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Technical Efficiency and Technological Change in Australian Building Societies

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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 a sample of Australian building societies. The results indicate that most building societies experienced productivity gain in the past several years, and this was largely the result of technological progress rather than efficiency improvements. That productivity growth which did occur due to an increase in efficiency over the period tended to be the result of improvements in scale efficiency, whilst efficiency gain was most pronounced in building societies with a high ratio of net interest income and non-interest income to total assets, low operating expense ratios, and relatively high expenditures on marketing and promotion.

Key words: Production frontiers, Technological progress, Technical efficiency.

For most of their history, building societies have operated within a well-defined, institution-specific, regulatory sub-sector of the Australian financial system. However, in the period following the major Australian Financial System (Campbell) Inquiry (1981) recommendations, building societies, along with other financial service providers, were forced to adapt to a newly deregulated environment. In its 1997 *Stocktake of Financial Deregulation*, the Financial System (Wallis) Inquiry (1997, p. 640) summarised the effect of these reforms 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 ... [however] there are equal grounds for concluding that deregulation has been neither complete, nor completely effective, in all respects.

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Unfortunately, this summary says little about the pattern of efficiency, technological and productivity change in pre-deregulatory, sub-sectors, including building societies. For example, while falling operating expense ratios were used as a pointer by the Wallis Inquiry to likely post-deregulatory increases in technical efficiency for banks, there is less elaboration on the fact that these ratios increased for building societies over the same period. Likewise, the impact of heightened competition in the home lending market, as amplified by falling barriers to entry facilitated by technological innovation, has had a disproportionate influence on some financial institution sub-sectors. For instance, over the last decade, building societies' share of home lending commitments (by number) have fallen from 15.7 percent to some 4.3 percent. Little is known about the relative impact of these technological changes on financial institution productivity.

A careful analysis of financial sector productivity at the institution-specific level should therefore add to our knowledge about the factors determining the pattern of efficiency gain and technological progress in Australia. In addition, such an analysis should provide useful information for two major elements of the Wallis proposals; namely, prudential supervision for all banks, credit unions, building societies, insurance companies and superannuation funds by the Australian Prudential Regulation Authority (APRA), and consumer protection and supervision by the Corporations and Financial Services Commission (CFSC). For example, there are still-unanswered questions relating to the provision of specialised liquidity facilities, the establishment of differential regulatory regimes, and the implicit guarantees thought to exist between State governments and state-based financial institutions (like building societies and credit unions) under the Wallis proposals (Edwards and Valentine, 1998). There is an obvious requirement for empirical studies to provide measures of efficiency changes and technological progress so as to help address these uncertainties.

In this paper an attempt is made to examine the progressive changes in technical efficiency and technology in Australian building societies. The exercise consists of two steps. First, we calculate measures of efficiency gain, technological change, and productivity growth using nonparametric methods. Second, we explain the calculated measures in terms of the financial characteristics of building societies. The paper itself is divided into four main sections. The second section focuses on the theoretical background to the indices of productivity and technical change employed. The third section deals with the specification of inputs and outputs employed in the evaluation of technical efficiency and technical change in building societies. The fourth section presents the resultant indices of productivity, efficiency and technical change and assesses their significance. The paper ends with some brief concluding remarks in the final section.

