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DISCUSSION PAPER NO. 271

Productivity, Scale Economies and Technical Progress in the Canadian Life Insurance Industry

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RÉSUMÉ

Le présent document traite de la productivité de l'industrie canadienne de l'assurance-vie. Nous mettons d'abord au point une mesure de la productivité totale des facteurs, dans le cas des sociétés d'assurance-vie, puis nous cherchons à définir les principaux facteurs de l'accroissement de la productivité de 1961 à 1977, en regroupant des données chronologiques et transversales relatives à 31 compagnies. Nous concluons ensuite que, pour l'ensemble de l'industrie, le progrès technique a représenté de loin la source de croissance de la productivité la plus importante, et qu'il n'existait pas d'économies d'échelle.

Abstract

The purpose of this paper is to examine the productivity performance of the Canadian life insurance industry. We construct a measure of total factor productivity for life insurance companies and then attempt to determine the main determinants of improved productivity during the period 1961-77 by pooling time-series and cross-section data from 31 firms. We conclude that for the industry as a whole technical progress was by far the most important source of productivity growth, while scale economies were nonexistent.

1. INTRODUCTION

Hitherto most studies of productivity in Canada and elsewhere have focused on manufacturing, even though this particular sector is responsible for little more than 20 per cent of Real Domestic Product (RDP). By contrast, the service sector, which accounts for over 60 per cent of RDP, has been largely neglected, mainly because of the inherent difficulty in deriving appropriate measures of real output for service industries. Needless to say, analyses of industry growth and productivity are only as good as the output measure on which they are based. Unfortunately, the output measures for most service industries are extremely poor. In many cases production in the service sector as measured in the national accounts is no more than an index of factor inputs, with the result that productivity change is, by definition, zero. Consequently, economists have had to reconcile themselves to the fact that at least part of the disparity in productivity growth between the service and goods-producing industries is a statistical illusion arising from the inadequacy of existing output measures. This in turn has led to the realization that the extent of the post-1973 decline in productivity growth in Canada may have been exaggerated due to the shift in output and factors of production from goods-producing industries to service industries where measured productivity growth has been relatively slower.

However, judging from recent work concerning the financial service sector, which is of growing relative importance in the economy, the problems involved in deriving appropriate measures of output and therefore productivity for service industries are not insurmountable. Hirshhorn and Geehan (1977) and Geehan and Allen (1978) have constructed indices of total output in the banking and life insurance industries in Canada, while Benston, Hanweck and Humphrey (1982), for example, have created an index for total output in the U.S. banking industry. Nevertheless, these studies stopped short of attempting to explain productivity growth in the financial service sector.

The intent of the present paper is to examine the productivity performance of one such service industry in Canada, namely, life insurance. Drawing on previous work by Hirshhorn and Geehan (1977), we construct a measure of total factor productivity (TFP) for firms in the life insurance industry and then attempt to determine the main sources of its growth during the period 1961-77 by pooling time-series and cross-section data from 31 federally registered Canadian companies operating throughout the 17-year period.[1]

Probably the most commonly cited source of TFP growth in life insurance has been scale economies. Studies by Johnston and Murphy (1957) together with Colenutt (1977) in the United Kingdom, Houston and Simon (1970) and Pritchett (1971, 1973) in the United States together with that by Geehan (1977) in Canada, all indicate downward sloping or at least L-shaped average cost curves, which implies increasing or constant returns to scale. But the foregoing studies use cost functions that are not sufficiently general to yield a U-shaped average cost curve. To correct this oversight, we fit a generalized translog cost function which allows us to determine whether average cost curves in the life insurance industry are U-shaped or not and, therefore, whether there exists an optimum or minimum cost company size. Use of the translog cost function also enables us to examine the impact of scale economies, technical progress, and other relevant variables, such as corporate form and foreign business, on TFP growth.

The next section highlights the importance of improvements in TFP for output growth in the life insurance industry. The translog cost function model is presented in section 3, and our empirical results are reported in section 4. A final section contains a summary of our main conclusions.

