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INFORMATION SPILLOVERS, MARGINS, SCALE AND SCOPE: WITH AN APPLICATION TO CANADIAN LIFE INSURANCE

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ABSTRACT

This paper develops a model of the production of life insurance services. The focus is on price setting ability and the cost advantages from size and diversity. The model characterizes insurers decisions on the face value and number of policies and the number of insurance lines.

The model is applied to Canadian life insurance firms. Price-cost margins average from 13% to 40%. These margins emanate from information spillovers generated by marketing activities. Cost advantages due to size are small, but are substantial from diversity. Returns to scale average from 1.13 to 1.40, while returns to scope average from 70% to 100%.

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1. Introduction*

Insurance services are purchased by most individuals and businesses in contemporary societies. We insure our lives, health, retirement income, homes, cars and employment. Insurance can be obtained in the event of merchandise defects, service malpractice and the closure of financial institutions. Despite the prominent role of insurance services, there has been virtually no empirical work concerning the relative profitability of alternative lines of insurance and the cost advantages of offering multiple lines.

An insurance policy is a multifaceted financial instrument that provides for the payment to the policyholder prescribed sums contingent on the occurrence on certain prescribed events (see Borch [1990]). The purpose of this paper is to develop and estimate a model which characterizes insurers decisions on the size of the benefits or face amount of a policy, the number of policies within a line of insurance and the number of lines that are offered. The theoretical model also provides some guidance towards the measurement issues concerning the notion of the price and quantity of an insurance policy. The model is applied to the Canadian life insurance industry. Estimates are obtained for price-cost margins of alternative insurance lines and scale and scope economies associated with various degrees of service expansion and diversification.

There are a number of stylized facts about the insurance industry in North America (see Joskow [1973]), and especially the life insurance industry.[1] First, there are numerous firms in the industry. Second, firms are quite different in size, whether size is measured by the number

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of policies or premiums or assets.[2] Third, some firms specialize in a few insurance lines while others offer many lines.[3] Lastly, premiums per policy for a given line of insurance differ among insurers. Indeed, there is some evidence that for any one insurance line, premiums per policy is positively correlated with firm size, as measured by premiums for the respective line (see Mathewson [1983]).

The cost and demand conditions for insurance services must account for these stylized facts of large numbers, diverse size, line variability and price dispersion. In terms of the Canadian life insurance industry we examine the possibility of scale and scope economies. In addition, we investigate the source and degree of price setting ability over the various lines of life insurance. One source of market power relates to the quantity of insurance, namely the number of policies that are written by an insurer. The other source pertains to the marketing of insurance and therefore the provision of information concerning insurance lines. Marketing of insurance through a commissioned sales force and advertising expenditures creates information spillovers between lines of insurance and allows insurers to differentiate their multiple lines among rival firms.

The existence of scale and scope economies, price setting and product differentiating ability are critical elements influencing firm behaviour and industry structure (see Tirole [1989]). Indeed, research on these topics is important to discern the efficiency implications of mergers and acquisitions within the insurance industry and among the four pillars of financial services.

This paper is organized into a number of sections. In section 2 the theoretical model is developed. This part of the paper outlines the equilibrium conditions concerning insurance services. Section 3 looks at the measurement issues relating to the concept of price and quantity of insurance policies. Section 4 discusses a parameterization of the theoretical model, along with estimation results applicable to the Canadian life insurance industry. In this section tests are conducted with respect to the source and degree of price setting ability. Section 5 looks at the cost structure of these firms and investigates the existence of scale and scope economies. Lastly, we summarize and conclude the paper.

2. Theoretical Model

To begin we consider the demand conditions facing an insurance firm. The demand functions relate to a particular policy, characterized by a specific benefit value (i.e. face value of the policy). The inverse demand function for the ith policy is denoted as,

$$(1) \qquad p^i = B^i(b^i, y^i, L, m^i; \psi^i) \qquad i = 1, \ldots, n$$

where p^i is the policy premium per unit value of the insured benefits (or per unit face amount), b^i is the face amount of the policy, y^i is the number of policies, m^i is a vector of exogenous variables affecting demand and $i = 1, \ldots, n$ denotes the types of policies or lines of insurance. L is the vector of marketing variables used for all the lines of insurance and $0 \leq \psi^i \leq 1$ is the probability of the event being insured against occurring during the period (e.g. it is the probability of death during the period). The inverse demand function is B, which is twice continuously differentiable with $B_b \leq 0, B_y \leq 0$, and $\nabla B_1 \geq 0$, where the derivatives relate to the effects of face value, number of policies and marketing variables on price.

The inverse demand functions capture a number of significant features. First, an insurance firm faces a distinct demand function for policy coverage of each insurance line that depends on its variables regarding coverage, number of policies and marketing of insurance lines. Thus an insurer has some price setting ability over policy coverage and can charge a price that is different from other insurers.[4] Second, a line of insurance output is not captured by a single quantity, but rather is reflected in two dimensions; face amount and policy numbers. Indeed the expression $p^i b^i y^i$ equals the value of premiums from the ith insurance line.[5] Face amount and policy numbers do not necessarily affect price to the same degree and so have different elasticities. Moreover, altering the face amount or policy coverage on a line is a way for insurers to differentiate their product among insurees.[6]

The third feature of the demand conditions is that marketing of insurance lines affects price, as it induces product differentiation. In addition, since there are multiple lines, marketing of line i can affect the price of line j. Thus there are demand interdependencies through the marketing of insurance lines. These interdependencies can be considered information spillovers across insurance lines. For example, firms selling life insurance that have earned a brand name are able to generate market share in annuity markets.

