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Cost efficiency and UK building societies. An econometric panel-data study employing a flexible Fourier functional form.

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Abstract

The paper empirically quantifies firm specific 'distribution free' cost efficiency, economies of scale and economies of scope in the UK building society sector between 1990-1995. Both a flexible Fourier and a translog functional form are employed with an intermediation representation of depository institution production. Differences in the performance of these two functional forms are found. A broad distribution of cost efficiency over the sample period is observed, with a mean efficiency of 76 per cent estimated using the flexible Fourier form and a mean efficiency of 72.52 per cent estimated employing the translog form. Distinct results for economies of scale are produced with the two models.

Introduction

In this paper, cost efficiency, economies of scale and economies of scope in the British building society industry are empirically quantified. The importance of such a study is primarily the provision of evidence as to whether, one, significant variation in cost efficiency exists within this most important commercial sector and if previous estimates employing the translog functional form have provided an adequate description of this. An intermediation model of depository institution production is applied. A flexible Fourier (Gallant, 1981) functional form and a translog functional form are both used to represent productive technology. A comparison of the efficiencies derived from the superior and relatively under-used flexible Fourier functional form and the widely applied translog functional form is undertaken to identify any mis-specification with the translog form. A one component fixed effects model is employed to incorporate the distinct data characteristics that are present within the data panel over time. Fixed effects models are employed for the estimation of distribution free cost efficiency, economies of scale and scope economies using an average cost function.

Many approaches have been used to estimate inefficiencies in the UK building society sector. These include a multiple regression model (Gough, 1979), the translog cost function and variants, (Hardwick, 1989, 1990, Drake, 1990, 1995, 1996, Drake and Weyman-Jones, 1996) and DEA methods (Field, 1990, Drake and Weyman-Jones, 1992, Piesse and Townsend, 1995, Drake, 1996, Drake and Weyman-Jones, 1996). Model specifications follow approaches pioneered in US banking studies. The studies fall into production (Hardwick, 1989, 1990, Field, 1990, Esho and Sharpe, 1995, Piesse and Townsend, 1995) and intermediation (Drake, 1990, 1995, 1996, Drake and Weyman-Jones, 1992, Esho and Sharpe, 1995, Piesse and Townsend, 1995, Drake and Weyman-Jones, 1996) specifications.

Most previous UK studies have considered distinct aspects of overall cost efficiency such as economies of scale and economies of product mix. The studies that have quantified overall cost efficiency for this sector have included both data envelopment analysis (DEA) (see Field, 1990, Drake and Weyman-Jones, 1992 and Piesse and Townsend, 1995) and stochastic frontier techniques (see Drake and Weyman-Jones, 1996). These efficiency studies have all employed cross sectional samples engendering a range of divergent results from different years. Field, employing a sample of 205 building societies in 1981 in a production model, estimated that only 14 per cent of the societies in this year are productively efficient. Drake and Weyman-Jones (1996) using both DEA and translog stochastic frontier approaches to found that only about 4 per cent of the societies were efficient with the DEA approach and observed very little allocative or technical inefficiency with the cost frontier approach. Piesse and Townsend, using a DEA approach (1995) estimated, five separate models with different objective functions producing a broad array of inefficiency estimates.

Cost studies employing flexible Fourier functional forms have been limited within the financial institutions literature. The earliest study to employ this form for analysis of depository institutions was McAllister and McManus (1993). Other studies have considered US commercial banks, including Onvural and Mitchell (1996), Berger and DeYoung (1997) and Berger and Mester (1997). Onvural and Mitchell and McAllister and McManus both compare the performance of the flexible Fourier functional form with that of the translog functional form. Consistently distinct estimates are found with these differing functional forms. This is the first study to employ the flexible Fourier form in the analysis of UK financial institutions.

Model specification

An intermediation model (see Aldaheff, 1957 and Sealey and Lindley, 1977) of depository institution production is assumed. Building societies are assumed to minimise costs and employ labour, capital and deposits to produce loans. The intermediation approach within the dual cost function would suggest:

$$C=g(Y_1, Y_2; P_1, P_2, P_3) \tag{1}$$

where outputs are quantified by their values; Y_1 denotes mortgage loans and Y_2 denotes non-mortgage advances. The price of labour, P_1, is proxied by the total wage bill divided by the number of full time equivalent employees. The price of capital, P_2, is proxied by the aggregation of property and equipment rentals and depreciation divided by the quantity of physical capital. The price of deposits, P_3, is total interest payable divided by the quantity of deposits inclusive of retail and non-retail costs. C represents the total cost of production for the building society, including administration expenses, depreciation and interest costs.

