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# Malmquist Indices of Productivity Change in Australian Financial Services

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## Abstract

In this study the nature and extent of efficiency and productivity growth in deposit-taking institutions is investigated using nonparametric frontier techniques. Employing Malmquist indices, productivity growth is decomposed into technical efficiency change and technological change for two hundred and sixty-nine Australian credit unions. The results indicate that most credit unions experienced technological progress after deregulation, and that any efficiency gain found was largely the result of improvements in technical efficiency rather than scale efficiency. That productivity growth which did occur due to an increase in efficiency over the period tended to be in credit unions with a small number of members and a large asset base, whilst technical progress was most pronounced in institutions with a relatively high proportion of residential and commercial loans.

*Keywords:* Technical and scale efficiency; Non-bank financial institutions; nonparametric techniques.

*JEL classifications:* C61; G21; D24.

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## 1. Introduction

Beginning with the Campbell Report in 1981, microeconomic reform of the Australian economy has dominated the policy agenda for almost two decades. At the time of its inception, the Campbell Committee was especially critical of the “negative influence of intrusive regulation on the efficiency of the Australian financial system [and] was given a wide ranging brief to recommend changes in the regulatory structure so as to promote efficiency and stability” (Financial System

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Inquiry, 1997, p. 587) [for further details see Australian Financial System (Campbell) Inquiry (1981)]. And despite the fact that a number of the Campbell Report's recommendations were not implemented until the late 1980s or 1990s, "in the period following the major Campbell Committee reforms in the mid-1980s, both suppliers and customers were forced to adapt to a newly deregulated environment" (Financial System Inquiry, 1997, p. 596). In its 1997 *Stocktake of Financial Deregulation*, the Financial System (Wallis) Inquiry (1997, p. 598) summarised the effect of this reform as follows:

Efficiency has improved in several areas since deregulation. Increased pricing efficiency in securities and foreign exchange markets in particular, has improved resource allocation. The productivity of finance sector participants has risen in many cases, as has their dynamic efficiency, with technological innovations playing a major role in these improvements.

In empirical support of this contention, the Wallis Inquiry presented evidence relating to three types of efficiency gain since deregulation. These concerned: (i) *allocative efficiency* (the extent to which resources are being allocated to their highest value use, including across time); (ii) *technical efficiency* (the extent to which the output of the finance sector is being maximised for a given amount of productive inputs); and (iii) *dynamic efficiency* (the extent to which the finance sector is engaging actively in product innovation and making use of the most cost-effective technologies as they become commercially available) (Financial System Inquiry, 1997, p. 606). However, the means by which the Inquiry measured productivity improvements, efficiency gains and technological progress may be subject to some criticism. For example, "operating expense ratios [were used as] one, albeit imperfect measure of technical efficiency" (Financial System Inquiry, 1997, p. 610). Worthington (1998b) and Berg, Førsund and Jansen (1992, p. 212), amongst others, have argued that while simple cost ratios are frequently used to compare productivity in banking, "as an industry which produces multiple outputs from multiple inputs, consistent aggregation does not seem possible". Another example is that capital expenditure on equipment was employed as a "necessarily anecdotal" indication of the take-up of technology (Financial System Inquiry, 1997, p. 615). While this indicator accounts for the sizeable expenditures in the finance and insurance sector

on items such as computer networks, automated teller machines (ATMs) and electronic funds transfer at point of sale (EFTPOS), it has been argued that it may not adequately reflect the actual change in functionality associated with the shift from “costlier paper based, labour intensive transaction services” (Financial System Inquiry, 1997, p. 616).

A further criticism of the Inquiry’s approach is that total factor productivity (TFP) indices were derived using finance sector assets as a broad proxy for output. Notwithstanding that this is an improvement on the conventional measure of sectoral output [gross operating surplus of financial enterprises plus wages and salaries], it does suffer from the limitation that it “fails to capture changes in the relative importance of transaction and other services in the finance industry” (Financial System Inquiry, 1997, p. 613). Lastly, and much more fundamentally, none of the measures used permitted the thorough analysis of post-deregulation productivity, including efficiency and technological change, within a comprehensive performance framework. Moreover, the evidence presented using either the partial-productivity or total factor productivity indicators does not “tell us anything about the dynamics of the microstructure and the spread of productivity growth rates within the industry” (Berg, Førsund and Jansen, 1992, p. 212).

We can see that in common with traditional approaches to productivity measurement, the Wallis Inquiry generally assumed that observed output is best-practice or frontier output. Accordingly, productivity growth, as measured by either partial productivity or total factor productivity indices (an index of output divided by an index of total input usage), is synonymous with technical progress (or shifts in the technology boundary). However, in a world in which inefficiency exists, total factor productivity can no longer be interpreted as technical change unless there is either no technical inefficiency or unless technical inefficiency does not change over time. If these conditions do not hold, then total factor productivity is redefined as the net effect of changes in efficiency (or movements relative to the existing frontier) and shifts in the production frontier (or technical change). This distinction is important from a policy viewpoint, since changes in productivity

growth due to inefficiency suggest different policies to those concerning technical change (Grosskopf, 1993, p. 169). For example, slow productivity growth due to inefficiency may be due to institutional barriers to the diffusion of innovations. In this case, policies to remove these barriers may be more effective in improving productivity than those aimed at innovation *per se*. The present paper is therefore concerned with a more complete assessment of post-deregulation financial sector productivity than that contained in the Wallis Inquiry.

These issues are especially important given the pace of microeconomic reform in the Australian financial sector. Undoubtedly, reform *per se* and the anticipation of reform has affected the sector's choice of input and output volumes. However, little is known about the effect of these reforms on productivity growth, and even less about the spread of productivity levels across the sector. By comparing annual changes in the productivity of individual financial institutions, it is possible to both identify general trends in the productivity of the financial sector as a whole, and to identify individual institutions exhibiting patterns of change in productivity that differ from the rest of the sector. A careful analysis of the results should add to our knowledge about the factors determining the pattern of financial sector productivity in Australia and provide at least some idea of the effectiveness of microeconomic reform.