2. THE IMPORTANCE OF TOTAL FACTOR PRODUCTIVITY IN THE LIFE INSURANCE INDUSTRY

The importance of improvements in TFP for output growth can be demonstrated by using the following well-known accounting relationship:[2]

$$\dot{Q} = S_K\dot{K} + S_L\dot{L} + S_M\dot{M} + \dot{TFP} \qquad (1)$$

which states that the rate of output growth (Q) is determined by the cost share weighted sum of the rates of growth of capital ($\dot{K}$), labour ($\dot{L}$), and intermediate materials ($\dot{M}$) plus TFP growth. S_i denotes the cost share associated with input i = K, L, M. The four terms on the right-hand side of equation (1) are displayed in subsequent rows of Table 1, which thus summarizes the relative importance of input and TFP growth for output growth. Three main points warrant attention.

First, improvements in TFP were the primary source of output growth in the Canadian life insurance industry. During the periods 1962-66, 1967-73 and 1974-77, TFP grew at average annual rates of 1.1, 2.1 and 2.4 per cent, thereby accounting for 32.3, 52.5, and 77.4 per cent of the output growth recorded in those respective periods. Second, unlike in most other major sectors of the economy, TFP growth accelerated slightly rather than slowed down after 1973. Third, TFP growth in the life insurance industry compares favourably with many other sectors of the economy, including manufacturing.[3] The remainder of this paper is concerned with the measurement of the main sources of TFP growth.

3. A TRANSLOG COST FUNCTION MODEL

Assuming firms minimize their total costs of production, the general form of the cost function (C) can be represented as:

$$C = C(P_K, P_L, P_M, Q, T) , \tag{2}$$

where P_K, P_L, P_M, respectively, are the input prices of capital, labour and materials, Q is the measure of output as defined in the Appendix, and T is time which serves as a proxy for the level of technology. This model maintains that all factor markets are competitive and that each firm is prepared to supply all life insurance demanded at any given price. The arguments of the cost function are exogenous variables whereas input levels are endogenous.

The translog cost function can be viewed as a second-order Taylor series approximation to any arbitrary twice-differentiable cost function satisfying the appropriate regularity conditions. As the translog in its general form imposes no prior restrictions on the production structure, it permits the estimation of U-shaped average cost curves as well as the substitution possibilities among factors of production, the degree of homotheticity, the extent of scale economies, and the nature of technical progress.

The translog approximation to the general form of the minimal cost function (2) is expressed as:

$$\ln C = \alpha_0 + \sum_i \alpha_i \ln P_i + 1/2 \sum_i \sum_j \alpha_{ij} \ln P_i \ln P_j$$

$$+ \alpha_Q \ln Q + 1/2\ \alpha_{QQ}(\ln Q)^2 + \alpha_T T + 1/2\ \alpha_{TT} T^2$$

$$+ \sum_i \alpha_{iQ} \ln P_i \ln Q + \sum_i \alpha_{iT} \ln P_i T + \alpha_{QT} \ln Q T. \qquad (3)$$

Logarithmic partial differentiation of (2) with respect to each input price and applying Shephard's lemma[4] yields a set of three cost share equations:

$$S_i = \alpha_{iQ} \ln Q + \sum_j \alpha_{ij} \ln P_j + \alpha_{iT} T . \quad (i,j = K,L,M) \qquad (4)$$

We can then compute the Allen-Uzawa partial elasticities of substitution between two inputs i and j.

In order to estimate the parameters of the translog cost function, we estimate jointly the cost function (3) and the cost share equations (4) as a multivariate regression system (subject to certain symmetry, input price homogeneity and duality conditions[5]) using an iterative Zellner procedure. This procedure greatly increases the statistical degrees of freedom and thus permits more accurate identification of the translog cost function parameters than estimation of the latter alone.

4. EMPIRICAL RESULTS

Parameter estimates for our translog cost function are reported in Table 2. They are then used to compute estimates of the own- and cross-price elasticities, shown in Table 3, as well as estimates of scale economies and technical progress given in Table 4. We can then determine the contributions of scale economies and technical progress to total factor productivity growth.

Elasticities of Substitution

As expected, the own-price elasticities are negative. The fact that their absolute values are all less than unity indicates that the usage of each input is inelastic with respect to its own price. The cross-price elasticities are positive, implying that all three inputs are substitutes for each other in the production of life insurance.

