TOTAL FACTOR PRODUCTIVITY GROWTH IN THE CANADIAN LIFE INSURANCE INDUSTRY: 1979-1989

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ABSTRACT

This is the first paper to directly measure and decompose total factor productivity growth (TFPG) for the Canadian life insurance industry.

TFPG averaged 1.0 percent per year over the period from 1979 to 1989, thereby outperforming many manufacturing industries. The rate of TFPG was 0.2 percent in the first half of the 1980's due to the depressed economy and 1.9 percent in the last half of the decade.

Technological change was the major element contributing to TFPG. There was a large residual element in the decomposition of TFPG, reflecting possible adjustment costs associated with new information processing technologies.

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1. Introduction*

Productivity growth is an important indicator of industry performance, in general, and production efficiency, in particular. There have been few attempts to directly measure total factor productivity growth (TFPG) for service industries, and s ecifically for the Canadian life insurance industry. Indeed, since services are two-thirds of Canada's gross domestic product, a careful undertaking of output and input measurement for services can yield a clearer picture of Canada's productivity performance and thereby, its competitive position.

Measured productivity growth rates for services are generally lower than the rates obtained for manufacturing industries. However, this finding is suspect because of the difficulties in using official statistics to measure output of service industries. The purpose of this paper is to compute, output, input, and productivity growth rates for the Canadian life insurance industry, based on firm-level data obtained from the Office of the Superintendent of Financial Institutions (OSFI). In addition, the rate of TFPG is decomposed in order to determine the relative contribution of returns to scale and rates of technological change to productivity growth.

This paper is organised in the following way. Section 2 discusses the position of the life insurance industry in the Canadian economy. Section 3 pertains to the measurement of output

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prices and quantities in the life insurance industry. Sections 4, 5, and 6 discuss labour, capital and intermediate input prices and quantities. Section 7 contains the discussion of the rate of TFPG. Section 8 presents the analysis of the decomposition of TFPG. The last section is the conclusion.

2. Life Insurance in the Canadian Economy

The largest sectoral contributor to Canadian gross domestic product (GDP) is services. Indeed, the proportion of GDP contributed by the manufacturing sector during the last three decades has been about 19.0 percent while the service sector has continued to grow, reaching 67.0 percent by 1992.[1] Along with services in general, the finance, insurance and real estate (FIRE) sector has grown over the 1980's from 14.6 percent in 1981 to 16.7 percent in 1992. Throughout this period, the insurance industry (that is, both life and property and casualty insurance) has kept pace with the service sector as a whole and the FIRE subsector. Insurance accounts for about 0.70 percent of GDP. The GDP contribution of life insurers from 1981 to 1992 has increased from 0.30 to 0.42 percent. Manufacturing industries that are of comparable size to life insurance, (in terms of GDP proportions) include industrial chemicals (0.43 percent), telecommunication broadcasting (0.43 percent), and air transportation and incidental services (0.51 percent).

In 1991, 79.0 percent of premiums written by life insurers were for life insurance policies and annuities with the remainder coming from accident and sickness insurance. Of these premiums, federally registered firms wrote 92.2 percent, and the remainder written by provincial insurers. In 1991, there were 175 federally registered life insurance companies in Canada, of which 69 (39.4 percent) were domestically owned and 106 were foreign firms or subsidiaries of foreign parent firms operating in Canada. The life insurance industry is one of the few Canadian industries in which the companies that dominate the industry are of Canadian nationality (in terms of ownership or registration). Despite being markedly outnumbered by foreign competitors, Canadian-owned firms accounted for 70.1 percent of premiums.

With respect to financial assets, in 1991 life insurers held 13.8 percent, or $153.2 billion. In comparison to other major financial intermediaries, chartered banks held 43.2 percent, credit unions and caisse populaires held 8.0 percent, trust and mortgage loan companies held 11.5 percent, trusteed pension plans held 20.3 percent, and property/casualty insurers held 3.2 percent. Although the percentage of financial assets held by life insurers has fallen over the post World War II period, (in 1961 the percentage was 26.5), by the middle 1980's the rate stabilised.[2]

In this paper, output, input and productivity growth rates are measured for the twelve major firms (as an aggregate or as a whole) that operate in the life insurance industry. These twelve firms account for 76 percent of all the premiums and 81 percent of all assets over the period from 1978 to 1989. A list of the companies studied, showing their sales as a percent of the total sales of all life insurance companies and their assets as a percent of the total assets of all life insurance companies is presented in table 1. Sales are measured by total premium revenue in all lines of life

Table 1: Life Insurance Companies

Assets and Premium Revenue as a % of Total Assets and Premium Revenue

(Average 1978-1989)

