

CPB Discussion Paper

No 48

September, 2005

**An exploration into competition and efficiency in
the Dutch life insurance industry**

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ISBN 90-5833-233-0

Abstract in English

The lack of available prices in the Dutch life insurance industry makes competition an elusive concept that defies direct observation. Therefore, this paper investigates competition by analysing several factors which may affect the competitive nature of a market and various indirect measurement approaches. After discussing various supply and demand factors which may constitute a so-called tight oligopoly, we establish the existence of scale economies and the importance of cost X-inefficiency, since severe competition would force firms to exploit any available scale economies further and to reduce X-inefficiencies. Both scale economies and X-inefficiencies turn out to be substantial, although more or less comparable to those found for insurers in other countries and to other financial institutions. Profits in the Netherlands appear to be high compared to profits of foreign peers, although this probably more a reflecting of the past than of the present. Further, we apply the Boone indicator, a novel approach to measuring the effects of competition. This indicator points to limited competition in comparison to other sectors in the Netherlands. Further investigations of submarkets should reveal what is behind this seemingly limited competition

Key words:

Competition, Insurance, X-inefficiency, Scale economies

JEL code: L16, L80

Abstract in Dutch

Het ontbreken van beschikbare prijsinformatie bemoeilijkt het meten van concurrentie in de Nederlandse levensverzekeringenmarkt. Om die reden gebruikt dit onderzoek verschillende indirecte maatstaven voor concurrentie. Na een bespreking van verscheidene aanbod- en vraagfactoren die kunnen leiden tot oligopolie, analyseren wij het bestaan van schaalvoordelen en X-inefficiëntie. Zowel schaalvoordelen als X-inefficiënties blijken substantieel te zijn, hoewel de niveaus van beide grootheden vergelijkbaar zijn met datgene wat we vinden in de financiële sectoren in andere landen. Winstmarges van Nederlandse levensverzekeraars blijken hoog te zijn in vergelijking met die van levensverzekeraars in andere landen, hoewel deze waarneming meer een reflectie is van succesvolle productie in het verleden dan in het heden. Verder gebruiken wij een nieuwe indicator voor concurrentie: de Boone indicator. Deze indicator wijst ook op beperkte concurrentie. Verder onderzoek van deelmarkten zou zichtbaar moeten maken wat de redenen zijn voor de kennelijk beperkte concurrentie

Steekwoorden: Concurrentie, verzekeringen, X-inefficiënties, Schaalvoordelen

Een uitgebreide Nederlandse samenvatting is beschikbaar via www.cpb.nl.

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Preface

This paper is part of a larger research project on competition in the life insurance industry, see Bijlsma et al. (2005). Other papers go into more detail with respect to barriers of competition, product choice and the role of financial advice. In this paper, we aim at measuring competitive behaviour and performance of the Dutch life insurance market as a whole. The current paper is complementary to that in the following sense: whatever goes on in the often discussed financial advice part of the business, the current paper verifies what can be said about competition on the market on an aggregate level. The authors are grateful to Jan Boone, Marcel Canoy, Wil Dullemond, Aerd Houben, Marc Pomp and participants of the CPB Conference on 'Competition in markets for life insurance' and the DNB Lunch Seminar for useful comment, Miriam Holman-Rijken and Leo Kranenburg for excellent research assistance and Marcel Eggenkamp and Usseb Karakhalil for providing the data.

Summary

This paper investigates efficiency and competitive behaviour on the Dutch life insurance market. In the Netherlands, life insurance sector is important with in 2003 a volume of business in terms of annual premiums paid of € 24 billion, invested assets of € 238 billion and insured capital of € 900 billion. This market provides important financial products, such as endowment insurance, annuities, term insurance and burial funds, of often sizeable value for consumers. Financial planning of many households depends on proper functioning of this market. However, complexity of the products and dependency on future investment returns make many life insurance products rather opaque. Therefore, competition and efficiency in this sector are important issues, from the point of view of consumers as well as that of supervisors whose duty it is to protect the interests of consumers.