The paper itself is divided into four main sections. Section 2 focuses on the theoretical background to Malmquist indexes of productivity and technical change. Section 3 deals with the specification of inputs and employed in the evaluation of technical efficiency and technical change in the credit union industry. Section 4 presents the resultant indices of productivity, efficiency and technical change and assesses their significance. The paper ends with some concluding remarks in the final section.

## **2. Malmquist indexes of productivity and technical change**

The framework employed in the current study can be illustrated by Figure 1 following Fare *et al.* (1990; 1993), Hjalmarsson and Veiderpass (1992), Berg, Førsund and Jansen (1992), and Price and

Weyman-Jones (1996). In this diagram, a production frontier representing the efficient level of output ( $y$ ) that can be produced from a given level of input ( $x$ ) is constructed, and the assumption made that this frontier can shift over time. The frontiers thus obtained in the current ( $t$ ) and future ( $t + 1$ ) time periods are labelled accordingly. When inefficiency is assumed to exist, the relative movement of any given financial institution over time will therefore depend on both its position relative to the corresponding frontier (technical efficiency) and the position of the frontier itself (technical change). If inefficiency is ignored, then productivity growth over time will be unable to distinguish between improvements that derive from a financial institution ‘catching up’ to its own frontier, or those that result from the frontier itself shifting up over time.

#### **FIGURE 1 HERE**

Now for any given financial institution in period  $t$ , say, represented by the input/output bundle  $z(t)$ , an input-based measure of efficiency can be deduced by the horizontal distance ratio  $ON/OS$ . That is, inputs can be reduced in order to make production technically efficient in period  $t$  (i.e. movement onto the efficient frontier). By comparison, in period  $t + 1$  inputs should be multiplied by the horizontal distance ratio  $OR/OQ$  in order to achieve comparable technical efficiency to that found in period  $t$ . Since the frontier has shifted,  $OR/OQ$  exceeds unity, even though it is technically inefficient when compared to the period  $t + 1$  frontier.

It is possible using the Malmquist input-orientated productivity index to decompose this total productivity change between the two periods into technical change and technical efficiency change. Input-orientation refers to the emphasis on the equiproportionate reduction of inputs, within the context of a given level of output. Berg, Førsund and Jansen (1992) also used an input-orientated approach to analyse the effects of deregulation in Norwegian financial services, and Fukuyama (1995) has employed an identical specification to measure efficiency and productivity in Japanese banking. Following Fare, Grosskopf and Lovell (1994), the input-based Malmquist productivity change index may be formulated as:

$$M_I^{t+1}(y^{t+1}, x^{t+1}, y^t, x^t) = \left[ \frac{D_I^t(y^{t+1}, x^{t+1})}{D_I^t(y^t, x^t)} \times \frac{D_I^{1+t}(y^{t+1}, x^{t+1})}{D_I^{1+t}(y^t, x^t)} \right]^{\frac{1}{2}} \quad (1)$$

where the subscript  $I$  indicates an input-orientation,  $M$  is the productivity of the most recent production point  $(x^{t+1}, y^{t+1})$  (using period  $t + 1$  technology) relative to the earlier production point  $(x^t, y^t)$  (using period  $t$  technology),  $D$  are input distance functions, and all other variables are as previously defined. A value greater than unity will indicate positive total factor productivity growth between the two periods. Following Fare, Grosskopf, Lindgren and Roos (1993) an equivalent way of writing this index is:

$$M_I^{t+1}(y^{t+1}, x^{t+1}, y^t, x^t) = \frac{D_I^{t+1}(y^{t+1}, x^{t+1})}{D_I^t(y^t, x^t)} \left[ \frac{D_I^t(y^{t+1}, x^{t+1})}{D_I^{t+1}(y^{t+1}, x^{t+1})} \times \frac{D_I^t(y^t, x^t)}{D_I^{t+1}(y^t, x^t)} \right]^{\frac{1}{2}} \quad (2)$$

or

$$M = E \cdot P \quad (3)$$

where

$$E = \frac{D_I^{t+1}(y^{t+1}, x^{t+1})}{D_I^t(y^t, x^t)} \quad (4)$$

$$P = \left[ \frac{D_I^t(y^{t+1}, x^{t+1})}{D_I^{t+1}(y^{t+1}, x^{t+1})} \times \frac{D_I^t(y^t, x^t)}{D_I^{t+1}(y^t, x^t)} \right]^{\frac{1}{2}}$$

where  $M$  (the Malmquist total factor productivity index) is the product of a measure of technical progress  $P$  (the two ratios in the square bracket) as measured by shifts in the frontier measured at period  $t + 1$  and period  $t$  (averaged geometrically) and a change in efficiency  $E$  over the same period (the term outside the square bracket).