Insurance firms invest premium revenues and generate investment income. Suppose that $0 \le \mu^i \le 1$ is the proportion of the ith policy premium per unit of face value that is invested. The rate of return is ρ^i and the unit cost of the investment is r^i.[7] The returns from investing premium revenues are random variables, with defined expected values. Unit investment cost represents the cost of investment bankers, portfolio analysts and other transaction costs relating to the various securities purchased by insurance firms.

Insurance firms must decide on the face value or benefits for each insurance line, the number of policies per line and the magnitude of the marketing variables. Firms undertake these decisions under the objective of expected profit maximization. The problem can be divided into stages. First, for a particular line, given the number of policies and marketing variables, expected profit per policy is,

(2) $$\max_{(b^i)} E[B^i(b^i,y^i,L,m^i;\psi^i)(1+\mu^i(\rho^i - r^i) - \psi^i)b^i] \quad i = 1,\ldots,n,$$

where E is the expectation operator. The solution to the program defined by (2) yields the face values for the n lines of insurance to be functions of the number of policies for a respective line, the marketing variables and the exogenous variables.[8] Thus the value of expected profit per policy for line i can be defined as,

(3) $$\phi^i = \Phi^i(y^i,L,m^i) \quad i = 1,\ldots,n.$$

The expression ϕ^i is the revenue per policy for the ith insurance line or, in other words, the policy price. Thus policy prices reflect the benefits, claims and net investment income of a policy for a particular line. Policy prices relate to the characteristics of policies and the price setting ability, if any exists, for an insurance firm.[9] Policy prices are nonincreasing in the number of policies and nondecreasing in the marketing variables.[10]

The second stage of the problem relates to the determination of the marketing variables across different insurance lines. Conditional on the number of policies per insurance line, the decisions on the marketing variables are governed by the maximization of expected profit relating to these variables. Thus,

(4) $$\max_{(L)} E[\Sigma_{i=1}^{n}\Phi(y^i,L,m^i)y^i - \upsilon^T L],$$

where υ is the vector of unit costs of the marketing variables. The conditions for the determination of the marketing variables can be written as,

(5) $$E\Phi_1 y - \upsilon = 0,$$

where Φ_1 is the matrix of first derivatives of the policy price function with respect to the marketing variables. The ith column of the matrix is $\nabla\Phi_1^i$ and y is the vector of policy numbers for the different insurance lines. Equation (5) means that for each marketing variable unit cost is equated to the respective expected marginal profit. The latter consists of the effect that a marketing variable exerts on policy revenue over the sum of insurance lines. The marketing variables act as a public good to the customers of each insurance line, since the marginal benefit of these variables is evaluated in terms of the sum over policyholders. Indeed, marketing variables generate information spillovers across the multiple lines of insurance. The solution to equation (5) yields $L = G(y)$. The profit maximizing values of the marketing variables is a function of the number of policies of all the insurance lines, which reflects demand interdependencies.

The last stage of the problem is to determine the number of policies for each insurance line. Using the solutions to the previous stages, the objective is to maximize expected profit from policies over all insurance lines. Thus,

(6) $$\max_{(y)}.\ E[\Sigma_{i=1}^{n}\Phi^i(y^i,G(y),m^i)y^i - \upsilon^T G(y)] - C(y,w),$$

where C is the twice continuously differentiable production cost function pertaining to all insurance lines, with $\nabla C_y \geq 0, \nabla C_w \geq 0$, w is the vector of factor prices for the inputs used to produce insurance policies. The production cost function is homogeneous of degree one and concave in the factor prices and it depends on the vector of policies over insurance lines so that any joint production costs are reflected in the function.[11] Using equation (5), the number of policies are determined from,

$$(7) \qquad E[\phi + \nabla\Phi_y^T y] - \nabla C_y \leq 0, \quad y^T(E[\phi + \nabla\Phi_y^T y] - \nabla C_y) = 0, \quad y \geq 0$$

where ϕ is the vector of policy prices.[12] Equation (7) implies that for insurance lines with positive numbers of policies, marginal revenue is equated to marginal cost. It is important to note that the conditions determining the number of policies admits the possibility that an insurance firm does not have to supply all lines of insurance. A firm can specialize in only a subset of insurance lines. In addition, there are demand interdependencies through the marketing variables and also joint production costs. This means that policy numbers for the various insurance lines must be solved simultaneously. Simultaneity exists, although the policy price of line i is not affected by the number of policies for any other line of insurance. For example, there is no reason for the number of group annuity policies sold by firms to influence the price of an individual life insurance policy. Yet, through the sales force and advertising, insurance lines are linked via policy prices.[13]

3. Output Price and Quantity Measurement

The theoretical model that we have previously described provides some guidance towards the measurement of prices and quantities of insurance outputs. Insurees purchase financial protection. An insurer is able to provide financial protection because it has created the opportunities to diversify risks. Hence insurers are financial intermediaries. Indeed, the range of activities an insurance firm undertakes to diversify risks define the services provided by an insurer.

