The GSBGM Working Paper Series

WORKING PAPER 10/95

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ISSN 1173-4523
ISBN 0-475-11489-2

The Graduate School of Business and Government Management Working Paper Series 10/95 June 1995.
M. Khaled, M.D. Adams and M. Pickford* 'Estimates of scale and scope economies in the New Zealand life insurance industry.'

Enquiries concerning this paper direct to the first author*
General enquiries concerning GSBGM publications to:
Monica Cartner
Research Co-ordinator
The Graduate School of Business and Government Management
The Victoria University of Wellington
PO Box 600
Wellington
New Zealand

Telephone: 64-4-495 5085
Facsimile: 64-4-496 5435
E-mail: Monica.Cartner@vuw.ac.nz

*M. Khaled
Economics Group
Faculty of Commerce and Administration
Victoria University of Wellington
PO Box 600
Wellington
New Zealand

Telephone: 64 4 471 5353
E-mail: Mohammed.Khaled@vuw.ac.nz

M.B. Adams
Department of Accountancy
Massey University
Private Bag 11222
Palmerston North
New Zealand

M. Pickford
School of Applied and International Economics
Massey University
Private Bag 11222
Palmerston North
New Zealand

ESTIMATES OF SCALE AND SCOPE ECONOMIES IN THE NEW ZEALAND LIFE INSURANCE INDUSTRY

M. Khaled*, M.B. Adams and M. Pickford*****

ABSTRACT

Recent multi-product statistical studies of life insurance industries in North America and the United Kingdom have produced mixed findings with regard to economies of scale and scope. This study presents results for the insurance industry in a small economy where the industry is comparatively unregulated. 135 pooled observations for the population of non-bank insurance companies in New Zealand for the period 1988-1992 are used in a two input/three output translog model. We find that while small companies enjoy economies of scale, the optimum plant size is modest, and medium- and large-sized companies experience a significant scale disadvantage. In contrast, all sizes of company benefit from scope economies, but such economies tend to be much greater for the larger companies.

Key Words: Economies of Scale; Economies of Scope; Translog Cost Function; Life Insurance; New Zealand.

ACKNOWLEDGEMENTS

We express our thanks to Steven Cahan, Rolf Cremer, Phil Hardwick, Cecilio Mar-Molinero, George McKenzie, Leigh Roberts, and Mike Sherris for their comments on earlier drafts of this paper. We are also grateful to Dick Jessup for the use of his firm's database, and to the Life Office Association of New Zealand, the Massey University Research Fund, and Price Waterhouse for their financial support of our research. Finally, the usual disclaimers apply.

* Senior Lecturer, Economics Group, Victoria University, PO Box 600, Wellington, New Zealand, PH: (64) 4 - 471 - 5353, FAX: (64) 4 - 471 - 2200,
E-MAIL: Mohammed.Khaled@vuw.ac.nz

** Lecturer, Department of Accountancy, Massey University, Private Bag 11222, Palmerston North, New Zealand, PH: (64) 6 - 356 - 9099, FAX: (64) 6 - 350 - 5617,
E-MAIL: M.B.Adams@massey.ac.nz

*** Senior Lecturer, School of Applied and International Economics, Massey University, Private Bag 11222, Palmerston North, New Zealand, PH: (64) 6 - 356 - 9099
FAX: (64) 6- 350 - 5660

INTRODUCTION

Only a few empirical studies have tested for economies of scale and of scope in the life insurance industry using recent advances in the theory of multiproduct cost functions (Kellner and Mathewson, 1983; Fields, 1988; Fields and Murphy, 1989; Grace and Timme, 1992; and Hardwick, 1994). However, the number of studies is larger if the field is widened to cover other insurance markets (Suret, 1991; Cummins and Weiss, 1993), or the financial services sector generally (e.g., Benston, Hanweck and Humphrey, 1982; Murray and White, 1983; Mester, 1987; Dowling and Philippatos, 1990). In life insurance, studies generally find an absence of scope economies, and disagree on whether scale economies are present. Only Kellner and Mathewson (1983) in Canada and Grace and Timme (1992) in the United States (US) found limited evidence of scope economies, while Hardwick (1994) reported diseconomies for all but one product pairing in the United Kingdom. Economies of scale were reported by Grace and Timme (1992), diseconomies by Fields (1988) for the US , significant economies only for the largest firms by Hardwick (1994), and generally constant returns by Kellner and Mathewson (1983).

Our purpose is not to attempt to resolve such contradictions - which may in part reflect differing model specifications and data sets - but rather to bring new results from outside of the large economies of North America and the United Kingdom to bear on the debate. These are derived from the estimation of a multiproduct translog cost function model for the New Zealand (NZ) life insurance industry. By explicitly allowing product-mix to vary between firms and input substitution to be highly flexible, the model should provide more robust estimates of scale economies than those of the only previous NZ study by Praetz (1983), which in common with much early research, suffers from the well-known drawbacks of using the single product Cobb-Douglas cost function (Benston et al., 1982). In addition, our model also permits the first estimation of scope economies for the NZ industry.

The NZ life insurance industry is unusual by international standards in being relatively small, highly concentrated, and largely unregulated. Despite a well established State pension scheme, the industry plays a significant role in the small NZ economy (KPMG Peat Marwick, 1994). In mid-1992 the industry held assets valued at NZ$12.1 billion, equal to about 15 per cent of GDP.

At year-end, there were 33 life insurance companies,[1] with the six largest having about 70 per cent of annual premium income. The "big six" sell a diversified range of products - including ordinary risk life insurance and investment-linked policies, superannuation business, and investment-only products, such as unit trusts - mostly through tied agents operating in extensive national networks of branch offices. In contrast, the smaller companies - the 20 or so with life funds below NZ$25 million - typically offer a narrower range of products aimed at particular market segments, distributed through non-tied agents and brokers. They rely heavily on reinsurance arrangements with either the largest companies or specialist international reinsurers.