Homotheticity

For the cost function to be homothetic, the optimal input combination must be independent of the scale of output so that the expansion path is linear. This is the case if all the input price-output interaction terms (α_{iQ}) are zero. The estimates reported in Table 2 indicate statistically significant nonhomotheticity involving all three inputs. The fact that α_{KQ} and α_{LQ}

are positive and α_{MQ} is negative implies that as output increases, proportionately more capital and labour but less materials are used.

Scale Economies

The elasticity of cost with respect to output, ε_{CQ}, can be interpreted as a measure of scale economies.[6] If ε_{CQ} is less (greater) than unity, cost increases less (more) than proportionately with increases in output, implying the existence of scale economies (diseconomies). From the translog cost function (3),

$$\varepsilon_{CQ} = \alpha_Q + \alpha_{QQ}\ln Q + \sum_i \alpha_{iQ}\ln P_i + \alpha_{QT}T \ . \qquad (5)$$

so that the degree of scale economies is determined by output, input price and time (technology). Estimates of ε_{CQ} for each of the 31 companies based on their scale of operation and input prices in each year are reported in Table 4. These estimates range from 0.73 to 1.12, with the smallest companies having the lowest values and the largest ones the highest values. This implies that the operations of relatively small companies are characterized by significant scale economies while those of the relatively large ones exhibit significant scale diseconomies, thus indicating the existence of U-shaped average cost (AC) curves in the life insurance industry. As the ten largest companies, which account for about 85 per cent of the industry's total output, have values of ε_{CQ} that exceed unity, the weighted average value of ε_{CQ} for all 31 companies was calculated to be 1.05 in each of the three periods. This implies that a 1 per cent increase in the industry's output results in approximately a 1.05 per cent increase in total costs.

The parameters responsible for the variability in the estimates of ε_{CQ} reported in Table 4 can be identified for equation (5). The impact of input prices on scale economies is measured by α_{KQ}, α_{LQ} and α_{MQ}, while α_{QQ} and α_{QT} capture the effects of output and time (technology). Positive (negative) values indicate that increases in the corresponding variables lead to lower (greater) scale economies. The estimates of the foregoing parameters found in Table 2 show that α_{KQ}, α_{LQ} and α_{MQ} are all statistically significant at the 99 per cent level. Consequently, changes in input prices result in input combinations along expansion paths that exhibit statistically significant differences in the degree of scale economies. Increases in the prices of capital and wages move firms to expansion paths characterized by lower scale economies while increases in material prices lead to greater scale economies. Also, the fact that α_{QQ} is positive and statistically significant means that changes in firm size have an impact on the degree of scale economies. By contrast, the effect of technical change, α_{QT}, was small and statistically insignificant.

Technical Progress

Technical progress is also an important source of productivity growth. The rate of technical progress, ε_T, can be represented as the negative of the rate of growth of total cost over time. Ignoring the term $\alpha_{TT}T^2$ in the translog cost function,

$$\varepsilon_T \equiv - \frac{\partial \ln C}{\partial T} = - (\alpha_T + \sum_i \alpha_{iT} \ln P_i + \alpha_{QT} \ln Q). \qquad (6)$$

The estimated values of ε_T for all 31 companies, based on the parameter estimates in Table 2 and the actual data on input prices and output observed for each company during each of the three periods, are also reported in Table 4. Two main features of ε_T warrant attention. First, the rate of technical progress has been increasing in all firms over the 17-year period. Second, larger firms experience greater rates of technical progress than smaller ones.

As defined in equation (6), technical progress is affected by changes in input prices and output. The parameter estimates suggest that technical progress is capital- and material-using (α_{KT}, $\alpha_{MT} > 0$) but labour-saving ($\alpha_{LT} < 0$). Consequently, increases in capital and material prices not only encourage the substitution of labour for these two inputs, it also makes the adoption of capital- and material-using innovation more expensive. This results in a lower rate of cost reduction associated with technical progress. On the other hand, as technical progress is labour-saving, higher wages tend to encourage technical progress. Remark, however, that all these parameters are small and/or statistically insignificant.

It also appears that increased output leads to more rapid technical progress ($\alpha_{QT} < 0$), a feature which helps to explain why the rate of technical progress is higher in larger firms. This result is consistent with previous research by Petersen, Rudelius and Wood (1972), as well as Globerman (1983), which found that large life insurance companies were quicker to adopt innovations than small ones. Part of this difference in behaviour is no doubt attributable to technological indivisibilities which arise because the adoption of new technology frequently requires a minimum expenditure that is substantial relative to the size of the average potential adopter, especially in the early stages of the diffusion process. These indivisibilities act as barriers to the adoption of new production techniques by small and medium-sized companies.