The sample has been constructed using data from Annual Reports and Accounts for 99 UK building societies from 1990 to 1995. The data are deflated to

1993 prices using the Retail Price Index. The data panel is unbalanced and contiguous.

Table 1 Descriptive Statistics; sample means

	Mean	Standard Deviation	Minimum	Maximum
Total Assets (£m's)	537.822	1573.855	0.002	18049.801
Mortgages (£m's)	2338.885	7111.443	2.728	74683.398
Non-Mortgage Advances (£m's)	155.060	442.298	0.000	5108.300
Number of Employees	636.658	1895.959	4.000	13802
Management Expenses (£m's)	28.419	81.682	0.060	689.000
Deposits (£m's)	2743.161	8296.709	3.640	70206.398
Interest Paid (£m's)	219.655	654.379	0.335	6445.980
Interest Received (£m's)	280.561	829.611	0.5163	7476.90
Profits (£m's)	29.145	96.893	-42.060	962.400
Total Fixed Assets (£m's)	26.843	77.490	0.100	750.500

The variables are characterised by a high level of dispersion within the data. Such a feature is strongly indicated through reference to both the large standard deviations of variables and the substantial range between maximum and minimum values.

To estimate an average cost function over a data panel (including building society observations both over time and across a cross section of institutions) a one component fixed effects model is used. 'Effects' models aggregate both period invariant and individual invariant variables with individual time varying variables. The basic linear relationship, may be defined,

$$y_{it} = u_i + b'X'_{it} + v_{it} \qquad (2)$$

Where y_{it} are the time and firm estimates dependent on; b' the parameters of the K explanatory variables within the model, $X'_{it,}$ the it^{th} observation of the K explanatory variables and $v_{it,}$ the disturbance term; for all $i = 1,\ldots., N$; $t = 1, \ldots, T$. u_i represents individual specific effects of the building societies and is used to the capture non-random disturbance between the building societies. v_{it} is employed to capture random error within the model. X'_{it} and v_{it} are assumed to be independent for i and t observations of the K variables within the model. The procedure for estimation is set out in detail within Greene (1993), Baltagi (1995) and Intriligator *et al* (1996).

Economies of scale, economies of scope and distribution free efficiency

Economies of scale are proxied by ray scale elasticity, a measure of elasticity of scale relative to cost outlined by Baumol *et al* (1982). Assumptions of proportional increases or decreases of cost in relation to scale and constant composition of outputs in relation to costs are made. These restrictions limit the measurement of elasticity to a single constant ray emerging from the origin. The measure considers changes in scale in isolation of changes in product mix.

Ray scale elasticity may be represented as ray average costs divided by the marginal change in cost of producing additional bundles of output or as the first derivative of cost with respect to output evaluated for a representative institution (usually assumed to be a mean value for a set of institutions). For a firm with *m* outputs, scale elasticity may be represented as:

$$RSE = \sum_{j} (\delta LnC/\delta LnY_j) \qquad (3)$$

j = 1, 2.

where C is total cost and Y_j represents the output of the *j*th product. Elasticities greater than unity imply diseconomies of scale and values less than unity indicate economies of scale; unity denotes constant returns to scale. Economies of scale are estimated overall, for individual year means and for asset group means.

Economies of scope, outlined by Baumol *et al* (1982), measure the cost savings from producing quantities of two output groups produced jointly within a single institution relative to specialised production of the output groups individually by two institutions. Thus the statistic measures the cost of simultaneous production relative to specialised production. Economies of scope may be measured by:

$$\text{Scope} = [C(\bar{P}, \bar{Y}_1, 0) + C(\bar{P}, 0, \bar{Y}_2) - C(\bar{P}, \bar{Y}_1, \bar{Y}_2)] / C(\bar{P}, \bar{Y}_1, \bar{Y}_2) \qquad (4)$$

where Y is the sample mean of output j, $C(\bar{P}, \bar{Y}_1, 0)$ represents the costs of production with complete specialisation in output one, $C(\bar{P}, 0, \bar{Y}_2)$ represents the costs of production with complete specialisation in output two and $C(\bar{P}, \bar{Y}_1, \bar{Y}_2)$

represents the cost of production for the multiproduct firm. If the estimated value is greater than zero then positive economies of scope are present, if the value is less than zero then diseconomies of scope exist. Estimates of economies of scope are made for specialised production within mortgages and non-mortgage advances, both overall and for individual asset groups.