In order to calculate these indices it is necessary to solve several sets of linear programming problems. We assume that there are  $N$  firms and that each firm consumes varying amounts of  $K$  different inputs to produce  $M$  outputs. The  $i$ th firm is therefore represented by the vectors  $x_i, y_i$  and the  $(K \times N)$  input matrix  $X$  and the  $(M \times N)$  output matrix  $Y$  represent the data of all firms in the sample. The purpose is to construct a nonparametric envelopment frontier over the data points such that all observed points lie on or below the production frontier. The calculations exploit the fact that

the input distance functions ( $D$ ) used to construct the Malmquist index are the reciprocals of Farrell's (1957) input-orientated technical efficiency measures. They therefore bear a close resemblance to the Charnes, Cooper and Rhodes (1978) data envelopment analysis (DEA) model. The first two linear programs are where the technology and the observation to be evaluated are from the same period, and the solution value is less than or equal to unity. The second two linear programs occur where the reference technology is constructed from data in one period, whereas the observation to be evaluated is from another period. Assuming constant returns-to-scale to start with, the following input-orientated linear programs are used:

$$\begin{aligned} [D_t^t(y_t, x_t)]^{-1} &= \min_{\theta, \lambda} \theta \\ \text{s.t. } -y_{it} + Y_t \lambda &\geq 0 \\ \theta x_{it} - X_t \lambda &\geq 0 \\ \lambda &\geq 0 \end{aligned} \quad (5)$$

$$\begin{aligned} [D_t^{t+1}(y_{t+1}, x_{t+1})]^{-1} &= \min_{\theta, \lambda} \theta \\ \text{s.t. } -y_{i,t+1} + Y_{t+1} \lambda &\geq 0 \\ \theta x_{i,t+1} - X_{t+1} \lambda &\geq 0 \\ \lambda &\geq 0 \end{aligned} \quad (6)$$

$$\begin{aligned} [D_t^{t+1}(y_t, x_t)]^{-1} &= \min_{\theta, \lambda} \theta \\ \text{s.t. } -y_{it} + Y_{t+1} \lambda &\geq 0 \\ \theta x_{it} - X_{t+1} \lambda &\geq 0 \\ \lambda &\geq 0 \end{aligned} \quad (7)$$

$$\begin{aligned} [D_t^t(y_{t+1}, x_{t+1})]^{-1} &= \min_{\theta, \lambda} \theta \\ \text{s.t. } -y_{i,t+1} + Y_t \lambda &\geq 0 \\ \theta x_{i,t+1} - X_t \lambda &\geq 0 \\ \lambda &\geq 0 \end{aligned} \quad (8)$$

This approach can be further extended by decomposing the constant returns-to-scale technical efficiency change into scale efficiency and pure technical efficiency components. This involves calculating further linear programs where the convexity constraint  $\sum \lambda = 1$  is introduced to programs (5) to (8). Once again, it is obvious that the input distance function as calculated here is the reciprocal of an input-orientated Farrell measure of technical efficiency calculated relative to

technology satisfying variable returns-to-scale vis-à-vis Banker, Charnes and Cooper (1984). By running these programs with the same data under a constant returns-to-scale (without convexity constraint) and variable returns-to-scale (with convexity constraint), measures of overall technical efficiency ( $E$ ) and ‘pure’ technical efficiency ( $PT$ ) are obtained. Dividing overall technical efficiency ( $E$ ) by pure technical efficiency then yields a measure of scale efficiency ( $S$ ). Using these models, and the Fare *et al.* (1994) approach, it is thus possible to provide four efficiency/productivity indices for each firm and a measure of technical progress over time. These are: (i) technical efficiency change ( $E$ ) (i.e. relative to a constant returns-to-scale technology); (ii) technological change ( $P$ ); (iii) pure technical efficiency change ( $PT$ ) (i.e. relative to a variable returns-to-scale technology); (iv) scale efficiency change ( $S$ ); and (v) total factor productivity ( $M$ ) change. Recalling that  $M$  indicates the degree of productivity change, then if  $M > 1$  then productivity gains occur, whilst if  $M < 1$  productivity losses occur. Regarding changes in efficiency, technical efficiency increases (decreases) if and only if  $E$  is greater (less) than one. An interpretation of the technological change index is that technical progress (regress) has occurred if  $P$  is greater (less) than one.

An assessment can also be made of the major sources of productivity gains/losses by comparing the values of  $E$  and  $P$ . If  $E > P$  then productivity gains are largely the result of improvements in efficiency, whereas if  $E < P$  productivity gains are primarily the result of technological progress. In addition, an indication of the major source of efficiency change can be obtained by recalling that overall technical efficiency is the product of pure technical efficiency and scale efficiency, such that  $E = PT \times S$ . Thus, if  $PT > S$  then the major source of efficiency change (both increase and decrease) is improvement in pure technical efficiency, whereas if  $PT < S$  the major source of efficiency is an improvement in scale efficiency. Further details on the interpretation of these indices may be found in Charnes *et al.* (1993).

An important task that arises after the calculation of the Malmquist productivity indices is to attribute variations in productivity, efficiency and technological change to specific characteristics of financial institutions and the environment in which they operate. The technique selected for explaining variation is a regression-based approach. The general form is:

$$m_i^* = z_i' \beta + e_i \quad i = 1, \dots, N \quad (9)$$

where  $m$  is the Malmquist productivity index,  $z_i'$  is a  $(1 \times J)$  vector of explanatory variables posited to explain productivity in financial institutions,  $\beta$  is a vector of parameters to be estimated, and  $e_i \sim N(0, \sigma^2)$ . Past approaches that have employed nonparametric techniques to measure financial institution efficiency followed by parametric techniques to assign variation in efficiency include Miller and Noulas (1996) and Berger and Mester (1997) [least squares], Mester (1993) [logistic], Cebenoyan *et al.* (1993) [tobit], and Fried, Lovell and Vanden Eeckaut (1993) and Fried, Lovell and Turner (1996) [systems].

### 3. Specification of inputs/outputs and explanatory variables

The data used in this study consists of annual observations of 269 Australian credit unions. All data is sourced from the Australian Financial Institutions Commission (AFIC). The time period selected is 1993/94 to 1996/97. The GDP deflator is used to deflate the monetary variables from 1994/95, 1995/96 and 1996/97 to 1993/94 prices.

