quantities, X is (KxM) matrix of K inputs by N banks, 1_N is $(Nx1)$ vector of one, and 0_M, 0_K, and 0_N are null vector of order M, K, and N, respectively.

It should be pointed out here that equation (1) assumes variable return to scale (VRS) by imposing the convexity constraint $(1'_N \lambda = 1)$. Hence, this model takes into account scale of production when measuring efficiency. Furthermore, q in the equation represents the 'contraction' factor corresponding to the level of efficiency. Thus, banks that are able to minimize the input–output combinations, relative to other banks, are considered fully efficient and are, thus, on the 'best practice' frontier with a value of $q = 1$. Those banks that are less efficient are some distance from the frontier and the q-values of these banks will be less than one. The distance from the frontier is used as a basic gauge for measuring the bank's inefficiency.

If the prices of inputs are available, the 'overall' or economic efficiency of the i-th bank can be calculated first by solving the following *minimum cost* linear program:

$$
\begin{aligned}
&\min_{\lambda, yi} C = w'_i x_i^* \\
&s.t. - y_i + Y\lambda \geq 0_M \\
&x_i^* - X\lambda \geq 0_K \\
&\lambda \geq 0_N \\
&1'_N \lambda = 1
\end{aligned}
\qquad (2)
$$

where w_i is a ($Kx1$) vector of input prices for the i-th bank, x_i^* is a ($Kx1$) vector of the optimal quantities of inputs for the i-th bank, and other variables are defined as in the previous equation. Equation (2) provides the minimum cost efficient solution for the i-th bank, and the overall efficiency (OE) is calculated as the ratio of the minimum cost solution $\left(w_i' x_i^*\right)$ to the actual cost incurred in production $\left(w_i' x_i\right)$; that is:

$$OE = w_i' x_i^* \big/ w_i' x_i \qquad (3)$$

Allocative efficiency (AE) is then residually derived by dividing overall efficiency by technical efficiency; that is:

$$AE = OE/TE \qquad (4)$$

The scale efficiency can be measured by dividing the technical efficiency under the assumption of constant return to scale (CRS), which can be measured from equation (1) without the convexity constraint $(1_N' \lambda = 1)$, by the technical efficiency under the variable return to scale (VRS).

In order to separate technological change from efficiency change, this study calculates the DEA-based Malmquist productivity index (MPI). The input-oriented MPI of period t+1 relative to period t (the base period) can be expressed as:

$$MPI_O^{t,t+1}\left(x_i^t, y_i^t, x_i^{t+1}, y_i^{t+1}\right) = \left[\frac{1/D_O^t\left(x_i^{t+1}, y_i^{t+1}\right)}{1/D_O^t\left(x_i^t, y_i^t\right)} \times \frac{1/D_O^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)}{1/D_O^{t+1}\left(x_i^t, y_i^t\right)}\right]^{\frac{1}{2}} \qquad (5)$$

where $MPI_O^{t,t+1}\left(x_i^t, y_i^t, x_i^{t+1}, y_i^{t+1}\right)$ is an MPI for two consecutive periods t and t+1; $D_O^t\left(x_i^{t+1}, y_i^{t+1}\right)$ represents a distance function that compares the i-th bank at the period t+1 to the technology at period t; $D_O^t\left(x_i^t, y_i^t\right)$ is a distance function for the i-th bank to period t technology; $D_O^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)$ denotes a distance function for the i-th bank to the t+1 period technology; and $D_O^{t+1}\left(x_i^t, y_i^t\right)$ is a distance function that compares the i-th bank at time t to period t+1 technology. The distance function $D_O^t\left(x_i^t, y_i^t\right)$ is equivalent to the optimized q in equation (1), which represents technical efficiency. Hence, the distance function represents the proportion by which the input vector of the i-th bank should be contracted to be fully efficient under period t technology.

Equation (5) can be expressed equivalently as:

$$MPI_O^{t,t+1}\left(x_i^t, y_i^t, x_i^{t+1}, y_i^{t+1}\right) = \left[\frac{1/D_O^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)}{1/D_O^t\left(x_i^t, y_i^t\right)}\right] \times \left[\frac{1/D_O^t\left(x_i^{t+1}, y_i^{t+1}\right)}{1/D_O^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)} \times \frac{1/D_O^t\left(x_i^t, y_i^t\right)}{1/D_O^{t+1}\left(x_i^t, y_i^t\right)}\right]^{\frac{1}{2}} \qquad (6)$$

The term in the first bracket represents the change in the technical efficiency between two consecutive periods, t and t+1; and the term in the second bracket represents technological change between period t and period t+1. Using equation (6), this study separates technical efficiency change from technological change. The DEAP2.1 computer program is used to solve both the DEA programs in equations (1) and (2) and the Malmquist productivity index of equation (6).[2] Using this DEAP2.1 we derive the indices of technical efficiency (TE), allocative efficiency (AE), scale efficiency (SE), overall efficiency (OE), and the decomposition of the MPI into technical efficiency change (TEC) and technological change (TC).

Technical efficiencies of banking institutions are not only affected by the core banking activities but also by the banks' adoption and use of technology, efficient management policies and good governance. Bank governance has become a burning issue in view of the financial crises and the collapse of some US and

European banks. Drawing on the earlier theoretical and empirical studies discussed above, the following equation is specified. Additionally, this model provides a comparison of the results with those reported by the previous studies.

$$TE_{it} = \beta_0 + \beta_1 BL_{it} + \beta_2 ICT_{it} + \beta_3 CG_{it} + \varepsilon_{it} \qquad (7)$$

where BL stands for bad loans, ICT for expenditure on information and communications technology, CG for corporate/bank governance and ε_{it} is the disturbance error term with usual statistical properties.

DATA SOURCE AND MEASUREMENT OF VARIABLES

Data for this study are extracted from the annual reports of related banks.[3] The data used is for nine Australian banks. Other than the major four banks, the following five regional retail banks are included in the study: Adelaide Bank, Bendigo Bank, Bank of Queensland, St.George Bank and Suncorp-Metway Corporation. This study deals with the operations and activities of these banks over the period 1997–2007.

There are two sets of variables used in this study. The first set consists of inputs and outputs for measuring the efficiency of banks. The second set is related to the determinants of efficiency. Definitions of each variable are given in Table 1 (opposite). In order to specify the input and output variables, this study adopts a value-added approach.[4] The output variables are loans, deposits and non-interest income, which are measured at million of (2004) Australian dollar; while the input variables are labor, capital, and interest-bearing liabilities.

While labor refers to total full-time employees at the end of the financial year, capital is calculated from the book value of property, plant and equipment at the end of the financial year and they are deflated to constant price of 2004. As the DEA requires input price variables, the study defines these variables as follows: the input price of labor is calculated from the expenses on staff divided by the number of full-time employees; the price of capital is measured from the ratio between expenses on fixed capital (property, plant and equipment) and the book values of these assets; and the price of interest-bearing liabilities equals the ratio of interest expenses over interest-bearing liabilities. The three variables chosen as the determinants of technical efficiency are bad loans, ICT and bank/corporate governance. These three variables have never been included in previous studies on Australian banking efficiency. The last two variables (i.e. ICT and good governance) have considerable influence on bank efficiency (Williams & Nguyen 2005). Due to the absence of the direct measurement of ICT, expenditures on computer systems, software, telephone, postal, and depreciations of computer hardware are used as proxy. The number of risk committee meetings attended by the bank directors is used as the proxy for bank governance since data for other bank governance are not available.

Descriptive statistics of the relevant variables are presented in Table 2 (p. 28). The statistics are calculated for total samples, the big four banks and regional banks. The mean values of outputs and inputs of the big four banks are on average much higher than those of regional banks and this reflects the differences between large and relatively small banks. Hence, when all banks are pooled together, the standard deviations of outputs and inputs are large. Furthermore, the large standard deviations of regional banks are mainly due to the relatively large size of St.George bank compared to other regional banks.

TABLE 1
Definitions of variables

Symbol	Category	Unit	Definition
Q1	Output	Million of (2004) A$	Loans
Q2	Output	Million of (2004) A$	Deposits
Q3	Output	Million of (2004) A$	Non-interest income
X1	Input	Employees	Number of full-time equivalent employees the bank employs at the end of the financial years
X2	Input	Million of (2004) A$	Fixed capital is measured as the book value of property, plant and equipment at the end of the financial years
X3	Input	Million of (2004) A$	Interest-bearing liabilities equal deposits, borrowing funds and other source of debts
P1	Input price	(2004) A$	Price of labor equals staff expenses divided by the number of full-time equivalent employees
P2	Input price	(2004) A$	Price of fixed capital equals expense associated with property, plant and equipment divided by the book value of these assets
P3	Input price	(2004) A$	Price of interest-bearing liabilities equals interest expenses divided by interest-bearing liabilities
BL	Variable as a contributing factor to technical efficiency	Billion of (2004) A$	Bad loans is the portion of loans estimated to be not collectible by banks at the end of financial years
ICT	Variable as a contributing factor to technical efficiency	Billion of (2004) A$	Information and communications technology is annual expenditure on technology and communication, which is calculated from expenditure on computer system, software, telephone, postage and depreciations of computer hardware
CG	Variable as a contributing factor to technical efficiency	Number of meetings	Corporate/bank governance is measured by the number of risk committee meetings attended by the designated members of the board of directors per year

TABLE 2
Descriptive statistics of samples, 1997–2007*

Variable	Total Sample				The Big Four Banks				Regional Banks			
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
Q1	2322	289361	93480	90883	96080	289361	184284	56011	2322	81058	20836	19956
Q2	2447	229261	76069	73501	81704	229261	150267	43174	2447	63850	16712	15676
Q3	28	16102	2584	2955	1949	16102	4761	2965	28	6107	842	1379
X1	684	49514	17067	16051	22482	49514	33848	7304	684	16319	3641	3468
X2	21	3168	833	867	434	3168	1645	666	21	750	184	207
X3	2622	381831	108951	109339	112760	381831	217386	70692	2622	90763	22203	21719
P1	31594	120438	73203	14298	53427	98236	77918	9495	31594	120438	69430	16327
P2	0.024	0.769	0.262	0.148	0.047	0.693	0.257	0.124	0.024	0.769	0.266	0.166
P3	0.023	0.086	0.044	0.010	0.031	0.086	0.044	0.010	0.023	0.086	0.045	0.010
BL	0.001	1.107	0.230	0.258	0.095	1.107	0.477	0.195	0.001	0.161	0.032	0.038
ICT	0.004	0.983	0.228	0.252	0.171	0.983	0.429	0.254	0.004	0.273	0.068	0.070
CG	0	18	7.606	4.959	0	17	6.727	3.979	0	18	8.309	5.557

* Figures denote million of (2004) A$; except for X1, which is measured in number of annual employees; and CG, which is measured in number of annual meetings attended by board members.

