Efficiency in Australian building societies: An econometric cost function approach using panel data

ANDREW C. WORTHINGTON

School of Economics and Finance, Queensland University of Technology, Brisbane QLD 4000, Australia.

This is the author-manuscript version of this paper. Published in:

Worthington, Andrew (1998) Efficiency in Australian building societies: An econometric cost function approach using panel data. *Applied Financial Economics* 8(5):pp. 459-467.

Maximum-likelihood estimates of a stochastic cost frontier function incorporating efficiency effects are obtained for twenty-two Australian building societies in the period 1992-1995. Cost inefficiency scores indicate that building societies' costs were twenty percent above what could be considered necessary. The results also indicate that capital adequacy restrictions are not a significant influence on the level of inefficiency; though branch and agency networks, asset size, and non-core commercial activities are. At the industry level that there has been an improvement in the level of cost efficiency of Australian building societies during the period in question.

I. INTRODUCTION.

At least four salient points characterise existing research into financial institution efficiency. First, all commentators concerned concede that in the financial services industry, the analysis of individual institutional efficiency is of paramount importance. For instance, the efficiency of an individual institution is intimately associated with the concepts of profitability and competitiveness, amongst others. However, the ability of these financial institutions to operate in an efficient manner affects not only their own condition, but also that of the economy in general; not least being the provision of quality financial intermediation, and the demands placed upon regulatory authorities and ultimately taxpayers (Berger *et al.*, 1993, p. 221). Second, "...most of the research into the efficiency of financial institutions has focused on North American institutions...[and] in general, the motivation of this research has been to investigate the nature of economies of scale and scope" (Drake and Weyman-Jones, 1992, p. 1). In this regard, "relatively little attention has been paid to measuring what appears to be a much more important source of efficiency differences - X-inefficiencies, or deviations from the efficient frontier" (Berger *et al.*, 1993, p. 222). Even when such avenues of investigation have been pursued, few studies have attempted to relate financial institutions' X-efficiency to possible determinants such as; agency problems; regulation, organisational and legal structures; and the scale and scope of operations (Berger *et al.*, 1993). Third, the efficiency of thrift institutions, like building societies and credits unions, has not been studied extensively to date [for exceptions, see Hardwick, 1989, 1990; Field, 1990; Drake and Weyman-Jones, 1992, 1996; Piesse and Townsend, 1995, in the UK, and Esho and Sharpe, 1994, 1996; and Worthington, 1996a, 1996b, in Australia]. Whilst commercial banks remain the major financial institution sector, the concentration of thrift institutions in areas such as consumer banking and property finance demands some attention (Berger *et al*., 1993). Finally, econometric techniques employed in all areas have in the main failed to recognise the competitive and institutional realities facing multi-product financial institutions, especially since the 1980s wave of financial deregulation (Hardwick, 1990; Piesse and Townsend, 1995). It is with these considerations in mind, that the present study has been framed.

The use of Australian building societies to address these issues is appropriate for a number of reasons. First, since the 1980s the fortunes of the building society industry have directly reflected the changing regulatory environment in Australia. In particular, as the competitive restrictions on the federally-regulated banks were relaxed - opening hours, interest rates on deposits, percentage valuation on loans, etc. - the state-regulated building societies once sound niche market has been progressively eroded. Accordingly, by a process of merger and acquisition, and the procurement of banking licenses, the building society sector is now characterised by large regionally-based institutions.[1] The extent to which these modifications in the institutional and competitive environment have affected the efficiency of those institutions which remain, either willingly or unwillingly, is as yet unquantified. Second, unlike credit unions, which have achieved a high degree of interstate and industry-wide cooperation and integration, building societies have apparently failed to capitalise on the opportunities presented by changes in the fee structure of the major commercial banks.[2] A similar line holds for the highly diversified property finance market. However, despite this, building societies still account for some six to seven percent by value of all housing finance, both construction and purchase. The issue thus arises as to whether technical efficiency is, at least a contributory factor in this scenario. Third, an adequate amount of statistical information is an obvious *sine qua non* for estimations of this type. Fortunately sets of extensive, comparable and consistent data exist for building societies; a requirement that is somewhat less likely to hold for Australian commercial banks for instance. Finally, there is some degree of correspondence between the situation facing Australian building societies and the decline of the US savings and loans (S&Ls) industry. In the latter's case, "the most often cited factors contributing to this downfall have been interest rate risk, deregulation, and the economic decline of specific geographic markets [and] more recently, the possibility of X-inefficiency in the use of inputs and outputs has been offered" (Berger *et al*., 1993). These same factors are also found in the Australian financial services industry; along with building society-specific efficiency concerns such as speculative commercial property lending, inadequate capitalisation, and over-branching (Esho and Sharpe, 1996, p. 247).[3]

The paper itself is divided into four main areas. Section 2 provides a synopsis of the econometric techniques employed in evaluating financial institution efficiency. Section 3 deals with the empirical methodology employed in the current paper, and the results are discussed in Section 4. The paper ends with some brief concluding remarks in Section 5.