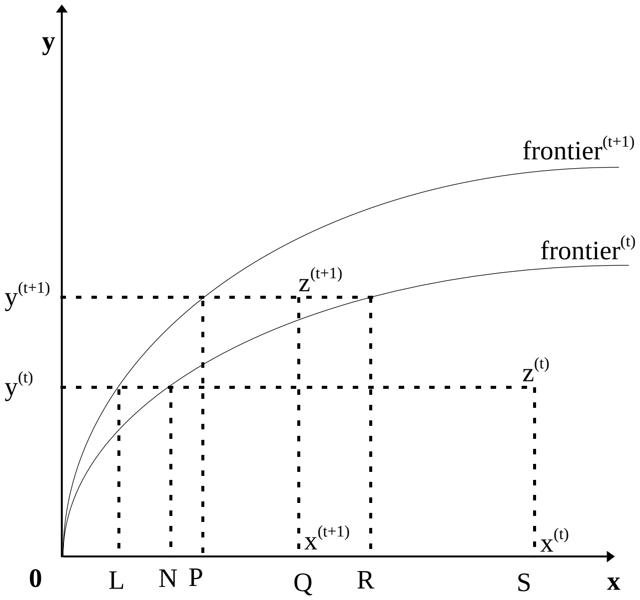
MALMQUIST INDEXES OF PRODUCTIVITY AND TECHNICAL CHANGE

Traditionally, economists have employed *production possibility frontiers* in their attempts to measure technical efficiency, technological progress and productivity growth in organisations and industries. Production possibility frontiers map a locus of potentially technically efficient input-output combinations an organisation is capable of producing at any point in time using the available technology. *Technical efficiency* here refers to the ability to use a minimal amount of input to make a given level of output. To the extent an organisation fails to achieve an output combination on its production possibility frontier, and falls beneath this frontier, it can be said to be technically inefficient. Over time, however, the level of output an organisation is capable of producing will increase due to *technological changes* that affect the ability to optimally combine inputs and outputs. These technological changes cause the production possibility frontier to shift upward, as more outputs are obtainable from the same level of inputs. Thus for any organisation in an industry, *productivity improvements* over time (that is, more outputs for the same or lower level of inputs) may be either technical efficiency improvements (catching up with their own frontier) or technological improvements (because the frontier is shifting up over time), or both. Accordingly, if we can determine production frontiers that represent the best currently known production techniques, then we can use this idealised yardstick to evaluate the performance of actual organisations and industries. Identifying changes in this frontier over time will then allow the decomposition of overall productivity growth into technical efficiency gains and technological improvements.

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.

PRODUCTIVITY CHANGES OVER TIME



Now for any given building society 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 *0N*/*0S*. That is, the inputs that 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 *0R*/*0Q* in order to achieve comparable technical efficiency to that found in period *t*. Since the frontier has shifted, *0R*/*0Q* exceeds unity, even though it is technical 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:

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

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:

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

or

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

where

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

$$P = \left[\frac{D_I^t(y^{t+1},x^{t+1})}{D_I^{t+1}(y^{t+1},x^{t+1})} \times \frac{D_I^t(y^t,x^t)}{D_I^{t+t}(y^t,x^t)}\right]^{1/2} \qquad (4)$$

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* building societies and that each consumes varying amounts of *K* different inputs to produce *M* different outputs. For the *i*th building society these are represented by the vectors x_i and y_i, respectively. The ($K \times N$) input matrix, *X*, and the ($M \times N$) output matrix, *Y*, represents the data of all *N* building societies 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.

In parenthesis for interested readers, DEA is a linear programming-based methodology designed to measure the efficiency of ‘decision making units’ or DMUs. Typically, each of the DMUs in a given population use the same multiple inputs in varying quantities to produce varying quantities of the same multiple outputs. Using the actual observed values for the inputs and outputs for each DMU, DEA constructs a piecewise extremal production surface, which in economic terms represents the revealed best-practice production frontier – the maximum output empirically obtainable for any DMU in the observed population, given its level of inputs. For each DMU that lies below the frontier, the level of efficiency is determined by comparing these *inefficient* DMUs to either a single referent DMU or a convex combination of other referent DMUs located on the *efficient* frontier. Efficient DMUs typically utilise the same level of inputs and produce the same level or higher of outputs. This is accomplished by requiring solutions to satisfy inequality constraints that can increase some outputs or decrease some inputs without worsening other inputs and outputs. Thus, the DEA measure of efficiency is *relative* in that it is calculated in relation to all other DMUs in the sample, as against the *absolute* measures of efficiency obtained when an production function is specified in, say, the econometric approach to efficiency measurement.

The first two linear programs (equations 5 and 6) 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 (equations 7 and 8) 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 (where any scaled-up or scaled-down versions of the input combinations are also included in the production possibility set), the following input-orientated linear programs are used:

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

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

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

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

where θ is a scalar and λ is a $N\times 1$ vector of constants. The value of θ will be the efficiency score for the ith building society. In (5) and (6) each building society's production points are compared with technologies from the same time period. In (7) and (8) they are compared to technologies from different time periods. Decomposing the constant returns-to-scale technical efficiency change into scale efficiency and pure technical efficiency components further extends this approach. This is useful in that the constant returns-to-scale specification is only appropriate where all building societies are operating at the optimal scale (which is unlikely where capital requirements and other regulatory constraints exist). Where this is not the case, the measures of technical efficiency obtained by the constant return-to-scale form will be confounded by the presence of scale efficiencies. The procedure itself involves calculating additional linear programs where the convexity constraint $N1'\lambda=1$ is introduced to programs (5) to (8), where $N1'$ is a transposed ($N\times 1$) vector of ones. Once again, it is obvious that the input distance function (*D*) 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 constant returns-to-scale (without convexity constraint) and variable returns-to-scale (with convexity constraint) assumptions, 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. 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 $E = PT \times S$. 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). The Malmquist DEA method described is constructed using DEAP Version 2.1.