Note: The table presents summary statistics of the variables used to construct the efficiency frontier and the determinants of bank efficiency.

(Source: Individual banks' annual reports)

ESTIMATION AND ANALYSIS OF RESULTS

Relative Efficiency of Australian Banks

The annual average overall efficiency, technical efficiency and allocative efficiency indices are presented in Table 3 (p. 30). These average efficiency indices are calculated from the efficiency indices of individual banks under a common frontier. Thus, the technical efficiency indices of each bank is measured and related to the most efficient banks in the whole sample. From the efficiency indices in Table 3, one might note that the overall efficiency of observed banks is mostly driven by technical efficiency. In other words, the inefficiency in Australian banks is mainly due to improper response to credit and interest risks (i.e. allocative efficiency) rather than managerial (i.e. technical efficiency) aspects. Given the input prices, the observed banks tend to choose the incorrect combination of inputs for producing outputs. Furthermore, the annual average technical efficiency index is equal to 1 since 2002, suggesting a full technical efficiency (i.e. 100%) of the observed banks under the defined input and output measurements.

Figure 3 (p. 31) presents the contrasting trend between technical efficiency and allocative efficiency. It reveals that the technical efficiency of the observed banks has increased significantly since 1998. It reached full efficiency level in 2001. In contrast, the allocative efficiency index declined significantly between 1997 and 2001, although these indices showed a slight increase from 2001 onward. Interestingly, over the whole sample years, the technical efficiency indices dominate the allocative efficiency indices, suggesting that the overall efficiency of the observed banks is mostly driven by technical efficiency. These findings are consistent with those of Kirkwood and Nahm (2006). These findings, however, are contrary to those provided by Neal (2004) in the sense that allocative efficiency indices dominated technical efficiency indices between 1997 and 1999. Such differences may be attributed to differences in sample size and the input-output definitions. Neal examines twenty-six banks including foreign banks while this study examines nine banks and excludes foreign banks. He has related labor to the number of branches while this study defines labor as the full-time employees. Furthermore, this study uses three outputs while he uses two outputs in the DEA modeling; and the results are bound to be varied because the DEA program's outputs are sensitive to sample size and the input-output definitions.

In order to compare the efficiency of major banks (the Big Four) with that of the regional banks, this study calculates the annual average overall efficiency indices and presents the results in Figure 4 (p. 31). Regional banks used to be more (overall) efficient than major banks till 2001. Figure 4 traces a steady increase in the overall efficiency indices of major banks during the sample years while the indices of regional banks decline in the same period. This indicates that major banks are relatively more efficient than the regional banks. On the basis of their market size, the Big Four banks can behave in an oligopolistic manner; and, hence, the regional banks cannot compete with the market dominance of their counterparts in Australia.

Technical Efficiency Change and Technological Change

This section presents the result of the Malmquist productivity index (MPI), which separates technical efficiency change from technological change. The cumulative changes in technical efficiency and technology over the sample years are shown in Figure 5 (p. 32). It does not show visible technical efficiency change though technology change is substantial, being the major source of total factor productivity (TFP) growth over the sample period. From 1998 to 2007 the cumulative growth of TFP was 58.2% of which 56.5% is contributed by technological change and only 1.7% contributed by technical efficiency change. This demonstrates that Australian banks experienced substantial technological progress between 1998 and 2007. A possible explanation for such development may be the persistent use of new technology by the Australian banking sector, which was manifested in the form of ATMs, credit cards, the widespread installation of EFTPOS, and the introduction of debit and smart cards.

In order to understand the differences between large and regional banks in terms of technical progress, annual average technological change indices are calculated and shown in Figure 6 (p. 34). It appears that both groups experienced substantial technological progress in 2000, but the progress was more evident in the regional banks (34.4%) than in the major banks (16.9%). Kirkwood and Nahm (2006)

TABLE 3
Annual averaged efficiency indices of Australian banks

Year	Overall Efficiency		Technical Efficiency		Allocative Efficiency	
	Mean	SD	Mean	SD	Mean	SD
1997	0.949	0.078	0.984	0.032	0.963	0.062
1998	0.944	0.090	0.982	0.098	0.960	0.062
1999	0.934	0.088	0.987	0.028	0.946	0.083
2000	0.936	0.092	0.997	0.008	0.938	0.088
2001	0.931	0.128	1.000	0.000	0.931	0.128
2002	0.941	0.131	1.000	0.000	0.941	0.131
2003	0.934	0.148	1.000	0.000	0.934	0.149
2004	0.944	0.144	1.000	0.000	0.944	0.144
2005	0.938	0.144	0.999	0.003	0.939	0.145
2006	0.946	0.132	1.000	0.000	0.946	0.123
2007	0.941	0.319	1.000	0.000	0.941	0.306
mean	0.940		0.995		0.944	

(Source: Authors' calculation from the individual bank efficiency indices measured using DEAP2.1)

attributed this difference to the application of improved technology, such as internet banking, by the regional banks at a relatively faster rate than by the large banks in 1998.

The Role of Bad-Debts, ICT and Corporate Governance in Determining Technical Efficiency of Australian Banks

The above analysis has focused mainly on the measurement of relative efficiency in the Australian banking industry. Still the question remains unanswered: Do certain factors affect bank efficiency and is there any empirical evidence in this regard? As the past studies did not provide an answer, the present study has considered three exogenous variables: bad or non-performing loans, ICT and corporate/bank governance.

This study performs common effect (pooled-data), random effect and fixed effect models, respectively, on equation 7. To choose an appropriate model representing the data set, it employs a simple Chow test and a Hausman test, as suggested by Baltagi (2008) and Greene (2008).[5] The simple Chow test is used to test the appropriateness of the common effect model given the fixed effect model; and the Hausman test is used to compare the random and the fixed effect models. The

FIGURE 3
Technical efficiency (TE) and allocative efficiency (AE) indices
(annual averaged)

FIGURE 4
Overall efficiency (OE) of major and regional banks

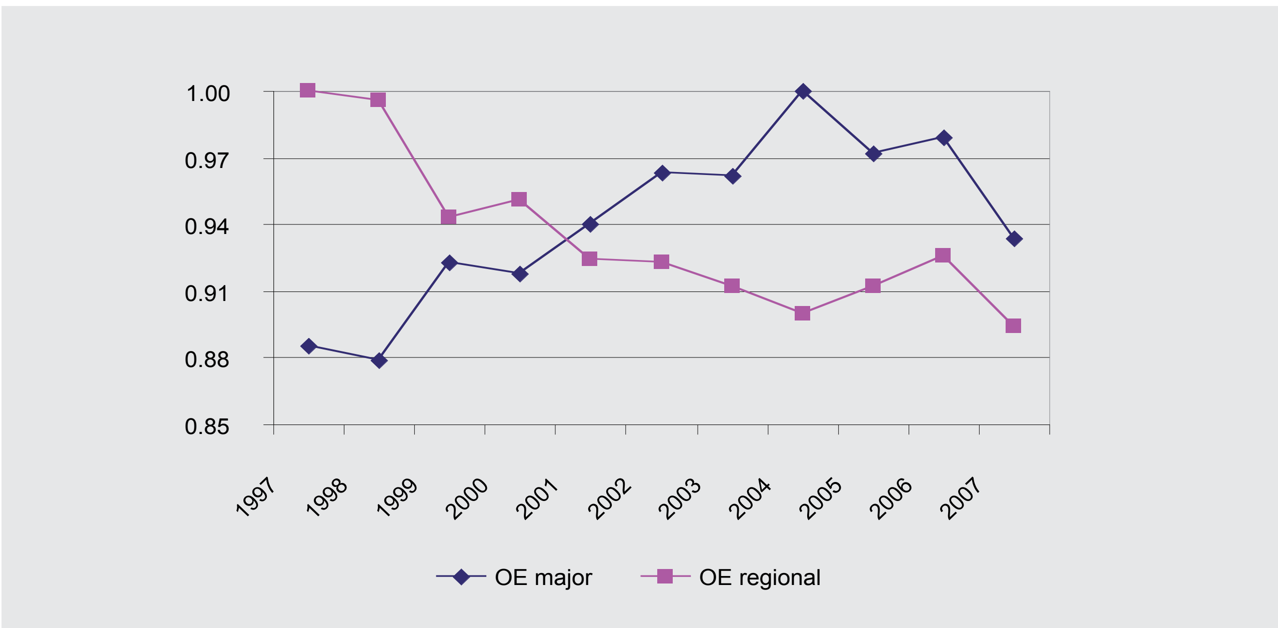
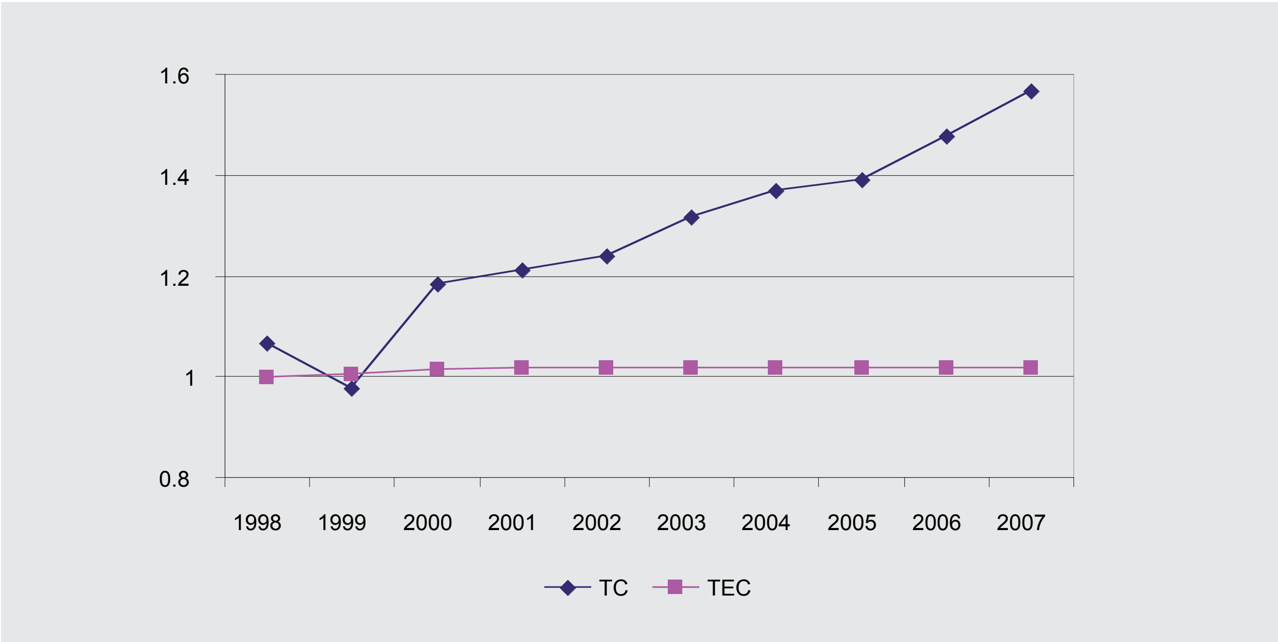