The inputs and outputs employed follow the intermediation approach to modelling financial institution behaviour, that is, credit unions combine non-deposit financial liabilities, labour and capital to produce deposits, loans, investments and physical services. Table 1 provides selected descriptive statistics for the 1996/97 financial year only. In terms of specific studies, the approach is most consistent with the value-added intermediation approach used by Berg *et al.* (1993), Favero and Papi (1995) and Fried *et al.* (1996). Starting with the inputs, members funds ( $MF$ ) are measured by summing share premium accounts, general and other reserves plus outside equity interests,

physical capital (*CP*) is measured by equipment, fixtures and premises, either purchased directly or via capitalised leases, and financial liabilities (*FL*) by summing inter-bank borrowings (Berger and Humphrey, 1991). Labour (*ST*) is measured by the number of full-time equivalent employees. Finally, recognising that branches (*BR*) form an important input into the credit union intermediation process, the number of full-branch equivalent operations is also included.

In terms of outputs, six categories are employed. These are: call deposits (*DC*), term deposits (*DT*), personal loans (*LP*), residential loans (*LR*), commercial loans (*LC*), and other financial investments (*SC*). The last measure includes current and term bank deposits, deposits with other financial institutions and governmental authorities, and securitised assets, such as bank bills. Specifying financial institution outputs in this manner follows the work of Rangan *et al.* (1988), Ferrier and Lovell (1990), Grabowski *et al.* (1993) and Elyasiani *et al.* (1994).

#### **TABLE 1 HERE**

The explanatory variables to be included in the second-stage regression are also presented in Table 1. The first group of variables is intended to account for the effect of the number of credit union members (*MEM*) on productivity. All other things being equal, a large credit union in terms of number of members will have a more diversified membership than one with a smaller membership. Generally this would imply that the prospects for attaining an efficient scale of operations are higher (Fried *et al.*, 1993). Similarly, credit unions with a large number of members are more likely to actively engage in the technological innovation associated with deregulation. Both hypotheses suggest a positive coefficient for credit union membership when used as an explanatory variable for total factor productivity, efficiency and technological progress. Alternatively, credit unions with a small (and presumably homogeneous and concentrated) membership may be able to direct greater effort at enhancing technical efficiency and technological innovation than those credit unions with a larger (more heterogeneous and widely-spread) membership. Ferrier and Lovell (1990) and Fried, Lovell and Turner (1996), amongst others, have

argued that the interaction between the number of members/accountholders and total deposits/loans is more important in determining efficiency than the absolute value of these variables. Thus, a low membership (with a high average deposit/loan account) may indicate *ex ante* a negative coefficient.

The second group of variables relate to the asset and risk management activities of the credit union. It is posited that a relatively large credit union (*TA*) (in terms of assets), with a high proportion of residential loans (*RL*) and commercial loans (*CL*) in its portfolio, a high level of fixed capital (*CAP*), and a high current ratio (*CUR*), should be relatively more productive (due to both a higher level of technical efficiency and more rapid adoption of technological innovation) [see, for example, Fried *et al.* (1993) and Worthington (1998a)]. One rationale for these variables is that such a credit union should be exposed to lower levels of financial risk, and hence able to attract purchased funds at a lower cost (Elyasiani, *et al.*, 1994). Similarly, a clear ‘market-orientation’ in regards to commercial and residential loans may also be associated with a relatively more efficient credit union (Mester, 1993). However, we could also expect that technological progress may be some function of relative and absolute capital expenditures on equipment, and that credit unions that are exposed to strong competitive forces in residential and commercial loan markets are obliged to undertake programs aimed at adopting new technologies. In both the case of efficiency and technology progress, and hence productivity, the *ex ante* sign on each of these coefficients is thought to be positive. The final group of variables detailed in Table 1 are a set of dummy variables included to account for the impact of legislative, geographic and economic variation across states. In the absence of strong hypotheses as to differences in productivity between states, no *a priori* coefficient is postulated.

#### **4. Empirical results**

In the previous section, we defined Malmquist indices of productivity growth relative to a reference technology. Malmquist indices for the period 1993/94 to 1996/97 are presented below for the sample of Australian credit unions. Using this information, three primary issues are addressed in

our computation of Malmquist indices of productivity growth over the sample period. The first is the measurement of productivity change over the period. The second is to decompose changes in productivity into what are generally referred to as a ‘catching-up’ effect (efficiency change) and a ‘frontier shift’ effect (technological change). In turn, the ‘catching-up’ effect is further decomposed to identify the main source of improvement, through either enhancements in technical efficiency or increases in scale efficiency. Finally, we test whether differences in the various indices for different sizes of credit unions have statistical significance.

We begin by looking at the changes in productivity, efficiency, and technology for financial services in the period 1993/94 to 1996/97. In Table 2 descriptive statistics of the indices of total factor productivity growth ( $M$ ), efficiency change ( $E$ ), and technological change ( $P$ ) across groups (by asset size) of credit unions are presented. It should be noted that categorising credit unions on this basis is entirely arbitrary, and any number of alternative criteria could have been used. For example, Fukuyama’s (1995) study of 154 Japanese banks examined productivity differences across organisational form (city, regional, former Sogo, trust and long-term credit) and revenue size.

#### **TABLE 2 HERE**

As indicated, there was a mean decrease in total factor productivity of 2.14 percent for the period ending 30 June 1997. Given that the Malmquist index of productivity change ( $M$ ) is a multiplicative composite of efficiency ( $E$ ) and technological change ( $P$ ), the major cause of productivity improvements can be ascertained by comparing the values of the efficiency change and technological change indexes. Put differently, the productivity losses described can be the result of efficiency decreases, technological regresses, or both. In the case of credit union services, the overall decline in productivity over the period is composed of an average efficiency increase (movement towards the frontier) of 0.0023 percent, and an average technological regress (downward shift of the frontier) of 1.95 percent. However, these figures serve to obscure very different results across a number of the groups of credit unions. For instance, for the seventieth

decile of credit unions, there was an average positive increase in total factor productivity over the period in question of 2.3 percent which was composed of a 1.3 percent efficiency gain and a 1 percent increase due to technological progress. Furthermore, even within asset classes there are sizeable variations in efficiency gain and technological change. For example, in the lowest ten percent of credit unions the mean efficiency loss was 1.88 percent over the sample period, though the most efficient credit union had a technical gain of 23.92 percent.