	Company	Total Assets (% of total)	Premium Revenue (% of total)
1	Manufacturers' Life Insurance	19.6	20.5
2	Great West Life Insurance	13.9	16.2
3	Sun Life Insurance	16.2	11.9
4	Canada Life Insurance	8.0	7.6
5	Mutual Life Insurance	6.3	5.4
6	London Life Insurance	6.2	4.6
7	North American Life Insurance	3.2	2.8
8	Imperial Life Insurance	2.9	2.3
9	Excelsior Life Insurance	1.5	1.4
10	Maritime Life Insurance	1.4	1.1
11	Assurance-Vie Desjardins	0.9	1.0
12	National Life Assurance	0.9	1.0
	Total	81.0	76.0

insurance and annuities. Assets include stocks and bonds, mortgages, real estate, short-term paper, and cash.[3]

All twelve firms offered life insurance lines that ranged from individual life insurance to group annuities. These companies were federally registered companies. The market share of the largest, the Manufacturers' Life Insurance Company was on average 20.5 percent over the period from 1978 to 1989, whereas the market share of the smallest company, National Life Assurance was approximately 1.0 percent over the same period. As we can see from table 1, the ranking of firms by premium revenue is quite similar to the ranking by assets.

3. Output Measurement

Insurance output has been measured generally as premiums paid, or premiums net of claims (see Bernstein and Geehan [1988], for a discussion and references concerning the different measures of insurance output). However, these variables do not represent output quantity. They are alternative measures of revenues that are defined in terms of current dollars, and thereby contain the influence of prices. Suppose that a unit of insurance is purchased this year for $100 (at this point we will not concern ourselves with the definition of a unit of insurance). Next year, the price of this unit becomes $110. Although premiums increased, insurance output has remained constant. In order to measure the growth rate of total factor productivity (that is output growth net of input growth) it is necessary to decompose insurance revenue into price and quantity components.[4]

Considerations of the nature of the product or products sold by insurers are important in the measurement of insurance output quantity. Purchasers of insurance are buying future financial protection when a particular event occurs. An insurance firm is able to offer this protection because it has created the facilities to pool risks. Indeed insurance policies specify the terms of agreement between insurers and insurees. With respect to life insurance, these terms relate to such elements as the premium, the dollar value of insurance (i.e. the face value), the event that is being insured against, and the time period over which the policy is in force. Clearly, then, a policy, with its detailed characterisation of the life insurance contract, delimits output quantity. For example, the number of policies defined for individuals, with face values of $100,000, for ten years, represents output quantity for this particular type of life insurance.

This view of life insurance output quantity recognises that insurers produce multiple outputs. With the availability of sufficiently detailed firm-level data, it is possible to define multiple policy types. Aggregating over policy types (by using the prices and quantities associated with each policy) leads to an aggregate measure of life insurance output quantity.

The adoption of this approach to output measurement highlights the difficulties in using official statistics. These data relate to 1) aggregate data, and 2) revenue (or current dollar) measures. Specifically, policy numbers are not available for a variety of policy types. The inference here is that attempts to measure output quantities of life insurers using official statistics is problematic.

There are a number of other aspects in the calculation of revenue, output price and output quantity of life insurance that must be considered. First, in the life insurance industry there are active reinsurance markets. In these markets insurers sell parts of a policy to other insurers in order to diversify risk. In this paper all premiums are included in revenue, and any premium revenue that has been sold or ceded to other insurers is included in intermediate inputs. When an insurer cedes part of a policy in reinsurance markets, it is purchasing services from another insurer.

A second consideration in output measurement pertains to claims. Premiums for a policy are set on an actuarial basis. Premiums reflect an expected intertemporal income flow taking into consideration the expected claims that will arise from the policy. Life insurers must set aside, or reserve, a portion of the premium in order to pay for the increase in expected claims that may arise from the policies in force. Changes in reserves represent the annual changes to expected claims associated with the annual premium paid on a policy. This means that changes in reserves must be subtracted from premiums to calculate annual revenue.

Third, life insurers invest part of the funds they obtain through premiums. The returns from these investments help diversify the risk and defray the costs of financial intermediation. Thus, gross returns from investment are added to premiums and the cost of obtaining these returns are reflected in the labour, intermediate inputs, and capital costs of the insurance firm.[5]

Outputs of life insurers have a number of different features or characteristics. There are three important features. The first characteristic represents the insured event, for example, death or retirement. The second characteristic pertains to the face amount of the policy. This is the value received by the insured if the insured against event occurs. The third characteristic concerns the policyholder. It is either an individual or group, and groups can consist of various numbers of individuals. There are many lines (i.e. different types of output) of insurance and any adjustments to premiums to obtain revenue must be carried out for each line. Once the 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.