In the literature relating to the production of insurance services, premiums, premiums net of claims, or premiums net of claims and reinsurance are often used as output measures (see Bernstein and Geehan [1988], for a survey of this literature). Although these variables can play a significant role in the analysis of insurance firms production decisions, they do not constitute output measures. The reason is that these variables do not capture the financial intermediary role of insurers. The argument can be highlighted by considering the example of a brokerage firm dealing in municipal bonds. The broker is a financial intermediary, as it provides the facilities to buy and sell bonds. Assume that the broker deals in one type of bond. The firm purchases the bond at $98 and sells it for $100. The revenue from the intermediary role is ($100-$98)n, where n is the number of bonds sold. Thus the revenue from the bond brokerage function is $2n, which must cover long run costs of the firm in order for it to remain solvent. Bond brokerage output quantity is n and output price is $2.

The example can be related to insurance firms. In this case $100 is the premium, $98 is the claim and n is the number of insurance policies (for the moment we are assuming that there is one line of insurance). The concept of revenues related to the intermediary role of insurers has not often been used in empirical studies of insurance. However, Geehan [1977] and Kellner and Mathewson [1983] are notable exceptions.

The calculation of revenue for an insurance firm is, of course, more complicated than the previous example that highlighted insurers as financial intermediaries. There are a number of other aspects in the calculation of revenue, price and quantity that must be considered. First, there are active reinsurance markets. In these markets insurers sell parts of a policy to other insurers in order to diversify the risk. Thus premiums and the consequent claims associated with the part of the policy that has been sold must be netted out of revenues. Simultaneously, segments of policies that have been purchased on reinsurance markets must be included in the revenue calculation.

A second consideration pertains to claims. Premiums for a policy are set on an actuarial basis. They reflect an expected intertemporal income flow taking into consideration the expected claims that will arise from the policy. Indeed, insurers must set aside reserves in order to pay for these expected claims. In order to calculate revenue for any period of time, changes in these reserves must be subtracted from premiums. Lastly, insurers invest part of the funds they obtain through premiums. The returns from these investments help to diversify risk and defray the costs of financial intermediation. Thus the net returns from investment must be added to premiums to reflect revenue from intermediation services. Indeed, we can see a matching of insurance lines and asset structure. For example, life insurance and pensions are long term in duration and so we observe that life insurers prefer long term assets such as mortgages and bonds.

There are many lines of insurance offered by firms and the adjustments to premiums to obtain revenue must be carried out for each line. Once revenue per line has been calculated, dividing it by the number of policies per line, which is output quantity, leads to the price of a policy per line of insurance. Each line or policy type has a number of characteristics. There are three important characteristics of an insurance policy. The first characteristic represents the insured event, for example, death, retirement, fire, accident and sickness. The second characteristic pertains to the face amount of the policy. This is the value to be received by the insured if the event that is being insured against occurs. The third characteristic concerns the policyholder, either an individual or group and groups can consist of various numbers of individuals.

There are many other characteristics or riders of an insurance policy. Some of these riders are the following. The surrender value is the amount available upon voluntary termination of a policy. Double indemnity provides for the payment of an additional amount equal to the face value of a life policy in case of death by accident. The disability waiver is a benefit such that if the insured is unable to pay the premium due to disability then the insurer will wave the premium while keeping the policy in force.

Table 1 shows revenue per policy, its components and number of policies by line of insurance and year. The data relate to Canadian federally chartered life insurance firms.[14] In the table insurance lines are distinguished by event (that is life and annuities), by policyholder (that is individual and group) and the third basic characteristic of face values is aggregated within each line. The first variable in table 1 is premiums (net of reinsurance or $p^i b^i y^i$ in our notation). We see a remarkable shift in the source of revenues over the last ten years. In 1979 group annuities accounted for only 28% of revenues and in 1988 this line generated 51% and became the largest revenue category. The second variable in table 1, net change in policy reserves, is subtracted from premiums in arriving at revenue per policy (this variable is $\psi^i b^i y^i$). Each life insurance firm is required to establish policy reserves (net of reinsurance).[15] This variable is calculated as the present value of future claims minus the present value of future premiums using prescribed discount and mortality rates. The changes in the net reserves (usually the changes are positive) appear as expense items

Table 1: Key Variables By Line And Year

(mean values over firms offering a line, and sample standard deviations in parentheses).

	Year	Indiv. Life	Indiv. Ann.	Group Life	Group Ann.
Premiums	1979	87.79	49.61	30.87	66.11
		(15.68)	(10.24)	(46.69)	(95.76)
(mill. cdn.$)	1982	126.74	77.17	46.99	128.12
		(224.07)	(13.98)	(78.16)	(226.34)
	1985	165.27	125.58	56.89	297.40
		(329.00)	(219.07)	(90.67)	(478.97)
	1988	270.10	150.03	77.40	506.82
		(571.27)	(252.61)	(122.85)	(870.00)
Net Change	1979	19.65	32.81	2.77	29.78
		(34.85)	(61.25)	(4.11)	(44.31)
Policy Res.	1982	14.61	54.66	3.82	65.85
(mill. cdn.$)		(33.28)	(93.42)	(7.62)	(11.20)
	1985	18.57	86.72	4.89	123.63
		(53.98)	(137.30)	(7.56)	(195.52)
	1988	60.47	88.40	7.28	184.28
		(156.34)	(154.27)	(1.27)	(326.75)
Net Invest.	1979	73.31	8.98	11.84	7.37
		(14.26)	(14.32)	(19.10)	(12.64)
Income	1982	49.35	34.20	5.83	39.73
(mill. cdn.$)		(90.13)	(58.90)	(9.87)	(59.97)
	1985	58.88	65.29	8.51	88.56
		(112.23)	(117.25)	(13.41)	(130.41)
	1988	80.71	94.99	11.40	138.82
		(150.80)	(173.17)	(18.69)	(205.23)