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 building societies. The technique selected for explaining variation is a regression-based approach. The general form is:

$$m_{it}^{*} = z_{it}^{'}\beta + e_{it} \quad \text{i} = 1,\ldots,\text{N. and t} = 1,\ldots,\text{T.} \tag{9}$$

where m_{it}^{*} is an index measure of either technical efficiency (*E*), technological (*P*) or total factor productivity (*M*) change, z'_{it} is a set of explanatory variables posited to explain productivity in financial institutions, β is a vector of parameters to be estimated, and $e_{it} \sim N(0,\sigma^2)$. In this approach, the productivity of the building society is related to a set of financial measures that characterise its operations. Past approaches that have employed nonparametric techniques to measure financial institution efficiency followed by parametric techniques to assign variation in efficiency include Mester (1993), Cebenoyan *et al*. (1993), Fried, Lovell and Vanden Eeckaut (1993), Fried, Lovell and Turner (1996), Miller and Noulas (1996), Berger and Mester (1997) and Worthington (1998b). SHAZAM Version 8.0 is used for the second-stage regression analysis.

SPECIFICATION OF INPUTS/OUTPUTS AND EXPLANATORY VARIABLES

The data used in this study consists of annual observations of a sample of 15 Australian building societies. All data is sourced from the Australian Financial Institutions Commission (AFIC) [On 1 July 1999 the Australian Prudential Regulation Authority (APRA) became responsible for the prudential regulation of building societies]. The time period selected is 1993/94 to 1996/97. The GDP implicit deflator is used to deflate the monetary variables from 1994/95, 1995/96 and 1996/97 to 1993/94 prices. A more extensive set of time-series data would, of course, be more valuable. For example, much regulatory reform and product innovation occurred during the late 1980s. Unfortunately, a national framework for prudential supervision of State-based non-bank deposit-taking institutions (along with the requisite database) was only established with the creation of AFIC in July 1992.

The inputs and outputs employed follow a production-type approach to modelling financial institution behaviour, that is, building societies combine capital (both membership-based and physical), labour and branches to produce deposits, loans, and investments. Table 1 provides selected descriptive statistics over the period in question. In terms of specific studies, the approach is most consistent with that used by Berg *et al.* (1993), Favero and Papi (1995) and Fried *et al.* (1996). This ‘production’ approach views financial institutions as producers of deposit accounts and loans; defining output as the number or dollar value of such accounts or their associated transactions. Inputs in this case are calculated as the number of employees, and capital expenditures on fixed assets and other material. This differs somewhat from the intermediation approach which conceptualises financial institutions as intermediators: converting and transferring financial assets from surplus units to deficit units. In that instance, the institutional inputs are labour and capital costs, and the interest payable on deposits, with the outputs denominated in loans and financial investments.

Starting with the inputs, members funds (x_1) are measured by summing permanent share capital, share premium accounts, general and other reserves plus outside equity interests, and physical capital (x_2) is measured by equipment, fixtures and premises, either purchased directly or via capitalised leases (Berger and Humphrey, 1991). Labour (x_3) is measured by the number of full-time equivalent employees. Finally, recognising that branches form an important input into the building society intermediation process, the number of full-branch equivalent operations (x_4) is also included.

In terms of outputs, six categories are employed. These are: call deposits (y_1), term deposits (y_2), personal loans (y_3), residential loans (y_4), commercial loans (y_5), and other financial investments (y_6). 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). The exact conceptualisation of financial outputs relies heavily on one’s *a priori* reasoning. Berger and Humphrey (1991), for example, proposed three ways in which financial outputs could be defined: an asset approach (outputs are loans and other assets); a user cost approach (outputs contribute to net revenue); and a value-added approach (outputs contribute to value added). All other things being equal, and in the current context, it is argued that a building society increasing the level of deposits and loans will increase its net production of value-added. Using the approach selected a relatively efficient building society *ceteris paribus* will therefore minimise the level of capital, the number of branches and staff employed, whilst maximising customer outputs in the form of deposit and loan facilities and other investments.