Optimum Firm Size

Scale economies in the provision of life insurance and the rate of technical progress are, of course, both major determinants of optimum firm size. On the basis of scale economies alone, minimum average cost and therefore optimum firm size would be achieved at output levels of between approximately $10 million and $23 million (1971$) during the 1974-77 period, that is, somewhat higher than the output level of National but below that of Imperial. However, it has to be kept in mind that technical progress shifts the average cost curve downward. The fact that technical progess increases with company size means that the resulting downward shift in the average cost curve is proportionately greater for larger than for smaller firms. Thus, technical progress tends to offset the adverse impact on costs of scale diseconomies in the largest firms. The optimum size, taking both scale economies and technical progress into account, is obtained by examining predicted average cost (PAC). As shown in Table 5, for the 1974-77 period predicted average cost reaches a minimum at the output level attained by Imperial, thus indicating that the latter's size is optimal. This suggests that the top three life insurance companies (Manufacturers Life, London Life, and Sun Life) are far too big while the 13 smallest ones are too small.

The existence of significant variation in unit costs and especially the survival alongside large and medium-sized firms of inefficient small ones despite the latters' higher unit costs, implies that the industry is not perfectly competitive. This situation is probably partly due to buyer ignorance, which permits high cost and high price insurers to continue to operate.

It may also be the consequence of noncompetitive "umbrella" pricing by larger more efficient firms; that is, large firms may set prices sufficiently high to earn excess profits for themselves while permitting small inefficient firms to earn the minimum necessary profit rate for survival. Large firms may do this rather than lower prices to drive out small competitors and increase their market share because they fear stiffer anti-combines legislation or other regulations in the wake of a higher degree of seller concentration, or because, in the trade-off between market share and profits they prefer higher profits and lower market share. In any event, the result is that the insurance industry's total output is being produced at a total cost in excess of the minimum achievable.

Some Additional Explanatory Variables

In an attempt to shed further light on the determinants of costs and productivity in the Canadian life insurance industry, the translog cost function was modifed to account for three additional firm characteristics: corporate form (X), the proportion of foreign business (Y), and computer facilities (Z). The parameter estimates of the modified translog cost function are reported in Table 6.

A popular hypothesis is that stock companies, being supposedly more profit oriented, are more efficient than mutual companies where the profits on all policies sold belong to the policy owners (Houston and Simon, 1970). However, differences in performance between stock and mutual companies in Canada are not likely to be very great for two reasons. First, a large proportion of the life insurance contracts sold in Canada by stock companies also consists of policies where virtually all the profits accrue to policy holders rather than shareholders. This is because Canadian legislation stipulates that, depending on the size of the fund, 90 to 97½ per cent of par fund profits on participating policies be allocated to the policyholders. In other words, for very large funds no more than 2½ per cent of the profits may be distributed to shareholders. Second, the industry is fairly competitive so that there is not much room for persistent differences in performance between mutual and stock companies. As it turns out, the coefficient of X, α_X, is neither of the expected sign, nor is it statistically significant.[7]

The proportion of foreign business seems to affect costs and therefore productivity in two opposite ways both of which are statistically significant. On the one hand, the higher the proportion of a firm's foreign business, the higher its costs ($\alpha_Y > 0$). This is perhaps due to the higher costs associated with operating in foreign countries with different legal and regulatory environments. On the other hand, the degree of returns to scale varies directly with the proportion of foreign business ($\alpha_{YQ} < 0$), which means that increased sales abroad result in higher scale economies and, consequently, TFP growth.

Finally, it would appear that computer facilities[8] also have a statistically significant bearing on costs, again working in two opposite directions. Computer facilities tend to reduce unit operating costs ($\alpha_Z < 0$). At the same time, however, they appear to have a negative impact on scale economies ($\alpha_{ZQ} > 0$), a finding which contradicts the widely held view that greater use of computers increases scale economies.