FIGURE 5
Cumulative technical efficiency change (TEC) and technological change (TC)



result of the simple Chow test suggests that the null hypothesis of the common effect cannot be rejected.[6] Hence, the common effect model is appropriate in representing the data set. Furthermore, the result of the Hausman test suggests that the null hypothesis (of no-systematic differences in coefficients) cannot be rejected; and, therefore, the random effect is preferable to the fixed effect.[7] Since the Chow test of model specification suggests that the common effect model is appropriate, the analysis in this study is conducted on the basis of the common effect model. The estimation results are presented in Table 4 (opposite).

It appears that the coefficient of BL is negative and statistically significant at the 1% level, suggesting that an increase in bad loans is associated with a decrease in technical efficiency. This result supports Berg, Forsund and Jansen (1992), Hughes and Mester (1993), and Berger and De Young (1997) who find that lack of adequate technological knowledge is related to the inefficiency of the loan managers. Furthermore, a positive and highly significant coefficient of ICT suggests that an increase in ICT expenditure leads to an increase in technical efficiency. This finding is not a surprise since the investment in ICT tends to improve the efficiency level of the bank for delivering increased volume of financial services. Perhaps the most striking finding is the negative and highly significant coefficient of CG (corporate/bank governance), which suggests that the more times the directors attend the risk committee meetings, the lower the technical efficiency. A possible explanation may be that the directors are not technologically literate, unlike their managers, or that they fail to keep pace with the technological advancement. As such, risk committee meetings attended by these directors fail to increase technical efficiency. In order

TABLE 4
Effects of bad loans, ICT and corporate/bank governance on technical efficiency

Variable	Coefficient	Standard Error	t	$P>\|t\|$
Constant	0.963	0.013	71.36	0.000
BL	–0.070	0.030	–2.33	0.022
ICT	0.129	0.031	4.18	0.000
CG	–0.003	0.001	–2.07	0.041
R^2	0.1748			
Adjusted R^2	0.1488			

(Source: Authors' estimations using STATA10. Figures are rounded)

to confirm the negative effect of corporate governance on technical efficiency, the authors also try 'the number of meetings by the board members' per year as an alternative proxy for corporate governance. The results are consistent with the above finding, but the coefficient is not statistically significant. Hence, it can be resolved that poor bank governance is related to a technologically inefficient board.

CONCLUSIONS

This paper attempts to study the relative efficiency of Australian banks over the period 1997–2007 by using linear programming–based data envelopment analysis (DEA) and the Malmquist productivity indices. It also examines the effects of bad loans, ICT and bank governance on technical efficiency. The empirical results show that technical efficiency constitutes the main source of overall efficiency in the observed Australian banks. Over the sample period, technical efficiency dominates allocative efficiency. Most of the Australian banks are closer to their 'best practice' frontier. The results also show that the level of technical efficiency in major banks is higher that that in the regional banks. The results from the Malmquist productivity index suggest that the growth of total factor productivity of Australian banks is attributed to technology-based delivery of financial service which is, again, due to their compliance and operational adjustment with technological change. Furthermore, analysis of the determinants of banking efficiency shows that an increase in bad loans is associated with the inadequate response of the loan managers to the technical changes. Bank governance has negative effects while ICT expenditure has positive and significant effects on the technical efficiency of Australian banks. Good governance of Australian banks is related to the quality of the members of the board which undoubtedly lifts the overall efficiency of banks.

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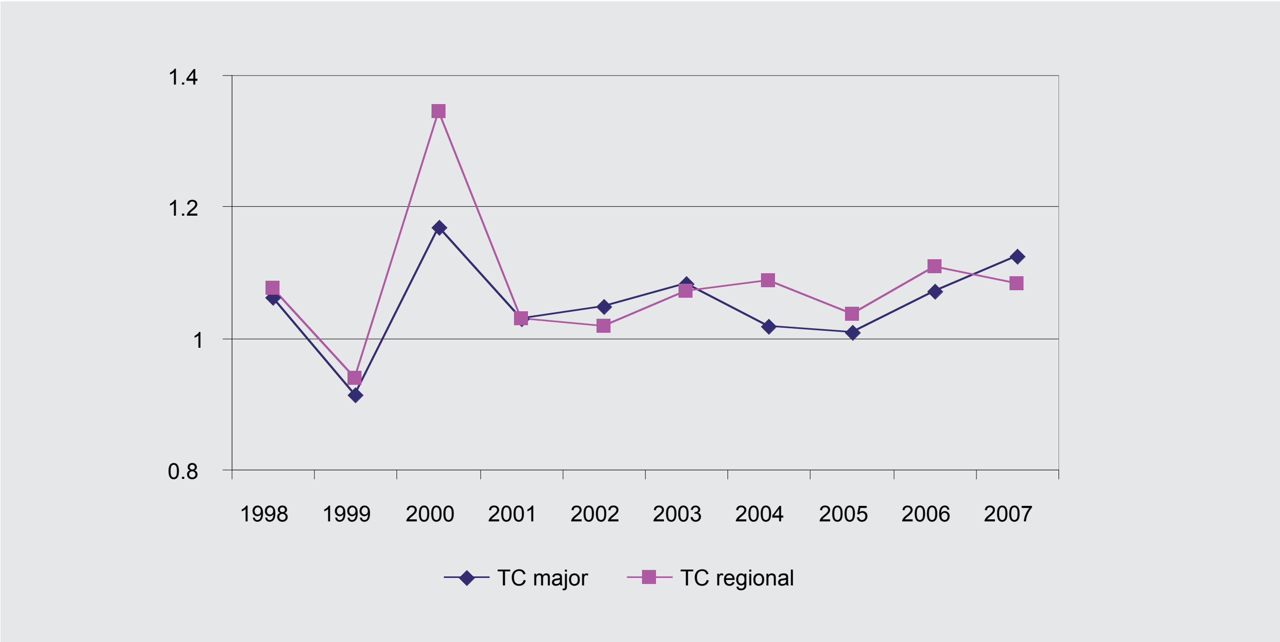
FIGURE 6
Technological change (TC) of major and regional banks



ENDNOTES

1. DEA can be generalized from either an input-oriented or output-oriented objective. For the input orientation, the objective is to obtain the minimum feasible input-combinations, given the outputs. Under the output orientation, the objective is to achieve the maximum feasible output-combinations, given the inputs.

2. DEAP2.1 computer software is developed by Coelli (1996) in the Center for Productivity and Efficiency Analysis (CEPA), Department of Econometrics, University of New England. This software is written in Shazam language and can be operated using an IBM personal computer. The instruction can be run by up-dating the available command file or by writing a new instruction command. It is available from <www.uq.edu.au/economics/cepa/>.

3. The annual reports are provided online and can be accessed from the website of each bank.

4. As noted by Berger and Humphrey (1992) and Sufian (2009), there are four commonly used approaches in defining inputs and outputs of banks, and there is no consensus among researchers on which method is the best. Under the *production* approach, a bank is defined as a service provider that produces outputs in forms of deposits and loans (measured by number of accounts) using inputs of physical resources (labor and capital). Similarly, the *value-added* approach also views deposits and loans as outputs and labor and capital as inputs, but the outputs are measured in values of dollar. Under the *intermediate* approach, banks are assumed as financial intermediaries between savers and borrowers; with loans and other assets treated as outputs, and deposits and other liabilities viewed as inputs. The *user-cost* approach defines outputs and inputs based on the net effects of financial products on bank revenue.

5. The detail procedures for the respective Chow and Hausman tests are excellently discussed in Baltagi (2008) and Greene (2008).

6. The *F*-statistics for the Chow test is –1.619 and the critical value at the 5% level is 3.633.

7. The Hausman statistics is 4.19 and the probability>Chi2 equals 0.1788, suggesting that the null hypothesis cannot be rejected at the 5% level. Hence, there is no systematic difference in coefficients between random and fixed effect models.

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View Item: The Role of Governance, ICT and Bad Loans in Australian Bank Efficiency: An Empirical Study

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Abstract

This paper analyzes the impact of governance, information and communications technology (ICT) and bad loans on bank efficiency over the period 1997–2007. Using linear programming–based data envelopment analysis, the study shows that the overall efficiency of Australian banks is influenced by a consistent growth of technical efficiency since 1997, with major banks showing relatively higher levels of technical efficiency than regional banks. The results from the Malmquist productivity index reveal that technological progress contributes substantially to banks' productivity growth. Furthermore, the results from the common effect panel data model show that bad loans and poor governance have negative effects while ICT has a positive impact on banks' technical efficiency.