Although all companies must, under the Life Insurance Act 1908, file annual solvency returns with the Department of Justice and Government Actuary, the industry is rated as the least regulated in the western world (Commerce Clearing House, 1991). In contrast to the heavily regulated Australian market, for example, there are no compliance costs of filing quarterly returns, and competition is not impeded by stringent licensing requirements. Freedom of entry and exit is evident from the fact that since 1989 five banks have entered the market, and four small firms have exited because of insolvency.

To sum up, the NZ life insurance industry provides an interesting subject for a study of economies of scale and scope. The wide range of company sizes and degrees of diversification in an apparently competitive, unregulated market raises questions about the optimal output-mix, and the survival ability of the smaller players. Moreover, company costs - and hence our estimated cost function - should not be distorted by regulation-induced inefficiencies, nor by insurance legislation (e.g., on taxation) which does not discriminate between mutual and stock companies.

Two striking results emerge from our study. The first is that the smaller companies experience scale economies up to an annual premium income of about NZ$20 million (equivalent to about US$12.6 million), and that diseconomies are evident around NZ$40-50 million (US$25.2-31.5 million), so that the medium-sized and large companies suffer from a significant scale disadvantage. This result is driven by costs associated with the life insurance

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1 This figure excludes friendly societies and reinsurance companies as they do not directly write significant amounts of life insurance business.

output, and not with the superannuation and other outputs. The second result is that companies of all sizes enjoy economies of scope, but that such economies tend to be much larger for the biggest companies.

The paper continues with an outline of the translog model, and of the various measures of scale and scope economies employed. The variables used in the model, and their measurement, are then described. This is followed by the specification of the estimating system, and a detailed presentation of the results. The implications of our findings are considered in the concluding section.

A MODEL OF LIFE INSURANCE PRODUCTION TECHNOLOGY

Assuming all life insurance firms have access to the same technology, and produce any given output-mix at the lowest cost, the production cost (C) of a firm will depend upon the vector of output (y) produced and on the various input prices (w). This relationship can be expressed as:

$$C = f(w,y) \qquad (1)$$

As with several recent cost studies in the financial services sector we use a multiproduct translog cost function to model life insurance production. Caves, Christensen and Tretheway's (1980) version of the function, which can accommodate zero production of some outputs, is expressed as:

$$\begin{aligned} \ln C = \; & \alpha_0 + \Sigma_i \alpha_i \ln w_i + \frac{1}{2}\Sigma_i\Sigma_j \alpha_{ij} \ln w_i \ln w_j \\ & + \Sigma_i \beta_i Y_i + \frac{1}{2}\Sigma_i\Sigma_j \beta_{ij} Y_i Y_j + \Sigma_i\Sigma_j \gamma_{ij} \ln w_i Y_j \qquad (2) \end{aligned}$$

where ln stands for natural logarithm, and $Y_i = \frac{y_i^{\lambda} - 1}{\lambda}$ has the limiting value $\ln y_i$ as $\lambda \to 0$. The theoretical requirement that the cost function be homogeneous of degree one in factor prices is met by imposing the following restrictions on parameters:

$$\Sigma_i \alpha_i = 1, \alpha_{ij} = \alpha_{ji}, \Sigma_j \alpha_{ij} = 0, \Sigma_i \gamma_{ij} = 0 \tag{3}$$

Since $\Sigma_i \Sigma_j \beta_{ij} Y_i Y_j$ is a quadratic form, we can also require that $\beta_{ij} = \beta_{ji}$ without any loss of generality. The underlying production function is weakly separable in inputs and outputs if $\gamma_{ij} = 0$, $\forall_{i,j}$. In this case, given the required weights, the various outputs can be aggregated to allow the conventional single output specification.

Demand equations in share form, obtained by applying Shepherd's Lemma (Shepherd, 1953), are:

$$s_k = \quad \alpha_k + \Sigma_j \alpha_{kj} \ln w_j + \Sigma_j \gamma_{kj} Y_j \tag{4}$$

where s_k is the share of input k. Joint estimation of the cost function and the share equations yields estimates of all the coefficients. The parameters appearing in the share equation are actually a subset of those in the cost equation, but joint estimation provides more efficient parameter estimates as the share equation embodies additional information on the permissible values of those coefficients.

Scale economy along a ray representing any given output mix (y_0) can be calculated as:

$$S = \left(\frac{\partial \ln C}{\partial \ln t} \right)^{-1} \tag{5}$$

where output is increased as $y = t\, y_0$, and t is the number of units of the output bundle y_0. Scale economies exist if $S > 1$, and scale diseconomies if $S < 1$. However, since outputs rarely change in fixed proportions, we prefer to use a general measure of scale economies which allows the output-mix to change as follows:

$$S^* = \left(\sum_k \frac{\partial \ln C}{\partial \ln y_k} \right)^{-1} \tag{6}$$

where:

$$\frac{\partial \ln C}{\partial \ln y_k} = y_k^{\lambda}\left(\beta_k + \sum_j \beta_{kj} Y_j + \sum_j \gamma_{jk} \ln w_j\right) \tag{7}$$

Of the various other measures suggested as indicators of the presence of cost subadditivity[2] in a multiple output function (Baumol, Panzar and Willig, 1988), we use two. Firstly, product specific scale economies can be measured for each output separately as:

$$S_i = \frac{AIC_i}{MC_i} \tag{8}$$

where AIC_i is the incremental average cost of output i, and MC_i is the marginal cost of that output. For example, if there are two outputs, 1 and 2, AIC_1 is calculated as:

$$AIC_1 = \frac{c(y_1, y_2) - c(0, y_2)}{y_1} \tag{9}$$

where $c(0,y_2)$ is the cost of production when commodity 1 is not produced at all. However, even if $S_i \leq 1$ for all i, there can be economies of joint production owing to the presence of shared inputs. Such economies of scope, our second measure of cost subadditivity, can be measured as:

$$S_C = \frac{c(0, y_2) + c(y_1, 0) - c(y_1, y_2)}{c(y_1, y_2)} \tag{10}$$

Economies of scope are present ($S_C > 0$) if the cost of joint production is less than the total cost of separate production of the same outputs.