TABLE 1.

INPUTS, OUTPUTS AND FINANCIAL CHARACTERISTICS, 1993-1997

	Variable	Mean	Std. dev.
Inputs			
x_1	Member's capital (share capital, general reserves and retained profits)	27388.15	37293.01
x_2	Physical capital (land, buildings, plant and equipment)	9215.24	10469.62
x_3	Full-time equivalent staff	147.96	145.98
x_4	Number of branches (including head office)	20.72	16.49
Outputs			
y_1	Call deposits	179458.25	211696.30
y_2	Term deposits	214714.57	168191.24
y_3	Personal loans	11651.76	17259.97
y_4	Residential loans	331563.37	312684.90
y_5	Commercial loans	17073.81	30044.61
y_6	Securities (including bank bills and bank deposits)	74727.99	60288.48
Profitability			
z_1	Net interest income/total assets	0.0362	0.0069
z_2	Non-interest income/total assets	0.0050	0.0072
Efficiency			
z_3	Operating expenses/total assets	0.0228	0.0111
z_4	Operating expenses/operating income	0.5522	0.2141
Credit quality			
z_5	Doubtful debts expenses/total receivables	0.0011	0.0048
Operations			
z_6	Marketing and promotional expenses/total expenses	0.1666	0.3101
z_7	Information technology expenses/total expenses	0.1035	0.0817

Of course, a large number of additional factors are thought to have an impact on productivity in financial services. For example, Rangan, Grabowski, Aly and Pasurka (1988) included an index of product diversity in their DEA study of U.S. commercial banks, and Ferrier and Lovell (1990) incorporated the average size of loans and deposits accounts across a range of U.S. deposit-taking institutions (DTIs). Alternatively, Cebenoyan, Cooperman, Register and Hudgins (1993) attempted to proxy the competitive environment in U.S. savings and loans (S&Ls) by including the industry concentration ratio and the market share held by individual firms, Shaffer (1993) included the proportion of off-balance sheet assets, and Mester (1987) and Drake and Weyman-Jones (1996) used liquid asset holdings in excess of capital requirements. The latter studies in particular highlight the fact that there may be a degree of conflict between strictly efficient performance and compliance with capital adequacy requirements and other regulations. Unfortunately, there is no data set available reflecting all factors relevant to calculating building society efficiency at the present time.

The explanatory variables to be included in the second-stage regression are also presented in Table 1. The first group of variables are intended to account for the relationship between building society profitability and productivity (including both technical efficiency and technological change). These are: (i) the ratio of net interest income (interest income less interest expense) to total assets (z_1); and (ii) the ratio of non-interest income (revenue less interest income and bad debt recoveries) to total assets (z_2) (Shaffer 1993; Worthington. 1998c). These aspects of building society financial management are closely linked with each organisation's theoretical ability to efficiently allocate resources. For example, the ratio of non-interest income is considered especially important since one aspect of the post-deregulation marketplace has been the emphasis on pricing services in order to provide incentives for efficiency improvements. It is argued *ceteris paribus* that a more profitable building society will be associated with greater productivity gains over the period due to the positive influence of these factors on the ability to operate efficiently. Positive coefficients are therefore hypothesised when productivity is regressed against measures of profitability (or financial management ability).

The second group of variables are traditional measures of financial institution efficiency. It is posited that a building society with a low ratio of operating expenses (total expenses before tax and bad debts less interest and doubtful debts expense) to total assets (z_3) and a low ratio of operating expense to operating income (net interest plus non-interest income) (z_4) should be relatively more productive due to a higher level of technical efficiency [see, for example, Fried *et al.* (1993) and Worthington (1998a)]. Negative coefficients are hypothesised.

The third group of variables is comprised of total provisions for doubtful debts divided by gross receivable (loans and advances) (z_5) and is therefore a measure of credit quality (Mester 1993). It is argued that a building society with a relatively higher level of credit quality will have achieved greater productivity gains over the period. This will have indicated its ability to weather the strong post-deregulation competitive forces in loan markets at the same time as minimising the side effects of delinquent loans. The emphasis here is on efficiency gains: building societies with an appropriately managed loan portfolio will be able to minimise inputs for any given level of loan output. The final group of variables detailed in Table 1 relate to two areas of expenditure that have grown markedly in the period since deregulation; namely, marketing and promotional expenses (z_6) and information technology expenses (z_7) (both as a percentage of total expenses). It is posited that the adoption of technological innovation and technically efficient behaviour may have been more rapid in those building societies devoting a relatively higher proportion of expenditures to these areas. Finally, a time index (z_8) is included to measure the movement of productivity change over the overall period in question. No sign is postulated *a priori* on the coefficient for the time index.