Most life insurance policies have a long life span, which makes consumers sensitive to the reliability of the respective firms. Life insurance firms need to remain in a financially sound condition over decades in order to be able to pay out the promised benefits. The sector has a safety net arrangement in the case a life insurer runs into trouble, but that does not cover all risks and the funds involved are limited. Without sufficient profitability, it could be questionable whether life insurers are able to face unfavourable developments such as a long-lasting decline of long-term interest rates. Obviously, there may be a complex trade off between heavy competition with the short-run advantage for consumers of low premiums, but possibly the drawback of higher long-run risk with respect to the insurance benefits. In practice, the likelihood that an insurer in the Netherlands fails appears to be rather limited with only one bankruptcy during the last twenty years. From that perspective, it seems worthwhile to further investigate competition in this market.

Life insurance firms sell different products using various distribution channels, thereby creating several submarkets. The degree of competition may vary across these submarkets. For instance, submarkets where parties bargain on collective contracts and submarkets for direct writers are expected to be more competitive than submarkets where insurance agents sell products to uninformed but trusting customers. Lack of sufficient data on prices of life insurance products, market shares of products and distribution channels, makes distinctions of competition on submarkets impossible.

Unavailable data also prohibits us to measure competition among life insurers directly, even on the total life insurance market. One qualitative way to investigate this market is to work out what its structural features are, particularly those related to its competitive nature. On the supply side, we find that market power of insurance firms is limited due to their plurality and that ample entry possibilities exist, all of which contributes to sound competitive conditions. But on the demand side, we observe that consumer power is limited, particularly due to the opaque nature of many life insurance products, and that there are few substitution possibilities for life insurance policies, which could hamper more heavy competition. Combining these

various insights, we have reasons to analyse the competitive nature of this market further. We use five indicators to estimate competition in an indirect manner.

The first indicator is of a qualitative nature. We investigated the structure of the insurance market using the so-called tight oligopoly analysis, yielding diverging results. For the supply side factors we find that supplier power is limited, due to the large number of insurance firms, and that ample entry possibilities exist, which in principle enable sound competition. However, on the demand side we observe that consumer power is limited, particularly due to the opaque nature of many life insurance products, and that few substitution possibilities exist for life insurance policies, which may rein in competition. In short, the resulting overall picture from these considerations is mixed.

The second indicator is the scale efficiency level. A translog cost function has been applied to measure scale economies in the Dutch life insurance industry. Estimates indicate that scale economies exist and amount to 20% on average, ranging from 10% for large firms to 42% for small firms. Such scale economies are substantial compared to what is usually found for other financial institutions such as banks and for insurance firms in other countries. All existing insurance companies are far below the estimated (theoretical) optimal size. This implies that further consolidation in the Dutch life insurance market would be beneficial. Apparently, competitive pressure in the insurance market has so far been insufficient to force insurance firms to employ the existing scale economies.

The third indicator is the X-efficiency level. We find cost X-inefficiency estimates of around 25%, on average, a magnitude which would not be expected in a market with heavy competition. Incidentally, such inefficiencies are not uncommon for other financial sectors such as banks, and for life insurance in other countries.

The fourth indicator is the profit margin. We observed that profit margins of the Dutch life insurance firms have been high compared to those of their peers in other European countries. This could indicate relatively less competitive pressure in the Netherlands. However, this result mainly reflects the competitive situation in the past rather than in the most recent years. Anecdotic evidence states that current profit margins are small.

The fifth indicator is the Boone indicator. Estimates of this indicator point to weak competition in the Dutch life insurance industry in comparison to indicator values in other service industries. All our empirical analyses are based on balance sheet and profit and loss data from both new and old business. Although the majority of annual premiums stems from new policies, the portfolio of policies is built up over the years. Hence, eventual improvement of competition would show up in these figures only with some delay, depending on the approach. However, annual estimates of the Boone indicator for the most recent years find a weakening rather than a strengthening of competition.