The product specific scale economies and economies of scope are related to the overall measure of scale economies (6) as:

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[2] Economies of scale and scope are special cases of subadditivity. A cost function c(y) is said to be subadditive at y if for any and all quantities of outputs y_i, produced by i=1,...n firms, $n \geq 2$, such that $\sum_i y_i = y$, $c(y) \leq \sum_i c(y_i)$, i.e it is cheaper to produce y in a single firm rather than by two or more firms. Note that y_i can be a scalar, or a vector of outputs with only one non-zero element, i.e. a cost function is subadditive if it exhibits economies of scale and/or economies of scope.

$$S^* = \frac{\sum_i \theta_i S_i}{1 - S_c} \qquad (11)$$

where the weight $\theta_i = \frac{y_i MC_i}{\sum_j y_j MC_j}$. Overall scale economies exist when $S^* > 1$. Clearly, sufficiently strong economies of scope can result in overall scale economies even when product specific scale economies are absent.

VARIABLES AND DATA

Sample Size

There were 33 life insurance companies in 1992. However, the five banks were excluded from our analysis as they did not report separate property and equipment values for their life insurance operations. Thus, our final data set pooled 135 observations for the years 1988-1992.[3] Use of a pooled data set, by increasing the degrees of freedom , helps to improve the precision of the parameter estimates. This is particularly useful for the translog-model (Goldstein, McNulty and Verbrugge, 1987) as it involves many more parameters than the Cobb-Douglas functional form. Moreover, variation in relative input prices over time also allows the estimation of input price elasticities without imposing any undue restrictions.

Output, Input Prices and Cost Variables

As life and superannuation business represent the core activities of NZ's life insurance industry (Life Office Association of New Zealand, 1994), we identify three kinds of output: life insurance premiums, superannuation premiums, and other premium incomes respectively.[4] The last consists primarily of annuity receipts and investment-only contributions, such as payments received on unit trusts. The output quantities (y_i) are derived from the value of annual premium incomes written, net of reinsurance and commission (V_i). They are measured

3 This five year period covered all years for which information was available at the time the research was undertaken.

4 We recognise the deficiencies of premium income as a measure of output (Geehan, 1986). The predominance of the life and superannuation outputs in the total outputs of all but the largest NZ life insurance companies is shown in Table 1.

as: $y_i = V_i/P_i$, where P_i is the price of the ith type of insurance product (i = 1, 2 and 3 for life, superannuation and other output, respectively).

Insurance production technology is such that the most significant input tends to be labour (Routledge and Tuckwell, 1974). Cost of labour is given by total operating expenses (TOE), which includes management expenses and commission paid to agents. If the wage rate of workers in the life insurance industry is w_1, then labour input into insurance output is given by TOE/w_1.

Most of the remaining inputs comprise the services of office buildings and equipment. Stocks of these inputs can be derived from the values of property (VOP) and equipment (VOE) of the insurance companies. If P_b and P_e are the prices of those capital goods, the respective capital stocks can be found approximately as $K_b = VOP/P_b$ and $K_e = VOE/P_e$. Following Jorgenson (1967), the price per unit of the services of these stocks can be calculated as:

$$w_b = (i+\delta_b)P_b - \dot{P}_b \quad (12a)$$

$$w_e = (i+\delta_e)P_e - \dot{P}_e \quad (12b)$$

where: i is a long term interest rate; δ_b and δ_e are the rates of economic depreciation of property and equipment respectively; and $\dot{P}_b$ and $\dot{P}_e$ are the expected capital gains from owning those inputs. Assuming that input services are proportional to the respective capital stocks, expenses attributable to office buildings and equipment can be found as w_bK_b and w_eK_e. Further, the service price of the aggregate capital input, w_2, can be obtained by a Divisia aggregation (Diewert, 1981) of the prices w_b and w_e using total industry cost shares of the respective inputs as weights. The aggregate capital input is then $(w_bK_b + w_eK_e)/w_2$.

Total cost of production, made up of the costs of labour and capital, is thus: $C = TOE + w_bK_b + w_eK_e$. Note that annual investment expenses are normally excluded from TOE, since such costs are netted-off against investment income prior to disclosure in published financial reports (Johnson, Flanagan and Weisbart, 1981).

Data Sources

Data on annual premium incomes (V_i), total operating expenses (TOE), value of property (VOP) (land and buildings) and value of equipment (VOE) (mostly business equipment and furniture) were obtained from the published annual financial statements and statutory returns of all the life insurance companies, supplemented by information obtained from an actuarial database.[5] Total annual operating expenses for each life insurance company is defined as management expenses (excluding depreciation), plus taxes and commission paid. Separate information on taxes paid is not available. However, no measurement errors are made if taxes paid are proportional to the operating expenses.