Sources of Productivity Growth

Given our estimates of ε_{CQ} and ε_T, we can determine the source of TFP growth in the life insurance industry. Following Denny, Fuss and Waverman (1981), estimated total factor productivity growth, $\dot{TFP}^*$ can be decomposed into parts related to scale economies, $(1-\varepsilon_{CQ})\dot{Q}$, and technical change, ε_T,

$$\dot{TFP} = (1-\varepsilon_{CQ})\dot{Q} + \varepsilon_T \cdot \qquad (7)$$

For the industry as a whole, the major source of TFP growth has been technical progress. Between 1961 and 1973 the average annual rate of technical progress was 1.3 per cent while during the 1974-77 period the rate increased to 1.5 per cent.

Throughout the entire period examined, the value of the ε_{CQ} for the industry has remained at around 1.05, implying the existence of scale diseconomies. There has thus been a tendency for output growth to reduce estimated TFP growth by an average of 0.2 percentage points annually in each of the three periods.

Remark that the estimated rate of TFP improvement falls short of the actual rate (see Table 1) during both the latter periods 1967-73 and 1974-77. Part of this discrepancy can be attributed to other factors that affect TFP growth. Notable among these are changes in the shares among relatively large and small firms of the industry's output. For example, between the periods 1961-66 and 1974-77, the ten largest firms, whose operations are characterized by scale diseconomies, lost nearly 2 per cent of their combined market share to smaller firms with scale economies. Such interfirm shifts contributed approximately 0.2 and 0.4 percentage points to estimated average annual TFP growth during the periods 1967-73 and 1974-77, respectively. However, these shifts account for only a small part of the discrepancy between estimated and actual rates of TFP growth in the latter periods.[9]

5. CONCLUSIONS

Having constructed an index of total factor productivity pertaining to the provision of life insurance and using a translog cost function model, we find that by far the greatest source of such productivity improvement during the 1961-77 period for the life insurance industry as a whole has been technical progress, the rate of which increases with firm size. By contrast, the predominance in the industry of a few large firms whose operations exhibit scale diseconomies has tended to reduce TFP growth slightly. Our empirical results also reveal that the average cost is U-shaped over the entire range of life insurance companies examined. Finally, when technical progress and scale economies are taken into account, we conclude that an optimum or minimum cost size occurs for institutions with about $23 million worth of real annual output in 1971$. In current (1983) dollar terms, using the GNE deflator, this corresponds to an output level of approximately $67 million.

We conclude by pointing out that in calculating optimum firm size, we were unable to take into account possible economies of scope and product-specific scale economies. To the extent that these are significant, optimum firm size also depends on product mix and the degree of diversification. Further work in this particular area may perhaps provide additional insights into the productivity performance of life insurance companies.

Table 1

Sources of Aggregate Life Insurance Output Growth:
Average Annual Rates of Growth

	1962-66	1967-73	1974-77
Capital ($S_K\dot{K}$)	0.5	0.3	0.1
Labour ($S_L\dot{L}$)	1.1	0.9	0.7
Materials ($S_M\dot{M}$)	0.7	0.7	-0.1
$\dot{TFP}$	1.1	2.1	2.4
$\dot{Q}$	3.4	4.0	3.1

Table 2

Estimates of Translog Cost Function Parameters

Parameter	Estimate	Parameter	Estimate
α_Q	0.0758 (0.8)	α_{QQ}	0.0320 (10.2)
α_T	0.0171 (0.8)	α_{KQ}	0.0024 (14.2)
α_{KK}	-0.0270 (0.5)	α_{LQ}	0.0165 (11.9)
α_{KL}	-0.0220 (2.2)	α_{MQ}	-0.0185 (13.4)
α_{KM}	0.0490 (1.9)	α_{KT}	0.0004 (5.7)
α_{LL}	0.0387 (1.1)	α_{LT}	-0.0012 (1.0)
α_{LM}	-0.0168 (0.5)	α_{MT}	-0.0008 (0.7)
α_{MM}	-0.0168 (0.8)	α_{QT}	-0.0018 (1.8)
R^2 = 0.9755			MSE = 0.05

Note: t-statistics in parentheses.

The constant terms α_0, α_K, α_L, and α_M are not reported as they do not play any role in our analysis.

The squared term (T^2) was excluded because it is perfectly collinear with T.