In this paper insurance output is divided into four categories. These are individual insurance, group insurance, individual annuities and group annuities. Individual and group insurance output includes whole life, term life and endowment insurance written as both participating and non-participating policies. The term of a whole life policy is the lifetime of the insured. Term insurance covers the life of the insured for a specific period only. Endowment polices provide a cash payment when the policy is ceased. Participating policies pay dividends to policyholders, as they are also equityholders. Individual and group annuities include pensions with and without last survivor and disability features.

All the output-related annual data for the twelve firms over the period from 1978 to 1989 are obtained from the Office of the Superintendent of Financial Institutions (OSFI). The output price measure for the ith line of insurance or annuity is

$$P_i = [(pd_i + pa_i) + giv_i - \Delta pr_i] / N_i \quad (1)$$

where P_i is the output price, pd_i is the premium revenue earned from direct sales, pa_i is the premium revenue earned by assuming reinsurance from another insurance firm, giv_i is the gross investment income, Δpr_i is the annual change in policy reserves, and N_i is the number of polices or group certificates, all in the ith line of insurance or annuity. The change in policy reserves reflects the expected change in future claims associated with the annual premiums. In the case of group insurance, or annuities, individuals do not own the policies. However, they are issued a certificate that establishes the life insurer's liability to them through the policy owned by the group. The output price of the ith line of insurance is the price per policy charged for the financial intermediary services provided by the life insurance firm. This price is normalized to 1.00 in 1986.

Next, output quantity of a line, given by the number of policies in that line, is multiplied by the normalized price. The product of the normalized output price and quantity is the revenue earned by the company for financial intermediation services in the respective line of insurance or annuity. This is $P_i N_i$, or the per policy price multiplied by the number of policies in the ith line of insurance or annuity.

Output prices are defined with respect to four characteristics, individual or group, and insurance or annuity. As previously noted, there are a number of other output characteristics. One specific characteristic is the face value of an insurance policy or annuity contract. Although data on face values (net of ceded insurance) are unavailable from OSFI, the output price index that is developed in this paper is consistent with a constant face value index. This result is presented in the appendix.[6]

The next step is to aggregate over the twelve firms to obtain growth rates for each of the four outputs. The ith output quantity is aggregated in the following way. First, a Tornquist aggregate (over firms) price index is formed for each output. The aggregate price formed in this way is then normalized to 1.00 in 1986. Second, output quantity (for the aggregation of the twelve firms) for each line is constructed by dividing revenue for a specific line by its price index.

Growth rates for each of the output lines aggregated over all twelve firms are presented in table 2. The four outputs are individual insurance, individual annuities, group insurance, and group annuities.

This table shows that over the period from 1979 to 1989 annuities grew significantly faster than insurance. In addition, the annual rates of growth for individual and group annuities were about equal with rates at around 10.0 percent. Individual insurance grew at around 3.25 percent over the period, while there was virtually no growth for group insurance. Output growth was greater in the latter half of the 1980's for each category. In fact, the positive growth in group insurance over this period just overcame the negative growth in the first half of the decade.

4. Labour Input

The number of persons employed by the life insurance industry in Canada increased from 50,400 in 1978 to 65,100 in 1989. In 1978, 38

Table 2: Growth Rates of Outputs

(Percent)

Period	Individual Insurance	Individual Annuity	Group Insurance	Group Annuity
1979	3.73	12.73	0.61	2.04
1980	1.00	22.98	0.27	7.36
1981	4.49	9.96	4.34	17.30
1982	-2.04	10.72	-6.92	-0.22
1983	0.55	8.06	-14.52	8.46
1984	3.88	7.67	-0.03	11.00
1985	2.87	5.48	-2.62	21.01
1986	8.15	13.67	1.44	15.32
1987	-1.11	5.88	-4.24	7.10
1988	8.91	7.74	8.45	12.93
1989	5.29	2.88	7.36	8.39
1979-1984	1.94	12.02	-2.71	7.65
1985-1989	4.82	7.13	2.08	12.95
1979-1989	3.25	9.79	-0.53	10.06

percent of all company employees were engaged in sales and 62 percent were engaged in administrative work. In 1989, these percentages were 35 percent and 65 percent respectively. Administrative labour input includes clerical, data processing, investment, and actuarial personnel. Sales labour input includes captive agents, sales managers, and clerical personnel. Captive agents are agents who represent only one company. In return, a life insurance company provides the captive agents their office space and equipment. The majority of life insurance sales are obtained through captive agents. Independent agents may work for more than one company and provide their own office facilities and equipment. There are few independent agents in life insurance.