Data on the remaining variables were obtained from Statistics NZ's on-line database PC-INFOS. The only available price index for the output of insurance companies is the producers' price index (PPI) for the insurance and finance sector (identifier PPIQ.SOS), which was used for all three kinds of output (P). This amounts to assuming that the three underlying price indices behaved in the same manner. Consequently, our estimated model does not allow relative output prices to influence changes in product-mix over time. However, inter-firm differences in product-mix resulting from economies of scope are still possible.

Price of the labour input (w_1) is measured by the weekly wage rate index of workers in the insurance and finance sector (PWIQ.S432S). The prices of capital goods, Pb (office buildings) and Pe (equipment), are given respectively by the non-residential buildings price index for shops and offices, (CEPQ.SBA) and by the plant, machinery and equipment price index for office and shop equipment (CEPQ.SFAY). The long term interest rate is measured by the five-year government stock yield on the secondary market (FINM.SKF). Many life insurance companies do not depreciate buildings (or land), but treat them as a non-depreciable investment. Outside life insurance, the usual practice is to depreciate buildings on a straight-line basis over their useful life, normally 50 years. Thus, we use a notional annual depreciation rate of two per cent per annum as a proxy for the economic rate of depreciation. Equipment is normally depreciated (straight-line) over five years, giving a rate of 20 per cent per annum. Expected capital gains in buildings and equipment are approximated by the realised capital

5 Source: Melville, Jessup, Weaver (Consulting Actuaries, Wellington).

gains in the previous time period. The user costs of buildings and equipment - w_b and w_e - were calculated by using this data in (12A) and (12B), and aggregated to find the user cost of the aggregate capital input w_2. Data on these prices - price of outputs (P), wage of labour (w_1) and rental price of capital (w_2) - are shown in Table 1.

Table 1
Output and Input Prices
in the New Zealand Life Insurance Industry, 1988-1992
(base year = 1992)

Year	P	w_1	w_2
1988	0.916	0.892	0.876
1989	0.965	0.926	0.923
1990	0.985	0.965	0.979
1991	0.982	0.987	0.999
1992	1.000	1.000	1.000

Table 2
Output and Production Cost of the New Zealand Life Insurance Companies
by Size Class in 1992 (NZ$)

Company size by premium income $m	Average total premium $m	Proportion of total premium in:			Average total cost $m	Labour share of total cost
		Life	Super	Other		
< 5	1.741	0.895	0.041	0.064	3.860	0.856
5 - 25	15.020	0.667	0.163	0.170	13.973	0.970
25 - 100	65.726	0.604	0.209	0.187	84.217	0.899
100 - 200	135.730	0.480	0.280	0.240	180.140	0.954
> 200	322.680	0.536	0.102	0.362	558.090	0.960

Summary of Output and Cost Data

Table 2 shows average output and cost data for 1992 for all companies grouped into five size classes measured by total annual premium income. Variation in the company sizes is enormous, with the average size in the biggest group being almost two hundred times larger than that in the smallest. Table 2 also reveals a wide variation in output-mix across size classes, with the smallest class being noteworthy for its relatively high degree of specialisation.[6] In common with other service industries, life insurance production is highly labour intensive, with labour cost exceeding 90 per cent of total annual expenses for most companies.

THE ESTIMATING SYSTEM

We estimate a two input (1 = labour, 2 = capital) and three output (1 = life, 2 = superannuation, 3 = other products) model of the NZ life insurance industry using data for 1988-1992. The cost
equation, with a random disturbance term added, is:

$$
\begin{aligned}
\ln C \quad &= \alpha_0 + \sum_{i=1}^{2} \alpha_i \ln w_i + \frac{1}{2}\sum_{i=1}^{2} \sum_{j=1}^{2} \alpha_{ij} \ln w_i \ln w_j \\
&+ \sum_{i=1}^{3} \beta_i Y_i + \frac{1}{2}\sum_{i=1}^{3} \sum_{j=1}^{3} \beta_{ij} Y_i Y_j + \sum_{i=1}^{2} \sum_{j=1}^{3} \gamma_{ij} \ln w_i Y_j \\
&+ \delta\, FORM + \sum_{i=1}^{2} \delta_{wi}\, FORM \ln w_i + \sum_{i=1}^{3} \delta_{yi}\, FORM\, Y_i + u \qquad (13)
\end{aligned}
$$

where: $\delta_{w1} + \delta_{w2} = 0$ in addition to the restrictions in (3) to make the cost function homogeneous of degree one in input prices. FORM is a dummy variable, such that FORM = 1 for a mutual company and 0 for a stock company, added to test the *managerial-discretion hypothesis* (Mayers and Smith, 1981). According to this hypothesis, mutual companies could be less efficient owing to difficulties in monitoring managers' activities. Previous scale economy studies (e.g., Grace and Timme, 1992) have not found support for this hypothesis.

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6 Using the Herfindahl (H) index as a measure of specialisation, H = 0.81 for the smallest class, and 0.50, 0.44, 0.37, and 0.43 respectively for the other four classes.

Since only one of the share equations is independent, we choose to include only the labour share equation - shown below with a random error term added - in our estimating system. Maximum likelihood parameter estimates are invariant to this choice.

$$s_1 = \alpha_1 + \sum_{j=1}^{2} \alpha_{1j} \ln w_j + \sum_{j=1}^{3} \gamma_{1j} Y_j + \delta_{w1} \text{FORM} + v \tag{14}$$

Expressing our dependent variables as logarithmic transformations of C and a cost share helps to alleviate any heteroscedasticity and extreme values in the data set. We assume that the two error terms are identically and independently distributed, but with contemporaneous covariance across equations. The functional form of the distribution is assumed to be multivariate normal.