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The Role of Bank Governance, ICT and Bad Loans on the Australian Banking Efficiency: An Empirical Analysis

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The Role of Governance, ICT and Bad Loans in Australian Bank Efficiency: An Empirical Study*

RUHUL SALIM, MOHAMMAD ZIAUL HOQUE AND SUYANTO

This paper analyzes the impact of governance, information and communications technology (ICT) and bad loans on bank efficiency over the period 1997–2007. Using linear programming–based data envelopment analysis, the study shows that the overall efficiency of Australian banks is influenced by a consistent growth of technical efficiency since 1997, with major banks showing relatively higher levels of technical efficiency than regional banks. The results from the Malmquist productivity index reveal that technological progress contributes substantially to banks' productivity growth. Furthermore, the results from the common effect panel data model show that bad loans and poor governance have negative effects while ICT has a positive impact on banks' technical efficiency.

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INTRODUCTION

Banking constitutes a vital part of the financial system of any economy. Despite the changing circumstances that have occurred in recent years as a result of the technological revolution, the development of various financial intermediaries and the globalization of financial markets, banks continue to play a dominant role in the economy. Hence, evaluating banks' performance in terms of productive efficiency is of critical importance not only to bank managers or banks' shareholders, but to policymakers as well. The inquiry into the efficiency measurement in the banking industry has attracted a lot of attention from researchers in Australia and elsewhere for the past two decades. Such attention is not surprising because the efficiency of banks is an important aspect of financial intermediation functions. This study throws light on the efficiency of the existing financial system and assesses whether financial resources are being used efficiently. The issue has become more pronounced, however, in the wake of the financial crises experienced by the developed and developing economies in the world.

The aims of this study are two-fold: one is to examine the productive efficiency of Australian banks; and the other is to analyze the impact of corporate governance, information and communications technology (ICT), and non-performing loans on banking efficiency using data over the period 1997–2007.

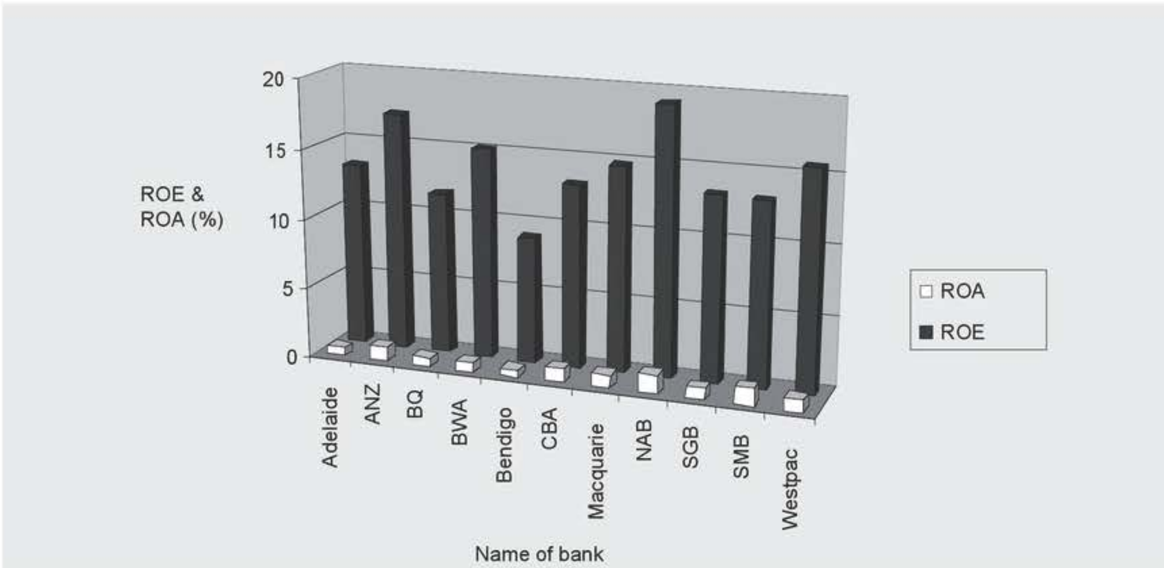
Good loans and good corporate governance provide sound resource allocation and ensure efficient performance in the banking sector. Several earlier studies confirm this proposition. Berg, Forsund and Jansen (1992), Kwan and Eisenbeis (1996), Resti (1996) and, more recently, Dongili and Zago (2005) report that there is a negative relationship between problem loans and the efficiency of banking institutions. These studies further argue that the institution with problem loans incurs high costs and generates low profits relative to the institution with the 'best practice' efficient frontier. Pi and Timme (1993), Berger and Mester (1997), Berger *et al.* (2005) and Gup (2007) argue that corporate governance affects the behavior and performance of banks, innovative activity, and the development and functioning of capital markets; and exerts a strong influence on resource allocation. It is also argued that the current financial crises, credit crunch and the collapse of some of the renowned financial institutions in the United States (US) and Europe are attributed to persistent default loans, bad governance and poor regulatory response from the banks. In addition, the whole banking landscape has been changing since the mid-1990s with the use of ICT, which has been transforming banks both quantitatively and qualitatively. Moreover, improvements in information technology continue at a high rate and are expected to have a significant impact on future banking methods and structures. Yet there is little empirical evidence on the effects of ICT adoption on banking efficiency gains. Furthermore, none of the previous studies focused on analysis of the sources of bank (in-)efficiency, Australian banks in particular, after incorporating the above three important determinants. This study attempts to close this gap and provides an important addition to the body of knowledge relating to bank efficiency.

The paper is organized in the following way. Firstly, an overview of Australian banking is presented, which is followed by a critical review of theoretical and empirical literature. The next section outlines the analytical framework, after which the data sources and variables construction are described. The empirical results are then presented along with a discussion about links between productive efficiency and corporate governance, ICT and non-performing loans (NPLs). Finally, there is a concluding section in which some policy implications are discussed.

OVERVIEW OF AUSTRALIAN BANKING

During the 1990s, the Australian government implemented a number of deregulatory measures in order to provide support for an efficient, responsive and innovative banking system. Central to the deregulation was legislation granting the banks the freedom to set their own pricing and product policies. In addition, the government allowed foreign banks to enter the domestic banking market for wholesale banking and such changes culminated in the rapid growth of the banking sector. Despite the existence of foreign entrants, the increased competition from non-bank financial institutions and the onslaught of technological innovation, the Australian banking sector remains highly concentrated and behaves in an oligopolistic manner. As of April 2009 the Australian banking system comprised fifty-eight authorized banks of which forty-two were foreign- owned. The largest four banks are the Australia and New Zealand Banking Group (ANZ), Commonwealth Bank of Australia (CBA),

FIGURE 1
Average ROE and ROA of Australian banks (1999–2005)

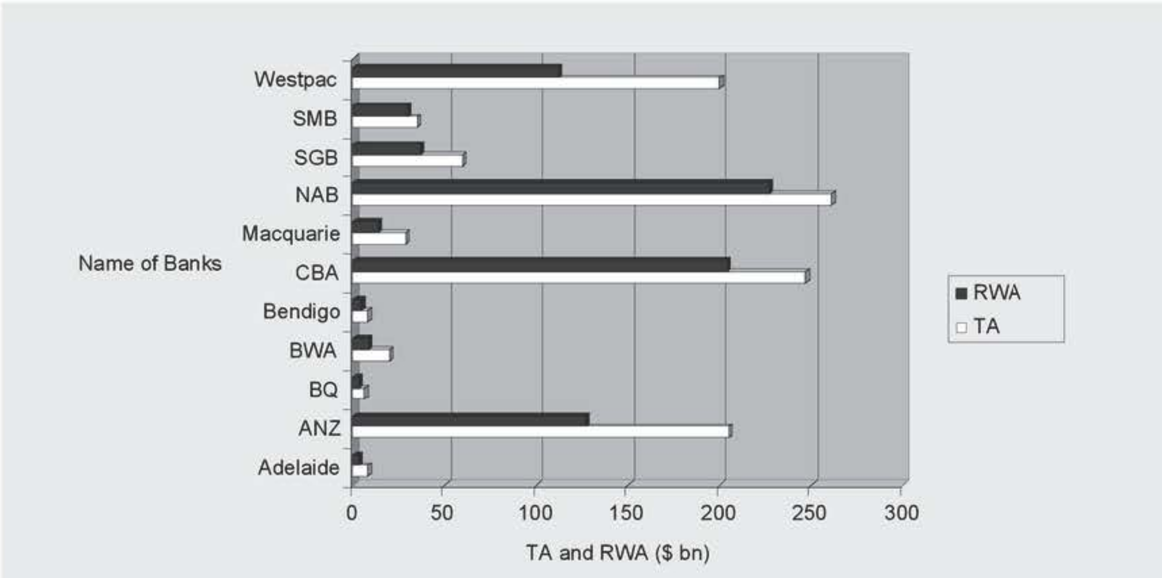


National Australia Bank (NAB) and Westpac Banking Corporation. These banks are highly diversified, both geographically and in their income. The most prominent regional banks are the Adelaide Bank, Bendigo Bank, Bank of Queensland (BQ), St.George Bank (SGB), Bank of Western Australia (BWA) and Suncorp-Metway Corporation (SMB). The market is highly dominated by the four largest banks which together control 67.5% of total banking assets and 32% of the assets of all financial institutions in Australia. Figure 1 shows that the National Australia Bank (NAB) was the largest bank in Australia during 1999–2005, with average total assets over the period of A$261 billion. It is also evident that it was the most profitable and efficient bank in Australia during this period, with 1.35% average return on assets (ROA) and 19.15% average return on equity (ROE).

The Commonwealth Bank of Australia (CBA) was the second largest bank (average assets of A$247 billion), while ANZ Banking Corporation (ANZ), the third largest bank (A$205 billion in assets), demonstrated high profitability with an average ROE of 17.0%. ANZ's efficiency, however, as measured by its average ROA (1.08%) was lower than that of Suncorp-Metway (1.25%). Similarly, Westpac Banking Corporation, the fourth largest bank (A$200 billion in assets), achieved ROE of 15%. The lowest ROE was recorded by the Bank of Bendigo with 9.02% ROE and 0.55% ROA. With the same average assets (A$8 billion), the Adelaide Bank achieved a 13.18% ROE.