The twelve major life insurance companies that are considered in this paper paid an average of 70 percent of all wages and benefits earned in the life insurance industry over the period 1978-1989. Wages include head office employee wages, branch office employee wages, sales manager salaries, agent salaries, commissions and allowances, and director fees. Benefits include contributions to company pension plans for employees and agents, the employer's contributions to government pension plans and unemployment insurance, hospitalisation and medical insurance for employees, and cafeteria expenses.

Labour input quantity is calculated in the following way. Current annual wages and benefits for each firm are divided by a labour price index constructed for the life insurance industry. This labour price index is constructed by first dividing total annual life insurance industry wages and benefits by total annual life insurance industry hours to obtain a series of annual hourly wage rates specific to this industry. This series of hourly wage rates is indexed to 1.00 in 1986. Total annual life insurance wages and benefits are obtained from the Canadian Life and Health Insurance Association. Total life insurance industry hours are obtained by multiplying total annual hours for the FIRE sector, by the percentage of life insurance employment to FIRE employment. Employment and hours data are obtained from Statistics Canada. The labour quantity for each of the twelve firms is then current annual wages and benefits for each firm divided by this labour price index.

Next, the labour quantities for each firm are aggregated to obtain a labour quantity for all twelve life insurance firms. Since the labour price index is identical for all firms, labour quantity for all firms is the sum of all firms' current labour costs divided by the industry labour price index.

Table 3 presents the rates of growth of labour quantity. From this table we see that labour quantity grew at around 2.5 per cent annually over the period. Moreover, unlike output quantity growth, the labour quantity growth rate was quite stable over the whole decade.

5. Capital Input

Two types of capital input are used in the life insurance industry, machinery and buildings. Buildings for own use are those buildings used by the life insurance firm for all of its insurance and investment activities. Machinery used in the life insurance industry consists of office furniture, electronic data processing equipment of all types, and computer software.

Table 3: Growth Rates of Inputs

(Percent)

Period	Labour	Building Capital	Machinery Capital	Intermediate Inputs
1979	4.76	-4.41	58.54	5.42
1980	-0.84	-15.09	53.83	-3.50
1981	3.67	-9.78	61.44	31.89
1982	-0.52	19.77	33.70	-6.82
1983	-1.53	31.95	29.74	-0.65
1984	8.41	5.40	31.72	7.37
1985	3.68	16.71	21.66	15.06
1986	1.34	22.35	30.02	4.32
1987	7.18	10.16	5.58	1.70
1988	-0.21	15.01	13.83	8.04
1989	-0.24	-3.86	14.81	-4.38
1979-1984	2.32	4.64	44.83	5.62
1985-1989	2.35	12.08	17.18	4.95
1979-1989	2.34	8.02	32.26	5.13

The measure of building capital is constructed from real estate expenses provided by firms to OSFI. Real estate expenses include imputed and actual rents on buildings for own use, maintenance expenses, and other real estate expenses. Actual and imputed rents include rents on head, and branch offices used for insurance and investment purposes. Building capital for a firm is measured as real estate expenses divided by the rental rate on building capital. This rate is defined as,

$$(2) \qquad w_b = p_b(\delta_b + r)(1 - u_p)$$

where w_b is the rental rate on buildings, p_b is the acquisition price index of building capital, δ_b is the depreciation rate on buildings, r is the long-term government bond interest rate, and u_p is the property tax rate. The acquisition price index relates to the FIRE sector. This price is published by Statistics Canada, and is indexed to 1.00 in 1986.[7] The depreciation rate is the annual depreciation on buildings divided by the value of buildings. These data are provided by OSFI. The property tax rate is the annual amount of property taxes paid as reported to OSFI divided by the value of buildings.

Next, the building capital stocks for each firm are aggregated in order to measure the buildings capital input quantity for all twelve life insurance firms. Since the building capital acquisition price index is identical for all firms, the building capital quantity for all firms is the sum of all firms annual costs of buildings capital divided by the building capital price index.

Turning to machinery capital, it is either owned or leased. Rental payments for leased machinery are obtained from general and miscellaneous expenses in the OSFI data. Many smaller insurance firms not only lease their office space but also lease equipment. This equipment usually includes electronic data processing equipment.

Imputed rent on owned equipment for each of the twelve firms is calculated by multiplying the quantity of owned equipment by the rental rate for equipment. The quantity of owned equipment is the current value of owned equipment reported as an asset in the OSFI data divided by the acquisition price for machinery capital. This price is obtained from Statistics Canada for the FIRE sector, and is indexed to 1.00 in 1986. The rental rate for machinery and equipment capital is,

$$(3) \qquad w_m = p_m(\delta_m + r)$$

where w_m is the rental rate on machinery, p_m is the acquisition price index of machinery capital, δ_m is the depreciation rate on machinery. The depreciation rate is the annual depreciation on owned machinery divided by value of machinery. These data are provided by OSFI.