EMPIRICAL RESULTS

After imposing the homogeneity restrictions and the symmetry requirements $\beta_{ij} = \beta_{ji}$, our estimating system, (13) and (14), involves 21 free parameters. These were estimated by the method of maximum likelihood as outlined in the econometric program SHAZAM by White (1993).[7] The results are presented in Table 3.

The asymptotic distribution of the t-ratios is the standard normal. There is only a five per cent chance that each will be greater than 1.96 in absolute value if the relevant null hypothesis was true. By this criterion, the hypothesis that $\alpha_{12} = 0$ cannot be rejected at the five per cent level of significance. The implication is that elasticity of input substitution is unitary, implying that the cost function has the Cobb-Douglas form except for the terms involving the outputs.

Another interesting feature of these results is that the coefficients associated with output 3 (other output) are individually not significant. Four of these coefficients - β_{13}, β_{23}, β_{33}, and

[7] The NL command of SHAZAM does not accept zero output values in evaluating the expression $\frac{y_i^{\lambda} - 1}{\lambda}$. This problem was overcome by replacing all zero output values by a very small number, 0.000000001. Since output quantities are measured in millions of 1992 dollars, this amounts to assuming that such companies had less than one cent of annual premium income in the outputs concerned.

Table 3
Maximum Likelihood Estimates of Coefficients

	Coefficient	t - ratio		Coefficient	t-ratio
α_0	1.218	4.350*	γ_{11}	0.024	4.299*
α_1	0.837	32.161*	γ_{12}	-0.002	-1.496
α_{12}	-0.019	-0.167	γ_{13}	0.001	0.935
β_1	0.462	2.919*	δ	0.806	3.989*
β_2	0.328	4.392*	δ_{y1}	-0.130	-2.169#
β_3	0.045	1.168	δ_{y2}	0.033	2.049#
β_{11}	0.154	4.152*	δ_{y3}	-0.012	-1.115
β_{22}	0.016	1.794@	δ_{w1}	0.026	1.154
β_{33}	0.004	0.920	λ	-0.058	-1.633
β_{12}	-0.011	-1.478			
β_{13}	0.001	0.223			
β_{23}	-0.001	-0.515			

The symbols *, # and @ indicate statistically significant differences (of the associated coefficient from zero) at the 1%, 5% and 10% levels respectively.

γ_{13} - have t-ratios less than one in absolute value. The likelihood-ratio test statistic for the joint hypothes is $\alpha_{12} = \beta_{13} = \beta_{23} = \beta_{33} = \gamma_{13} = 0$, which is a chi-square random variable with five degrees of freedom, had a value of only 3.465. As a consequence, this hypothesis cannot be rejected at the five per cent level of significance, the critical value being 11.07.

Under the above hypothesis, two of the dummy variable coefficients - δ_{w1} and δ_{y3} - have t-ratios barely above one in absolute value. Hence, we tested the extended hypothesis $\alpha_{12} = \beta_{13} = \beta_{23} = \beta_{33} = \gamma_{13} = \delta_{w1} = \delta_{y3} = 0$. The corresponding likelihood ratio statistic is a chi-square variable with seven degrees of freedom. As the test statistic had a value of 8.482 compared to the critical value of 14.067, this hypothesis also cannot be rejected at the five per cent level of significance.

Given these results, we estimated a simpler model with coefficients as shown in Table 4. In this model, output 3 appears through the coefficient β_3 only. Its estimated value, though not significant at the 10 per cent level, has a t-ratio greater than one. Retention of this coefficient is justified on the theoretical grounds that the total size of all outputs is an important determinant of the cost of production. Our subsequent results and tests are based on this model as our maintained hypothesis.

Table 4
Maximum Likelihood Estimates of Coefficients of the Simpler Model

	Coefficient	Standard Error	t - ratio
α_0	1.338	0.214	6.254*
α_1	0.824	0.024	33.619*
β_1	0.349	0.115	3.025*
β_2	0.378	0.079	4.768*
β_3	0.025	0.023	1.067
β_{11}	0.067	0.038	1.785@
β_{22}	0.082	0.020	4.117*
β_{12}	-0.069	0.021	-3.297*
γ_{11}	0.026	0.007	3.767*
γ_{12}	-0.010	0.005	-2.086#
δ	0.753	0.212	3.555*
δ_{v1}	-0.166	0.058	-2.872*
δ_{v2}	0.137	0.049	2.796*
λ	0.131	0.055	2.390#

The symbols *, # and @ indicate statistically significant differences (of the associated coefficients from zero) at the 1%, 5% and 10% levels respectively.

As single equation R^2 measures are not appropriate in an equation system context, we measure overall goodness of fit as:

$$\tilde{R}^2 = 1 - \frac{|E'E|}{|y'y|} \tag{15}$$

where E is the matrix of residuals in the two equations, and y is the matrix of deviations of the two dependent variables from their respective means (Berndt, 1991, pp.468). For the model in Table 4, $\tilde{R}^2$ = 0.959, indicating an adequate fit to the data.

The meaning of the results accepted from Table 4 is as follows: $\delta_{w1} = 0$ implies that input demands and their price elasticities do not depend on organisational form (stock or mutual), and $\delta_{y3} = 0$ indicates that organisational form makes no difference to the responsiveness of cost to output 3. However, cost efficiency and measures of economies of scale and scope may differ by the form of organisation, as the joint hypothesis $\delta = \delta_{y1} = \delta_{y2} = 0$ was decisively rejected at the five per cent level. The chi-square test statistic (with three degrees of freedom) was 15.687 compared to the critical value 7.815. Given these results, the effect of organisational form on cost of production is measured as:

$$\frac{\partial \ln C}{\partial FORM} = \delta + \delta_{y1} Y_1 + \delta_{y2} Y_2 \qquad (16)$$

Since our estimates of δ_{y1} and δ_{y2} are of opposite signs, the overall effect of organisational form will be highly sensitive to the scale and composition of output. The effects on the product specific measures are, however, obvious. Mutual companies tend to be more cost efficient in producing life insurance (δ_{y1}= -0.166), but less efficient in superannuation output (δ_{y2}= 0.137), than stock companies.