Distribution-free cost efficiency is a relative measure of firm specific efficiency. The efficiency of sample institutions is derived through reference to the efficiency of the most cost efficient building society within the sample. The advantage of this approach is that it removes many of the strong distributional assumptions of efficiency imposed in alternative techniques such as econometric frontiers (see Drake and Weyman Jones, 1996 and Ashton and Hardwick 1997, for further discussion of this issue). Efficiency is derived directly from the individual effects produced by the fixed effects model, where the individual effects, υ_i, would include the " … unobservable entrepreneurial or managerial skills of the firm's executives" (Baltagi, 1995, p.9). This is a development of the approach initially proposed by Berger (1993) who employed the average residuals from cross-section regressions for a ten-year period to provide estimates of relative and distribution free efficiency. The approach assumes that efficiency is constant over time and random variation in efficiency may be removed through averaging over time. The individual effects (υ_i) may be employed as an indicator of non-negative cost efficiency. Thus distribution free efficiency may denoted:

$$Efficiency_i = exp\,(min[Ln\, u_i]\text{-}Ln\, u_i) = \mathrm{Min}[u_i]/\,u_i \qquad (5)$$

for the i^{th} building societies, where min(u_i) is assumed to be the most efficient building society in the sample. For further discussion of this measure see Allen and Rai (1996, 1997) and DeYoung (1997).

The choice of functional form

The firms' production or transformation process has been represented in empirical studies with the use of generalised functional forms. In selecting a functional form the choice between flexibility and better global behaviour across a spectrum of observations is presented. Simple functional forms such as the Cobb-Douglas form satisfy many conditions or properties of a cost function over a broad range of observations. Their simplicity enables properties within the function to be consistently, if bluntly and robustly, applied. Difficulties with the use of simple forms centre on the limited scope of productive technologies that may be represented with such a simple form. The representation of a more sophisticated productive technology, as envisaged within the UK building society sector, requires a greater degree of flexibility, this in turn enables a wider range of productive characteristics to be represented. This flexibility may be obtained by employing a more complex functional form, such as the translog to model the situation.

The translog function form may be represented

$$\mathrm{L}nC = \sum_j a_j LnY_j + \sum_r b_r Ln\,P_r + 1/2 \sum_j \sum_s c_{js}\, LnY_j\, LnY_s +$$

$$\tfrac{1}{2}\sum_{r}\sum_{q} w_{rq}\, Ln\, P_r\, Ln\, P_q + \sum_{j}\sum_{r} ¶_{jr} Ln Y_j\, Ln\, P_r + u_i + v_{it} \qquad (6)$$

where $j, s = 1, 2$ and $r, q = 1, 2, 3$. Restrictions are imposed following established cost and production theory including symmetry (which requires that $c_{js}= c_{sj}$ and $w_{rq}= w_{qr}$) and linear homogeneity in input prices (where linear homogeneity suggests if all input prices are doubled then costs are exactly doubled).

In previous studies of UK building society sector, the translog functional form has been primarily employed. This Diewert flexible functional form, provides a cost function that could accommodate a second order differential approximation to an arbitrary twice continuously differential cost function. Such a cost function will satisfy linear homogeneity in prices property at any point only within certain parameters or an 'admissible domain' (Diewert, 1971). This representation of productive technology, whilst deemed appropriate for the consideration of the building society sector may only be quantified or estimated consistently within a certain range of observations or ‘specified domain’, leaving the possibility of specification error in estimation.

White (1980) indicated that while second order approximations of the translog flexible functional form allow the attainment of any arbitrary function at a given point, nothing implies that the true cost function is consistently estimated from this point. There have been a limited number of studies that have considered the workings of the translog functional form in applied work. Wales (1977) and Caves and Christensen (1980) have undertaken investigations into the viability of approximation, as the number and variability of observations is increased. Wales (1977) found the behaviour of the translog to deteriorate substantially as the true substitution elasticity departs from unity. Caves and Christensen (1980) found the translog to be better behaved over a broader range of observations than the generalised Leontief function. Guilkey (1980), Guilkey *et al* (1983) and Ivaldi (1996) have undertaken Monte Carlo tests of the performance of different functional forms. These tests examined the ability of the translog functional form and other forms to represent properties or characteristics of productive technology using pre-defined test data. Guilkey (1980, 1983) examined the productive characteristics such as economies of scale and factor substitution of the translog and other Diewert flexible forms. Tests were performed with data representing varying degrees of technology. Guilkey (1980) found that the translog functional form performed well over a broad range of technologies. Guilkey *et al* (1983) found the translog to broadly display better global behaviour than other Diewert flexible forms such as the generalised Box Cox and the Generalised Leontief functional forms, where "… the translog form provides a dependable approximation to reality provided that reality is not too complex" (p.614). Ivaldi *et al* (1996) in a comparison of the translog and the flexible Fourier functional forms with a panel data model indicated that, although both functional forms provide equivalent descriptions of the productive technology, the flexible Fourier functional form was able to represent a wider range of cost structures.