### **TABLE 3 HERE**

These differences can be emphasised with reference to the characteristics of the credit union productivity growth indices contained in Table 3. As we can see, 147 credit unions (some 55 percent) experienced technological progress over the period 1993/94 to 1996/97. However, only 49 percent of credit unions experienced an overall gain in total factor productivity. In part, the overall additional loss in productivity can be attributed to the efficiency losses of several credit unions. Once again, there is variation across institutions on the basis of asset class. For example, ninety percent of credit unions in group 4 experienced technological progress, and seventy percent had an overall gain in productivity. Alternatively, the major source of efficiency gain for the largest credit unions in the sample was from scale efficiencies, whereas for smaller credit unions efficiency gains were largely the result of improvements in technical efficiency.

Using the Kruskal-Wallis (one way analysis of variance) test, an effort was made to determine whether the frontier shift and catching-up effects differed statistically across these groups. While there are no precedents in financial services for testing changes in Malmquist indices on this basis, several comparable studies in other industries have employed these techniques. For example, Price and Weyman-Jones (1996) have used nonparametric Kolmogorov-Smirnov tests for the purposes of analysing Malmquist indices in the privatised U.K. gas industry, and Fukuyama (1995) used Spearman's rank correlation for measuring efficiency and productivity growth in Japanese banking. The test for efficiency change using the Kruskal-Wallis test statistic [ $KW = 9.855 \sim \chi^2(10)$ ] fails to

reject the null hypothesis of equal means. However, the test for technological change ( $KW = 16.244 \sim \chi^2(10)$ ) is asymptotically significant at the .10 level. Similar results are obtained for Kruskal-Wallis tests with the null hypotheses of equal medians for efficiency [ $KW = 9.985 \sim \chi^2(10)$ ] and technical change [ $KW = 21.345 \sim \chi^2(10)$ ]. This would suggest that although changes in efficiency are fairly uniform across the sample, there are statistically significant differences in the frontier shift effects. In order to further investigate this possibility, groups of credit unions combining a number of deciles are compared on the basis of the Mann-Whitney and Kolmogorov-Smirnov nonparametric test statistics. The null hypothesis in the first instance is that the indices are equivalent in location, while in the second the null hypothesis is that the groups are equivalent in the shape and location of the efficiency distribution. On this basis, it was found that larger credit unions (Groups 6 to 10) have a significantly different distribution of frontier shift effects, whereas smaller credit unions differ statistically in terms of total factor productivity change. The results indicate that larger credit unions tended to exhibit greater efficiency gains over the period, and these could be mainly attributed to improvements in scale efficiency. Conversely, for the smaller credit unions which experienced an efficiency increase, the primary source appeared to be improvements in technical efficiency.

#### **TABLE 4 HERE**

Table 4 presents the results of a pooled time-series, cross-sectional regression with a set of assumptions that give a cross-sectionally heteroskedastic and time-wise autoregressive model. The dependent variables are the efficiency ( $E$ ), technological progress ( $P$ ) and total factor productivity ( $M$ ) indices for each year of the sample compared to the previous year (the time-series therefore starts with 1994/95 since no indices are computed for the first year of the sample). The explanatory variables are the number of members ( $MEM$ ), the proportion of residential ( $RL$ ) and commercial loans ( $CL$ ) in the loan portfolio, total assets ( $TA$ ), the proportion of fixed capital ( $CAP$ ), the current

ratio (*CUR*), and dummy variables for geographic location (*NSW*, *VIC*, *QLD*, *WA*, *SA*, *TAS*) for each year in the sample period 1994/95 to 1996/97.

The first three columns of Table 4 are the estimated coefficients, standard errors and elasticities (at the means) for the regression of the efficiency indices (*E*) on the vector of explanatory variables. A test of the null hypothesis that all the slope coefficients are jointly zero is rejected at the .01 level using a Wald chi-square statistic. As indicated, efficiency gain over the sample period is higher for credit unions with a low number of members (*MEM*), a high level of total assets (*TA*), a high proportion of commercial loans (*CL*), and a high proportion of current assets to current liabilities (*CUR*). The marginal effect of these variables on technical efficiency is highest for total assets (0.1062) followed by the proportion of commercial loans in the credit union's portfolio (0.0469). Since the scale variable (*TA*) has a significant positive effect, there is the suggestion that the scale of financial service provision may be sub-optimal for smaller credit unions. In addition, there is significant negative relationship between the level of fixed capital (*CAP*) and the level of technical efficiency, and Queensland (*QLD*) and Tasmanian (*TAS*) credit unions *ceteris paribus* experienced a lower efficiency gain over the period than institutions in other states. One implication derived from the measure of fixed capital is that any benefits in terms of the take-up of technology on productivity since deregulation may have been off-set by an efficiency loss. In terms of the determinants of efficiency, the results are broadly comparable with cross-sectional studies by Miller and Noulas (1996) on the positive effect of asset size on financial service efficiency, Mester (1993) with similar benefits associated with commercial lending activity, and Elyasiani *et al.* (1994) on the adverse effects of a high level of fixed assets.