Our results also indicate that the cost function is not separable in input prices and outputs, meaning that the aggregation of outputs is not permitted. As established earlier, it is a part of our maintained hypothesis that $\gamma_{13} = 0$, but the joint hypothesis that $\gamma_{11} = \gamma_{12} = 0$ can be rejected at the five per cent level, the chi-square test statistic having a value of 20.365 versus the critical value 5.991. Thus, the common practice of aggregating several outputs into a single measure is likely to be flawed. Finally, rejection of the hypothesis $\lambda = 0$ - its t-ratio being 2.390 - implies that the output variables do not enter the cost function in the usual logarithmic form.

Measures of economies of scale and scope for NZ life insurance companies producing all three output types are shown in Table 5 for the year 1992. The firms are arranged by size in ascending order. The general scale measure is calculated using (6) and (7) and allowing for the dummy variable. Economy of scope with three kinds of output is calculated, by extension of (10), as:

$$S_C = \frac{c(y_1,0,0)+c(0,y_2,0)+c(0,0,y_3)-c(y_1,y_2,y_3)}{c(y_1,y_2,y_3)} \quad (17)$$

Similarly, average incremental cost of output 1 in the three output case is given, by extension of (9), as:

$$AIC_1 = \frac{c(y_1,y_2,y_3)-c(0,y_2,y_3)}{y_1} \quad (18)$$

AIC_2 and AIC_3 are defined in a similar way.

As our measure of scope economies compares cost of production with and without multiple outputs, Table 5 reports measures only for those companies producing all three types of output in 1992. [8] One significant feature of these results is that scale economies disappear quite quickly. Measuring size by total annual premium income, returns to scale become constant at about NZ$20 million (i.e., at about the size of SOVEREIGN and CIGNA). Results for the medium-sized firms (NORWICH, FAI, SUN ALL, GRE and CML) indicate that scale diseconomies have clearly set in at about NZ$40-50 million. The five industry leaders exceeding NZ$130 million (AMP, NML, TOWER, PRU and NZI) experience considerable overall scale diseconomies. In contrast, all firms enjoy non-trivial economies of scope, but these tend to increase with company size. The five largest companies gain enormous economies, to the extent that separate production of their 1992 output mixes would cost 45 - 100 per cent more than joint production. In contrast, the very small firms (FARMERS, PACIFIC, and FIDELITY) have much smaller economies of scope, and are disadvantaged by diseconomies of small size. As our measure of scope economies also depends upon product-mix, the effect of size of business on economy of scope is not obvious for the medium-sized firms, which have rather different output compositions.

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[8] These companies can be classified by size as: very big :Australian Mutual Provident (AMP), National Mutual Life (NML) and Tower Life (TOWER); big: The Prudential (PRU) and New Zealand Insurance Life (NZI); medium: Colonial Mutual Life (CML), Guardian Royal Exchange (GRE), Sun Alliance Life (SUN ALL), FAI Metropolitan Life (FAI METRO) and Norwich Union (NORWICH); small: Cigna Life (CIGNA), Sovereign Assurance (SOVEREIGN), Fidelity Life (FIDELITY) , Pacific Life (PACIFIC) and Farmers Mutual Life (FARMERS).

A practical difficulty in implementing formulae like (17) and (18) is that they require estimating costs when some outputs are zero. For most firms, this involves extrapolation at potential observations well outside the sample range used to estimate the cost function parameters (Suret, 1991). In calculating economies of scope measures in Table 5, we required incremental costs like $c(y_1, y_2, y_3) - c(0, 0, y_3)$ to be non-negative as they are supposed to be

Table 5
Economies of Scale and Scope in the 15 New Zealand Life Insurance Companies Producing All Three Outputs, 1992

	Scale	Scope
FARMERS	1.326	0.304
PACIFIC	1.245	0.286
FIDELITY	1.090	0.297
SOVEREIGN	1.000	0.188
CIGNA	0.980	0.550
NORWICH	0.931	1.000
FAI METRO	0.824	0.846
SUN ALL	0.857	0.277
GRE	0.850	0.387
CML	0.838	0.441
NZI	0.740	1.000
PRU	0.753	0.706
TOWER	0.745	0.457
NML	0.729	1.000
AMP	0.714	1.000

theoretically.[9] As some were not, measurement of product-specific scale economies using (8) led to implausible estimates. As an alternative, some studies (e.g., Grace and Timme, 1992)

9 Economies of scope are optimised when the output-mix corresponding to the lowest point of the cost surface along a transray is chosen. A local measure of economies of scope not subject to the extrapolation problem might be developed by measuring the loss of cost advantage resulting from a movement away from the optimal choice of product-mix.

rely on product-specific diminishing marginal costs. However, this feature is sufficient, but not necessary for the existence of such economies, since economies can be present when marginal costs are rising, but below average costs. Apart from this underestimation problem, the approach also provides only an indication of the presence of economies, and not a measure of its magnitude. As an alternative, some authors (e.g., Caves et al., 1980; Friedlander and Spady, 1980) have used the reciprocal of product-specific output elasticity of cost. However, this causes an over-estimation of scale economies (Kim, 1987).