Whilst it may be concluded that use of the translog form may be appropriate when substantial dispersion of data is not present, the potential for specification error when considering a diverse data set, as used here, may present difficulties. To amend for such potential mis-specification both the translog and the flexible Fourier functional forms are employed. The flexible Fourier functional form (see Gallant, 1981, 1984) is a second order polynomial in the explanatory variables together with a combination of sine and cosine functions in the explanatory variables. This form is Sobelev flexible (see Gallant, 1981) and therefore can estimate elasticities consistently and has negative prediction bias, thus removing the potential for specification bias within the representation of productive technology. The flexible Fourier form has the translog form (3) nested within and should provide a similar interpretation of productive technology whilst reducing the potential for specification error. The expansion of the functional form to fit the scale of the data set is performed through the inclusion of additional trigonometric terms. This novel approach of fitting the size of the functional form to the sample size (Eastwoood and Gallant, 1991, suggested the total number of parameters should equal the number of observations raised to the two thirds power) differs from the method employed when using Diewert function forms, such as the translog, where the functional form is assumed to provide *a prori* a representation of the true cost function.

The trigonometric transformations of the variables are functions that re-scale the periodic sine and cosine values so that they fall within a sample specific domain of $(0, 2\pi)$. Chalfant and Gallant (1985) and Mitchell and Onvural (1996) indicate that the semi non-parametric sample-specific scaling procedure may be simplified through the imposition of a number of *a priori* assumptions allowing the flexible Fourier series expansion to be used as an effective expansion technique even with small samples (Rossi, 1985). The non-parametric sample specific scaling procedure employed for the flexible Fourier functional form may be denoted:

p_r^{min} = sample minimum for the r^{th} input price

p_r^{max} = sample maximum for the r^{th} input price

y_j^{min} = sample minimum for the j^{th} output quantity

y_j^{max} = sample maximum for the j^{th} output quantity

$Wp_r = 0.00001 - Lnp_r^{min}$, $Wy_i = 0.00001 - Lny_j^{min}$

$M = Lnp_r^{max} + Wp_r$, $l = 6/M$, $m = 6/[Lny_j^{max} + Wy_j]$,

Input price $l = l[Lnp_r + Wp_r]$,

Output quantity $Z = lm[Lny_j^{max} + Wy_j]$

The flexible Fourier functional form may be represented:

$$
\begin{aligned}
\mathrm{Ln}C = {} & \sum_j a_j LnY_j + \sum_r b_r Ln\,P_r + 1/2 \sum_j \sum_s c_{js}\, LnY_j\, LnY_s + \\
& 1/2 \sum_r \sum_q w_{rq}\, Ln\,P_r\, Ln\,P_q + \sum_j \sum_r \P_{jr} LnY_j\, Ln\,P_r + \\
& \sum_j j_j \cos Z_j + \sum_j k_j \sin Z_j + \sum_r g_r \cos l_r + \sum_r J_r \sin l_r + \\
& \sum_{js} j_{js}(\cos Z_j + \cos Z_s) + \sum_{js} k_{js}(\sin Z_j + \sin Z_s) + \\
& \sum_{js} v_{js}(\cos Z_j - \cos Z_s) + \sum_{js} q_{js}(\sin Z_j - \sin Z_s) + \\
& \sum_{rq} g_{rq}(\cos l_r + \cos l_q) + \sum_{rq} J_{rqr}(\sin l_r + \sin l_q) +
\end{aligned}
$$

$$\sum_{rq} y_{rqr}(\cos l_r - \cos l_q) + \sum_{rq} z_{rq}(\sin l_r - \sin l_q) +$$

$$u_i + v_{it} \qquad (7)$$

where j, s = 1, 2 and r, q = 1, 2, 3. Where α, β, χ, ω, δ, φ, κ, ϖ, φ, θ, γ, ϑ, ψ and z are coefficients to be estimated. $u_i + v_{it}$ denotes non-random disturbance of the individual building societies and random error respectively.

Symmetry is imposed on the translog portion of the model. The trigonometric vectors within the model are choosen *a priori* as opposed to pre-testing. The vectors include single outputs $cos(Z_j)$ and $sin(Z_j)$ and single input prices $cos(l_r)$ and $sin\ (l_r)$. Pairs of outputs $(cosZ_j + cosZ_s)$, $(sinZ_j + sinZ_s)$, $(cosZ_j - cosZ_s)$, $(sinZ_j - sinZ_s)$, and input prices $(cosl_r + cosl_q)$, $(sinl_r + sinl_q)$, $(cosl_r - cosl_q)$, $(sinl_r - sinl_q)$ are employed. Linear homogeneity is imposed through the use of opposite signs in the input price vectors and the imposing the restriction that parameters of the input price vector sum to zero (Mitchell and Onvural, 1996). Monotonicty and quasi-concavity in input prices are not imposed due to the semi-non-parametric (non-multiplicative) technique underlying the flexible Fourier functional form. Gallant (1981) stressed this does not hinder the the flexible Fourier form from closely approximating the true cost function.