The evidence in this paper does not allow us to draw strong conclusions on competition in the insurance market. The reason is that our analysis is on an aggregate level and potentially relevant institutional details are lacking. Yet, all five indicators point to limited competition.

1 Introduction¹

This paper investigates efficiency and competitive behaviour on the Dutch life insurance market. In the Netherlands, the life insurance sector is important with in 2003 a volume of business in terms of annual premiums paid of € 24 billion, invested assets of € 238 billion and insured capital of € 900 billion. This market provides important financial products, such as endowment insurance, annuities, term insurance and burial funds, of often sizeable value for consumers. Financial planning of many households depends on proper functioning of this market. Complexity of the products and dependency on future investment returns make many life insurance products rather opaque. Therefore, competition and efficiency in this sector are important issues, from the point of view of consumers as well as that of supervisors whose duty it is to protect the interests of consumers.

Most life insurance policies have a long life span, which makes consumers sensitive to the reliability of the respective firms. Life insurance firms need to remain in a financially sound condition over decades in order to be able to pay out the promised benefits. The sector has a safety net arrangement in the case a life insurer fails, but that does not cover all risks and the funds involved are limited. Without sufficient profitability, it could be questionable whether life insurers are able to face unfavourable developments such as a long-lasting decline of long-term interest rates. Obviously, there may be a complex trade off between heavy competition with the short-run advantage for consumers of low premiums, but possibly the drawback of higher long-run risk with respect to the insurance benefits. In practice, the likelihood that an insurer in the Netherlands fails appears to be rather limited with only one bankruptcy during the last twenty years. From that perspective, it seems worthwhile to further investigate competition in this market.

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Unavailable data also prohibits us to measure competition among life insurers directly, even on the total life insurance market. One qualitative way to investigate this market is to work out what its structural features are, particularly those related to its competitive nature. On the supply side, we find that market power of insurance firms is limited due to their plurality and that ample entry possibilities exist, all of which contributes to sound competitive conditions. But on the demand side, we observe that consumer power is limited, particularly due to the opaque

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nature of many life insurance products, and that there are few substitution possibilities for life insurance policies, which could hamper more heavy competition. Combining these various insights, we have reasons to analyse the competitive nature of this market further.

An often-used quantitative indirect measure of competition is efficiency. Heavy competition is assumed to force firms to operate more efficiently, so that high efficiency might indicate the existence of competition and vice versa. We distinguish between various types of efficiency, particularly scale efficiency and X-efficiency. Scale economies are related to output volumes, whereas cost X-efficiency reflects managerial ability to drive down production costs, controlled for output volumes and input price levels. There are various methods to measure scale economies and X-efficiency. We use a translog cost function to reveal the existence of scale economies, and a stochastic cost frontier model to measure X-efficiency. Further, large unexplained scale economies may raise questions about the competitive pressure in the market. Note that the existence of scale efficiency is also important for the potential entry of new firms, an important determinant of competition. Strong scale effects would put new firms into an unfavourable position.

A straightforward measure of competition is the profit margin. Supernormal profits would indicate insufficient competition. We observe profits of Dutch life insurers over time and compare them with profits of foreign peers.

Another indirect measure of competition is the so-called Boone indicator. This approach is based on the notion that competition rewards efficiency and punishes inefficiency. In competitive markets efficient firms perform better – in terms of market shares and hence profit – than inefficient firms. The Boone indicator measures the extent to which efficiency differences between firms are translated into performance differences. The more competitive the market is, the stronger is the relationship between efficiency differences and performance differences. The Boone indicator is usually measured over time, which yields a picture of the development of competition. Further, the level of the Boone indicator in life insurances can be compared with levels in other parts of the service sector, to assess the relative competitiveness of the life insurance market.