For each of the twelve firms, summing the imputed rent on owned machinery with the rental payments on leased machinery results in the total rent on machinery. Dividing this sum by the rental rate yields machinery capital input quantity.[8]

Next the machine capital input quantities for each firm are aggregated to give machinery capital quantity relating to all twelve life insurance firms, as a whole. Since the price index is identical for all firms, aggregate machinery capital quantity is the sum of all twelve firms' annual cost of machinery capital divided by the price index.

Table 3 presents the capital input growth rates for building and machinery capital respectively. This table shows that the average annual growth rate of building capital was 8 percent. In addition, growth was significantly greater in the last half of the decade. Table 3 also shows the enormous growth in machinery capital over the 1980's. The average annual rate of around 32 percent reflects the importance of new equipment associated with information processing technologies. In fact, the growth rate of equipment was greater in the first half of the decade. Recall that this was a period of slower output growth.

6. Intermediate Inputs

Intermediate inputs consist of materials, supplies and hired, or purchased services. Reinsurance services are a component of purchased services. They are purchased from other insurance companies. In addition, hired services consist of professional services purchased from medical practitioners, lawyers, accountants, and investigators.

For each of the twelve firms, the current value of materials and supplies expenses is added to the current value of professional service expenses to form the current cost of materials, supplies, and professional services. The quantity of materials, supplies and professional services is obtained by dividing the current cost by the intermediate input price deflator published by Statistics Canada for the FIRE sector. This index is 1.00 in 1986.

The quantity of ceded reinsurance for each of the twelve firms is constructed in the following way.[9] The number of ceded policies, contracts or certificates in any one line of insurance or annuity is calculated as the proportion of ceded reinsurance premiums to direct insurance and assumed reinsurance premiums, multiplied by the number of direct and assumed policies or certificates in that line of insurance or annuity. The total quantity of ceded insurance or annuities for each firm is the sum of quantities across the four lines of insurance and annuities. Next, the price of ceded insurance is obtained by dividing the total current value of ceded insurance by the total quantity of ceded insurance. The value of reinsurance ceded over all four categories of output is collected from the OSFI data. This value is the premiums net of the change in policy reserves associated with reinsurance ceded. The price of ceded insurance is normalised to 1.00 in 1986.

The measure of the quantity of intermediate inputs for each of the twelve firms is the aggregation of the quantities of materials, supplies, and professional services relating to insurance and investment activity, and the quantity of reinsurance ceded. Price indices of materials, supplies, and professional services, and reinsurance ceded are combined as a weighted-sum to form the price index of intermediate inputs. The weights used in this summation are the contemporaneous cost shares of materials, supplies, and professional services, and ceded insurance. This aggregate price is normalised to 1.00 in 1986. The quantity of intermediate inputs, for each firm, is the current cost of intermediate inputs divided by the price index of intermediate inputs.

Next intermediate input quantities for each of the twelve firms must be aggregated across firms. An aggregate intermediate input price index is constructed using the weighted-sum of individual firm price indices. The weights are firm intermediate input cost as a proportion of aggregate (across firms) intermediate input cost. This price index is normalised to 1.00 in 1986. Aggregate intermediate input quantity is measured as aggregate intermediate input cost divided by the aggregate intermediate input price index.

The last column in table 3 presents the growth rates for intermediate input quantity. This table shows that the average annual growth for intermediate inputs was 5.1 percent. This growth rate was quite stable over the decade.

7. Total Factor Productivity Growth

The rate of total factor productivity growth (TFPG), for all twelve firms combined as an aggregate, is the rate of output growth minus the rate of input growth. The rate of growth of output in period t is given by,

$$(4) \qquad \Delta lnY(t) = \sum_{j=1}^{4} [(s_{yj}(t+1) + s_{yj}(t))/2] \ln(y_j(t+1)/y_j(t))$$

where $s_{yj}(t)$ is the jth output revenue share in period t, and $y_j(t)$ is the jth output period t. Recall that the four outputs are individual insurance, individual annuities, group insurance, and group annuities. The annual growth rates of output, for the twelve firms as an aggregate, are shown in table 4. The average output growth rate was 4.5 percent in the first half of the decade and about 7.0 percent in the second half. In fact over the whole decade output growth for averaged 5.5 percent.

In a similar fashion to output growth, input growth, for all twelve firms as a whole, can be measured as,

$$(5) \qquad \Delta lnV(t) = \sum_{j=1}^{4} [(s_{vj}(t+1) + s_{vj}(t))/2] \ln(v_j(t+1)/v_j(t))$$

where $s_{vj}(t)$ is the cost share of the jth input in period t, and $v_j(t)$ is the quantity of the jth input in period t. There are four inputs; labour, building capital, machinery capital and intermediate inputs. Table 4 shows that input growth averaged around 4.5 percent over the decade and this was quite stable.