Table 3

Estimated Range of Own- and Cross-Price Elasticities, 1962-1977

Elasticity	Estimates	
	Minimum	Maximum
ε_{KK}	-0.638	-0.656
ε_{LL}	-0.146	-0.165
ε_{MM}	-0.675	-0.677
ε_{KL}	0.030	0.035
ε_{KM}	0.275	0.298
ε_{LM}	0.115	0.134

Table 4

Estimated Average Scale Elasticities and Rates of Technical Progress

Company (ranked by 1974-77 size)	1962-66			1967-73			1974-77		
	ε_{CQ}	ε_T	Q	ε_{CQ}	ε_T	Q	ε_{CQ}	ε_T	Q
Toronto	0.84	0.75	0.94	0.82	0.75	0.83	0.81	0.77	0.79
Acadia	0.73	0.45	0.36	0.83	0.76	0.90	0.83	0.82	1.03
Dominion of C	0.85	0.79	1.17	0.84	0.80	1.12	0.83	0.82	1.04
Fidelity	0.85	0.77	1.08	0.84	0.80	1.09	0.86	0.90	1.61
Wawanesa	0.76	0.53	0.28	0.80	0.69	0.64	0.87	0.93	2.00
Commercial	0.85	0.78	1.14	0.86	0.86	1.60	0.87	0.94	2.05
Sovereign	0.90	0.91	2.34	0.89	0.93	2.35	0.88	0.97	2.39
Cooperative	0.86	0.81	1.36	0.88	0.93	2.28	0.90	1.01	3.03
Eaton	0.84	0.76	0.99	0.84	0.81	1.33	0.90	1.01	3.04
Montreal	0.90	0.93	2.55	0.89	0.95	2.64	0.91	1.04	3.60
Sauvegarde	0.91	0.96	3.07	0.91	1.00	3.37	0.91	1.05	3.81
Equitable	0.89	0.89	2.03	0.89	0.94	2.47	0.91	1.05	3.83
Zurich	0.89	0.89	1.99	0.89	0.95	2.56	0.91	1.06	3.89
Northern	0.92	0.99	3.48	0.93	1.05	4.57	0.93	1.09	4.69
Maritime	0.90	0.92	2.54	0.92	1.03	4.16	0.93	1.11	5.45
Alliance	0.93	1.00	4.00	0.94	1.10	5.47	0.95	1.16	7.17
Excelsior	0.96	1.10	6.14	0.95	1.11	6.36	0.96	1.20	8.45
Desjardins	0.89	0.91	2.28	0.91	1.00	3.36	0.95	1.16	9.35
Monarch	0.94	1.04	4.67	0.95	1.10	6.19	0.97	1.21	9.38
Dominion Life	0.98	1.14	8.38	0.97	1.17	8.84	0.97	1.22	9.79
National	0.96	1.08	5.86	0.96	1.15	7.80	0.97	1.22	9.88
Imperial	1.01	1.22	13.21	1.01	1.29	17.33	1.03	1.38	23.00
N. American	.03	1.29	18.60	1.03	1.34	22.36	1.03	1.39	25.01
Confederation	1.03	1.30	20.35	1.05	1.38	29.49	1.05	1.44	32.47
Canada	1.06	1.38	30.85	1.05	1.40	32.51	1.06	1.46	37.13
Greatwest	1.05	1.36	27.89	1.06	1.42	35.48	1.07	1.49	43.37
Mutual	1.06	1.37	29.24	1.06	1.42	34.61	1.07	1.51	47.22
Crown	1.04	1.33	23.79	1.06	1.42	34.47	1.07	1.49	47.36
Manufacturers	1.08	1.44	43.10	1.09	1.50	53.47	1.10	1.57	67.52
London	1.10	1.50	58.81	1.10	1.54	68.09	1.11	1.60	80.60
Sun	1.12	1.54	75.91	1.12	1.59	88.65	1.12	1.64	97.95
Aggregate	1.05	1.34	397.73	1.05	1.33	486.30	1.05	1.50	592.75

Note Q in constant 1971$ million.

Table 5

Predicted Average Cost ($ per unit of output).