EMPIRICAL RESULTS

In the previous section, we defined Malmquist indices of productivity growth relative to a reference technology for the period 1993/94 to 1996/97. Using this information, three primary issues are addressed in our computation of Malmquist indices of productivity growth. 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 building societies and differences in the indices for each of the included years have statistical significance. This usually requires the use of nonparametric statistical methods.

We begin by looking at the changes in productivity, efficiency, and technology for financial services in the period 1993/94 to 1996/97. Inputs were specified in terms of members funds, physical capital, and the number of staff and branches, and outputs in terms of the dollar value of loans and deposits across six categories. In Table 2 descriptive statistics of the indices of productivity growth (M), efficiency change (E), and technological change (P) for each building society are detailed. Wilcoxon (one-sample) signed-ranks tests are used to test the significance of the efficiency, technology and productivity index measures over the pooled institutions and years. This is necessary since at least part of the following analysis assumes that these measures differ from unity. The test statistics indicate that all three measures are asymptotically significant at the .01 level or better.

For each building society in the sample, the total factor productivity change is the product of efficiency and technical change. Index measures greater (less) than unity indicate that there has been productivity gain (loss), efficiency increase (decrease) or technical progress (regress). Similarly, the overall efficiency change is the product of pure technical efficiency and scale efficiency change. For example, in building society number six there was an average positive increase in total factor productivity over the period in question of 16 percent (1.160 – 1.000). This was composed of a 6.1 percent efficiency gain (1.061 – 1.000) and a 9.4 percent increase (1.094 – 1.000) due to technological progress. As discussed earlier, the efficiency change can be decomposed into its pure technical efficiency and scale efficiency portions. In this building society there has been no change in pure technical efficiency (1.000 – 1.000) so the efficiency change is solely the product of scale efficiency improvements (1.061 – 1.000). These results contrast with building society number fifteen where the 11 percent increase in productivity was composed entirely of technical progress.

Table 3 presents the means for each of the sample years. The Malmquist index averages over the entire period (bottom row) are geometric means of the indices computed for each of the sample years. However, whereas the annual indices for efficiency, technical and productivity changes are significantly different from unity across the pooled sample, in individual years they are sometimes insignificant. For instance, in 1995 the Wilcoxon (one-sample) signed-ranks test indicates that none of the index measures are significantly different from unity. In 1996, the efficiency and productivity changes are asymptotically significant at the .10 level and technical change is insignificant, and in 1997 productivity change and technical change are significant at the .05 level but efficiency change is insignificant.

As indicated in Table 3, there was a mean annual increase in total factor productivity of 4.9 percent (1.049 – 1.000) over 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 improvements described can be the result of efficiency gains, technological progress, or both. In the case of Australian building societies, the overall improvement in productivity over the period is composed of an average efficiency decrease (movement away from the frontier) of 0.30 percent, and an average technological progress (upward shift of the frontier) of 5.3 percent. However, these figures serve to obscure some variation in productivity for each of the years in the sample. For example, annual total factor productivity gains range from 1.7 percent in 1995 to 7.2 percent in 1994, and efficiency changes range from a loss of 1.8 percent in 1994 to a gain of 2.7 percent in 1996. The results generally support the findings of the Wallis Inquiry that building society technical efficiency fell in the period to June 1997.

TABLE 2.