Our paper is part of a larger research project on competition in the life insurance industry, see Bijlsma et al. (2005). Other papers go into more detail with respect to barriers of competition, product choice and the role of financial advice. This paper aims at measuring competitive behaviour and performance of the Dutch life insurance market as a whole. The current paper is complementary to that in the following sense: whatever goes on in the often discussed financial advice part of the business, the current paper verifies what can be said about competition on the market on an aggregate level. Any problems (or lack of problems) should ultimately show up in aggregate indicators of competition. Since we use four different empirical aggregate indicators (average profit margins, scale economies, X-inefficiencies and the Boone indicator), we are to get a reasonable picture of competition in this market.

The outline of the paper is as follows. Section 2 provides a brief and general explanation of the production of life insurance firms. Section 3 investigates the competitive structure of demand and supply sides of the Dutch life insurance market. Section 4 measures scale economies based on the so-called translog cost function, while the next section introduces the measurement of X-efficiency. Section 6 discusses the Boone indicator. Section 7 describes the data used and Section 8 presents the empirical results of the four indirect measures of competition. The last section sums up and draws conclusions.

2 The production of life insurances

The business of insurance firms is the sale of protection against risks. There are two quite different types of insurance products: life insurance and non-life or property & casualty (P&C) insurance.² Life insurance covers deviations in the timing and size of predetermined cash flows due to (non-)accidental death or disability. While some life insurance products pay out only in the incident of death (term insurance and burial funds), others do so at the end of a term or a number of terms (endowment insurance).³ A typical annuity policy pays an annual amount starting on a given date (if a specific person is still alive) and continues until that person passes away. The benefits of insurance can be guaranteed beforehand so that the insurance firm bears the risk that invested premiums may not cover the promised payments. Such guaranteed benefits may be accompanied by some kind of profit sharing, e.g. depending on indices of bonds or shares. The benefits of insurance can also be linked to capital market investments, e.g. a basket of shares, so that the insurance firm bears no investment risk at all. Such policies are usually referred to as unit-linked funds. We also observe mixed products, e.g. unit linked funds with guaranteed minimum investment returns.

A major feature of life insurance is its long-term character, often continuing for decades. Therefore, policyholders need to trust their life insurance company, making insurers very sensitive to their reputation. Life insurers need large reserves to cover their calculated insurance liabilities. These reserves are financed by – annual or single – insurance premiums and invested mainly on the capital market. The major risk of life insurers concerns mismatches between liabilities and assets. Idiosyncratic life risk is negligible as it can be well diversified. Systematic life risk, however, such as increasing life expectancy, can also pose a threat to life insurers. Yet their major risk will always be investment risk. The main services which life insurance firms provide to their customers are life (and disability) risk pooling and adding value to the invested premiums. Significant expenditures include sales expenses, whether in the form of direct sales costs or of fees paid to insurance agencies, administrative costs, investment management and product development.

In the Netherlands, the insurance product market is heavily influenced by fiscal privileges. In the past, endowment-insurance allowances, including any related investment income, used to be tax-exempt, up to certain limits, provided that certain none-too-restrictive conditions were met. Annuity premiums were tax deductible, but annuity allowances were taxed. Again this implies that investment income was enjoyed tax-free while consumers could often also benefit from lower marginal tax rates after retirement. In 2001 a major tax revision reduced the tax benefits. The tax reduction was made public in earlier years, so that consumers could advance their spending on annuities and insurers were eager to sale. Endowment insurance policies

² In the Netherlands, health insurance is part of non-life insurance, whereas in Anglo-Saxon countries, health insurance is seen as part of life insurance.

³ A typical endowment insurance policy pays a given amount at a given date if a given person is still alive, or earlier when he or she passes away. Of course, there are many variants to these archetypes.

became subject to wealth tax and income tax exemption limits were reduced. At the same time, both the standard deduction for annuity premiums and the permission for individuals to deduct annuity premiums to repair pension shortfalls were also reduced. The reduced subsidy on annuities, in particular, has had a great impact on volumes. Finally, in 2003, the standard deduction for annuity premiums was abolished entirely, whereas the permission to do so on an individual basis was limited even further.