II. THE ECONOMETRIC APPROACH TO EFFICIENCY MEASUREMENT

The recent history of efficiency measurement begins with Farrell (1957) who defined a simple measure of firm efficiency which could account for multiple inputs. In this approach, Farrell (1957) proposed that the efficiency of any given firm consisted of two components: technical efficiency, or the ability of a firm to maximise output from a given set of inputs, and allocative efficiency, or the ability of a firm to use these inputs in optimal proportions, given the respective prices. Combining the two measures provides a measure of total or economic efficiency.

The essence of Farrell's (1957) argument may be derived from Figure 1. Here two inputs, x_1 and x_2 are utilised to produce a single output y, under an assumption of constant returns to scale. The isoquant of the fully efficient firm SS' permits the measurement of technical efficiency. For a given firm using quantities of inputs defined by point P, to produce a unit of output, the level of technical efficiency may be defined as the ratio OQ/OP, which is the proportional reduction in all inputs that

[1] Indeed, from 1978 to 1990 the number of individual societies fell from 153 to 52: even the in period 1993-1995, the number of individual societies fell from 39 to 28.

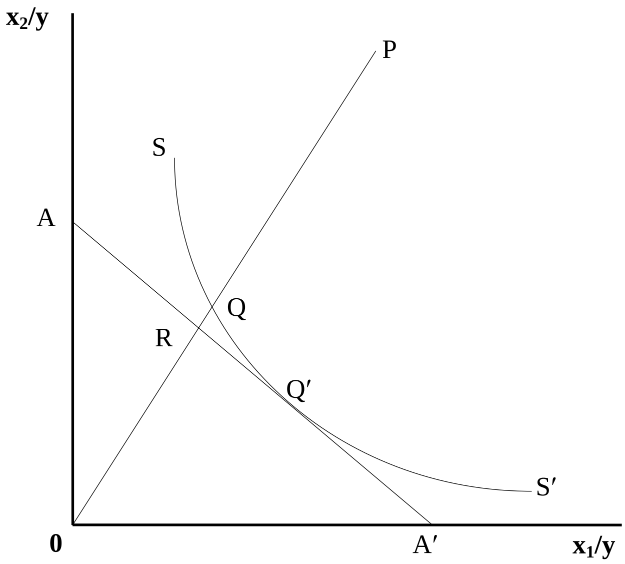
[2] The 1995 Prices Surveillance Authority inquiry into banking charges freed up the ability of financial institutions to charge account-keeping and transaction fees. At the height of bank customer dissatisfaction, many credit unions reported a 55 percent increase in the growth of new accounts (though at least 20 percent of these were costly "high transaction/low balance" accounts). On the other hand, building societies have more readily adopted a fee structure similar to that of the major commercial banks.

[3] "Non-Bank Financial Institutions: A Special Report" [*The Australian Financial Review,* Thursday 20 June 1996, 42–50] provides an up-to-date analysis.

could be theoretical achieved without any reduction in output. Point *Q* on the other hand is technically efficient since it already lies on the efficient isoquant. Extending the model when the input price ratio *AA′* is known, then allocative efficiency at point *P* is the ratio *OR*/*OQ*, where the distance *RQ* is the reduction in production costs which would occur if production occurred at *Q′* - the allocatively and technically efficient point, rather than *Q* - the technically efficient, but allocatively inefficient point. Hence, the total economic efficiency is the ratio *OR*/*OP*, with the cost reduction achievable being the distance *RP*.

It is Farrell’s (1957) suggestion that inefficiency could be measured in terms of realised deviations from an idealised, frontier isoquant that provides the basis for the current empirical analysis: that is, inefficiency may be readily identified with disturbances in an econometric model (Greene, 1993, p. 68). Attempts to estimate the efficient isoquant under a number of alternative assumptions are the subject of significant and protracted debate; certainly to the point of precluding a review in this instance. Suitable surveys are to be found in Førsund, Lovell and Schmidt (1980), Seiford and Thrall (1990), Greene (1993), Lovell (1993), Bauer *et al*., (1993), and Ali and Seiford (1993).

Figure 1. *Technical and Allocative Efficiencies*



Of the many approaches employed in the past, one consistently popular methodology has been the stochastic frontier function (see Aigner, Lovell and Schmidt, 1977; Meeusen and van den Broeck, 1977; Battese and Corra, 1977). In the case of a production approach, the stochastic frontier methodology posits that the realised production of a firm is bounded from above by the sum of (i) a parametric function of known inputs, involving unknown parameters, and (ii) a random error, associated with either misspecification in the model or uncontrollable factors (such as equipment failures, weather, etc.) It is the appropriate recognition of the later that characterises the stochastic frontier methodology, and provides the basis for a two-component error structure: one component represents random, uncontrollable factors, whilst the second measures the individual firm deviation due to factors within a manager’s control, such as technical and allocative efficiency. In addition, the methodology may also be easily extended to alternative representations of the technology, such as a cost or profit function. In the case of the former, errors in production decisions will necessarily translate into costs of production higher than those theoretically obtainable, whilst for the later these same errors will imply lower profits.