MALMQUIST INDEX SUMMARY OF FIRM MEANS, 1993 – 1997

Firm	*Efficiency change*	*Technical change*	*Pure technical efficiency*	*Scale efficiency*	*Total factor productivity change*
1	1.000	1.216	1.000	1.000	1.216
2	0.936	0.946	0.942	0.994	0.885
3	1.001	1.006	0.996	1.005	1.007
4	1.000	0.679	1.000	1.000	0.679
5	1.000	1.207	1.000	1.000	1.207
6	1.061	1.094	1.000	1.061	1.160
7	1.000	0.992	1.000	1.000	0.992
8	1.000	1.065	1.000	1.000	1.065
9	1.000	1.256	1.000	1.000	1.256
10	0.959	1.111	0.974	0.984	1.065
11	1.000	0.910	1.000	1.000	0.910
12	1.000	1.241	1.000	1.000	1.241
13	1.000	1.161	1.000	1.000	1.161
14	1.000	1.067	1.000	1.000	1.067
15	1.000	1.011	1.000	1.000	1.011

Using Mann-Whitney and Kolmogorov-Smirnov nonparametric tests an effort is made to determine whether the frontier shift and catching-up effects differ statistically across building societies and years. 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. 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 Kolmorogov-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 across time using the Mann-Whitney test statistic rejected the null hypothesis of equal means in technological progress for 1993/1994 [MW = 111.98] and for total factor productivity in 1995/1996 [MW = 99.25]. Differing results are obtained for the Kolmogorov-Smironov tests where the efficiency differences between 1994/1995 and 1995/1996 are found to be asymptotically significant at the .01 and 0.10 levels respectively [KS = .365 and .548 respectively]. This would suggest that there are statistically significant differences in the frontier shift effects and efficiency change for each of the years in the sample.

TABLE 3.

MALMQUIST INDEX SUMMARY OF ANNUAL MEANS, 1993/94 – 1996/97

Year	*Efficiency change*	*Technical change*	*Pure technical efficiency*	*Scale efficiency*	*Total factor productivity change*
1993/94	0.9820	1.0920	0.9790	1.0030	1.0720
1994/95	0.9930	1.0240	1.0070	0.9860	1.0170
1995/96	1.0270	1.0170	1.0000	1.0270	1.0450
1996/97	0.9850	1.0800	0.9890	0.9960	1.0640
Mean	0.9970	1.0530	0.9940	1.0030	1.0490

To further investigate variation in productivity, the building societies are grouped into asset size quartiles and compared on the basis of Kolmogorov-Smirnov nonparametric test statistics. It is found that building societies in the highest quartile have larger efficiency and productivity gains than either the second or third quartiles. Put differently, efficiency and productivity gains were higher in the largest 25 percent of building societies than in the middle 50 percent of building societies by asset size over the sample period. In addition, building societies in the second quartile differ from those in the bottom two quartiles (the smallest 50 percent of building societies) in having larger frontier shift effects and efficiency gains. These results generally show that productivity improvements and efficiency gains vary across the sample. However, the main source of productivity improvement in all building societies, irrespective of asset size, was technological progress rather than efficiency gains.

The second part of the analysis of building society productivity is a regression-based approach. Table 4 presents the results of a pooled time-series, cross-sectional regression with a set of assumptions that give a cross-sectionally correlated 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 ratios of net interest income (z_1) and non-interest income (z_2) to total assets, the ratio of operating expenses to total assets (z_3) and operating income (z_4), provision for doubtful debts divided by gross receivables (z_5), the proportion of total expenses made on marketing and promotion (z_6) and information technology (z_7), and a time index (z_8).

TABLE 4.

DETERMINANTS OF PRODUCTIVITY VARIATION, 1994/95 - 1996/97

	Total factor productivity			*Efficiency gain*			*Technological progress*		
Variable	Coefficient	Std. error	Elasticity	Coefficient	Std. error	Elasticity	Coefficient	Std. error	Elasticity
z_1	$^{(0.01)}$18.4170	3.7200	0.5952	$^{(0.01)}$21.7330	0.8915	0.7671	$^{(0.01)}$18.6960	3.5290	0.6059
z_2	$^{(0.01)}$36.0800	11.6600	0.1817	$^{(0.01)}$19.1970	3.1930	0.1056	$^{(0.01)}$34.6580	10.4000	0.1750
z_3	$^{(0.01)}$-49.4190	13.1500	-0.9464	$^{(0.01)}$-33.6260	3.7120	-0.7033	$^{(0.01)}$-47.9710	11.3200	-0.9213
z_4	$^{(0.01)}$-2.3786	0.3877	-1.1020	$^{(0.01)}$-1.4521	0.1163	-0.7347	$^{(0.01)}$-2.2651	0.3514	-1.0524
z_5	24.1990	52.2400	0.0074	-4.7291	13.4300	-0.0016	13.9320	46.4300	0.0043
z_6	0.1055	0.3235	0.0136	$^{(0.01)}$0.3035	0.1073	0.0429	0.0829	0.2973	0.0108
z_7	-0.0556	0.4535	-0.0053	-0.1426	0.1114	-0.0149	0.0724	0.4336	0.0070
z_7	0.0139	0.0191	0.0319	$^{(0.01)}$0.0275	0.0061	0.0688	0.0160	0.0191	0.0368