Table 1: Key Variables By Line And Year (continued)

(mean values over firms offering a line, and sample standard deviations in parentheses)

	Year	Indiv. Life	Indiv. Ann.	Group Life	Group Ann.
No. of Pol. (thousands)	1979	320.13 (565.90)	19.20 (32.20)	1093.67 (1784.14)	19.33 (33.08)
	1982	397.74 (696.71)	33.16 (50.75)	1081.54 (3217.50)	31.93 (66.00)
	1985	379.24 (662.41)	42.39 (64.52)	858.56 (1308.23)	44.09 (94.35)
	1988	460.04 (971.21)	54.07 (80.13)	855.79 (1285.80)	72.75 (148.80)
Rev. Per Policy (cdn.$)	1979	277.26 (197.32)	1208.14 (3742.39)	69.81 (102.66)	2554.23 (4215.17)
	1982	317.27 (212.03)	1222.11 (1053.85)	59.84 (73.73)	3781.62 (18041.73)
	1985	348.27 (263.71)	1797.89 (2103.46)	130.11 (398.42)	5037.11 (17014.49)
	1988	423.84 (397.95)	2754.42 (5433.74)	110.14 (167.93)	6426.81 (12735.37)

the income statement of each life insurer. Changes in net reserves reflect annual expected pay outs associated with each line of insurance. We see from the table that policy reserves tend to be greater for annuity lines relative to lines of life insurance.

The third variable in table 1 is net investment income (which is $p^i\mu^i(\delta^i - r^i)b^iy^i$). This variable is added to premiums to arrive at revenue per policy for each line of insurance. Clearly, from table 1, the growth rate of net investment income from annuities over the last decade has substantially exceeded the rate of growth from life insurance. In 1979 net investment income from annuities was 16%, while in 1988 the fraction grew to 71%.

Combining the first three variables in table 1 and dividing by the number of policies for each line gives the revenue per policy for each line of business. In table 1 the number of policies for group lines is measured by the number of certificates. Certificates account for the number of individuals associated with each group line. From table 1, the number of policies for life insurance is substantially larger than for annuities and this trend has persisted over the last ten years. Thus with the relatively small numbers of annuity policies, and the growth in annuity revenues, especially group annuities, we then find that revenue per policy for annuity lines is substantially greater than per policy revenue for life insurance.

4. Model Parameterization and Estimation

In order to estimate the cost and demand structure associated ith offering multiple lines of insurance, the production cost and inverse demand functions need to be parameterized. In this way it is possible to determine the existence of any cost advantages to size and diversity, as well as, price setting ability and informational spillovers across insurance lines. The production cost function used in (6) is assumed to be,

$$(8) \qquad C(w,y) = H(w)(\alpha_0 + \Sigma_{i=1}^{n}\alpha_i y^i + .5\Sigma_{i=1}^{n}\Sigma_{j=1}^{n}\alpha_{ij}(y^i y^j)^2),$$

where $\alpha_{ij}=\alpha_{ji}$. The function is a generalized quadratic in the number of policies across insurance lines. The cost function and marginal cost for each insurance line is defined for zero output levels.[16] The function also admits the possibility of scale and scope economies. It is assumed that the firms pay the same factor prices for the inputs used to produce insurance services and the insurers are input price takers. Thus in terms of equation (8), we can assume that $H(w)=1$.

Next, the inverse product demand functions used in (6) are specified as,

$$(9) \qquad \phi^i/m^i = \eta_i - \xi_i \ln y^i + \gamma_i c^m(\delta_i - \ln y^i)/m^i, \quad y^i, m^i > 0, \quad i = 1,\ldots,n,$$

where ϕ^i/m^i is the normalized ith policy price, m^i is a scalar representing income of insurees of the ith line of insurance, and c^m is marketing cost.

Normalized inverse demand functions allow for price setting power through the number of policies offered on a line of insurance and through the marketing of all insurance lines.[17] Using equations (8) and (9), (7) becomes (after rearranging),

$$(10). \qquad \phi^i = \xi_i m^i + \gamma_i c^m + \alpha_i + 2y^i\, \Sigma_{j=1}^{n}\alpha_{ij}(y^j)^2, \quad i = 1,\ldots,n,$$

for $y^i>0$ and also for $y^i \geq 0$ the difference between the two sides of (10) equal zero when multiplied by y^i. The first two terms on the right side of (10) show the deviation between policy price and marginal revenue for the ith line of insurance.

Equations (8) and (10) define a system where insurance production cost and policy prices are endogenous variables. The system is linear in the endogenous variables and in the parameters. Appending random errors that are jointly normally distributed with zero expected values and a symmetric positive definite variance-covariance matrix, the system can be estimated using the full information maximum likelihood estimator.[18] The errors represent optimizing and technology errors.