Results

Parameter estimates for the translog and flexible Fourier models are presented in *Table 2*. Diagnostic statistics are provided with the parameter estimates. The parameter estimates of translog functional form display lower levels of approximation error than the flexible Fourier model due to the larger number of parameters to be estimated with the latter model. Building society specific estimates of cost efficiency are presented in *Table 3*. Estimates of economies of scale and scope are given in *Table 4*.

Table 2 Parameter estimates

Coeff.	Fourier		Coeff.	Fourier		Coeff.	Translog	Coeff.
β_1	-0.10	(0.11)	κ_2	0.01	(0.03)	β_1	-0.07	(0.02)*
β_2	-0.09	(0.04)*	ϖ_{12}	-0.02	(0.03)	β_2	-0.15	(0.05)*
β_3	-0.10	(0.11)	φ_{12}	-0.04	(0.02)*	β_3	1.22	(0.05)*
α_1	-0.15	(0.42)	κ_{12}	0.06	(0.05)	α_1	0.73	(0.05)*
α_2	-0.30	(0.22)	θ_{12}	0.00	(0.02)	α_2	0.01	(0.05)
χ_{11}	0.03	(0.03)	γ_1	0.61	(0.45)	χ_{11}	-0.01	(0.01)
χ_{22}	-0.02	(0.01)*	γ_2	0.01	(0.02)	χ_{22}	-0.01	(0.01)
χ_{12}	0.03	(0.02)	γ_3	-0.09	(0.02)*	χ_{12}	0.01	(0.01)
ω_{11}	0.00	(0.01)*	ϑ_1	-0.56	(0.47)	ω_{11}	0.01	(0.01)
ω_{22}	0.00	(0.00)	ϑ_2	-0.05	(0.02)*	ω_{22}	0.00	(0.00)
ω_{33}	0.00	(0.01)	ϑ_3	-0.12	(0.02)*	ω_{33}	0.08	(0.00)*
ω_{12}	0.00	(0.00)*	ψ_{12}	-0.04	(0.03)	ω_{12}	0.00	(0.00)*
ω_{13}	0.01	(0.04)	γ_{12}	0.00	(0.02)	ω_{13}	0.06	(0.01)*
ω_{23}	0.00	(0.00)*	ψ_{13}	0.38	(0.37)	ω_{23}	-0.01	(0.00)*
δ_{11}	0.01	(0.01)	γ_{13}	-0.10	(0.14)	δ_{11}	0.02	(0.01)*
δ_{12}	0.00	(0.01)	ψ_{23}	-0.12	(0.02)*	δ_{12}	0.02	(0.01)*
δ_{13}	0.01	(0.01)	γ_{23}	0.08	(0.02)*	δ_{13}	-0.09	(0.01)*
δ_{21}	-0.01	(0.01)	ϑ_{12}	0.07	(0.03)*	δ_{21}	-0.01	(0.01)
δ_{22}	0.00	(0.01)	ζ_{12}	0.02	(0.02)	δ_{22}	-0.02	(0.01)*
δ_{23}	0.00	(0.01)	ϑ_{13}	0.13	(0.13)	δ_{23}	0.04	(0.01)*
φ_1	-0.04	(0.05)	ζ_{13}	-0.43	(0.31)			
φ_2	0.01	(0.02)	ϑ_{23}	-0.05	(0.02)*			
κ_1	0.20	(0.06)*	ζ_{23}	-0.09	(0.02)*			

* denotes significant at 10 per cent

Diagnostic Statistics

Flexible Fourier Model

Adjusted R-squared = 0.99623

F Test for the model [143, 377] = 962.32, Prob value = 0.00000

Diagnostic: Log-Likelihood = 405.0186

F Test for the restrictions [1, 376] = 9.2232, Prob = 0.0026

Translog model

Adjusted R-squared = 0.99162

F test for model [115, 405] = 536.09, Prob value = 0.00000

Diagnostic: Log-Likelihood = 175.6761

F Test for the restrictions [3, 402] = 31.1525, Prob = 0.0000

Likelihood ratio between the two functional forms 458.685 significant at 1 per cent.

Acceptable levels of model fit are appreciated for both models. The likelihood ratio test indicates significant differences exists in the degree of 'fit' between the two models suggesting the translog could be replaced by the flexible Fourier form.