The rate of TFPG in period t is,[10]

$$(6) \qquad TFPG = \Delta lnY(t) - \Delta lnV(t)$$

The last column in table 4 presents TFPG. Table 4 shows that total factor productivity growth in the life insurance industry is higher during the period 1985-1989, relative to the first half of the decade. The average annual rate of TFPG for life insurance was about 1 percent over the decade.

The life insurance industry, as reflected by the twelve major firms, experienced a slowdown in productivity growth similar that experienced in Canadian manufacturing industries during the first half of the 1980's (see Denny, Bernstein, Fuss, Nakamura and Waverman (DBFNW) [1992]). The average TFPG rate for the life insurance

Table 4: Growth Rates of Output, Input and Productivity

(Percent)

Period	Output Growth	Input Growth	TFPG
1979	4.50	3.60	0.90
1980	6.12	-3.48	9.60
1981	7.80	5.50	2.30
1982	0.27	4.28	-4.01
1983	1.81	6.86	-5.05
1984	5.76	8.41	-2.66
1985	7.30	8.65	-1.35
1986	10.42	7.00	3.42
1987	2.67	6.28	-3.61
1988	9.17	4.70	4.47
1989	5.67	-0.87	6.54
1979-1984	4.38	4.20	0.18
1985-1989	7.05	5.15	1.90
1979-1989	5.59	4.63	0.96

industry over the period 1979-1989 outperformed twelve of the eighteen manufacturing industries (calculated by DBFNW) over the period 1973-1985. Moreover, over the depressed period 1979-1984 the rate of TFPG for life insurance was greater than the rate for seven of eighteen manufacturing industries. During the period from 1980 to 1985 only five Canadian manufacturing industries had a better TFPG performance than the life insurance industry during the period from 1979 to 1989. These industries were rubber, leather, lumber, primary metals, and electrical machinery.

The period from 1979 to 1985 in North America covers a trough to peak period. Such a period is accompanied by large changes in capital utilisation and good TFPG performance is experienced by industries characterised by a large quantity of fixed assets. The life insurance industry does not have a large stock of fixed assets when compared to such industries as lumber and electrical machinery industries, and thus is more likely to show poor TFPG during such a period.

Productivity growth studies pertaining to the banking industry also show low TFPG rates in the period from 1967 to 1987. Hunter and Timme [1991] used aggregate output and input data and found TFPG, in the U.S. commercial banking industry, to range from -0.07 to 0.60 percent a year during the period from 1977 to 1987. Humphrey [1991] also found lower positive and less negative annual rates of productivity growth over the period from 1967 to 1987 compared to Hunter and Timme. Parsons, Gotlieb, and Denny [1990] calculated TFPG rates for Canadian commercial banking. They found an average annual TFPG rate of 1.9 percent from May 1974 to October 1987. Thus we find that over the 1980's the rate of TFPG for life insurance is comparable to the rate found for commercial banking.

8. Decomposition of Total Factor Productivity Growth

TFPG rates can be decomposed into two parts. One part relates to the degree of returns to scale and the other pertains to the rate of technological change. The decomposition can be written as (see Diewert [1988] and Bernstein [1996]),

$$(7) \quad TFPG = (1 - \rho_y^{-1})\, \Delta lnY(t) + z_c(t) + \varepsilon$$

where ρ_y is the measure of scale economies, z_c is the (input-based) rate of technological change, and ε is the residual due to other factors. From equation (7), if there are constant returns to scale then there is no scale effect on TFPG. If there are increasing returns to scale along with positive rates of output growth then scale contributes to TFPG. In addition, positive rates of technological change contribute to TFPG.

Equation (7) shows us how to decompose measured TFPG rates into scale, technology, and residual components. In this paper we do not estimate the degree of returns to scale or the rate of technological change. We obtain these estimates from the existing literature. The estimates of scale economies (ρ_y) are taken from Bernstein [1992]. The estimates of scale are, 1.40 for the period from 1978 to 1981, 1.17 for the period from 1982 to 1984, 1.31 for the period from 1985 to 1987, and 1.13 for the period from 1987 to 1989. As equation (7) shows, these estimates of returns to scale are multiplied by the output growth rates that pertain to the twelve firms as a whole, and found in table 4. The estimate of the rate of technological change (z_c) is from Daly, Rao and Geehan [1985]. The annual rate is 1.5 percent.