The model is estimated for data based on a cross section of 38 Canadian life insurance firms. However, to allow for changes in factor prices and technology over time the model is estimated separately for the years 1979, 1982, 1985 and 1988.[19]

The data are obtained from form 54 of the Office of the Superintendent of Financial Institutions. Table 1 shows the mean values for each year of the number of policies and the policy prices (as well as their components). There are four lines of insurance that are considered; individual life, group life, individual annuities and group annuities. Production cost includes all cost except sales-related and advertising expenses. The major cost components for life insurance firms relate to input purchases and therefore reflect market prices.[20] The major asset or capital item of life insurers is their head-office. In the data forms, life insurers are asked to impute the annual rental of their headquarters space based on either the rental charged to other firms renting space in the same buildings or the rental for equivalent commercial space in neighbouring sites. Thus production cost is relatively free of the measurement errors associated with book values of assets. Marketing cost consists of all sales and advertising expenses. Income for insurees of insurance line i equals the sum of dividends and the provision for dividends pertaining to the ith line plus per capita consumption expenditures in the economy multiplied by the number of policies for line i.[21]

The estimation model, (8) and (10), consists of five equations. Besides the cost function, the conditions determining the number of policies for each insurance line are estimated. Line 1 is individual life, line 2 is individual annuities, line 3 is group life and line 4 is group annuities. In the estimation of equation set (8) and (10) firm differences are introduced to allow for heterogeneity in the number of policies within each line of insurance. Life firms are divided into four groups depending on the number of policies they write for each insurance line. To reflect these firm differences, the parameter α_i varies across the groups of firms. Firms could change groups from year to year.

The first result to emerge from the estimation is presented in table 2. In the life insurance industry firms do not have price setting ability arising from the number of policies in each line of insurance. Thus there is no market power from output quantities and this conclusion arises for all four markets. In the estimation results with $\xi_i \neq 0$, the estimates of this parameter are small and statistically insignificant. Table 2 shows that there is no significant difference between the values of the logarithm of the likelihood functions for the cases with $\xi_i = 0$ and the cases for $\xi_i \neq 0$. This result occurs for each year.

The second conclusion is that firms exhibit price setting ability through their sales force and advertising expenditures. In addition, this ability varies by insurance line. Table 3 shows the estimation results for the preferred models and from this table it is clear that the γi parameter estimates do indeed differ by line of insurance and are generally statistically significant. The estimation results presented in Table 3 show that most of the parameter estimates are statistically significant. The fitted values of production cost are positive for each firm and for

Table 2: Values of Log of Likelihood Functions for $\xi \neq 0$ and $\xi = 0$

Year	Unrestricted	Restricted	No. of Rest.	Crit. Value
1979	-1846.92	-1849.11	4	9.488
1982	-1891.93	-1893.60	4	9.488
1985	-1957.89	-1958.99	4	9.488
1988	-1961.69	-1964.23	4	9.488

Table 3: Estimation Results

Parameter	1979 Estimate	1979 Std. Error	1982 Estimate	1982 Std. Error
α_0	0.496E+06	0.472E+06	0.430E+06	0.381E+06
α_1	20.855	7.836		
α_{d12}			47.781	32.435
α_{d13}			21.474	4.118
α_{d14}			47.234	9.765
α_2	634.840	120.920	103.790	44.146
α_{d22}				
α_{d23}				
α_{d24}				
α_3	0.720	0.766	3.652	0.611
α_{d32}			30.051	2.756
α_{d33}			109.43	10.896
α_{d34}			49.464	9.454
α_4	51.102	189.830	172.090	118.490
α_{d42}	0.208E+04	0.872E+03		
α_{d43}	0.104E+04	0.197E+03		
α_{d44}	0.557E+04	0.566E+03		
α_{11}	-0.691E-17	0.538E-17	-0.446E-19	-0.608E-19
α_{22}	-0.199E-11	0.901E-12	-0.254E-12	0.273E-13

Table 3: Estimation Results (continued)

	1979		1982	
Parameter	Estimate	Std. Error	Estimate	Std. Error
α_{33}	0.463E-20	0.418E-20	0.307E-20	0.318E-20
α_{44}	-0.188E-11	0.161E-11	0.442E-13	0.288E-13
α_{12}	0.882E-14	0.370E-14	0.226E-14	0.454E-15
α_{13}	-0.147E-17	0.158E-17	-0.226E-17	0.393E-18
α_{14}	0.213E-14	0.551E-14	0.202E-14	0.129E-14
α_{23}	-0.261E-14	0.125E-14	-0.259E-15	0.555E-16
α_{24}	0.540E-12	0.196E-11	0.967E-13	0.506E-13
α_{34}	0.127E-14	0.513E-15	-0.509E-04	0.998E-16
γ_1	0.264E-04	0.515E-05	0.140E-04	0.282E-05
γ_2	0.176E-03	0.329E-03	0.589E-04	0.169E-04
γ_3	0.745E-05	0.261E-05	0.339E-05	0.102E-05
γ_4	0.167E-03	0.144E-03	0.363E-03	0.140E-02

Table 3: Estimation Results (continued)