3 The competitive structure of the Dutch life insurance market

This section briefly discusses structural characteristics of the market for life insurance that may affect competition. For a fuller discussion we refer to Bijlsma et al. (2005). The diagnostic framework developed in CPB (2003) enables an assessment whether a market structure constitutes a tight oligopoly. A tight oligopoly is an oligopoly which facilitates the realisation of supernormal profits for a substantial period of time. Facilitate reflects that the probability that supernormal profits are observed are higher than in a more competitive market. Supernormal profits exceeds a market conform rate of risk-adjusted return on capital. Substantial period of time reflects that oligopolies will be stable for a number of years. We use this framework for the life insurance market as a starting point of our analysis, as the five largest firms have around 60% of the market which in principle could point to an tight oligopoly. Furthermore, many firms operate as a branch of a larger insurance group.

3.1 Supply side factors

The diagnostic framework presented in CPB (2003) contains a list of coordinated and unilateral factors that increase the probability of a tight oligopoly, see Table 3.1. Coordinated factors refer to explicit and tacit collusion, while unilateral factors refer to actions undertaken by individual firms without any form of coordination with other firms. Economic theory indicates that a high concentration and high entry barriers are conducive to the realisation of supernormal profits. Frequent interaction, transparency and symmetry (in terms of equal cost structures) are conducive to a tight oligopoly since they make it easier for firms to coordinate their actions and to detect and punish deviations from the (explicitly or tacitly) agreed upon behaviour. Heterogeneous products make it easier for firms to raise prices independently of competitors, as consumers are less likely to switch to another firm in response to price differences. Structural links between firms such as cross-ownerships would give firms a stake in each other's performance, thus softening competition.⁴ Information about risks plays a crucial role in markets for financial products. In the case of life insurance, adverse selection may play a role when consumers have more information regarding their life expectancy than insurance companies. To incorporate this risk firms may set higher price-costs margins.

⁴ For a detailed analysis of the various effects we refer to CPB (2003).

Table 3.1 Determinants of competition

	Coordinated factors	Unilateral factors
Supply side factors		
Essential	Few firms High entry barriers Frequent interaction	Few firms High entry barriers Heterogeneous products
Important	Transparency Symmetry	Structural links Adverse selection
Demand side factors		
	Low firm-level elasticity of demand Stable demand	Imperfection in financial advice

Source: CPB, 2003, p. 34 (except adverse selection).

An indicator of market concentration is the Herfindahl-Hirschman Index (HHI).⁵ Over 1995–2003 we calculate an average HHI index value of 0.078 for the Dutch life insurance industry, which is far below any commonly accepted critical value. This low figure reflects also the large number of Dutch life insurance firms, which, over the respective years, ranged from over one hundred to above eighty. An alternative indicator is the so-called k-firm concentration ratio, which sums the market shares of the k largest firms in the market. In 1999, the five largest firms together controlled 66% of the market, see Table 3.2. The largest firm had a market share of 26%. These figures are not unusual for large countries such as Australia, Canada and Japan, although Germany, the UK and the US have considerably lower ratios. However, one should keep in mind that, by definition, such ratios are substantially higher in smaller markets or countries. We conclude that insurance market concentration in the Netherlands is not particularly moderate, although in market segments, such as collective contracts, concentration may be substantial (Bijlsma et al., 2005).

The second determining factor of competition is the set of barriers to entry. Table 3.2 shows that the number of entrants as a percentage of the total sample of Dutch insurance firms varied from 2% in 1991 to 8% in 1997. These numbers are relatively high compared to countries such as Canada, Germany and the UK, where the degree of entry varied between 1% and 4%. This suggests that entry opportunities in the Dutch life insurance market seem to be quite large compared to other countries⁶. For discussion on the other supply factors in Table 3.1 we refer to Bijlsma et al. (2005).

⁵ Concentration ratios are discussed in Bikker and Haaf, 2002. $HHI = \sum_{i=1}^n s_i^2$ where s_i represents the market share of firm i .

⁶ The entry barriers could be low because firms do not build up their own brand name upon entry, but lend a foreign brand name.