An alternative approximation to (8) that neither systematically underestimates nor overestimates scale economies, can be developed as follows. Let C_i be the incremental cost of product i; by (8), product -specific scale economy then becomes:

$$S_i = \left(\frac{C_i}{y_i}\right) MC_i^{-1} = \left(\frac{C_i}{C}\right)\left(\frac{C}{y_i}\right) MC_i^{-1} = \left(\frac{C_i}{C}\right)\left(\frac{\partial \ln C}{\partial \ln y_i}\right)^{-1}. \tag{19}$$

If we approximate the cost share of the ith output by its share in the total value of all outputs, $SY_i = \frac{P_i y_i}{\sum_j P_j y_j}$, then product specific scale economies can be measured as:

$$S_i = SY_i \left(\frac{\partial \ln C}{\partial \ln y_i}\right)^{-1} \tag{20}$$

Product-specific estimates based on this definition, and the coefficient estimates in Table 4, are displayed in Table 6. The pattern of economies and diseconomies of scale for life insurance (S1) - the main output of the industry - mirrors quite closely, and is clearly the driving force behind, the overall pattern in Table 5. With superannuation output (S2) all companies - even the smallest ones - experience diseconomies of scale, which increase with size, whereas with other output (S3) substantial economies of scale is the norm. Table 6 also reveals that, for a given size of company, mutual companies tend to have higher scale economies in life insurance output, and greater diseconomies in superannuation, than stock companies.

As our measures of economies of scale and scope depend on size, composition of output and organisational form, it is useful to know how these measures vary with two of the determinants remaining the same. These results are reported in Table 7 for a representative range of eight companies. Each column (for the mutual form) shows, for a given size of total output, the variations in scale economies caused by variations in output-mix between the companies. Each row shows, for a given output-mix, the extent of scale economies as total output is expanded. The output-mixes and total outputs used (the latter measured by annual premium income) are those of the companies concerned in 1992. Values in parentheses are the estimates if the firms had been stock companies.

Table 6
Product Specific Economies of Scale in the 15 New Zealand Life Insurance Companies Producing All Three Products, 1992

Firm	S1	S2	S3	FORM
FARMERS	2.536	0.678	0.195	1
PACIFIC	1.516	0.846	0.185	0
FIDELITY	1.199	0.676	4.201	0
SOVEREIGN	1.090	0.488	3.611	0
CIGNA	0.870	0.625	8.165	0
NORWICH	1.222	0.245	5.334	1
FAI	0.983	0.634	0.562	0
SUN ALL	0.790	0.401	6.704	0
GRE	0.804	0.442	6.428	0
CML	1.230	0.359	7.382	1
NZI	0.677	0.501	6.096	0
PRU	0.696	0.409	6.159	0
TOWER	0.726	0.213	11.484	1
NML	0.673	0.134	6.866	1
AMP	0.729	0.145	4.984	1

Table 7 thus shows that scale economies are experienced only by the smaller companies, and diseconomies only by the larger companies, regardless of mix of output. Constant returns to scale are reached by stock companies at an annual premium income of about NZ$20 million, and at a somewhat larger figure for mutual companies.

Table 7
Variation of Scale Economies by Size and Mix of Output of Selected New Zealand Life Insurance Companies, 1992

	Size of Total Output ($m)							
Output-mix	FARM 3.76	FIDEL 10.15	SOV 19.09	SUNAL 60.33	CML 89.79	PRU 136.93	TOWER 278.78	AMP 346.83
77 : 13 : 10 SOV	1.39 (1.27)	1.20 (1.09)	1.09 (1.00*)	0.91 (0.84)	0.86 (0.79)	0.80 (0.74)	0.72 (0.66)	0.69 (0.64)
73 : 05 : 22 AMP	1.45 (1.30)	1.25 (1.12)	1.13 (1.02)	0.95 (0.85)	0.89 (0.80)	0.83 (0.75)	0.74 (0.67)	0.71* (0.65)
68 : 32 : 00 FARM	1.33* (1.25)	1.14 (1.08)	1.04 (0.98)	0.87 (0.82)	0.82 (0.78)	0.77 (0.73)	0.69 (0.65)	0.67 (0.63)
67 : 23 : 10 FIDEL	1.35 (1.26)	1.17 (1.09*)	1.06 (0.99)	0.89 (0.83)	0.84 (0.79)	0.79 (0.74)	0.70 (0.66)	0.68 (0.64)
63 : 13 : 24 SUNAL	1.40 (1.29)	1.21 (1.12)	1.10 (1.02)	0.93 (0.86*)	0.87 (0.81)	0.82 (0.76)	0.73 (0.68)	0.71 (0.65)
56 : 20 : 24 PRU	1.38 (1.29)	1.19 (1.11)	1.08 (1.01)	0.91 (0.85)	0.86 (0.80)	0.80 (0.75*)	0.72 (0.67)	0.69 (0.65)
43 : 29 : 28 CML	1.35 (1.28)	1.16 (1.11)	1.06 (1.01)	0.89 (0.85)	0.84* (0.80)	0.78 (0.75)	0.70 (0.67)	0.68 (0.65)
24 : 21 : 55 TOWER	1.42 (1.36)	1.23 (1.18)	1.12 (1.07)	0.94 (0.90)	0.89 (0.85)	0.83 (0.80)	0.74* (0.71)	0.72 (0.69)

A number marked by an asterisk is the measure of scale economy for the company concerned using its own size, product-mix and form.