	1985		1988	
Parameter	Estimate	Std. Error	Estimate	Std. Error
α_0	0.985E+06	0.543E+06	0.244E+06	0.563E+06
α_1	16.797	6.533		
α_{d12}			41.514	12.108
α_{d13}			68.124	12.213
α_{d14}			132.170	5.521
α_2	290.060	120.120	157.360	40.476
α_{d22}	-217.430	117.020		
α_{d23}	798.410	128.230		
α_{d24}	0.161E+04	0.235E+03		
α_3	4.295	0.988		
α_{d32}			4.475	0.962
α_{d33}			76.145	8.588
α_{d34}			45.195	4.943
α_4			0.114E+04	0.105E+03
α_{d42}	611.080	156.470		
α_{d43}	0.152E+04	0.350E+03		
α_{d44}	0.401E+04	0.249E+03		
α_{11}	-0.299E-17	0.306E-17	-0.125E-17	0.102E-17
α_{22}	-0.439E-14	0.162E-13	-0.558E-14	0.693E-14

Table 3: Estimation Results (continued)

	1985		1988	
Parameter	Estimate	Std. Error	Estimate	Std. Error
α_{33}	-0.944E-20	0.352E-19	0.104E-18	0.231E-19
α_{44}	0.172E-12	0.276E-13	-0.120E-13	0.516E-14
α_{12}	0.180E-14	0.694E-15	-0.105E-14	0.123E-15
α_{13}	0.682E-18	0.184E-17	0.848E-18	0.754E-18
α_{14}	-0.231E-14	0.782E-15	0.132E-14	0.459E-15
α_{23}	-0.382E-18	0.465E-16	-0.781E-16	0.260E-16
α_{24}	-0.221E-12	0.317E-13	-0.377E-13	0.148E-13
α_{34}	-0.173E-14	0.350E-15	0.266E-16	0.992E-16
γ_1	0.187E-04	0.273E-05	0.118E-04	0.214E-05
γ_2	0.768E-04	0.254E-04	0.103E-03	0.368E-04
γ_3	0.834E-05	0.402E-05	0.139E-05	0.139E-05
γ_4	0.289E-03	0347E-03	0.557E-03	0.249E-03

Table 4: Price-Cost Margins (mean values and sample standard deviations in parentheses)

Year	Ind. Life	Ind. Ann.	Group Life	Group Ann.
1979	0.37	0.22	0.38	0.18
	(0.36)	(0.30)	(0.39)	(0.25)
1982	0.32	0.25	0.13	0.39
	(0.32)	(0.30)	(0.23)	(0.42)
1985	0.40	0.26	0.36	0.21
	(0.37)	(0.30)	(0.41)	(0.31)
1988	0.30	0.27	0.23	0.30
	(0.35)	(0.31)	(0.34)	(0.39)

each year. In addition, the vast majority of the estimated values of marginal cost for each insurance line, firm and year are positive.[22]

There are information spillovers between lines of insurance that arise from the marketing of insurance. Policy prices or per unit policy revenues differ from the marginal cost of production due to the marginal benefit created by the commissioned sales force and advertising expenditures applicable to all insurance lines. Indeed, table 3 shows that the estimates of γ_i are positive for each line of insurance and for each year. The margins between policy prices and marginal production costs are presented in table 4. From this table, we see that the margins for individual annuities are quite constant. For this case, unit revenue exceeds marginal production cost by 22% to 27%. Price-cost margins for individual life insurance are also relatively constant. In this case the range is from 30% to 40%. Margins for group life and group annuities are more varied with ranges from 13% to 38% and from 18% to 39% respectively. From these results, we see that information spillovers between lines generate significant price-cost margins for each line of insurance.

5. Scale and Scope Economies

The cost advantages due to size and product diversity can be evaluated with respect to the measures of ray returns to scale and returns to scope (see Baumol et.al [1982]). Surprisingly, nearly all studies of the cost structure of insurance firms (irrespective of the type of insurance or country of origin of the insurer) assume that insurers produce a single output (see Bernstein and Geehan [1988] for a survey of this literature).[23] Given the multiplicity of insurance products and the diversity of offerings by insurers, to adequately capture the cost structure of insurance services, it is important to recognize these features. Indeed, failure to do so can lead to specification bias. In particular, assuming a single output cost function can lead to biased estimates of returns to scale by attributing economies of scope to scale economies. In this case scale is made to account for size and diversity.

The local measure of ray returns to scale is defined as,

$$(11) \qquad RRS = 1/(\Sigma_{i=1}^{n}\partial \ln c/\partial \ln y_i).$$

Table 5 shows that there are slightly increasing ray returns to scale in the Canadian life insurance industry. Moreover in each year there are about ten firms with ray returns to scale that do not exceed 1.15. In addition, only three firms exhibit decreasing ray returns to scale. Thus similar to the majority of studies surveyed in Bernstein and Geehan [1988], for life insurers in the US, Canada, Australia and other countries, there are modest increasing returns to scale.

The degree of returns to scope is defined as,

$$(12) \qquad RSC = (\Sigma_{i=1}^{n}C(y^i) - C(y))/C(y).$$

Table 5 shows that there are significant increasing returns to scope in this industry. The cost savings from jointly producing insurance services relative to individually producing each service on a stand alone basis on average is between 69% and 107%. Moreover, in each year there is no more than one firm that exhibits decreasing returns to scope in both life insurance and annuities.