The estimated coefficients of the regression where technological progress (*P*) is specified as the dependent variable are also detailed in Table 4. A test of the null hypothesis of the joint insignificance of the explanatory variables is rejected at the .01 level, and we may conclude that the vector of financial indicators exerts a significant influence on the magnitude of technological

progress. However, unlike the previous analysis, the only individual characteristics which exert an influence on technological progress are the proportion of residential (*RL*) and commercial (*CL*) loans in the credit union's portfolio. One explanation is that these measures are associated with some of the most competitive financial services on offer, and that credit unions entering these markets are obliged to actively engage in product innovation and to explore new market opportunities in this area. The results also suggest that technological progress over the period varies significantly across states. Several additional influences on the degree of technological progress are hypothesised, although these are empirically untestable at the present time given the lack of suitable data. One possible reason for the contraction of the frontier mentioned earlier is that the large input 'start-up' requirement associated with deregulation is distorting the shape of the best-practice frontier over very short sample periods. Other factors could include interest rate movements, and any number of technological restrictions which may have been placed on credit union's financial services function during this period, particularly by regulatory authorities.

The final three columns in Table 4 are the estimated coefficients, standard errors and elasticities where the dependent variable is specified in terms of total factor productivity (*M*). The estimated coefficients on the number of members (*MEM*) and total assets (*TA*) are respectively negative and positive at the .05 level, while that for residential loans (*RL*) is positive at the .01 level. The suggestion is that productivity gain has generally been higher since deregulation for credit unions with a high level of assets, a smaller membership base, and an orientation to the residential loan market. Other significant variables are the negative sign on the share of fixed assets (*CAP*) (suggesting that capital expenditure on equipment may not be an appropriate indicator of productivity), while the sign on the current ratio indicates that relatively high levels of current assets are not adversely affecting productivity. In terms of total factor productivity, there does not appear to be any significant variation amongst credit unions across states, though since seventy-five

percent of the sample are based in either NSW or Victoria, this may obscure some interesting variation across comparable credit unions.

## **5. Concluding remarks**

We have analysed productivity growth in Australian credit unions over the period 1993/94 to 1996/97 within the framework of the DEA piecewise linear production function and the Malmquist productivity index. This allowed the simultaneous analysis of changes in best-practice due to frontier growth and changes in the relative efficiency of credit unions owing to movements towards existing frontiers. Overall, the results indicate that there was little or no productivity growth at the frontier during the period in question, although there was substantial improvement in the relative efficiency of nearly all credit unions. That productivity growth which did occur appears largely due to an increase in efficiency over the period, with improvements in scale efficiency dominating for larger credit unions, and improvements in technical efficiency being notable for smaller ones.

The results also indicate that a number of variables help explain variation in technical and technological change in the period since deregulation. The most important factors in determining the level of efficiency appear to be the number of members and the level of assets, whereas the proportion of residential and commercial loans in the asset portfolio appear to be more significant at the margin in determining technological progress. Overall, productivity change in credit union services appears to relate more to individual credit union characteristics rather than to any differences that may result in regulatory structure.

However, these results suffer from a number of limitations. First, the primary limitation is that the outputs used in the study are subject to exogenous shocks that may place credit unions generally in a poor light. For example, financial outputs are defined in terms of the dollar value of loans and deposits. Both of these indicators may have exhibited a general downward trend during the sample period due to changes in overall economic activity. Second, no allowance is made to examine allocative efficiency, which may have changed during this early period of microeconomic reform.

This omission may be aggravated by the necessarily shortened sample period. Third, another limitation is the failure to incorporate contextual or nondiscretionary factors into the analysis. This omission is largely the result of inadequate data, and means that it is difficult to understand why the changes in productivity, efficiency, and especially technology, have occurred. Fourth, the measures of efficiency and technological progress provided in this study are best-practice in that the production frontier is derived from the sample itself. While this is an advantage in most cases, there is nothing to suggest that productivity change in credit unions since deregulation has either been meritorious nor comparable to that found in other deposit-taking institutions. Finally, the present study shares its deterministic nature in common with other DEA-based approaches; that is, no allowance is made for measurement or specification error. However, the Malmquist index approach is entirely general and can also be implemented in econometric frontiers (but rarely has been done so). This indicates an important area for future research.