III. MODELS AND HYPOTHESES

3.1 Stochastic cost frontier

In terms of the specific estimation technique which follows, a stochastic cost frontier using panel data and incorporating efficiency effects is formulated, following Battese and Coelli (1993). The most notable features of this model are: (i) a stochastic cost frontier approach, (ii) the use of panel, or pooled time-series, cross-sectional data, and (iii) the single-stage estimation of both the cost frontier and the coefficients of firm-specific variables that identify the sources of cost inefficiency.

In the first instance, an alternative dual form - such as a cost or profit function - of the production technology is to be preferred for at least two reasons. First, more often than not the explicit assumption of the production function approach that input levels are fixed, and that managerial inputs are attempting to maximise output, will not hold. In particular, one would expect that for a financial institution, such as a building society, the imposition of capital adequacy requirements would tend to restrict the amount of output possible in any one time period. Hence, a suitable behavioural objective for these institutions would be that of cost minimisation, rather than output maximisation. Second, building societies are multiple-output concerns, encompassing both loans (consumer, property, commercial) and investment in financial assets (cash, governmental securities, bank bills and negotiable certificates of deposit). The argument for a cost function is enhanced *a fortiori*, given the necessity of integrating multiple financial outputs (Cebenoyan *et al*., 1993; Mester, 1987, 1993; McKillop and Glass, 1994; Piesse and Townsend, 1995).[4]

In the second instance, panel (or pooled time-series, cross-sectional) techniques offer a number of advantages over traditional cross-sectional estimations. Not least amongst these is: the ability to increase the degrees of freedom for parameter estimations; the provision of consistent estimators of firm efficiencies; the removal of the necessity to make particular assumptions about the behaviour of cost efficiencies, and the ability to simultaneously investigate the impact of technical change and technical efficiency over time (Coelli, 1995, p. 8). In the case of building societies, the small number of institutions, and the relative importance of technological advances in the industry, point to the use of this data form (Cornwell, Schmidt and Sickles, 1990; Atkinson and Cornwell, 1993).

Finally, not content with merely estimating firm-level efficiencies, many studies have attempted to identify the sources of said inefficiencies. More often than not, this has involved regressing the predicted inefficiencies on firm-specific variables, such as managerial inputs, agency issues, and financial structure (Cebenoyan *et al*., 1993; Mester, 1993). However, it has been argued that the method of parameter estimation used in the second-stage inefficiency model is based on assumptions clearly inconsistent with those found in the estimation of the stochastic frontier. For example, most studies assume that the firm-specific effects are independently distributed in the first-stage estimation, yet regress the predicted inefficiencies on firm-specific factors in the second stage. This problem is addressed by several studies which consider a stochastic frontier in which the non-negative inefficiency effects are a linear function of firm-specific characteristics. The additive random error of the inefficiency model is assumed to be a truncation of a normal distribution with mode zero, with the point of truncation being dependent on firm characteristics [Battese and Coelli (1993) provide a survey of recent work in this area]. Battese and Coelli (1993) extend this approach to allow for panel data, expressing the explanatory variables in the inefficiency model as an explicit function of the vector of firm-specific variables and time effects, and the explanatory variables of the stochastic frontier - all relevant parameters are estimated simultaneously.

The stochastic cost frontier is defined:

$$TC_{it} = X_{it}\beta + \varepsilon_{it} \qquad i = 1,....,N \text{ and } t = 1,....,T. \qquad (1)$$

[4] The cost approach implies that any errors in optimisation, technical or allocative, must appear as higher costs. Therefore, any results obtained should be interpreted as cost inefficiencies (the sum of technical and allocative inefficiency).

where TC_{it} is the logarithm of the total cost of production of the *i*-th firm in the *t*-th time period; X_{it} is a $(k\times 1)$ vector of input prices *P* and output *Q*, β is a vector of unknown parameters to be estimated, and ε_{it} is a disturbance term where:

$$\varepsilon_{it} = (V_{it} + U_{it}) \qquad i = 1,....,N \text{ and } t = 1,....,T. \tag{2}$$

As per the earlier discussion, the disturbance is composed of two influences: V_{it} are random variables assumed to be *iid* $N(0,\sigma_V^2)$ and independent of U_{it}, which are non-negative random variables assumed to account for the cost of inefficiency in production. The later are assumed to be independently distributed as truncations at zero of the $N(m_{it}, \sigma_U^2)$ distribution; where $m_{it} = z_{it}\delta$ is a $(p\times 1)$ vector of variables *Z* which influence the efficiency of a firm; and δ is an $(1\times p)$ vector of parameters to be estimated.

The error term is decomposed using the conditional distribution approach proposed by Jondrow *et al*. (1982) for a truncated normal distribution; providing an unbiased, though inconsistent, estimate of the cost of inefficiency. The measure of cost inefficiency relative to the cost frontier is defined as:

$$E[U/\varepsilon] = [\sigma\lambda/(1+\lambda^2)][\phi(\mu^*/\sigma)/\Phi(\mu^*/\sigma) + \mu^*/\sigma] \tag{3}$$

where $\sigma = \sigma_V^2 + \sigma_U^2$, $\lambda = \sigma_U^2/(\sigma_V^2 + \sigma_U^2)$, $\mu^* = \varepsilon\lambda/\sigma + \mu/(\sigma\lambda)$, ϕ is the standard normal density function, and Φ the cumulative normal density function, and all other terms are as previously defined [further details are presented in the Appendix, Battese and Coelli (1993)]. To obtain estimates of (3), maximum likelihood estimates of the parameters of the stochastic cost frontier (1) are first estimated. Two further *a priori* specifications are therefore required. These are: (i) the selection of a suitable cost function, and (ii) the identification of the vectors of variables. These are detailed in Sections 3.2 and 3.3 respectively.