The relationship between risk and return is well known, so one would expect to see a relationship between the level of risk and the financial performance of Australian banks. The per cent of risk-weighted assets (RWA) to total assets (TA) provides one indication of risk, whereby the lower the ratio, the lower the risk. The relationship between risk and returns, however, shows no conclusive results in this regard. Figure 2 (opposite) shows that with TA of A$247 billion and RWA of A$204 billion (83%),

FIGURE 2
TA and RWA of Australian banks



the CBA generated an annual average ROE of 13.14%; whereas a 17.05% ROE was earned by ANZ with 62% of RWA to TA. Much the same ROE was achieved by the Adelaide Bank with 42.50% RWA, St.George Bank with 62% RWA, and Suncorp-Metway with 84.28% RWA. All these show that the Australian banks have demonstrated a convincing and satisfactory growth of RWA and bank efficiency in terms of ROA.

LITERATURE REVIEW

Banking Efficiency: International Literature

A remarkable number of studies on the efficiency of the banking industry has been carried out over the last two decades. Some studies focus on measuring the efficiency indices and separating efficiency change from technological change, while others pay more attention to the determinants of efficiency. Aly *et al.* (1990) measure the efficiency of US banking and find that the technical component is relatively more important than the allocative component as a source of overall inefficiency. Elyasiani and Mehdian (1995) estimate the efficiency of the US banks, but they extend further to separate efficiency change and technological change. They show that the productive performance of the observed banks comes mainly from technological change. Similar types of evidence are found by Grifell-Tatje and Lovell (1997) and Casu, Girardone and Molineux (2004) for Spanish and European banks, respectively. Most of the earlier studies identify some key determinants such as size, age, market share, and loan-asset ratio that influence banking efficiency. These studies include Berger and Mester (1997) for the US; Delis and Papanikolaou (2009) for the European Union; Hassan, Al-Sharkas and Samad

(2007) for Bahrain; and Sufian (2009) for Malaysia.

Some studies focus on the effects of bad-debts or problem loans on banking efficiency. Berg, Forsund and Jansen (1992) make the original observation by including bad-debts into a production function in their study on Norwegian banking. Their results show a negative effect of bad-debts on productivity growth, but the magnitude was very small, which indicates a non-binding constraint of bad-debts in Norwegian banking. In a similar vein, Berger and De Young (1997) examine the inter-temporal relationship between problem loans and the efficiency of US banks between 1985 and 1994. They find that the increase in problem loans is related to the decrease in overall efficiency of US banks. Resti (1996) and Matthews, Guo and Zhang (2007) also find a negative effect of bad-debts on efficiency for Italian and for Chinese banks.

Empirical literature on the relationship between banking efficiency and ICT is not plentiful. The authors of this paper found only two working papers on the issue. Suhaimi (2005) examines the effect of ICT on the overall efficiency of Malaysian banks between 1995 and 2003 and finds that expenditure on ICT significantly decreases inefficiency. More recently, Erber and Madlener (2008) made an attempt to examine the link between ICT expenditure and banking efficiency in the European financial sector. Their results suggest that expenditure on ICT might need to be complemented by learning-by-doing and learning-by-using modes of training in the new technology in order to increase the efficiency of financial institutions. Although these two studies bring a significant contribution to the literature, they suffer from some drawbacks. While Suhaimi's study is dated, Erber and Madlener's study is laced with an implicit homogeneity assumption in the observed relationship across European countries.

An extensive literature search failed to locate a significant number of studies on the relationship between corporate governance and productive efficiency of banking institutions. Only two recent studies could be located that focused on the relationship between corporate governance and banking performance. Williams and Nguyen (2005) identify corporate governance in terms of bank ownership (state-owned, private-owned, and foreign-owned) and find that privatization raises banking performance. Berger *et al.* (2005) report identical findings in the sense that privatization increases banks' performance. Although these studies do not typically examine the effects of corporate governance on banking efficiency, they may provide a foothold for furthering the study on the linkage between corporate governance and banking efficiency. Furthermore, elements of some empirical studies that examine the link between corporate governance and technical efficiency in the manufacturing sector may provide some insights for studying such a relationship in the banking sector. In a study on Ukrainian manufacturing industries, Zulenyuk and Zheka (2006) find a positive relationship between the level of corporate governance quality and the technical efficiency level. But Destefanis and Sena (2007) find otherwise in the case of Italian manufacturing firms. Since standard economic theories do not provide an explicit link between corporate governance and technical efficiency, it largely remains a matter of empirical issue.

Australian Literature

Studies on Australian banking efficiency are relatively sparse compared to the enormous numbers of those in other developed countries. Berger and Humphrey (1997) published a literature survey on 130 empirical studies on banking efficiency in twenty-one countries and none of the studies was related to Australian banks. Allen and Rai (1996) may be the first authors to have studied Australian banking efficiency. Using cross-border data they concluded that Australia had a relatively efficient banking system. Applying a *translog* cost function to twelve Australian banks, Walker (1998) shows that there is no evidence of diseconomies of scale although some evidence is found of constant returns to scale. Analyzing post-deregulation bank mergers, however, between 1986 and 1995, Avkiran (1999) finds inefficiency in the post-deregulation period, and that acquiring banks are more efficient than the target banks in the merger process. He further reports that bad loans affect banking efficiency negatively. He did not test this proposition empirically, however. Subsequently, using the same data set, Avkiran (2000) extends the analysis in respect of productivity decomposition and shows that technological progress (TP) is the main driver behind productivity growth.

Applying the data envelopment analysis (DEA) to Australian banking data for the year 1996, Sathye (2001) investigates X-efficiency and finds that average technical efficiency is lower than average allocative efficiency. In addition, he estimates the relationship between efficiency and several factors that might contribute to inefficiency. But he did not consider bad loans, ICT or corporate governance as important factors for his study. Later on, Sathye (2002) measures the productivity growth of Australian banks over the period 1995–99 using the Malmquist index, and finds that technical efficiency decreases by 3.5% during the sample period. By segmenting Australian banks into two groups (major and regional banks), he shows that there is no relationship between bank size and productivity growth. Neal (2004) imitated the same DEA technique for the same data period considered by Sathye (2002) and finds that allocative efficiency is higher than technical efficiency for the sample period and that allocative efficiency tends to increase over time. He also finds that the average annual total factor productivity (TFP) growth is 7.6%, which is 1.013% in Sathye's (2002) study, and that such change is mostly driven by technological progress. Furthermore, Neal provides evidence that the Australian banks are less efficient in 1999 compared to 1995. Dividing Australian banks into three categories: national, regional and international, he shows that regional banks are the worst performers in terms of efficiency and productivity. Also, he reports that the unproductive regional banks may become the target of the large banks. A more recent study is conducted by Kirkwood and Nahm (2006). Using data of ten Australian banks from 1995 to 2002, Kirkwood and Nahm find that technological progress is the main driver of TFP growth, which is identical to what is found by Neal (2004). Unlike Neal, however, they also find that regional banks have higher cost efficiency than large national banks during the period in question. In fact, regional banks experienced lower efficiency after 2000, since they have a fairly constant level of cost efficiency. Kirkwood and Nahm also show that the cost efficiency in Australian banks is mostly driven by allocative efficiency, which contradicts Sathye's (2001) findings.

It is now clear that past studies did not focus on the impact of bad loans, ICT and corporate governance on the efficiency of Australian banks, and the present study endeavours to close this gap. It appears from the preceding discussion that there is no consensus regarding whether allocative or technical efficiency is the major driver of cost efficiency in Australian banks. This study, by using more updated data, attempts to provide efficiency estimates for bolstering cost efficiency for Australian banks. Furthermore, debates about the contradictory findings reported by Neal (2004) and Kirkwood and Nahm (2006) provide scope to carry out further study to confirm the differences of efficiency between regional and large national banks in

Australia; to the extent that this exercise constitutes one of the objectives of the current study.

METHOD AND EMPIRICAL MODEL

Generally speaking, two approaches are used to estimate banking efficiency: the parametric approach and the non-parametric approach. The commonly used parametric technique is stochastic frontier analysis (SFA) and the non-parametric approach is data envelopment analysis (DEA). The SFA has the advantage of separating the inefficiency component from the purely random component, which represents the effect of variables beyond control of production units; whereas the DEA assumes that deviations from the efficient frontier arise due to inefficiency. Nonetheless, this study adopts the DEA, for three reasons. First, it requires no functional form when measuring efficiency. Imposition of a common functional structure on the production technology of Australian banks would be inappropriate, given the fact that there is wide variation among the banks in terms of delivery of technology-assisted financial services. Secondly, DEA accommodates multi-outputs, which is ideal for studying banking efficiency. Thirdly, DEA is suitable for analysis of small sample sizes, such as those of Australian banks. Given the existence of so few banks in Australia and the dearth of adequate data, together with restricted access to the data regime, an analysis of banking efficiency using the parametric approach might not be suitable.

This study adopts the input-oriented DEA for measuring the efficiency of Australian banks.[1] To present the formal model, consider a group of N banks transforming K inputs into M outputs. The DEA model for measuring technical efficiency (TE) of the i-th bank is expressed as

$$\begin{aligned} &\min_{q,\lambda} TE = q \\ &s.t. -y_i + Y\lambda \geq 0_M \\ &qx_i - X\lambda \geq 0_K \\ &1'_N \lambda = 1 \\ &\lambda \geq 0_N \end{aligned} \qquad (1)$$

Where, q is a scalar value between 0 and 1, λ is a $(Nx1)$ vector of constraints, y_i is $(Mx1)$ vector of the output quantities, Y is (MxN) matrix of actual quantities of M outputs by N banks, x_i is $(Kx1)$ vector of input quantities, X is (KxM) matrix of K inputs by N banks, 1_N is $(Nx1)$ vector of one, and 0_M, 0_K, and 0_N are null vector of order M, K, and N, respectively.