Finally, in Table 8, we show variation in cost of production by output size and mix in 1992 for all companies listed in ascending order of output size. The estimated production cost of each company using its own product-mix in 1992 is given in the first column.. The last five columns show the estimated cost for each company of producing its 1992 total output using the average output mixes of the five size classes identified in Table 2 (COST1 refers to the output-mix of the smallest size class, COST5 to the largest). Given our finding of substantial economies of scope, it is not surprising that production cost varies considerably by output-mix. Interestingly, the output mixes of the smallest companies appear to have been optimal for

Table 8
Variation of Production Costs ($m) by Size and Mix of Output of New Zealand Life Insurance Companies, 1992

COMPANY	ACTUAL COST	COST1	COST2	COST3	COST4	COST5
SWANN	0.1850	0.3772	0.4510	0.4670	0.4838	0.4089
CICOAM	0.2554	0.5331	0.6522	0.6788	0.7071	0.5820
EQUITABLE	0.3266	0.6831	0.8488	0.8867	0.9273	0.7490
ANSVAR	0.2092	0.5389	0.5926	0.6017	0.6000	0.5217
GWICH	0.6543	0.7319	0.8073	0.8206	0.8182	0.7028
HALLMARK	1.4957	1.3861	1.5361	1.5645	1.5595	1.3062
INVINCIBLE	1.7706	1.4659	1.6250	1.6553	1.6500	1.3790
CUNA	1.4494	2.3570	3.1302	3.3263	3.5463	2.6119
SSURE	3.3271	4.8391	6.6280	7.1092	7.6624	5.3552
OCEANIC	6.5633	3.9844	4.4200	4.5154	4.4993	3.6158
AMLIFE	4.7026	5.7930	7.9893	8.5887	9.2820	6.4035
FARMERS	10.0443	5.8473	8.0670	8.6732	9.3746	6.4631
MEDICAL	4.3254	5.8690	8.0980	8.7070	9.4117	6.4869
PACIFIC	5.4981	4.4876	4.9764	5.0855	5.0671	4.0533
NATINS	9.1891	10.5428	14.8433	16.0745	17.5270	11.5842
FIDELITY	12.0556	9.9718	11.0038	11.2669	11.2241	8.7044
SOV	20.3797	18.2753	20.0373	20.5435	20.4634	15.5030
CIGNA	23.9780	21.6289	23.6626	24.2686	24.1735	18.1955
NORWICH	79.6064	62.9326	92.4445	102.1626	114.3054	66.6752
FAI	86.2817	63.9940	68.7582	70.6589	70.3771	50.8184
SUNALL	63.0671	65.0048	69.8226	71.7546	71.4684	51.5756
GRE	67.9173	66.2162	71.0978	73.0672	72.7758	52.4821
CML	189.0177	102.8919	152.2128	169.0896	190.5029	107.4427
NZI	206.6583	182.3026	191.3037	196.8961	196.1174	136.0934
PRU	186.6243	186.7795	195.8810	201.6136	200.8167	139.2265
TOWER	494.0189	431.8453	645.4808	727.3690	835.9078	428.0135
NML	464.1931	577.4088	863.3468	975.5505	1125.5661	565.3100
AMP	533.6260	588.0851	879.3121	993.7613	1146.8625	575.3069

their output sizes in 1992, whereas most of the medium-sized and larger companies could have produced at a lower cost by using the average output mix of the largest size group of companies.

IMPLICATIONS AND CONCLUSIONS

In this paper we have developed and applied a two input/three output translog model of production to the New Zealand life insurance industry. The data used has the advantage of being company- based, not fleet-based as in some US studies, and of covering the entire population of companies (except recent bank entrants), giving a great range of sizes and degrees of diversification. Moreover, in the small market most companies operate on a country-wide basis, and with the industry being almost unregulated by international standards, the data is unlikely to suffer distortion from regulatory constraints. The tax system also does not discriminate between mutual and stock companies. Against these advantages, we have to recognise, in common with many other studies, the problem posed by premiums as a proxy measure of output. Its use implies that different companies sell similar types of policies at similar premium rates. A second problem is that the results may be biased by the fact that the larger companies (as overseas) tend to be "composites", in that they sell general as well as life insurance, whereas the small companies do not.

Bearing these caveats in mind, the results reveal that economies of scale are important, but only for the smallest companies. The most efficient size is reached at a premium income of only about NZ$20 million (US$12.6 million), beyond which diseconomies set in, and these significantly raise costs for the medium-sized and large companies. This result is driven by the pattern of product-specific economies and diseconomies of scale experienced in the production of the largest single output, life insurance. With the superannuation output, all firms inexplicably encounter diseconomies, and these increase with company size. For the "other" (investment-type) output substantial scale economies is the norm.

Our study appears to be the first to uncover widespread economies of scope in life insurance, which are found to be enjoyed by all firms, but which tend to increase with company size. Despite the lack of previous empirical support, this finding is consistent with the view that life insurance production is likely to involve the employment of the shared (or *quasi-public*) inputs that are required to generate economies of scope (Hardwick, 1993, 1994). Nonetheless, within the range of product-mixes experienced by the diversified firms, scale economies tend to override scope economies, so that the smallest firms of differing product-mixes still operate with scale economies, and the larger firms with scale diseconomies. This raises the awkward question as to how the relatively inefficient smallest and larger firms have managed to survive, when competition would be expected to drive them out. The answer may be that competition is blunted by the inability of buyers to compare the prices and products of rival companies, as evidence from the US suggests (Fields, 1988). And in these circumstances the largest companies may have marketing advantages stemming from their longevity in the market, the reputation they have built up over that time, and their extensive advertising. This suggests that the smallest firms are the most vulnerable, and indeed four have exited since 1989.

Finally, the organisational from of life insurance companies does appear to influence their costs, but not in the way expected by the *managerial discretion hypothesis*. Our results show that mutual companies tend to be lower cost producers of (or enjoy greater product-specific scale economiesin) life insurance, but face higher costs in producing superannuation, compared to stock companies.

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