3.2 Cost function formulation

The Cobb-Douglas and translog (transcendental logarithmic) are the two most commonly used cost functions employed in stochastic frontier analyses. Following Cebenoyan, *et al.* (1993) and Esho and Sharpe (1996) for an X-efficiency analysis, and Mester (1993), McKillop and Glass (1994) and Esho and Sharpe (1994) for scale and scope analyses, a translog cost function is employed. The advantages of this formulation are twofold. First, the translog places no *a priori* restrictions on the elasticity of substitution between inputs, and second, economies of scale are not restricted to take the same value across all firms. However, the translog does suffer a number of deficiencies. Esho and Sharpe (1994, p. 261) observe that most of these relate to the estimation of economies of scope and scale. However, problems with the large number of parameters to be estimated also applies to cost efficiency estimates. In part, this issue is resolved by the use of panel data, but it also serves to highlight concerns that might appear if the same procedure is employed with, say, a cross-section of Australian banks. Accordingly, to estimate the cost function in equation (1), the following translog cost formulation is specified:

$$lnTC = \alpha_0 + \Sigma_i lnQ_i + \Sigma_j\beta_j lnP_j + ½\Sigma_i\Sigma_k\delta_{ik}lnQ_i lnQ_k + ½\Sigma_j\Sigma_h\gamma_{jh}lnP_j lnP_h + \Sigma_i\Sigma_j\rho_{ij}lnQ_i lnP_j \tag{4}$$

for $i,k = 1, . . . , a$ and $j, h = 1, . . . , p$ where TC = total operating and interest costs, P_j = unit price of factor input *j*, and Q_i = quantity of output *i*. Equation (3) is then reformulated to impose the standard symmetry and linear input price homogeneity restrictions, following Cebenoyan, *et al*., (1993) and Esho and Sharpe (1994). The reformulated translog cost function is:

$$lnTC^* = \alpha_0 + \Sigma_i lnQ_i + \Sigma_j\beta_j lnP_j^* + ½\Sigma_i\Sigma_k\delta_{ik}lnQ_i lnQ_k + ½\Sigma_j\Sigma_h\gamma_{jh}lnP_j^* lnP_h^* + \Sigma_i\Sigma_j\rho_{ij}lnQ_i lnP_j^* \tag{5}$$

where $i,k = 1, . . . , a$ and $j, h = 1, . . . , p - 1$, and $TC^* = TC/P_p$, $P_j^* = P_j/P_p$, and $P_h^* = P_h/P_p$.

3.3 Variable specification

Quarterly data for twenty-two continuously operating building societies in the period September 1992 to September 1995 is obtained from the Australian Financial Institutions Commission (AFIC). Primarily in the form of quarterly profit and loss (income) statements and balance sheets, this information provides all inputs for the necessary calculations.

TABLE 1. *Cost function and explanatory variables*

TC	Total cost	Operating + interest expenses of the i-th building society in the t-th time period.
Q_1	Personal loans	Personal loans and consumer credit facilities held by the i-th building society in the t-th time period.
Q_2	Property loans	Property and real estate loans held by the i-th building society in the t-th time period.
Q_3	Commercial loans	Commercial loans held by the i-th building society in the t-th time period.
Q_4	Other securities	Governmental securities, BBs and NCDs, deposits with other building societies and banks, held by the i-th building society in the t-th time period.
P_1	Price of physical capital	Sum of physical capital expenditures (office and equipment expenses, etc.) divided by the book value of net total office premises and equipment (including office buildings and land, leasehold improvements, furniture and fixtures, capitalised leases) the i-th building society in the t-th time period.
P_2	Price of deposits	Total interest expense divided by total deposits and other borrowings for the i-th building society in the t-th time period..
P_3	Price of labour	Total expenditures on employees divided by the number of full-time equivalent employees for the i-th building society in the t-th time period.
Z_1	Assets	Total financial and nonfinancial assets of the i-th building society in the t-th time period.
Z_2	Capital	Total capital divided by total assets of the i-th building society in the t-th time period.
Z_3	Branches	Number of branches operated by the i-th building society in the t-th time period.
Z_4	Agencies	Number of agencies operated by the i-th building society in the t-th time period.
Z_5	Time	Time trend
Z_6	Commercial	Total commercial loans held divided by total assets of the i-th building society in the t-th time period.