Notes: Figures in brackets indicate level of significance; elasticities calculated at the means; dependent variables are: M – total factor productivity, E – Efficiency gain, and P – technological progress; log-likelihoods 4.60, 79.07, and 9.56 respectively, Buse Raw-Moment R-Square 0.9852, 0.9981 and 0.9838 respectively.

The first three columns of Table 4 are the estimated coefficients, standard errors and elasticities (at the means) for the regression of the total factor productivity indices (M) 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 are joint tests for the significance of the profitability and efficiency measures. The Buse Raw-Moment R-Squares detailed in Table 4 are obviously high, though these should be interpreted with the usual caution, especially when considering the inclusion of time-series data in the sample. As indicated, productivity gain over the sample period is higher for building societies with higher profitability and lower operating expense ratios. The marginal effect of these variables on productivity is highest for the ratio of operating expense to operating income (-1.1020) followed by the ratio of operating expense to total assets (-0.9464). Of course, there are any number of additional variables which may be more appropriate in explaining the productivity of Australian building societies. For example, no allowance has been made for changes in macroeconomic conditions, differences in accounting procedures, or modifications in the competitive structure of financial services. The possible effect of these additional dimensions of firm performance and exogenous shocks on productivity has been ignored in both the input/output calculations and the second-stage regression.

The estimated coefficients of the regressions where technical efficiency (E) and technological progress (P) are specified as the dependent variables 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 both efficiency change and technological progress. The estimated coefficients and levels of significance are broadly comparable to those found in the earlier discussion. However, unlike the previous analysis, the coefficients on the proportion of marketing expenditure and the time index are positive and significant in the efficiency regression. The latter would suggest that efficiency has steadily improved in relative terms over the sample period.

CONCLUDING REMARKS

We have analysed productivity growth in Australian building societies over the period 1993/94 to 1996/97 within the framework of the DEA piece-wise 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 building societies owing to movements towards existing frontiers. Overall, the results indicate that there was productivity growth at the frontier during the period in question, and that most of the productivity growth resulted from shifts in the production frontier, rather than gains in technical efficiency by inefficient building societies. This appears to be consistent with the general findings of the Wallis Report on post-deregulation technological developments [this is necessarily qualified since the sample dates only from 1993/94]. The results also indicate that a number of variables help explain variation in technical efficiency and technological change in the period since deregulation. The most important factors in determining the overall pattern of productivity appear to be the levels of profitability, efficiency and, in some cases, expenditures on marketing and promotion.

However, a major limitation of the present study relates to the possibility of errors of measurement in inputs and outputs. For example, within a given building society measures of physical capital (as defined) are subject to changes over time in accounting principles, embracing both historical cost and current-cost accounting, and variation in accounting principles between societies. This would indicate that the definition of 'best-practice' is likely to vary over time and societies, and that at least some efficiency, technical and productivity change may arise from variation in accounting procedure. Likewise, the imposition of capital requirements by regulatory authorities would also impact upon the theoretical ability of building societies to alter input-output bundles (notwithstanding the variable returns-to-scale specification's allowance for building societies operating at a sub-optimal scale). The focus on extreme observations makes DEA-based methods, such as those employed here, particularly sensitive to variable selection, model specification and measurement errors such as these. However, the Malmquist index itself is entirely general, and could be applied to stochastic efficiency measurement techniques as at least one way of addressing these concerns.

There is any number of ways in which this research could be extended. One possibility is to subject different sub-groups of financial institutions, such as credit unions and banks, to the same approach. This would highlight the relative patterns of productivity gain in these related groups of institutions. Another possibility is to combine a broader classification of deposit-taking institutions, say, banks, building societies and credit unions, within a single analysis. This would serve to provide some idea of the relative efficiency gains of institutions now supervised by the Australian Prudential Regulation Authority (APRA). Finally, a longer series of observations on any or all of these deposit-taking institutions would allow the closer investigation of productivity gains, efficiency change, and technological progress in financial services. This would yield more thorough information about the impact of recent microeconomic reform.

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