The distribution free cost efficiency estimates indicate substantial variation in the level of efficiency between building societies during the sample period. Average efficiency levels of 76 per cent with the flexible Fourier model and 72.52 per cent with the translog model are observed. The magnitude of efficiency dispersion differs considerably between the models, with the flexible Fourier model reporting a standard deviation of 6.869 with a minimum 68.54 per cent efficiency. The distribution of efficiency of the translog model is far greater with a standard deviation of 16.55 and a minimum value of 28.38 per cent. These cost efficiency estimates display lower efficiency levels are prevalent in the building society sector than was previously observed by Drake and Weyman Jones (1996) who suggested that little allocative or technical inefficiency were present when using data for 1988.

Table 2 Distribution free efficiency (percentages)

	Fourier	translog		Fourier	translog		Fourier	translog
Alliance & Leicester	71.16	50.13	Hampshire	73.70	65.03	North of England	71.24	57.37
Barnsley	74.09	90.41	Hanley Economic	74.65	82.55	Northern Rock	71.95	59.14
Bath Investments	82.26	88.57	Harpenden	83.33	84.09	Norwich & Peterborough	71.29	68.30
Bedford Crown	88.14	89.55	Haywards Heath	73.85	76.02	Nottingham	72.21	82.78
Beverley	84.25	88.83	Heart of England	70.00	49.84	Nottingham Imperial	82.97	85.14
Bexhill	90.38	91.21	Hendon	82.71	78.30	Penrith	84.88	87.52
Birmingham Midshires	69.00	35.35	Hinckley & Rugby	72.73	81.50	Portman	71.08	59.88
Bradford & Bingley	70.99	36.59	Holmesdale	78.72	75.18	Portsmouth	68.54	42.00
Bristol & West	70.27	37.48	Ilkeston Permanent	92.10	98.73	Principality	72.36	74.53
Britannia	71.00	49.94	Ipswich	73.31	80.55	Progressive	72.11	78.61
Buckinghamshire	81.68	82.43	Kent Reliance	70.68	66.61	Saffron Walden, Herts & Essex	71.72	71.90
Cambridge	71.26	75.57	Lambeth	71.53	77.17	Scarborough	70.74	67.94
Catholic	88.89	93.96	Lancastrian	70.03	65.10	Scottish	77.67	85.75
Chelsea	69.94	47.45	Leamington Spa	68.62	28.38	Shepshed	85.16	81.32
Cheltenham & Gloucester	72.37	46.47	Leeds	71.12	42.83	Skipton	69.26	42.52
Chesham	79.18	85.09	Leeds & Holbeck	70.57	53.17	Southdown	71.08	63.64
Cheshire	71.89	70.59	Leek United	71.81	81.32	St Pancras	75.78	71.49
Cheshunt	69.86	54.86	Londonderry Provident	100.00	96.36	Stafford Railway	84.35	84.20
Chorley & District	82.25	83.58	Loughborough	76.03	79.04	Staffordshire	71.23	75.64
City & Metropolitan	76.06	72.93	Manchester	76.41	72.79	The Standard	90.83	94.53
Clay Cross	91.48	96.67	Mansfield	77.53	92.05	Stroud & Swindon	70.00	62.62
Coventry	72.40	70.66	Market Harborough	72.66	79.16	Surrey	75.04	54.86
Cumberland	70.69	72.59	Marsden	71.73	72.59	Swansea	85.89	91.51
Darlington	71.90	74.92	Melton Mowbray	73.14	81.20	Teachers	76.94	88.26
Derbyshire	72.63	82.49	Mercantile	74.97	81.38	Tipton & Coseley	78.66	88.26
Dudley	79.57	88.99	Mid-Sussex	84.58	88.88	Town & Country	70.37	54.68
Dunfermline	71.92	74.26	Monmouthshire	74.65	78.61	Tynemouth	81.53	83.86
Earl Shilton	81.31	78.67	Mornington	73.25	71.42	Universal	74.36	87.36
Ecology	96.84	100.00	National & Provincial	71.99	58.81	Vernon	75.64	81.20
Furness	71.49	74.06	National Counties	72.53	70.66	West Bromwich	72.04	79.53
Gainsborough	88.15	87.95	Nationwide Anglia	69.78	32.12	West Cumbria	85.23	88.57
Greenwich	73.31	74.26	Newbury	72.40	75.44	Woolwich	71.48	55.30
Halifax	70.36	43.45	Newcastle	71.30	65.86	Yorkshire	71.13	60.78