The variables selected follow the intermediation approach to financial institution operations (Elyasiani and Mehdian, 1990; Hardwick, 1990; Drake and Weyman-Jones, 1992; Cebenoyan *et al*., 1993; Piesse and Townsend, 1995).[5] Under this approach, a financial institution, in this case, a building society, "...uses physical capital, deposits and other borrowings, and labour as inputs to produce earning assets as outputs" (Cebenoyan *et al*., 1993, p. 157). Given the model detailed above, building societies are thus characterised as incurring operating and interest costs (*TC*), whilst producing four categories of output (*Q*), using three input prices (*P*), and operating under six

[5] In the alternative production approach, financial institutions utilise capital and labour inputs to produce the outputs of loans and deposit accounts. Outputs are measured by the number of deposit and loan accounts, and costs include operating expenses, but exclude interest. The intermediation approach is preferred on the basis that it; (i) incorporates all expenses (of which interest expenses are generally the most significant), and (ii) recognises that deposits are more accurately inputs into financial intermediation, rather than outputs (Elyasiani and Mehdian, 1990, p. 543).

selected explanatory variables (*Z*).[6] The incorporation of the first three categories of variables closely follows Drake and Weyman-Jones (1992; 1996), Cebenoyan *et al*. (1993), and Piesse and Townsend (1995). Sample descriptive statistics are presented in Table 2.

TABLE 2. *Descriptive Statistics*

Variable	Mean	Standard Deviation	Minimum	Maximum
Total cost (000s)	$10,479	$14,543	$54	$66,788
Personal loans (000s)	$7,647	$15,602	$0	$65,094
Property loans (000s)	$380,352	$564,095	$1,279	$2,572,769
Commercial loan (000s)	$16,155	$32,969	$0	$148,390
Other securities (000s)	$79,914	$98,498	$1,562	$440,929
Price of physical capital	1.379	4.259	0.104	20.220
Price of deposits	0.016	0.003	0.012	0.026
Price of labour (000s)	$9.224	$5.211	$4.995	$2.309
Assets (000s)	$493,155	$674,189	$2,849	$3,034,810
Capital	0.069	0.023	0.041	0.139
Branches (n)	21	26	1	110
Agencies (n)	46	76	0	352
Commercial loans	0.048	0.059	0.000	0.196

As at financial year ending 30 June 1995.

The six explanatory variables are included to identify sources of cost inefficiency in Australian building societies. The first variable, total assets, is intended to control for the overall size of a building society (Hardwick, 1990; Drake and Weyman-Jones, 1992; Mester, 1993). It may be argued that larger building societies direct more managerial inputs into identifying and resolving inefficiency; *ex ante* one would expect a negative coefficient when cost inefficiency is regressed against total assets. The second explanatory variable included is the firm's capital to asset ratio. All other things being equal, "moral hazard theory suggests [the capital asset ratio] should be inversely related to inefficiency" (Mester, 1993, p. 282). The number of branches and agencies of each building society are also included, generating two somewhat conflicting hypotheses. The first is that under the intermediation approach, branches and agencies are recognised as "...central to the intermediation process for most building societies, it may also be the case that differences in the intensity of branching may be an important factor" (Drake and Weyman-Jones, 1992, p. 5). Accordingly, the number of branches are closely related to the level of financial intermediation provided - a negative coefficient is inferred. The second hypothesis is that the number of branches and agencies are a critical, and possibly negative factor, in the ability of head offices to promote efficient behaviour. In this case, we would expect a positive coefficient, *ceteris paribus*.[7] The next variable is a time trend to identify the general direction of changes in efficiency/inefficiency over the period in question. The coefficient would necessarily depend on the relative impact of technological change over the period, and the impact of institutional and structural considerations, amongst other factors. No *a priori* coefficient is postulated. Finally, the extent of non-core lending activity is proxied by the level of commercial loan activity. One hypothesis here is that exposure to non-core loan activity may serve to "impose market discipline" (Mester, 1993, p. 282) on building society managers - thus a negative coefficient is hypothesised. Alternatively, existing concerns on

[6] In the interests of correctly estimating the input prices associated with deposits, it would be preferable to make the distinction between wholesale and retail funds. Unfortunately, the data set obtained does not include this level of detail.

[7] A further view exists that "...building society branching should be regarded as an output jointly supplied with accounts...more branches improve the accessibility of building society services" (Hardwick, 1990, p. 451).

the impact of this apparently speculative lending may be justified - a positive coefficient is inferred. The *ex ante* sign would therefore depend on one's perception of the relative strengths of these factors.

IV. RESULTS

The maximum-likelihood estimates for the parameters of the normalised translog cost frontier detailed in (5) are presented in Table 3. Asymptotic standard errors and levels of significance are also presented. Overall, the translog cost function has performed well. The null hypothesis of the joint insignificance of the cost function coefficients ($\beta_0 = \beta_1 ... = \beta_{27} = 0$) is rejected using the log-likelihood ratio statistic found in Battese and Coelli (1993) with chi squared distribution (χ_{27}^2 = 40.113, χ_{STAT} = 48.23, α = 0.05) as is the null that the nested Cobb-Douglas cost function would have been appropriate ($\beta_5 = \beta_6 ... = \beta_{14} = \beta_{17} ... = \beta_{27} = 0$) ($\chi_{20}^2$ = 31.41, χ_{STAT} = 48.23, α = 0.05).