Company	1962-66	1967-73	1974-77
Toronto	1.33	1.29	1.25
Acadia	2.97	1.28	1.19
Dominion of C	1.29	1.23	1.19
Wawanesa	1.72	1.39	1.08
Fidelity	1.31	1.24	1.11
Commercial	1.29	1.17	1.07
Sovereign	1.18	1.11	1.05
Cooperative	1.27	1.12	1.03
Eaton	1.32	1.24	1.03
Montreal	1.17	1.10	1.01
Savegarde	1.15	1.07	1.00
Equitable	1.20	1.11	1.00
Zurich	1.20	1.10	1.00
Northern	1.14	1.05	0.99
Maritime	1.18	1.06	0.98
Alliance	1.13	1.03	0.96
Excelsior	1.10	1.03	0.95
Desjardins	1.19	1.07	0.97
Monarch	1.12	1.03	0.95
Dominion Life	1.09	1.01	0.95
National	1.11	1.02	0.95
Imperial	1.09	1.01	0.94
N. American	1.10	1.01	0.95
Confederation	1.10	1.03	0.95
Canada	1.13	1.03	0.96
Greatwest	1.12	1.04	0.97
Mutual	1.12	1.03	0.97
Crown	1.10	1.03	0.98
Manufacturers	1.15	1.07	1.00
London	1.19	1.09	1.02
Sun	1.22	1.12	1.04

Table 6

Estimates of Modified Translog Cost Function Parameters

Parameter	Estimate	Parameter	Estimate
α_Q	-0.9770 (0.9)	α_{QQ}	0.0340 (10.2)
α_T	0.0037 (0.2)	α_{KQ}	0.0024 (14.1)
α_{KK}	-0.0302 (1.1)	α_{LQ}	0.0165 (11.9)
α_{KL}	-0.0226 (1.8)	α_{MQ}	-0.0189 (13.4)
α_{KM}	0.0528 (2.1)	α_{KT}	0.0004 (2.6)
α_{LL}	0.0389 (1.1)	α_{LT}	-0.0012 (1.0)
α_{LM}	-0.0163 (0.5)	α_{MT}	-0.0008 (0.6)
α_{MM}	-0.0365 (0.9)	α_{QT}	-0.0194 (1.0)
α_X	-0.0194 (1.0)		
α_Y	4.9609 (3.7)	α_{YQ}	-0.2641 (3.4)
α_Z	-4.3834 (3.4)	α_{ZQ}	0.2752 (2.9)
$R^2 = 0.9790$			MSE = 0.04

Note: t-statistics in parentheses.

Table 7

Estimated Sources of TFP Growth in the Life Insurance Industry

Source	1962-66	1967-73	1974-77
Scale: $(1-\varepsilon_{CQ})\dot{Q}$	-0.2	-0.2	-0.2
Technical Progress: ε_T	1.3	1.3	1.5
Interfirm Shifts	0.0	0.2	0.4
Unexplained Residual	0.0	0.8	0.7
TFP	1.1	2.1	2.4

Data Appendix

The data base consists of annual time series of outputs, inputs and input prices for 31 life insurance companies for the years 1961 to 1977. These 31 companies comprise all but five of the federally registered Canadian companies operating throughout the 17-year period. Four of the five exclusions are very small and the fifth specializes in reinsurance. No foreign companies are included in the sample because they report only their operations in Canada, whereas Canadian companies report their global operations.

Output is measured as a Laspeyres quantity index of 23 activities or products and product characteristics. The data are taken from the annual Report of the Superintendent of Insurance, Vols. I and III. The weights (proxies for base year output prices) are 1971 unit costs of each activity as calculated by the Expense Committee of the Canadian Institute of Actuaries (1970-71) and modified by Hirshhorn and Geehan (1977) and Geehan (1977). The activities and their weights are listed in Table 1. All dollar series are deflated by the Consumer Price Index. In most industries explicit prices would be used as weights for aggregating different products, but in the life insurance industry explicit prices for the various services do not exist, so unit costs are used as weights instead. The payment made by the holder of an insurance policy or annuity is partly a payment for a bundle of services and partly a transfer into an investment asset.

The input (cost) data are taken from the annual Report of the Superintendent of Insurance, Vol. III. Labour costs, calculated as the sum of commissions, wages, salaries and allowances plus employees and agents' welfare expenses, is deflated by an index of average wages, salaries and supplementary labour income per employee in the industry, provided by Statistics Canada. Fifteen other categories of expense are separately deflated by the price indexes prepared by Input-Output Division, Statistics Canada, to deflate the industry totals. Charitable donations, reported as a cost by the companies, are excluded here. The cost category "all other miscellaneous" is deflated by the implicit price index calculated from all other categories except labour, rent and professional fees. The Input-Output Division price indexes are only available from 1961, and the detailed data on firm costs are not published in the Superintendent of Insurance Reports after 1977, limiting the time series to the 17-year period 1961-1977. Firm-specific price indexes would be desirable, but are not available.