Table 4 *Ray Scale economies (RSE) and economies of scope.*

	Translog		Flexible Fourier	
	RSE	SE	RSE	SE
Overall	1.0031	(0.0421)	0.7501	(0.043)*
1990	0.8317	(0.0457)*	0.7330	(0.045)*
1991	1.0225	(0.0457)	0.7880	(0.054)*
1992	0.9825	(0.0422)	0.7534	(0.043)*
1993	1.1252	(0.0408)	0.7540	(0.042)*
1994	1.1610	(0.0397)*	0.7589	(0.042)*
1995	1.1779	(0.0393)*	0.7570	(0.042)*
<10m	0.6300	(0.0767)*	0.5996	(0.0817)*
10m-50m	0.8869	(0.0578)*	0.6596	(0.0596)*
50m-150m	1.0546	(0.0405)	0.7642	(0.0412)*
>150m	1.2435	(0.0275)*	0.9405	(0.0376)
	Scope	SE	Scope	SE
Overall	-4.4817	(0.4835)*	-0.5268	(0.5366)
<10m	-8.5621	(1.4246)*	-0.4934	(0.5125)
10m-50m	-5.4467	(0.5612)*	-0.5055	(0.5244)
50m-150m	-4.5180	(0.4366)*	-0.5260	(0.5366)
>150m	-3.2040	(0.2290)*	-0.5477	(0.5540)

** denotes significant at 10 per cent*

The two functional forms provide fairly distinct results for economies of scale. The translog functional form in indicates constant costs are present overall. The distribution of economies of scale over assets size of the building societies indicates sharply decreasing levels of economies of scale as asset size increases. Constant costs are indicated for building societies between £50m and £150m in total assets. Building societies with assets in excess of £150m in total assets display diseconomies of scale. The distribution of economies of scale over time suggests the level of economies of scale within the sample is decreasing. In 1990, significant economies of scale were recorded, between 1991 and 1993 constant economies where recorded and during 1994 and 1995 significant diseconomies of scale where appreciated, overall suggesting a U shaped cost function.

The economies of scale results produced with the flexible Fourier functional form indicate far higher levels of economies of scale than the translog functional form, with a value of 0.75 being recorded overall, suggesting substiantial economies to be gained by expansion. The distribution of economies of scale over asset groups indicate substantial significant economies exist for growth for societies with total assets up to £150m. Societies with total assets in excess of £150m are assumed to appreciate constant economies of scale. The distribution of economies of scale over time displays significant scale economies for all years.

Dis-economies of scope are indicated for both the translog and flexible Fourier models. This suugest that the separate provision of mortgage loans and advances would be preferable for the societies considered. The degree of dis-economies are more exaggerated within the translog specification. The translog distribution of scope diseconomies over asset size suggests the magnitude of diseconomies of scope decreases as asset size rises.

Overall, it may be inferred that the translog specification overestimates economies of scope, provides some fairly implausible efficiency results and has underestimated the level of economies of scale. Such conclusions indicate that substantial specification bias may be present when employing the translog functional form in this study. The sensitivity of the two functional forms also differs. The translog specification displays a greater degree of responsiveness of economies of scale and scope both over time and across total asset size, perhaps being a result of the lower levels of approximation error appreciated.

Conclusions

The empirical quantification and comparison of cost efficiency using the flexible Fourier and the translog functional form models provides evidence that the two approaches produce divergent estimates. These results indicate that the translog functional form does not estimate consistently over the broad range of building societies during the sample period. Consideration of the behaviour of the translog functional form is thus required through reference to the data to ensure that the results are consistent with the theory underpinning the analysis and are plausible to what should broadly be expected. It may be concluded that the use of this functional form in similar analysis should be undertaken with great care, ensuring that the distribution of the 'raw data' is both within limited parameters and the cost structure estimated corresponds to what may be considered credible. Whilst differences in estimation suggest that the translog both underestimates the levels of economies of scale and overestimates the dispersion of efficiency, the underlying cost structure of the building society sector appears to be similar to that produced by the flexible Fourier form (the correlation between the two distribution free efficiency measures was 0.717), supporting the conclusions of Ivaldi *et al* (1996), that the two forms estimate equivalent cost structures, with the Fourier form estimating more consistently over a wider range of observations.

The efficiency results indicate that many previous studies of economies of scale that have employed the translog functional form may have substantially under-estimated the economies of scale within the building society sector. Average levels of 76 per cent cost efficiency are recorded for the 1990 to 1995 period, indicating that substantial gains may be possible both through growth and improved managerial and entrepreneurial decision-making. It may be indicated that the previous use of Diewert flexible forms for the measurement of economic characteristics, as considered here, may have provided biased results.

References

Alhadeff, D. A. (1954) *Monopoly and Competition in Banking,* University of California Press.

Allen. L, and Rai. A, (1996) "Operational efficiency in banking: An international comparison" *Journal of Banking and Finance,* vol.20, 655-672.