It should be pointed out here that equation (1) assumes variable return to scale (VRS) by imposing the convexity constraint $(1'_N \lambda = 1)$. Hence, this model takes into account scale of production when measuring efficiency. Furthermore, q in the equation represents the 'contraction' factor corresponding to the level of efficiency. Thus, banks that are able to minimize the input–output combinations, relative to other banks, are considered fully efficient and are, thus, on the 'best practice' frontier with a value of $q = 1$. Those banks that are less efficient are some distance from the frontier and the q-values of these banks will be less than one. The distance from the frontier is used as a basic gauge for measuring the bank's inefficiency.

If the prices of inputs are available, the 'overall' or economic efficiency of the i-th bank can be calculated first by solving the following *minimum cost* linear program:

$$\begin{aligned} &\min_{\lambda, yi} C = w'_i x_i^* \\ &s.t. -y_i + Y\lambda \geq 0_M \\ &x_i^* - X\lambda \geq 0_K \\ &\lambda \geq 0_N \\ &1'_N \lambda = 1 \end{aligned} \qquad (2)$$

where w_i is a $(Kx1)$ vector of input prices for the i-th bank, x_i^* is a $(Kx1)$ vector of the optimal quantities of inputs for the i-th bank, and other variables are defined as in the previous equation. Equation (2) provides the minimum cost efficient solution for the i-th bank, and the overall efficiency (OE) is calculated as the ratio of the minimum cost solution $\left(w_i' x_i^*\right)$ to the actual cost incurred in production $\left(w_i' x_i\right)$; that is:

$$OE = w_i' x_i^* / w_i' x_i \tag{3}$$

Allocative efficiency (AE) is then residually derived by dividing overall efficiency by technical efficiency; that is:

$$AE = OE/TE \tag{4}$$

The scale efficiency can be measured by dividing the technical efficiency under the assumption of constant return to scale (CRS), which can be measured from equation (1) without the convexity constraint $(1_N' \lambda = 1)$, by the technical efficiency under the variable return to scale (VRS).

In order to separate technological change from efficiency change, this study calculates the DEA-based Malmquist productivity index (MPI). The input-oriented MPI of period t+1 relative to period t (the base period) can be expressed as:

$$MPI_O^{t,t+1}\left(x_i^t, y_i^t, x_i^{t+1}, y_i^{t+1}\right) = \left[\frac{1/D_O^t\left(x_i^{t+1}, y_i^{t+1}\right)}{1/D_O^t\left(x_i^t, y_i^t\right)} \times \frac{1/D_O^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)}{1/D_O^{t+1}\left(x_i^t, y_i^t\right)}\right]^{\frac{1}{2}} \tag{5}$$

where $MPI_O^{t,t+1}\left(x_i^t, y_i^t, x_i^{t+1}, y_i^{t+1}\right)$ is an MPI for two consecutive periods t and t+1; $D_O^t\left(x_i^{t+1}, y_i^{t+1}\right)$ represents a distance function that compares the i-th bank at the period t+1 to the technology at period t; $D_O^t\left(x_i^t, y_i^t\right)$ is a distance function for the i-th bank to period t technology; $D_O^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)$ denotes a distance function for the i-th bank to the t+1 period technology; and $D_O^{t+1}\left(x_i^t, y_i^t\right)$ is a distance function that compares the i-th bank at time t to period t+1 technology. The distance function $D_O^t\left(x_i^t, y_i^t\right)$ is equivalent to the optimized q in equation (1), which represents technical efficiency. Hence, the distance function represents the proportion by which the input vector of the i-th bank should be contracted to be fully efficient under period t technology.

Equation (5) can be expressed equivalently as:

$$MPI_O^{t,t+1}\left(x_i^t, y_i^t, x_i^{t+1}, y_i^{t+1}\right) = \left[\frac{1/D_O^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)}{1/D_O^t\left(x_i^t, y_i^t\right)}\right] \times \left[\frac{1/D_O^t\left(x_i^{t+1}, y_i^{t+1}\right)}{1/D_O^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)} \times \frac{1/D_O^t\left(x_i^t, y_i^t\right)}{1/D_O^{t+1}\left(x_i^t, y_i^t\right)}\right]^{\frac{1}{2}} \tag{6}$$

The term in the first bracket represents the change in the technical efficiency between two consecutive periods, t and t+1; and the term in the second bracket represents technological change between period t and period t+1. Using equation (6), this study separates technical efficiency change from technological change. The DEAP2.1 computer program is used to solve both the DEA programs in equations (1) and (2) and the Malmquist productivity index of equation (6).[2] Using this DEAP2.1 we derive the indices of technical efficiency (TE), allocative efficiency (AE), scale efficiency (SE), overall efficiency (OE), and the decomposition of the MPI into technical efficiency change (TEC) and technological change (TC).

Technical efficiencies of banking institutions are not only affected by the core banking activities but also by the banks' adoption and use of technology, efficient management policies and good governance. Bank governance has become a burning issue in view of the financial crises and the collapse of some US and

European banks. Drawing on the earlier theoretical and empirical studies discussed above, the following equation is specified. Additionally, this model provides a comparison of the results with those reported by the previous studies.

$$TE_{it} = \beta_0 + \beta_1 BL_{it} + \beta_2 ICT_{it} + \beta_3 CG_{it} + \varepsilon_{it} \qquad (7)$$

where BL stands for bad loans, ICT for expenditure on information and communications technology, CG for corporate/bank governance and ε_{it} is the disturbance error term with usual statistical properties.

DATA SOURCE AND MEASUREMENT OF VARIABLES

Data for this study are extracted from the annual reports of related banks.[3] The data used is for nine Australian banks. Other than the major four banks, the following five regional retail banks are included in the study: Adelaide Bank, Bendigo Bank, Bank of Queensland, St.George Bank and Suncorp-Metway Corporation. This study deals with the operations and activities of these banks over the period 1997–2007.

There are two sets of variables used in this study. The first set consists of inputs and outputs for measuring the efficiency of banks. The second set is related to the determinants of efficiency. Definitions of each variable are given in Table 1 (opposite). In order to specify the input and output variables, this study adopts a value-added approach.[4] The output variables are loans, deposits and non-interest income, which are measured at million of (2004) Australian dollar; while the input variables are labor, capital, and interest-bearing liabilities.

While labor refers to total full-time employees at the end of the financial year, capital is calculated from the book value of property, plant and equipment at the end of the financial year and they are deflated to constant price of 2004. As the DEA requires input price variables, the study defines these variables as follows: the input price of labor is calculated from the expenses on staff divided by the number of full-time employees; the price of capital is measured from the ratio between expenses on fixed capital (property, plant and equipment) and the book values of these assets; and the price of interest-bearing liabilities equals the ratio of interest expenses over interest-bearing liabilities. The three variables chosen as the determinants of technical efficiency are bad loans, ICT and bank/corporate governance. These three variables have never been included in previous studies on Australian banking efficiency. The last two variables (i.e. ICT and good governance) have considerable influence on bank efficiency (Williams & Nguyen 2005). Due to the absence of the direct measurement of ICT, expenditures on computer systems, software, telephone, postal, and depreciations of computer hardware are used as proxy. The number of risk committee meetings attended by the bank directors is used as the proxy for bank governance since data for other bank governance are not available.

Descriptive statistics of the relevant variables are presented in Table 2 (p. 28). The statistics are calculated for total samples, the big four banks and regional banks. The mean values of outputs and inputs of the big four banks are on average much higher than those of regional banks and this reflects the differences between large and relatively small banks. Hence, when all banks are pooled together, the standard deviations of outputs and inputs are large. Furthermore, the large standard deviations of regional banks are mainly due to the relatively large size of St.George bank compared to other regional banks.

TABLE 1
Definitions of variables

Symbol	Category	Unit	Definition
Q1	Output	Million of (2004) A$	Loans
Q2	Output	Million of (2004) A$	Deposits
Q3	Output	Million of (2004) A$	Non-interest income
X1	Input	Employees	Number of full-time equivalent employees the bank employs at the end of the financial years
X2	Input	Million of (2004) A$	Fixed capital is measured as the book value of property, plant and equipment at the end of the financial years
X3	Input	Million of (2004) A$	Interest-bearing liabilities equal deposits, borrowing funds and other source of debts
P1	Input price	(2004) A$	Price of labor equals staff expenses divided by the number of full-time equivalent employees
P2	Input price	(2004) A$	Price of fixed capital equals expense associated with property, plant and equipment divided by the book value of these assets
P3	Input price	(2004) A$	Price of interest-bearing liabilities equals interest expenses divided by interest-bearing liabilities
BL	Variable as a contributing factor to technical efficiency	Billion of (2004) A$	Bad loans is the portion of loans estimated to be not collectible by banks at the end of financial years
ICT	Variable as a contributing factor to technical efficiency	Billion of (2004) A$	Information and communications technology is annual expenditure on technology and communication, which is calculated from expenditure on computer system, software, telephone, postage and depreciations of computer hardware
CG	Variable as a contributing factor to technical efficiency	Number of meetings	Corporate/bank governance is measured by the number of risk committee meetings attended by the designated members of the board of directors per year

TABLE 2
Descriptive statistics of samples, 1997–2007*

Variable	Total Sample				The Big Four Banks				Regional Banks			
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
Q1	2322	289361	93480	90883	96080	289361	184284	56011	2322	81058	20836	19956
Q2	2447	229261	76069	73501	81704	229261	150267	43174	2447	63850	16712	15676
Q3	28	16102	2584	2955	1949	16102	4761	2965	28	6107	842	1379
X1	684	49514	17067	16051	22482	49514	33848	7304	684	16319	3641	3468
X2	21	3168	833	867	434	3168	1645	666	21	750	184	207
X3	2622	381831	108951	109339	112760	381831	217386	70692	2622	90763	22203	21719
P1	31594	120438	73203	14298	53427	98236	77918	9495	31594	120438	69430	16327
P2	0.024	0.769	0.262	0.148	0.047	0.693	0.257	0.124	0.024	0.769	0.266	0.166
P3	0.023	0.086	0.044	0.010	0.031	0.086	0.044	0.010	0.023	0.086	0.045	0.010
BL	0.001	1.107	0.230	0.258	0.095	1.107	0.477	0.195	0.001	0.161	0.032	0.038
ICT	0.004	0.983	0.228	0.252	0.171	0.983	0.429	0.254	0.004	0.273	0.068	0.070
CG	0	18	7.606	4.959	0	17	6.727	3.979	0	18	8.309	5.557

* Figures denote million of (2004) A$; except for X1, which is measured in number of annual employees; and CG, which is measured in number of annual meetings attended by board members.