The results on the decomposition of TFPG are presented in table 5. On average the main element contributing to TFPG for life insurance is technological change. This result is similar to that found for banking. In addition, the rate of technological change used in the decomposition is similar to rates estimated for banking. In the U.S. banking industry the rate of technological change has been estimated to be 0.96 percent per year for the period from 1980 to 1986. This estimate relates to a panel of 219 U.S. banks (see Hunter and Timme [1991]), although Humphrey [1991] estimated the rate to be -0.90 percent for the period from 1977 to 1988 for a panel of 683 banks accounting for two thirds of all U.S. bank assets. This finding is consistent with Parsons, Gotlieb and Denny [1990], who find an average rate of technological change in Canadian banking of 1.0 percent over the period from 1980 to 1987. These rates of technological change compare with 1.5 percent for the Canadian life insurance industry found by Daly et al [1985] for the period from 1974 to 1977.

Bernstein [1992] finds evidence of slightly increasing returns to scale in the life insurance industry. Indeed, scale economies, on average, account for a slightly smaller effect on TFPG than the rate of technological change. Moreover, in comparison to banking, Hunter and Timme [1991], and Humphrey [1991] find that returns to scale are almost constant in U.S. commercial banking, while Parsons, Gotlieb

Table 5: Decomposition of Total Factor Productivity Growth

(Percent for selected periods)

Period	TFPG	Scale	Technological Change	Residual
1979-1980	5.25	1.52	1.50	2.23
1981-1983	-2.25	0.84	1.50	-4.60
1984-1986	-0.19	1.68	1.50	-3.37
1987-1989	2.47	0.78	1.50	0.19
1979-1984	0.18	1.07	1.50	-2.39
1985-1989	1.90	1.31	1.50	-0.91
1979-1989	0.96	1.18	1.50	-1.72

and Denny [1990] find constant returns to scale in Canadian banking. Thus there appears to be a somewhat greater degree of returns to scale in life insurance and these scale economies contribute to the rate of TFPG.

The residual term in the decomposition represents a number of elements. First it represents measurement errors in the rate of TFPG. For example, if output or input prices are not measured correctly then errors will appear in TFPG rates. Indeed, the significant growth of machinery capital has caused measured TFPG to decline because the substantial decline in computer prices is not fully captured by Statistics Canada price indexes.

Second, the residual can reflect output prices that are not equal to marginal costs of production. This means that the measured rate of TFPG reflects more than just technological efficiency. In this case, the residual encompasses price-cost margins, which are not reflected in measures of the degree of returns to scale and rates of technological change.

Third, the existence of a residual can mean that estimates of the degree of returns to scale or the rate of technological change need to be improved. Indeed, this may be the case for the rate of technological change. There is little contemporaneous evidence on the rate of technological change in the Canadian life insurance industry. This omission is especially important in light of the importance of developments in information technologies in the delivery of life insurance services.

Fourth, the residual captures elements that contribute to TFPG other than scale and technological change. One such element pertains to capital adjustment. For example, there may be significant costs associated with the implementation of information technology (such as training costs) that have not been captured in the decomposition of the rate of TFPG. Clearly, given the annual variations and size of the residual, further work is needed in determining the decomposition of TFPG for the Canadian life insurance industry.

9. Conclusion

In this paper, for the first time, comprehensive estimates of total factor productivity growth for the Canadian life insurance industry have been developed. We find that over the period from 1979 to 1989 the average annual rate of productivity growth was about 1 percent. Based on the existing empirical evidence, productivity growth in the life insurance industry was generally higher than the rates estimated for the two-thirds of Canadian manufacturing industries over the comparable period from 1973 to 1985.

The major source of output growth in the calculation of TFPG was the significant growth in annuities, as individual and group annuities had average annual growth rates of around 10 percent. Information technologies were an important source of input growth. Average annual growth for machinery capital, which reflects information technology, was an astounding 32 percent over the decade.

The rate of technological change and the degree of scale economies are two important elements that contribute to productivity growth. Current estimates suggest that technological change is relatively more significant as a source of productivity growth. However, we found a large residual element in the decomposition of productivity growth. Although this residual can arise from numerous sources, we believe that two main deficiencies account for the residual. First, there are only a few, and dated estimates of the rate of technological change for the life insurance industry. Second, the decomposition analysis did not account for the rapid, significant and costly adjustment associated with implementation of information processing technologies in the delivery of life insurance services. Further research is needed to provide a more comprehensive decomposition of TFPG rates. Nevertheless, notwithstanding improvements in our understanding of the decomposition of productivity growth, we have clearly shown that the productivity performance of the Canadian life insurance industry is comparable to manufacturing industries.