Allen. L, and Rai. A, (1997) "Operational efficiency in banking: An international comparison. Reply to the comment" *Journal of Banking and Finance,* vol.21, 1451-1455.

Ashton, J. K. And Hardwick, P. (1997) "Cost efficiency in UK building societies: A panel data study, 1990-1995" presented at the *4th Annual Conference of the Multinational Finance Society,* June 25-29, 1997, Thessaloniki, Greece.

Baumol, W. J., Panzar, J. C. And Willig, R. D. (1982) *Contestable Markets And the Theory of Industry Structure* Harcourt Brace Jovanovich, Inc New York.

Baltagi, B. H. (1995) *Econometric Analysis of Panel Data,* John Wiley & Sons Chichester.

Berger A N (1993) “Distribution free estimates of efficiency in the U.S. banking industry and tests of the standard distributional assumptions” *The Journal of Productivity Analysis* vol.4 261-292.

Berger, A. N. and Mester, L. J. (1997) "Inside the black box: What explains differences in the efficiencies of financial institutions?" *Journal of Banking and Finance* vol.21, 895-947.

Berger, A. N. and DeYoung, R. (1997) "Problem loans and cost efficiency in commercial banks" *Journal of Banking and Finance* vol.21 849-870.

Caves, D. W. and Christensen, L. R. (1980) "Global properties of flexible functional forms" *American Economic Review* vol.70, 422-432.

Chalfant, J. A. and Gallant, A. R. (1985) “Estimating substitution elasticities with the Fourier cost function” *Journal of Econometrics* vol.28 205-222.

Diewert, W. E. (1971) "An application of the Shephard duality theorem: A generalized Leontief production function" *Journal of Political Economy* vol.79 481-507.

Drake, L. (1992) "Economies of scale and scope in U.K. building societies: an application of the translog multi-product cost function" *Applied Financial Economics* vol.2 211-219.

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

Drake, L. (1995) "Testing for expense preference behaviour in UK building societies: The implications for measures of scale and scope economies" *The Service Industries Journal* vol.15 no.1 (January) 50-65.

Drake, L. and Weyman-Jones, T. G. (1996) "Productive and allocative inefficiencies in UK building societies: A comparison of non-parametric and stochastic frontier techniques" *The Manchester School* vol.64 no.1 (March) 22- 37.

Eastwood, B. J. and Gallant, R. A. (1991) “Adaptive rules for seminonparametric estimators that achieve asympototic normality” *Econometric Theory* vol.7 307-40.

Field, K. (1990) "Production efficiency of British building societies" *Applied Economics* vol.22 413-426.

Gallant, A. R. (1981) "On the bias in flexible functional forms and an essentially unbiased form" *Journal of Econometrics* vol.15, 211-245.

Gallant, A. R. (1984) “The Fourier Flexible Form” *American Journal of Agricultural Economics* May 204-208.

Gough, T. J. (1979) "Building society mergers and the size-efficiency relationship" *Applied Economics* vol.11 185-194.

Guilkey, D. K. and Knox Lovell, C. A. (1980) “On the Flexibility of the Translog Approximation” *International Economic Review* vol.21 137-147.

Guilkey, D. K., Knox Lovell, C. A. and Sickles, R. (1983) "A comparison of the performance of three flexible functional forms" *International Economic Review* vol.24 591-616.

Greene, W. H. (1993) *Econometric Analysis* 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey.

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

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

Intrigator, M. D. Bodkin, R. G. and Hsiao, C. (1996) *Econometric Models, Techniques, and Applications* Second Edition, Prentice Hall, NewJersey.

Ivaldi, M., Ladoux, N., Ossard, H., and Simioni, M. (1996) “Comparing Fourier and Translog specifications of multiproduct technology: Evidence from an incomplete panel of French farmers” *Journal of Applied Econometrics* vol.11 649-667.

McAllister, P. H. and McManus, D. (1993) "Resolving the scale efficient puzzle in banking" *Journal of Banking and Finance* vol.17, 389-405.

Mitchell, K. and Onvural, N. M. (1996) "Economies of scale and scope at large commercial banks: Evidence from the Fourier flexible functional form" *Journal of Money, Credit and Banking* vol.28, no.2, (May), 178-199.

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

Rossi, P. E. (1985) “Comparison of alternative functional forms in production” *Journal of Econometrics* vol.30 345-361.

Sealey, C. W. and Lindley, J. T. (1977) "Inputs, outputs, and a theory of production and cost at depository financial institutions" *The Journal of Finance* vol.32, no.4, (September), 1252-1253.

Wales, T. J. (1977) “On the flexibility of flexible functional forms” *Journal of Econometrics* vol.5 183-193.