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Figure 1

Malmquist index and productivity changes over time

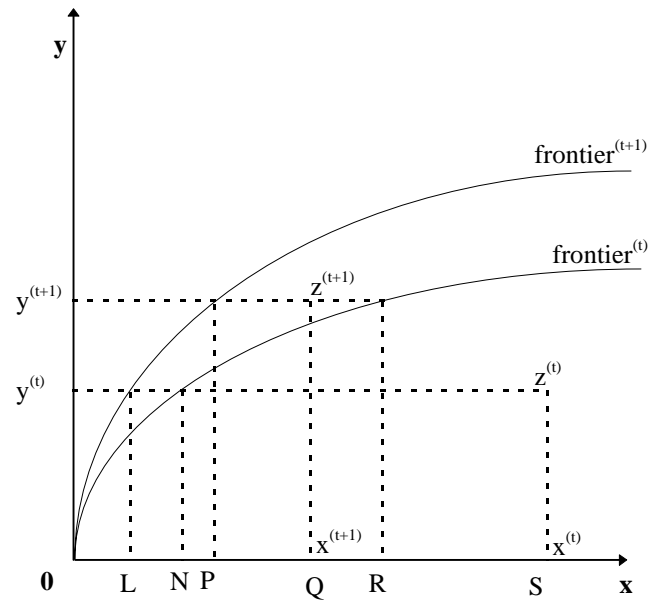


Table 1

Variables and selected descriptive statistics <sup>a</sup>

	Variable	Mean	Standard deviation
<i>MF</i>	Member's funds in dollars	5955037	10032184
<i>CP</i>	Book value of land, buildings and plant in dollars	1284067	2961869
<i>FL</i>	Financial liabilities in dollars	923145	6087684
<i>ST</i>	Number of full-time equivalent staff	29.84	46.83
<i>BR</i>	Number of branches including head office	4.04	6.42
<i>DC</i>	Call deposits in dollars	25923701	48835640
<i>DT</i>	Term deposits in dollars	28105062	48512830
<i>LP</i>	Personal loans in dollars	21217391	35801363
<i>LR</i>	Residential loans in dollars	25897783	53856259
<i>LC</i>	Commercial loans in dollars	1495195	3797109
<i>SC</i>	Marketable securities in dollars	11455410	19001544
<i>MEM</i>	Number of members	12778.06	19756.14
<i>RL</i>	Residential loans (in dollars) divided by total loans (in dollars)	0.2878	0.1918
<i>CL</i>	Commercial loans (in dollars) divided by total loans (in dollars)	0.0202	0.0308
<i>TA</i>	Total assets (in dollars)	62181328	1.06E+08
<i>CAP</i>	Fixed capital (in dollars) divided by total assets (in dollars)	0.0174	0.0239
<i>CUR</i>	Current assets (in dollars) divided by current liabilities (in dollars)	1.4337	0.4575
<i>NSW</i>	Dummy variable if credit union is in New South Wales	136	
<i>VIC</i>	Dummy variable if credit union is in Victoria	67	
<i>QLD</i>	Dummy variable if credit union is in Queensland	25	
<i>WA</i>	Dummy variable if credit union is in Western Australia	14	
<i>SA</i>	Dummy variable if credit union is in South Australia	14	
<i>TAS</i>	Dummy variable if credit union is in Tasmania	7	

<sup>a</sup> All dollar figures are in Australian dollars. Descriptive statistics for dummy variables are the number of credit unions in selected category. Descriptive statistics are for financial year 1996/97 only.

Table 2  
Credit union productivity by asset size over sample period <sup>a,b</sup>

Group	Index	Mean	Standard deviation	Minimum	Maximum	Group	Mean	Standard deviation	Minimum	Maximum
1	<i>E</i>	0.9812	0.2392	0.5690	1.4360	7	1.0134	0.0697	0.8560	1.1561
	<i>P</i>	0.9629	0.1258	0.7210	1.1690		1.0108	0.0950	0.6700	1.2071
	<i>M</i>	0.9290	0.1838	0.4880	1.2900		1.0237	0.1142	0.6705	1.2660
2	<i>E</i>	0.9977	0.1294	0.7850	1.3670	8	1.0180	0.0851	0.7796	1.1850
	<i>P</i>	1.0089	0.0917	0.7231	1.1540		0.9740	0.0647	0.8050	1.0752
	<i>M</i>	1.0083	0.1699	0.6480	1.4280		0.9920	0.1049	0.6277	1.1820
3	<i>E</i>	1.0006	0.0977	0.8270	1.1990	9	0.9881	0.0560	0.8910	1.1575
	<i>P</i>	0.9869	0.0980	0.7453	1.1690		1.0002	0.0419	0.9080	1.0870
	<i>M</i>	0.9867	0.1284	0.6870	1.1970		0.9888	0.0781	0.8550	1.1890
4	<i>E</i>	1.0152	0.0837	0.8840	1.2550	10	0.9918	0.0665	0.8370	1.1574
	<i>P</i>	1.0537	0.0541	0.9190	1.1730		0.8366	0.4233	0.9202	1.4763
	<i>M</i>	1.0696	0.1010	0.8944	1.2980		0.8242	0.4237	0.9569	1.4760
5	<i>E</i>	0.9817	0.1116	0.7740	1.2170	All	0.9997	0.1135	0.5690	1.4362
	<i>P</i>	0.9906	0.1340	0.5812	1.2050		0.9804	0.1654	0.6521	1.4760
	<i>M</i>	0.9728	0.1722	0.5246	1.2600		0.9785	0.1913	0.7511	1.4760
6	<i>E</i>	1.0154	0.0962	0.8770	1.2500					
	<i>P</i>	0.9840	0.0623	0.8020	1.0800					
	<i>M</i>	0.9981	0.1028	0.7870	1.2330					

<sup>a</sup> M is the geometric mean total factor productivity index over the period 1993/94-1996/97. E is the geometric mean technical efficiency index over the period 1993/94-1996/97. P is the geometric mean of the technological change index over the period 1993/94-1996/97.

<sup>b</sup> Figures 1 to 10 indicate groups of credit unions based on decile asset sizes, with group 1 being the lowest ten percent of credit unions by dollar value of assets and group 10 being the top ten percent of credit unions in terms of assets. All represents all credit unions across asset sizes.