TABLE 3. *Maximum-likelihood estimates*

Parameter	Variable	Coefficient	Std. Error	Parameter	Variable	Coefficient	Std. Error
β_0	*CONST*	-3.2429***	1.1233	β_{18}	lnP_2P_2	-0.1070***	0.0089
β_1	lnQ_1	0.1597***	0.0397	β_{19}	lnP_1P_2	0.0040	0.0134
β_2	lnQ_2	0.0245	0.6204	β_{20}	lnQ_1P_1	0.0074***	0.0018
β_3	lnQ_3	-0.0397	0.0292	β_{21}	lnQ_1P_2	-0.0015	0.0017
β_4	lnQ_4	-0.1002	0.6961	β_{22}	lnQ_2P_1	-0.0444***	0.0151
β_5	lnQ_1Q_1	0.0015*	0.0009	β_{23}	lnQ_2P_2	0.0052	0.0146
β_6	lnQ_2Q_2	-0.1163**	0.0525	β_{24}	lnQ_3P_1	-0.0030**	0.0014
β_7	lnQ_3Q_3	0.0002	0.0010	β_{25}	lnQ_3P_2	0.0027**	0.0013
β_8	lnQ_4Q_4	-0.1333**	0.0647	β_{26}	lnQ_4P_1	0.0288*	0.0159
β_9	lnQ_1Q_2	0.0119**	0.0050	β_{27}	lnQ_4P_2	-0.0454***	0.0161
β_{10}	lnQ_1Q_3	-0.0003	0.0004	σ^2	*Sigma squared*	0.3285***	0.0308
β_{11}	lnQ_1Q_4	-0.0192***	0.0054	γ	*Gamma*	0.4857***	0.0143
β_{12}	lnQ_2Q_3	-0.0026	0.0050	δ_1	Z_1	-0.2E-8***	0.32E-9
β_{13}	lnQ_2Q_4	0.2609**	0.1106	δ_2	Z_2	-1.4103	1.0640
β_{14}	lnQ_3Q_4	0.0057	0.0054	δ_3	Z_3	0.0178***	0.0063
β_{15}	lnP_1	0.1371	0.2173	δ_4	Z_4	-0.0015***	0.0004
β_{16}	lnP_2	-1.1312***	0.1976	δ_5	Z_5	-0.1001***	0.0172
β_{17}	lnP_1P_1	-0.0133***	0.0026	δ_6	Z_6	4.7616***	1.0850

Asterisk(s) denote significance: *, **, *** at the .10, .05 and .01 levels, respectively. Log-likelihood: 57.884

However, the interpretation of the estimate of γ indicates that much work remains to be done in accounting for the inefficiency effects (δ_i). For the model specification used in this study, it may be interpreted as an indication of the amount of unexplained variation in the cost inefficiency effects, relative to the sum of this value and the variance of V_{it} (Coelli, 1995, p. 19). To this end, the explanatory variables employed only account for some fifty-two percent of the variation in inefficiency. The inclusion of institutional dummies to account for manifest state-based regulation would certainly go some way towards remedying this deficiency. However, and as noted by Esho and Sharpe (1996, p. 257), "future research should [also] aim at developing better proxies for risk and service quality and potential measures of organisational structure and managerial ability".

Sample inefficiency scores using the calculations (3) are presented in Table 4. In terms of building society efficiency, the stochastic cost function technique employed produces efficiency scores ranging from unity to infinity; in economic terms the inefficiency scores indicate how far above the cost function the building society is operating. As shown in Table 4, the mean inefficiency score varied in four sample quarters from 0.019 to 0.50 (cost inefficiencies of 1.9 to 50.0 percent); the overall mean inefficiency for the entire sample being 0.212 - suggesting that the typical building society produces its products at a cost that is approximately 21.2 percent greater than necessary during the period in question. The scores during the entire thirteen quarters ranged from 0.000 to 0.610 indicating a wide variety of inefficiency in the building society sample. However, there does appear to be some consistency in ranking, as shown in Table 4. In particular, trends exist in efficiency ratings, more than likely the result of fixed managerial inputs. Moreover, there has been a general improvement in both the average level of efficiency, and the level of dispersion of efficiency, during the period in question. Whilst these results are consistent with those of Cebenoyan *et al*. (1993), Mester (1993), Esho and Sharpe (1996) and others in the analysis of non-bank financial institution efficiency, variance in samples and estimation techniques precludes valid comparison.

TABLE 4. *Sample cost inefficiencies*

Institution	June 1993	June 1994	June 1995	Institution	June 1993	June 1994	June 1995
1	0.019	0.343	0.178	14	0.346	0.083	0.063
2	0.323	0.271	0.125	15	0.096	0.304	0.124
3	0.420	0.417	0.364	16	0.139	0.062	0.042
4	0.496	0.179	0.057	17	0.116	0.069	0.070
5	0.382	0.134	0.228	18	0.281	0.090	0.110
6	0.271	0.076	0.187	19	0.064	0.269	0.045
7	0.120	0.216	0.070	20	0.140	0.123	0.380
8	0.478	0.500	0.052	21	0.049	0.071	0.030
9	0.316	0.110	0.110	22	0.450	0.346	0.150
10	0.135	0.176	0.032	Mean	0.239	0.204	0.120
11	0.430	0.459	0.123	Std. Dev	0.158	0.139	0.098
12	0.126	0.049	0.022	Minimum	0.019	0.049	0.022
13	0.068	0.150	0.073	Maximum	0.496	0.500	0.380