Note: The table presents summary statistics of the variables used to construct the efficiency frontier and the determinants of bank efficiency.

(Source: Individual banks' annual reports)

ESTIMATION AND ANALYSIS OF RESULTS

Relative Efficiency of Australian Banks

The annual average overall efficiency, technical efficiency and allocative efficiency indices are presented in Table 3 (p. 30). These average efficiency indices are calculated from the efficiency indices of individual banks under a common frontier. Thus, the technical efficiency indices of each bank is measured and related to the most efficient banks in the whole sample. From the efficiency indices in Table 3, one might note that the overall efficiency of observed banks is mostly driven by technical efficiency. In other words, the inefficiency in Australian banks is mainly due to improper response to credit and interest risks (i.e. allocative efficiency) rather than managerial (i.e. technical efficiency) aspects. Given the input prices, the observed banks tend to choose the incorrect combination of inputs for producing outputs. Furthermore, the annual average technical efficiency index is equal to 1 since 2002, suggesting a full technical efficiency (i.e. 100%) of the observed banks under the defined input and output measurements.

Figure 3 (p. 31) presents the contrasting trend between technical efficiency and allocative efficiency. It reveals that the technical efficiency of the observed banks has increased significantly since 1998. It reached full efficiency level in 2001. In contrast, the allocative efficiency index declined significantly between 1997 and 2001, although these indices showed a slight increase from 2001 onward. Interestingly, over the whole sample years, the technical efficiency indices dominate the allocative efficiency indices, suggesting that the overall efficiency of the observed banks is mostly driven by technical efficiency. These findings are consistent with those of Kirkwood and Nahm (2006). These findings, however, are contrary to those provided by Neal (2004) in the sense that allocative efficiency indices dominated technical efficiency indices between 1997 and 1999. Such differences may be attributed to differences in sample size and the input-output definitions. Neal examines twenty-six banks including foreign banks while this study examines nine banks and excludes foreign banks. He has related labor to the number of branches while this study defines labor as the full-time employees. Furthermore, this study uses three outputs while he uses two outputs in the DEA modeling; and the results are bound to be varied because the DEA program's outputs are sensitive to sample size and the input-output definitions.

In order to compare the efficiency of major banks (the Big Four) with that of the regional banks, this study calculates the annual average overall efficiency indices and presents the results in Figure 4 (p. 31). Regional banks used to be more (overall) efficient than major banks till 2001. Figure 4 traces a steady increase in the overall efficiency indices of major banks during the sample years while the indices of regional banks decline in the same period. This indicates that major banks are relatively more efficient than the regional banks. On the basis of their market size, the Big Four banks can behave in an oligopolistic manner; and, hence, the regional banks cannot compete with the market dominance of their counterparts in Australia.

Technical Efficiency Change and Technological Change

This section presents the result of the Malmquist productivity index (MPI), which separates technical efficiency change from technological change. The cumulative changes in technical efficiency and technology over the sample years are shown in Figure 5 (p. 32). It does not show visible technical efficiency change though technology change is substantial, being the major source of total factor productivity (TFP) growth over the sample period. From 1998 to 2007 the cumulative growth of TFP was 58.2% of which 56.5% is contributed by technological change and only 1.7% contributed by technical efficiency change. This demonstrates that Australian banks experienced substantial technological progress between 1998 and 2007. A possible explanation for such development may be the persistent use of new technology by the Australian banking sector, which was manifested in the form of ATMs, credit cards, the widespread installation of EFTPOS, and the introduction of debit and smart cards.

In order to understand the differences between large and regional banks in terms of technical progress, annual average technological change indices are calculated and shown in Figure 6 (p. 34). It appears that both groups experienced substantial technological progress in 2000, but the progress was more evident in the regional banks (34.4%) than in the major banks (16.9%). Kirkwood and Nahm (2006)

TABLE 3
Annual averaged efficiency indices of Australian banks

Year	Overall Efficiency		Technical Efficiency		Allocative Efficiency	
	Mean	SD	Mean	SD	Mean	SD
1997	0.949	0.078	0.984	0.032	0.963	0.062
1998	0.944	0.090	0.982	0.098	0.960	0.062
1999	0.934	0.088	0.987	0.028	0.946	0.083
2000	0.936	0.092	0.997	0.008	0.938	0.088
2001	0.931	0.128	1.000	0.000	0.931	0.128
2002	0.941	0.131	1.000	0.000	0.941	0.131
2003	0.934	0.148	1.000	0.000	0.934	0.149
2004	0.944	0.144	1.000	0.000	0.944	0.144
2005	0.938	0.144	0.999	0.003	0.939	0.145
2006	0.946	0.132	1.000	0.000	0.946	0.123
2007	0.941	0.319	1.000	0.000	0.941	0.306
mean	0.940		0.995		0.944	

(Source: Authors' calculation from the individual bank efficiency indices measured using DEAP2.1)

attributed this difference to the application of improved technology, such as internet banking, by the regional banks at a relatively faster rate than by the large banks in 1998.

The Role of Bad-Debts, ICT and Corporate Governance in Determining Technical Efficiency of Australian Banks

The above analysis has focused mainly on the measurement of relative efficiency in the Australian banking industry. Still the question remains unanswered: Do certain factors affect bank efficiency and is there any empirical evidence in this regard? As the past studies did not provide an answer, the present study has considered three exogenous variables: bad or non-performing loans, ICT and corporate/bank governance.

This study performs common effect (pooled-data), random effect and fixed effect models, respectively, on equation 7. To choose an appropriate model representing the data set, it employs a simple Chow test and a Hausman test, as suggested by Baltagi (2008) and Greene (2008).[5] The simple Chow test is used to test the appropriateness of the common effect model given the fixed effect model; and the Hausman test is used to compare the random and the fixed effect models. The

FIGURE 3
Technical efficiency (TE) and allocative efficiency (AE) indices
(annual averaged)