Appendix: Output Price Aggregation and Face Amounts

When measuring output over time, it is necessary to account for all output characteristics. With respect to insurance, output measures must reflect a constant face value for a given policy. This constant face value reflects the quantity of risk insured. In the case of life insurance this quantity of risk is a single life valued in constant dollars. With respect to annuities, the quantity of risk associated with a single life or annuitant is reflected by a constant dollar annual annuity payment. This appendix shows that the Tornquist output price indexes are consistent with constant face amounts of insurance and annuities.

The premium per policy (or in other words the price) of line i in period t is,

$$\text{(A.1)}\quad P_t^i = (p_t^i b_t^i N_t^i) / N_t^i$$

where p_t^i is the price of insurance per unit face amount or the price of an annuity of one dollar in period t, b_t^i is the face amount of insurance or the annuity payment in period t, and N_t^i is the number of policies of line i insurance or the number of annuity contracts in the case of an annuity. The value $p_t^i b_t^i N_t^i$ is the premium revenue of line i of insurance or annuity in period t.

We can construct an index of constant face amounts of insurance as,

$$\text{(A.2)}\quad FI_t^i = b_t^i / b_{t-1}^i$$

where FI^i_t is the index of individual face amounts or annual annuity payments, having a value of 1.0 in period t-1. The price of insuring a base year unit face or the price of a constant dollar annuity of $1 is,

$$\text{(A.3)}\quad \begin{aligned} P^i_t &= p^i_t FI^i_t \\ &= p^i_t b^i_t N^i_t / [b^i_{t-1} N^i_t] \end{aligned}$$

where $b^i_{t-1} N^i_t$ is the period t face amount of insurance in units of period t-1 face, or the constant period t-1 dollar payments of annuities.

The Tornquist price index of the prices of constant face amounts of insurance or a constant dollar annuity is

$$\text{(A.4)}\quad \begin{aligned} \Pi^n_{i=1}[P^i_t / P^i_{t-1}]^{s^i_t} &= \Pi^n_{i=1}[p^i_t b^i_t N^i_t /[b^i_{t-1} N^i_t] b^i_{t-1} N^i_{t-1} /[p^i_{t-1} b^i_{t-1} N^i_{t-1}]]^{s^i_t} \\ &= \Pi^n_{i=1}[P^i_t / P^i_{t-1}]^{s^i_t} \end{aligned}$$

where $s^i_t = (p^i_{t-1} b^i_{t-1} N^i_{t-1} / \sum^n_{j=1} p^j_{t-1} b^j_{t-1} N^j_{t-1} + p^i_t b^i_t N^i_t / \sum^n_{j=1} p^j_t b^j_t N^j_t)^{0.5}$, and $P^i_t / P^i_{t-1} = p^i_t b^i_t / p^i_{t-1} b^i_{t-1}$. The Tornquist price index of the prices of constant face amounts of insurance or a constant dollar annuity is equivalent to the Tornquist price index of the per policy price of insurance or an annuity.

Footnotes

1. This paper relates to the measurement of productivity growth for life insurance over the period 1979-1989. Thus we want to characterise the life insurance industry within the economy during this time period.

2. The relative decline in life insurers holdings of financial assets, compared to other financial institutions was due to the 1967 revision of the bank act. This revision made it profitable for chartered banks to enter the mortgage market (see Bernstein and Geehan [1988] for a discussion).

3. In 1991 total premiums for the life insurance industry were $35.5 billion, and total assets were $166.6 billion.

4. If life insurers produced a single output, under constant returns to scale in competitive product and factor markets, then TFPG could be measured as the weighted average of input price growth rates net of the output price growth. In this case output growth rates would not be needed to calculate TFPG. Unfortunately, life insurers produce multiple products, under joint cost conditions. In addition, there is evidence of increasing returns to scale (see Bernstein and Geehan [1988], and Bernstein [1992]).

5. An alternative approach is to treat investment activity as distinct from insurance and annuities. In other words an additional distinct class of output could be defined. However, the present approach permits us to take advantage of the detailed manner that the data is provided by life insurers to OSFI.

6. In the appendix, we are assuming that there is no change in the distribution of face values across product lines over time.

7. Capital acquisition prices for the life insurance are unavailable from Statistics Canada.

8. Alternatively, rental payments could be divided by the rental rate on owned machinery and equipment, and then the implied rented machinery and equipment capital and owned stocks could be added to obtain machinery and equipment capital.

9. There were some large percentage changes in intermediate inputs in 1981 and 1985 (see the last column in table 3) due to ceded insurance. However, average annual growth remained stable over the decade. In addition, from table 4, we shall see that input growth, and thereby TFPG, was not affected by these large changes in intermediate inputs.

10. Notice that TFPG is measured as the difference in growth rates between outputs and inputs. It is an index number, or growth accounting, calculation. There is no estimation of production or cost functions.

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