Following Battese and Coelli (1993) the relationship between firm inefficiency and building society organisational form is also evaluated in Table 3. The signs of all six coefficients conform to their *a priori* coefficients, with only the coefficient on capital being insignificant. The null hypothesis that the inefficiency effects are absent from the model (H_0: $\gamma=\delta_1=\delta_2=\delta_3=\delta_4=\delta_5=\delta_6=0$) is rejected using the generalised likelihood-ratio test statistic with chi-square distribution. Likewise, the null hypothesis that the inefficiency is not a linear function of the explanatory effects (H_0: $\delta_1=\delta_2=\delta_3=\delta_4=\delta_5=\delta_6=0$) is also rejected.

A number of points can be made. First, it would appear that branch and/or agency networks have a dramatic impact on overall building society efficiency. In the case of extensive branch networks the ability of central offices to promote cost efficiency is mitigated, whilst the reverse would seem to hold for building societies which rely on agencies. The results contrast sharply with Cebenoyan *et al*. (1993) who found the coefficient associated with the number of branches/agencies to be insignificant. Second, the negative coefficient of the time variable suggests that the cost efficiency of Australian building societies over the sample period has improved. Associated with this observation, one may recognise the possible influences of technological advances, as well as the changing institutional and competitive structure of the industry. Drake and Weyman-Jones (1992, p. 6) rationalise similar findings in the UK scenario “as an indication that the intensification of competition...and the associated increase in merger activity has resulted in a marked improvement in the overall level of efficiency within the building society industry". Conversely, in a study of pre- and post-deregulation Australian building societies, Esho and Sharpe (1996, p. 258) fail to support the proposition that deregulation provided "...a competitive stimulus for [permanent building societies] to improve their operating efficiency".

Third, in terms of assets, larger organisations appear to have an advantage in managing institutional operations. This conflicts with Cebenoyan *et al*. (1993, p. 164) where "inefficiency differences across [non-bank financial institutions] does not appear to be related to firm size". This finding is offset somewhat by the negative impact of branches - a condition most likely to be found in firms with larger assets. Fourth, the sign of coefficient on capital accords with the "moral hazard" view of firm behaviour, though it is insignificant. As detailed by Mester (1993, p. 283) in the case of US thrifts, higher levels of capitalisation are associated with higher levels of efficiency. Finally, the coefficient for commercial loans suggests that the positive impact of the market discipline imposed by non-core assets for efficiency is subverted to the speculative risk associated with such assets, as against the results of Mester (1993). In terms of a study incorporating comparable methodology and data, the results contrast sharply with Esho and Sharpe (1996, p. 257), who found that "...attempts to examine the determinants of [permanent building society] X-efficiency proved largely unsuccessful".

V. CONCLUDING REMARKS

The present study uses a stochastic cost frontier approach to investigate the efficiency of Australian building societies during the period 1992 to 1995. The current paper extends existing empirical work in this area in three ways. First, it incorporates pooled time-series, cross-sectional data; permitting consistent estimators of firm efficiency, across both firms and time. Second, the study evaluates non-bank financial institution efficiency in an Australian context, complementing the existing US and UK institutional focus. Finally, the present paper incorporates a model for the single-stage estimation of inefficiency effects. The evidence provided suggests that, on average, Australian building societies operated at a high level of cost efficiency during the period in question. Moreover, it would appear that the overall level of efficiency has improved over time. With the incorporation of efficiency effects, the paper also sheds some light on the relationships between financial institution efficiency and organisational structure. In this respect, the evidence suggests that branch and agency networks, institutional size, and non-core commercial activities have a significant influence on efficient outcomes, though the level of capital (and by insinuation, capital adequacy regulation) does not.

There are at least three ways in which this research may be extended. First, it would be useful to derive more appropriate proxies for organisational structure and managerial ability as an attempt to account for the sources of financial institution inefficiency. However, a more fundamental limitation of existing studies would appear to be the failure to address (and correctly model) the institutional structure produced by regulation. A second extension would be to use nonparametric techniques, such as data envelopment analysis, to analyse non-bank financial institution efficiency. It may be that the imposition of a specific structural form, as is the case with a stochastic frontier, may not be entirely appropriate. Finally, similar techniques to the present study could be extended to alternative conceptualisations of financial institution behaviour. More particularly, where accurate data on account transactions and individual deposit characteristics could be obtained, a production approach may provide alternative criteria for assessing efficiency. The latter point highlights the necessity for accurate and consistent data being made available for research into non-bank financial institution efficiency.

REFERENCES

Aigner, D. Lovell, C.A.K. and Schmidt, P. (1977) Formulation and estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics* **86**, 21–37.

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

Atkinson, S.E. and Cornwell, C. (1993) Measuring technical efficiency with panel data: A dual approach". *Journal of Econometrics* **59**, 257–261.