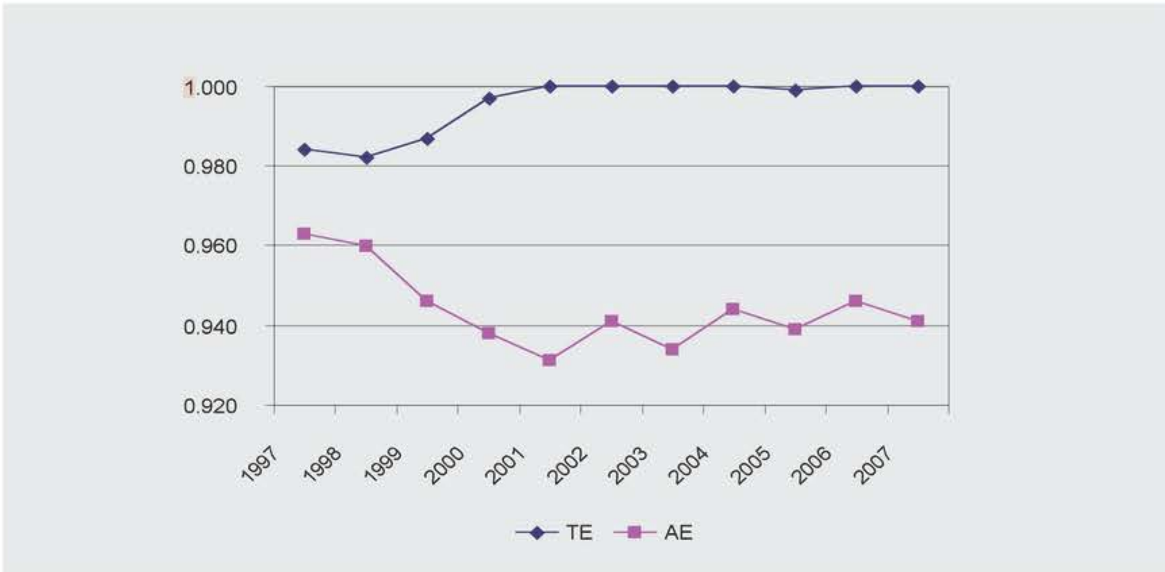


FIGURE 4
Overall efficiency (OE) of major and regional banks

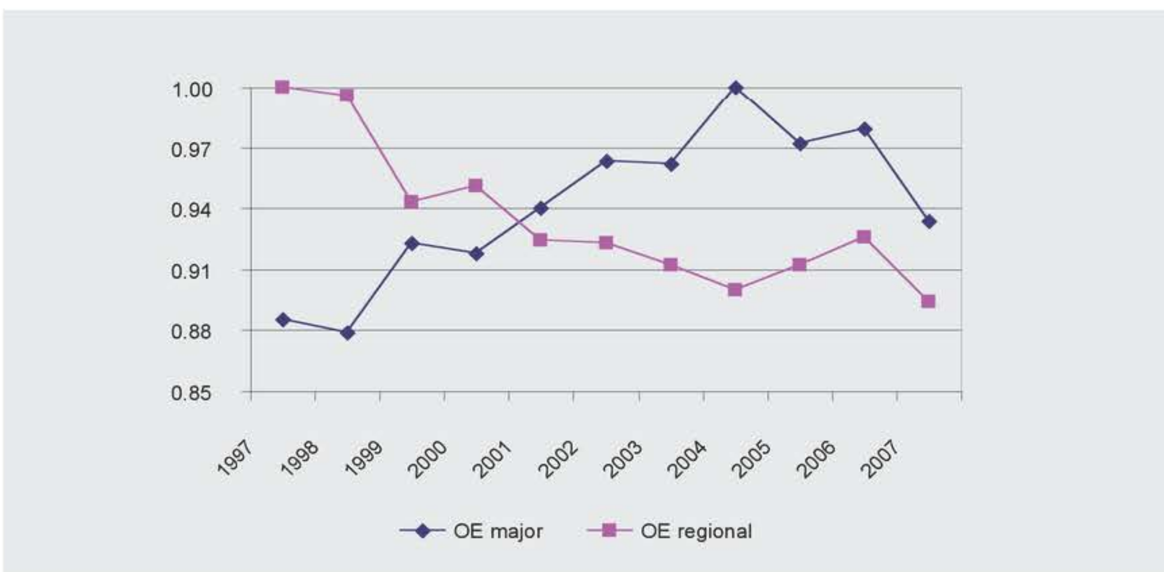
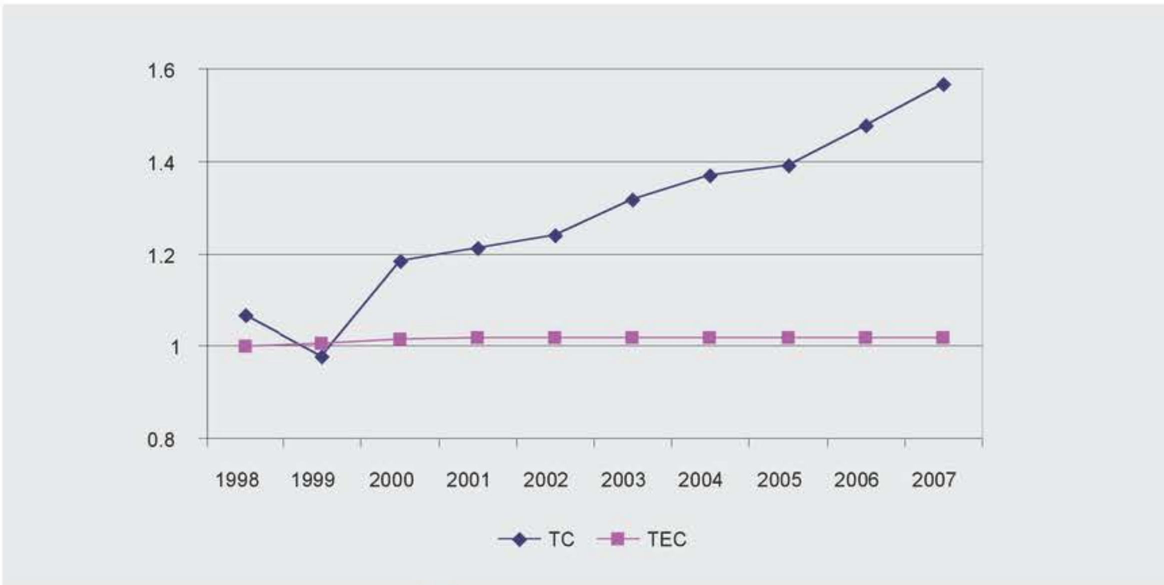


FIGURE 5
Cumulative technical efficiency change (TEC) and technological change (TC)



result of the simple Chow test suggests that the null hypothesis of the common effect cannot be rejected.[6] Hence, the common effect model is appropriate in representing the data set. Furthermore, the result of the Hausman test suggests that the null hypothesis (of no-systematic differences in coefficients) cannot be rejected; and, therefore, the random effect is preferable to the fixed effect.[7] Since the Chow test of model specification suggests that the common effect model is appropriate, the analysis in this study is conducted on the basis of the common effect model. The estimation results are presented in Table 4 (opposite).

It appears that the coefficient of BL is negative and statistically significant at the 1% level, suggesting that an increase in bad loans is associated with a decrease in technical efficiency. This result supports Berg, Forsund and Jansen (1992), Hughes and Mester (1993), and Berger and De Young (1997) who find that lack of adequate technological knowledge is related to the inefficiency of the loan managers. Furthermore, a positive and highly significant coefficient of ICT suggests that an increase in ICT expenditure leads to an increase in technical efficiency. This finding is not a surprise since the investment in ICT tends to improve the efficiency level of the bank for delivering increased volume of financial services. Perhaps the most striking finding is the negative and highly significant coefficient of CG (corporate/bank governance), which suggests that the more times the directors attend the risk committee meetings, the lower the technical efficiency. A possible explanation may be that the directors are not technologically literate, unlike their managers, or that they fail to keep pace with the technological advancement. As such, risk committee meetings attended by these directors fail to increase technical efficiency. In order

TABLE 4
Effects of bad loans, ICT and corporate/bank governance on technical efficiency

Variable	Coefficient	Standard Error	t	$P>\|t\|$
Constant	0.963	0.013	71.36	0.000
BL	–0.070	0.030	–2.33	0.022
ICT	0.129	0.031	4.18	0.000
CG	–0.003	0.001	–2.07	0.041
R^2	0.1748			
Adjusted R^2	0.1488			

(Source: Authors' estimations using STATA10. Figures are rounded)

to confirm the negative effect of corporate governance on technical efficiency, the authors also try 'the number of meetings by the board members' per year as an alternative proxy for corporate governance. The results are consistent with the above finding, but the coefficient is not statistically significant. Hence, it can be resolved that poor bank governance is related to a technologically inefficient board.

CONCLUSIONS

This paper attempts to study the relative efficiency of Australian banks over the period 1997–2007 by using linear programming–based data envelopment analysis (DEA) and the Malmquist productivity indices. It also examines the effects of bad loans, ICT and bank governance on technical efficiency. The empirical results show that technical efficiency constitutes the main source of overall efficiency in the observed Australian banks. Over the sample period, technical efficiency dominates allocative efficiency. Most of the Australian banks are closer to their 'best practice' frontier. The results also show that the level of technical efficiency in major banks is higher that that in the regional banks. The results from the Malmquist productivity index suggest that the growth of total factor productivity of Australian banks is attributed to technology-based delivery of financial service which is, again, due to their compliance and operational adjustment with technological change. Furthermore, analysis of the determinants of banking efficiency shows that an increase in bad loans is associated with the inadequate response of the loan managers to the technical changes. Bank governance has negative effects while ICT expenditure has positive and significant effects on the technical efficiency of Australian banks. Good governance of Australian banks is related to the quality of the members of the board which undoubtedly lifts the overall efficiency of banks.

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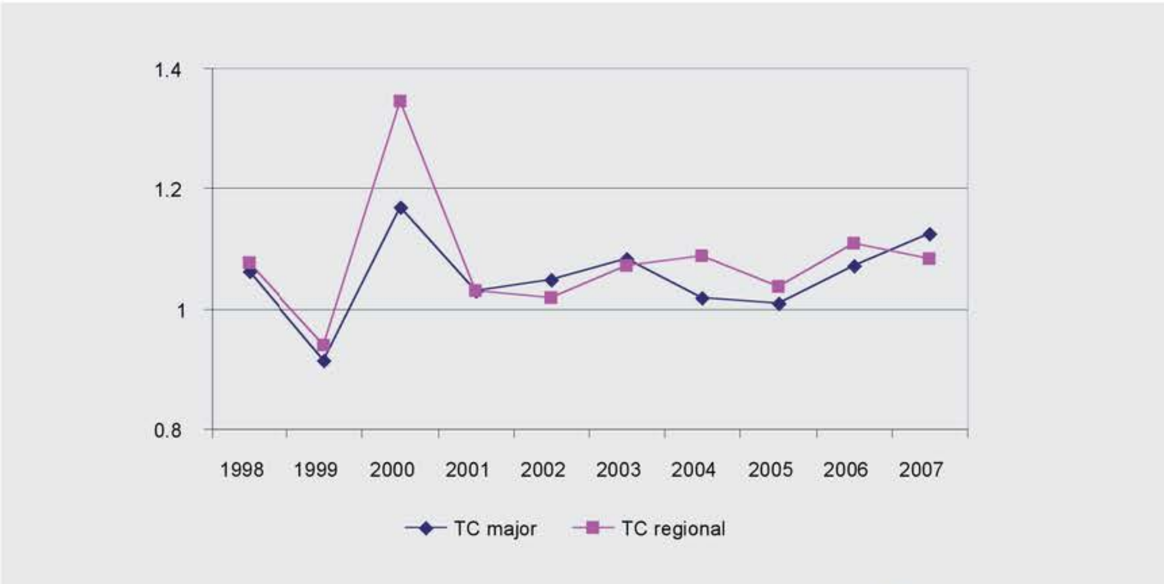
FIGURE 6
Technological change (TC) of major and regional banks



ENDNOTES

1. DEA can be generalized from either an input-oriented or output-oriented objective. For the input orientation, the objective is to obtain the minimum feasible input-combinations, given the outputs. Under the output orientation, the objective is to achieve the maximum feasible output-combinations, given the inputs.

2. DEAP2.1 computer software is developed by Coelli (1996) in the Center for Productivity and Efficiency Analysis (CEPA), Department of Econometrics, University of New England. This software is written in Shazam language and can be operated using an IBM personal computer. The instruction can be run by up-dating the available command file or by writing a new instruction command. It is available from <www.uq.edu.au/economics/cepa/>.

3. The annual reports are provided online and can be accessed from the website of each bank.

4. As noted by Berger and Humphrey (1992) and Sufian (2009), there are four commonly used approaches in defining inputs and outputs of banks, and there is no consensus among researchers on which method is the best. Under the *production* approach, a bank is defined as a service provider that produces outputs in forms of deposits and loans (measured by number of accounts) using inputs of physical resources (labor and capital). Similarly, the *value-added* approach also views deposits and loans as outputs and labor and capital as inputs, but the outputs are measured in values of dollar. Under the *intermediate* approach, banks are assumed as financial intermediaries between savers and borrowers; with loans and other assets treated as outputs, and deposits and other liabilities viewed as inputs. The *user-cost* approach defines outputs and inputs based on the net effects of financial products on bank revenue.

5. The detail procedures for the respective Chow and Hausman tests are excellently discussed in Baltagi (2008) and Greene (2008).

6. The *F*-statistics for the Chow test is –1.619 and the critical value at the 5% level is 3.633.

7. The Hausman statistics is 4.19 and the probability>Chi2 equals 0.1788, suggesting that the null hypothesis cannot be rejected at the 5% level. Hence, there is no systematic difference in coefficients between random and fixed effect models.

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