Table 5: Returns to Scale and Scope (mean values and sample standard deviations in parentheses)

Year	RRS	RSC	RSC(Life)	RSC(Ann.)
1979	1.40	1.04	0.51	0.36
	(0.63)	(0.91)	(0.26)	(0.39)
1982	1.17	0.69	0.25	0.51
	(0.36)	(0.70)	(0.23)	(0.50)
1985	1.31	0.96	0.49	0.45
	(0.78)	(0.98)	(0.31)	(0.39)
1988	1.13	1.07	0.34	0.65
	(0.38)	(0.88)	(0.30)	(0.34)

We also looked at the potential for scope economies within life insurance and within annuities but across individual and group policies. We find that there are increasing returns to scope within life insurance and within annuities. Generally, the cost savings from offering individual and group policies as compared to only individual or group ranges from 25% to 65% for life insurance and annuities. In any year there are no more than three firms that have decreasing returns to scope in life insurance. In addition, there are no more than three firms that have decreasing returns to scope in annuities. Lastly, since overall returns to scope exceed the returns for either life insurance or annuities, then firms generally reduce cost by offering both life insurance and annuities.

6. Summary and Conclusion

Insurance industries are generally characterized by large numbers of firms, of various sizes, producing a diverse array of products and appearing to have some degree of price-setting power. In order to account for these stylized facts, in this paper we emphasized marketing expenditures incurred by insurers as a means of differentiating their products and creating information spillovers across lines of insurance. In addition, we highlighted the cost advantages of jointly producing multiple insurance lines. The model was parameterized and applied to firms operating in the Canadian life insurance industry. We found that policy prices exceed marginal production costs and the source of these margins were the marginal benefits generated by jointly marketing lines of insurance. In addition, we estimated that there were significant cost savings from offering not just individual and group life policies or annuities, but also from offering both life policies and annuities together.

There are many avenues open to further research. The model can be applied to other types of insurance and to firms operating in other countries. In addition, more extensive data can be developed so that the model can be applied to a panel of firms. With the importance of regulatory reform pertaining to the four pillars of financial intermediation, it would be of interest to pool firm data from insurance and other intermediaries to determine the extent of any cost advantages from joint production.

1. In Canada in 1989 there were 180 firms operating in the life insurance industry. These firms were both Canadian and foreign.

2. In Canada for the life insurance industry, in 1988 the assets of the smallest firm is 0.01 times the assets of the largest firm.

3. In 1988, the Canadian life insurance industry had twice as many firms offering individual life policies as offering individual life and group annuities.

4. Distinct demand functions can arise from differential information on the part of insurees, because they have to incur search costs and have different marginal opportunity costs of search (see Mathewson [1983] and Dionne [1984]). Distinct functions can also occur due to product differentiation on the part of insurers through policy coverage (that is benefits) and marketing (see Spence [1978]). Demand functions can also depend on the variables pertaining to rival insurers, as along as conjectural variations are zero, which seems reasonable given the large number of insurers of various sizes, producing different lines (see Hellwig [1988]).

5. Per unit premiums are defined net of reinsurance ceded. Reinsurance ceded means the portion of a policy relating to a particular insurance line that has been sold to other insurance firms. Reinsurance markets help to provide the means by which firms can diversify underwriting risks (see Doherty and Garvin [1986], Crocker and Snow [1986] and Mayers and Smith [1990]).

6. It is not necessary for the analysis that insurees for a specific line and form have the same probability of the insured against event occurring, only that there is uncorrelated risk of the event arising among insurees.

7. The proportion of per unit premiums is invested is part of the portfolio decisions of insurance firms. However, since we are not concerned with those decisions, we assume that each of the proportions for the n insurance lines are fixed. In addition, the returns from investment across different insurance lines do not have to be equal, because of the timing elements relating to the different insurance lines and regulatory constraints (see Fairley [1979]).

8. Face values are also functions of the probability of the insured event occurring, investment proportions, rates of return and unit investment costs, for ease of notation we delete these variables from the relevant functions that follow.

9. An outcome of this model is that the measurement of policy prices encompasses a hedonic approach, since these prices are reduced forms from the determination of face values per line and reflect policy characteristics.

10. It is assumed that the second order conditions are satisfied with respect to this stage and all other stages of the problem.

11. The three stages of the insurance problem can be handled in one simultaneous step. The reason that the stages can be separated is due to the assumption that production cost is independent of marketing costs. This is a reasonable assumption given that sales and advertising are handled by independent firms and individuals or are independent of actuarial and office expenses.

12. In deriving (7), we use the Envelope Theorem (see Tirole [1989].

13. We assume that an equilibrium exists in the insurance markets. For discussions on this point, see Borch [1962], Rothchild and Stiglitz [1976], Wilson [1977] and Cooper and Hayes [1978].

14. The data are obtained from the office of the Superintendent of Financial Institutions. The sample omits provincially chartered firms and firms that do not have their head-office in Canada. There are 38 firms in the sample.

15. See Finsinger and Pauly [1984] on the importance of policy reserves.

16. The function H(w) specifies the way that factor prices affect cost.

17. The normalized inverse product demand functions allow marketing costs to affect marginal revenue associated with increases in the number of policies for each line of insurance. This function is generalization of the function defined by Diewert [1982] to analyze price-cost margins.