The total factor productivity index is calculated as the ratio of the Laspeyres quantity index of outputs to the sum of deflated costs.

Notes

1 See data appendix.

2 See Solow (1957).

3 According to Rao and Preston (1983), total factor productivity growth in durable manufacturing averaged 1.10 per cent annually in 1958-66, 1.23 per cent in 1967-73, and 0.17 per cent in 1974-80. In non-durable manufacturing the rates were 0.73 per cent, 0.88 per cent and 0.14 per cent for the same periods respectively.

4 See Shephard (1970).

5 Symmetry is imposed through the restrictions $\alpha_{ij} = \alpha_{ji}$ while input price homogeneity is imposed through the summation restrictions

$$\sum_i \alpha_i = 1, \ \sum_i \alpha_{iQ} = \sum_i \alpha_{iT} = \sum_i \alpha_{ij} = 0.$$

The first-order duality condition (monotonicity) requires that the predicted values of the cost shares be nonnegative. The second-order duality condition (cost function concavity) requires that the Hessian matric $[\partial^2 C/\partial P_i \partial P_j]$ be negative semi-definite.

6 According to Hanoch (1975), the scale elasticity is identical to the reciprocal of ε_{CQ}.

7 X is a dummy variable (one for a mutual company and zero for a stock company).

8 Computer facilities, Y, are measured by the amount of core memory in 1974, the only year for which such information was available. Note, however, that one should not attach much importance to this variable as computer usage is already included as a component of material inputs. We were unable to incorporate a separate computer (electronic data processing) input into the model because of the difficulty in constructing a satisfactory price index for such inputs and in any case computer usage is only a small proporiton of total material inputs.

9 TFP growth is also affected by interfirm shifts insofar as TFP levels differ among firms. If the ten largest firms had lower levels of TFP than the other firms, then the latter's increased share of the market would contribute to an improvement in the industry's overall productivity performance.

Appendix Table 1

Unit Costs (Weights) of Life Insurance Activities

OUTPUT CATEGORY	UNIT COST
ORDINARY INSURANCE	
FIRST YEAR	$100.00 PER POLICY
TERM AND TEMPORARY ADDITIONS	$ 10.92 PER $1,000 NEW EFFECTED
BASIC INSURANCE	$ 28.22 PER $1,000 NEW EFFECTED
RENEWAL	$ 7.10 PER POLICY
TERM AND TEMPORARY ADDITIONS	$ 0.94 PER $1,000 IN FORCE
BASIC	$ 2.03 PER $1,000 IN FORCE
GROUP INSURANCE	
FIRST YEAR	$100.00 PER POLICY
ORDINARY DEFERRED ANNUITIES	
FIRST YEAR	$100.00 PER POLICY $ 31.25 PER $1,000 ANNUAL PAYMENT, NEW EFFECTED 60% OF FIRST YEAR PREMIUM INCOME
RENEWAL	$ 6.60 PER POLICY $ 1.67 PER $1,000 ANNUAL PAYMENT, IN FORCE 4.5% OF RENEWAL PREMIUM INCOME
SINGLE PREMIUM ANNUITIES	5.0% OF SINGLE PREMIUM INCOME (NET OF DIVIDENDS TO POLICYHOLDERS)
GROUP ANNUITIES	
FIRST YEAR	$100.00 PER POLICY 20% OF PREMIUM INCOME
RENEWAL	10% OF RENEWAL PREMIUM INCOME
SINGLE PREMIUM	3% OF SINGLE PREMIUM INCOME (NET OF DIVIDENDS TO POLICYHOLDERS)
VESTED ANNUITIES (ORDINARY AND GROUP)	$ 12.00 PER POLICY
MORTGAGE AND REAL ESTATE ASSETS	0.32% OF ASSETS ($)
POLICY LOANS	0.64% OF ASSETS ($)
SEGREGATED FUNDS	0.18% OF ASSETS ($)
BALANCE OF LEDGER ASSETS	0.12% OF ASSETS ($)

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