Table 3

Credit union productivity characteristics over sample period <sup>a,b</sup>

Group	Productivity		Main source of productivity change		Efficiency change		Main source of efficiency change		Technological change	
	Gain	Loss	Efficiency	Technology	Increase	Decrease	Technical	Scale	Progress	Regress
1	11	16	11	16	11	14	14	11	11	16
	<i>41</i>	<i>59</i>	<i>41</i>	<i>59</i>	<i>41</i>	<i>52</i>	<i>52</i>	<i>41</i>	<i>41</i>	<i>59</i>
2	14	13	10	17	11	12	11	12	16	11
	<i>52</i>	<i>48</i>	<i>37</i>	<i>63</i>	<i>41</i>	<i>44</i>	<i>41</i>	<i>44</i>	<i>59</i>	<i>41</i>
3	14	13	12	15	10	12	12	10	15	12
	<i>52</i>	<i>48</i>	<i>44</i>	<i>56</i>	<i>37</i>	<i>44</i>	<i>44</i>	<i>37</i>	<i>56</i>	<i>44</i>
4	19	8	8	18	12	13	12	13	24	2
	<i>70</i>	<i>30</i>	<i>30</i>	<i>67</i>	<i>44</i>	<i>48</i>	<i>44</i>	<i>48</i>	<i>89</i>	<i>7</i>
5	12	14	13	14	9	13	12	10	17	10
	<i>44</i>	<i>52</i>	<i>48</i>	<i>52</i>	<i>33</i>	<i>48</i>	<i>44</i>	<i>37</i>	<i>63</i>	<i>37</i>
6	11	16	14	13	10	13	12	11	11	16
	<i>41</i>	<i>59</i>	<i>52</i>	<i>48</i>	<i>37</i>	<i>48</i>	<i>44</i>	<i>41</i>	<i>41</i>	<i>59</i>
7	17	10	13	14	12	9	9	12	15	11
	<i>63</i>	<i>37</i>	<i>48</i>	<i>52</i>	<i>44</i>	<i>33</i>	<i>33</i>	<i>44</i>	<i>56</i>	<i>41</i>
8	13	14	19	8	13	9	11	11	10	17
	<i>48</i>	<i>52</i>	<i>70</i>	<i>30</i>	<i>48</i>	<i>33</i>	<i>41</i>	<i>41</i>	<i>37</i>	<i>63</i>
9	11	16	13	14	7	14	14	7	14	13
	<i>41</i>	<i>59</i>	<i>48</i>	<i>52</i>	<i>26</i>	<i>52</i>	<i>52</i>	<i>26</i>	<i>52</i>	<i>48</i>
10	10	16	14	12	8	7	10	5	14	11
	<i>37</i>	<i>59</i>	<i>52</i>	<i>44</i>	<i>30</i>	<i>26</i>	<i>37</i>	<i>19</i>	<i>52</i>	<i>41</i>
All	132	136	127	141	103	116	117	102	147	119
	<i>49</i>	<i>50</i>	<i>47</i>	<i>52</i>	<i>38</i>	<i>43</i>	<i>43</i>	<i>38</i>	<i>55</i>	<i>44</i>

<sup>a</sup> Figures indicate number of credit unions exhibiting specified productivity characteristic over the period 1993/94 to 1996/97. Figures below (in italics) are the number of credit unions exhibiting productivity characteristic as a percentage of sample group.

<sup>b</sup> Groups 1 to 10 are based on decile asset sizes, with group 1 being the lowest ten percent of credit unions by dollar value of assets and group 10 being the top ten percent of credit unions in terms of assets. All represents all credit unions, regardless of decile asset size.

Table 4

Determinants of productivity variation <sup>a,b</sup>

Variable	Efficiency gain			Technological progress			Total factor productivity		
	Coefficient	Std. error	Elasticity	Coefficient	Std. error	Elasticity	Coefficient	Std. error	Elasticity
<i>CONS.</i>	***0.9842	0.0502		***1.0753	0.0225		***0.8340	0.0408	
<i>MEM</i>	***-2.13E-06	5.33E-07	-0.0266	1.46E-07	2.12E-07	0.0150	** -9.1E-07	4.19E-07	-0.0115
<i>RL</i>	0.0076	0.0195	0.0063	***0.0371	0.0084	0.0105	***0.1073	0.0099	0.1180
<i>CL</i>	***0.3269	0.1099	0.0469	**0.0876	0.0391	0.0155	-0.0105	0.0674	-0.0002
<i>TA</i>	*2.42E-10	1.29E-10	0.1062	9.67E-12	3.87E-11	0.0052	**6.12E-11	2.35E-11	0.0357
<i>CAP</i>	***-0.4861	0.1474	-0.0085	-0.1388	0.0867	-0.0024	*-0.2186	0.1195	-0.0038
<i>CUR</i>	***0.0629	0.0160	0.0992	-0.0065	0.0046	-0.0090	***0.0847	0.0086	0.1777
<i>NSW</i>	-0.0431	0.0439	-0.0219	** -0.0435	0.0205	-0.0218	0.0357	0.0386	0.1036
<i>VIC</i>	-0.0683	0.0441	-0.0171	***-0.0686	0.0204	-0.0169	0.0423	0.0387	0.1062
<i>QLD</i>	*-0.0773	0.0445	-0.0072	***-0.0590	0.0205	-0.0054	0.0175	0.0389	0.0295
<i>WA</i>	-0.0579	0.0469	-0.0030	***-0.0661	0.0203	-0.0034	0.0386	0.0393	0.0498
<i>SA</i>	-0.0693	0.0459	-0.0036	***-0.0540	0.0204	-0.0028	0.0073	0.0390	0.0094
<i>TAS</i>	** -0.0977	0.0474	-0.0026	***-0.0727	0.0245	-0.0019	0.0148	0.0401	0.0137

<sup>a</sup>  $E_{it} / P_{it} / M_{it} = \beta_0 + \beta_1 MEM_{it} + \beta_2 RL_{it} + \beta_3 CL_{it} + \beta_4 TA_{it} + \beta_5 CAP_{it} + \beta_6 CUR_{it} + \beta_7 NSW_{it} + \beta_8 VIC_{it} + \beta_9 QLD_{it} + \beta_{10} WA_{it} + \beta_{11} SA_{it} + \beta_{12} TAS_{it} + e_{it}$ . Dependent variables in the three separate regressions are  $E_{it}$  (index measure of efficiency gain),  $P_{it}$  (index measure of technological progress) and  $M_{it}$  (total factor productivity index).

<sup>b</sup>  $MEM_{it}$ ,  $RL_{it}$ ,  $CL_{it}$ ,  $TA_{it}$ ,  $CAP_{it}$  and  $CUR_{it}$  are the number of members, the proportion of residential loans, the proportion of commercial loans, total assets, the book value of capital and the current ratio of the individual credit union at time  $t$ .  $NSW_{it}$ ,  $VIC_{it}$ ,  $QLD_{it}$ ,  $WA_{it}$ ,  $SA_{it}$  and  $TAS_{it}$  are dummy variables for each state. Asterisks indicate significance at the \* – .10, \*\* – .05 and \*\*\* – .01 level. Elasticities are calculated at the means.