Battese, G.E. and Coelli, T.J. (1993) A stochastic frontier production function incorporating a model for technical efficiency effects. *Working Papers in Econometrics and Applied Statistics* **69**. University of New England, Armidale.

Battese, G. E. and Corra, G.S. (1977) Estimation of a Production Frontier Model with Application to the Pastoral Zone of Eastern Australia. *Australian Journal of Agricultural Economics* **21**, 169–179.

Bauer, P.W. Berger, A.N. and Humphrey, D.B. (1993) Efficiency and productivity growth in U.S. banking. In H.O. Fried, C.A. Lovell and S.S. Schmidt, eds. *The Measurement of Productive Efficiency: Techniques and Applications*. Oxford University Press, New York, pp. 386–413.

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

Cebenoyan, A.S. Cooperman, E.S. Register, C.A. and Hudgins, S.C. (1993) The relative cost efficiency of stock versus mutual S&Ls: A stochastic cost frontier approach. *Journal of Financial Services Research* **7**, 151–170.

Coelli, T. (1994) *A Guide to FRONTIER Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation*. Unpublished Mimeo. Department of Econometrics, University of New England.

Coelli, T.J. (1995) *Recent Developments in Frontier Modelling and Efficiency Measurement.* Paper presented to the 39th Annual Conference of the Australian Agricultural Economics Society, University of Western Australia, 14-16 February.

Cornwell, C. Schmidt, P. and Sickles, R.C. (1990) Production frontiers with cross–sectional and time–series variation in efficiency levels. *Journal of Econometrics* **46**, 185–200.

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

Drake, L. and Weyman-Jones, T.G. (1996) Productive and allocative inefficiencies in U.K. building societies: A comparison of non-parametric and stochastic frontier techniques. *The Manchester School* **64**, 22–37.

Esho, N. and Sharpe, I.G. (1994) Scale and scope economies of Australian permanent building societies in a Dynamic Framework. *Asia Pacific Journal of Management* **11**, 255–273.

Esho, N. and Sharpe, I.G. (1996) X-efficiency of Australian permanent building socities, 1974-1990. *The Economic Record* **72**, 246–259.

Elyasiani, E. and Mehdian, S. (1990) Efficiency in the commercial banking industry: A production frontier approach. *Applied Economics* **22**, 539–551.

Farrell, M.J. 1957. The measurement of productive efficiency. *Journal of the Royal Statistical Society. Series A (General)* **120**, 253–289.

Ferrier, G.D. and Lovell, C.A.K. (1990) Measuring cost efficiency in banking: Econometric and linear programming evidence. *Journal of Econometrics* **46**, 229–245.

Field, K. (1990) Production efficiency of British building societies. *Applied Economics* **22**, 415–426.

Førsund, F.R. Lovell, C.A.K. and Schmidt, P. (1980) A survey of frontier production functions and of their relationship to efficiency measurement. *Journal of Econometrics* **13**, 5–25.

Greene, W.H. (1993) The econometric approach to efficiency analysis. In H.O. Fried, C.A. Lovell and S.S. Schmidt, eds. *The Measurement of Productive Efficiency: Techniques and Applications*. Oxford University Press, New York, pp. 68-119.

Hardwick, P. (1989) Economies of scale in building societies. *Applied Economics* **21**, 1291-1304.

Hardwick, P. (1990) Multi-product cost attributes: A study of U.K. building societies. *Oxford Economic Papers* **42**, 446–461.

Jondrow, J. Lovell, C.A.K. Materov, I.S. and Schmidt, P. (1982) On estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics* **19**, 233–238.

Lovell, C.A. (1993) Production frontiers and productive efficiency. In H.O. Fried, C.A. Lovell and S.S. Schmidt, eds. *The Measurement of Productive Efficiency: Techniques and Applications*. Oxford University Press, New York, pp. 3–67.

McKillop, D.G. and Glass, C.J. (1994) A cost model of building societies as producers of mortgages and other financial products. *Journal of Business Finance and Accounting* **21**, 1031–1046.

Meeusen, W. and van den Broeck, J. (1977) Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review* **73**, 15–25.

Mester, L.J. (1987) A multiproduct cost study of savings and loans. *The Journal of Finance* **42**, 423–445.

Mester, L.J. (1993) Efficiency in the savings and loan industry. *Journal of Banking and Finance* **17**, 267–286.

Piesse, J. and Townsend, R. (1995) The measurement of productive efficiency in UK building societies. *Applied Financial Economics* **5**, 397–407.

Seiford, L.M. and Thrall, R.M. (1990) Recent developments in DEA: The mathematical programming approach to frontier analysis. *Journal of Econometrics* **46**, 7–38.

Worthington, A.C. (1996a) Non-bank financial institution efficiency: An econometric cost frontier approach. *Conference Proceedings of the Third International Conference on Economics in Business and Government,* Griffith University, 18-19 July, pp. 658–666.

Worthington, A.C. (1996b) *Non-Bank Financial Institution Efficiency: An Application Incorporating Data Envelopment Analysis (DEA).* Paper presented to 25th Annual Conference of Economists, Australian National University, Canberra, 22-26 September 1996.