18. In order to identify the parameters, equation (9) does not have to be estimated. Thus we assume that (9) is a nonstochastic equation and that η_i, δ_i i=1,...,n are known constants. The parameter η_i represents the marginal cost of search and $\delta_i > \ln y^i$ so the marginal benefit of marketing $\gamma_i(\delta_i - \ln y^i) > 0$.

19. There were 37 firms used in 1979. The Ina Life Insurance Company existed in this year. However it only produced segregated funds but not life policies and annuities.

20. The means and standard deviations of production cost in millions of Canadian dollars for firms in the sample are, 21.52 (34.73) in 1979, 41.16 (64.21) in 1982, 52.22 (81.14) in 1985, and 69.51 (11.06) in 1988.

21. The means and standard deviations of marketing cost in millions of Canadian dollars for the firms in the sample are 4.14 (6.78) in 1979, 7.34 (12.85) in 1982, 9.70 (17.07) in 1985, and 13.03 (24.06) in 1988. The means and standard deviations of insuree income for individual life and annuities and group life and annuities in millions of Canadian dollars are 2073.41 (3667.13), 124.48 (207.18), 7028.10 (11484.01) 125.26 (213.60) respectively

in 1979, 3415.00 (5978.20), 283.56 (433.73), 9234.91 (14945.10), 274.41 (564.67) respectively in 1982, 4144.51 (7243.16), 447.38 (701.36), 9018.36 (14213.50), 480.70 (1025.84) respectively in 1985, and 6232.54 (13150.00), 706.61 (1079.81), 10830.90 (17322.90), 883.90 (2004.80) respectively in 1988.

22. For any one line of insurance in any year, there were generally not more than two negative values of marginal costs out of a possible thirty-eight (which is the number of firms). Moreover, for each line and year the average marginal cost was always positive.

23. An exception is the paper by Kellner and Mathewson [1983], for Canadian life insurance. However, they did not look at returns to scope, but only the local measure of returns to diversity (or cost complementarities). Braeutigam and Pauly [1986] investigate the cost structure for US automobile insurance with a single output and single quality variable.

References

Appel, D, Worrall, J.D., and R.J. Butler: Survivorship and the size distribution of the property-liability insurance industry, Journal of Risk and Insurance 52, 424-440, 1985.

Baumol, W.J. and J. Panzar and R. Willig: Contestable Markets and the Theory of Industry Structure, Harcourt Brace Jovanovich, New York, 1982.

Bernstein, J.I. and R.R. Geehan: The Insurance Industry in Canada, Fraser Institute, Vancouver, 1988.

Borch. K.: Equilibrium in a reinsurance market, Econometrica 30, 424-444, 1962.

Borch, K.: Economics of Insurance, North Holland, Amsterdam, 1990.

Braeutigam, R.R. and M.V. Pauly: Cost-function estimation and quality bias; the regulated automobile insurance industry, Rand Journal of Economics 17, 606-617, 1986.

Cooper, R. and B. Hayes: Multi-period insurance contracts, International Journal of Industrial Organization 5, 211-231, 1987.

Crocker, K.J., and A. Snow: The efficiency effects of categorical discrimination in the insurance industry, Journal of Political Economy 94, 321-344, 1986.

Diewert, W.E.: Duality approaches to microeconomic theory, in K. Arrow and M. Intrilligator, editors, Handbook of Mathematical Economics, Vol. II. Elsevier Science Publishers, The Netherlands, 1982.

Dionne, G.: Search and insurance, International Economic Review 25, 237-367, 1984.

Doherty, N. and J.R. Garven: Price regulation in property/liability insurance; a contingent claims approach, Journal of Finance 41, 1031-1050, 1986.

Fairley, W.: Investment income and profit margins in property-liability insurance; theory and empirical results, Bell Journal of Economics 10, 192-210, 1979.

Finsinger, J. and M.V. Pauly: Reserve levels and reserve requirements for profit maximizing insurance firms, in G. Bamberg and K. Spremann (eds.), Risk and Capital, Spinger-Verlag, 160-180, 1984.

Geehan, R.R.: Returns to scale in the life insurance industry, Bell Journal of Economics 8, 497-514, 1977.

Hellwig, M.: A note of the specification of interfirm communication in insurance markets with adverse selection, Journal of Economic Theory 46, 154-163, 1988.

Kellner, S. and G.F. Mathewson: Entry, size distribution, scale, and scope economies in the life insurance industry, Journal of Business 56, 25-44, 1983.

Joskow, P.J.: Cartels, competition and regulation in the property-liability insurance industry, Bell Journal of Economics and Management Science 4, 327-427, 1973.

Mathewson, G.F.: Information, search, and price variability of individual life insurance contracts, Journal of Industrial Economics 32, 131-148, 1983.

Mayers, D. and C.W. Smith: On the corporate demand for insurance; evidence from the reinsurance market," Journal of Business 63, 19-40, 1990.

Rothschild, M. and Stiglitz, J.E.: Equilibrium in competitive insurance markets, the economics of markets with imperfect information, Quarterly Journal of Economics 90, 1629-650, 1976.

Tirole, J.: The Theory of Industrial Organization, MIT Press, Cambridge, Mass., 1989.

Spence, M.: Product differentiation and performance in insurance markets, Journal of Public Economics 10, 427-447, 1978.

Wilson, C.: A model of insurance markets with incomplete information, Journal of Economic Theory 12, 167-207, 1977.