Table 3.2 Concentration indices, numbers of firms and numbers of entrants as %

	1980	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
5-firm concentration ratio	%										
France		48.2	48.9	51.3	49.2	48.5	49.6	53.9	53.2	58.4	56.0
Germany		29.9	29.1	29.4	29.6	29.5	29.5	29.1	28.9	29.9	29.4
Netherlands		65.7	63.3	63.6	63.3	63.1	61.4	60.5	59.0	57.7	65.7
UK		36.3	35.3	34.2	38.1	35.9	34.7	35.6	34.8	38.6	
Australia	82.2	73.5	70.9	65.8	64.1	61.5	30.0	58.3	61.6	60.0	
US				28.2	27.5	26.0	25.3	25.7	25.5	25.2	
Canada							65.6	68.4	70.6	73.1	73.3
Japan	66.9	63.9	63.6	63.8	64.1	64.2	64.2	63.7	65.1	53.8	
Number of firms											
Germany		338	342	326	327	319	323	320	319	318	314
Netherlands		96	96	97	98	95	96	99	107	108	109
UK		205	202	196	194	191	174	177	177	176	
Canada								146	151	150	146
Japan		30	30	30	30	31	31	44	45	46	47
New entries as % of firms											
Germany					0.9	0.9	2.2	1.6	1.3	1.3	1.6
Netherlands		0.0	4.2	2.1	5.1	5.3	3.1	6.1	8.4	2.8	3.7
UK		4.4	2.0	1.5	2.1	1.0	3.4	1.1	1.1		
Canada								2.1	3.3	0.7	0.7
Japan ^a		0.0	0.0	0.0	0.0	3.2	0.0	29.5	2.2	2.2	4.3

^a In 1996, Japanese entrance increased sharply due to a structural change.

Source: Group of Ten (2001).

3.2 Demand side factors

Also demand-side factors affect the intensity of competition, see Table 3.1. As above, we distinguish coordinated and unilateral factors. The elasticity of residual demand determines how attractive it is for a firm to unilaterally change its prices. High search and switching costs contribute to low firm-level demand elasticity. Stable, predictable demand makes it easier for firms to collude in order to keep prices high, as in that case cheating by one or more firms will be easier to detect than with fluctuating demand.

In practice, the elasticity of residual demand for life insurance policies is limited, due to in the absence of substitutes. Investment funds or bank savings could in principle be an alternative for old-age savings (such as annuities), but lack the risk-pooling element, which is essential for life insurance policies. Moreover, annuities enjoy a more favourable fiscal status related to the tax deductibility of premiums (although less since 2001), which is another reason why good alternatives hardly exist. A large part of the endowment insurance policies is used in combination with mortgage loans. Here, the importance of risk-pooling is less dominant and

may diverge across policyholders, but fiscal treatment with respect to income and wealth taxation is also linked to the life-policy status.

High switching costs are typical for life insurance policies, since contracts are often of a long-term nature and early termination of contracts is costly because it involves disinvestments and a reimbursement of not yet paid acquisition costs, which have a front loading nature.⁷

Search costs for life insurance products are high as these products are complicated and the market is opaque. Search cost could be alleviated if search could be entrusted to insurance agents. This would help consumers to avoid errors in their choice of product. Moreover, it would make the market more competitive by raising the elasticity of demand. Thus, it is very desirable to have a well-functioning market for financial advice. However, the market for financial advice market may not function properly. In particular, due to the incentive structure in this market (notably commissions) coupled with inexperienced consumers, insurance agents may give advice that is not in the best interest of consumers.

Consumer power is weaker as the market is less transparent. Strong brand names are indicators of non-transparency, as confidence in a well-known brand may replace price comparisons or personal judgment. Another indicator is the degree to which buyers organise themselves, for instance to be informed and to reduce the opaque nature of the market. The major consumer organisation in the Netherlands (Consumentenbond), many Internet sites⁸ and other sources such as the magazine Money View, compare prices and inform consumers continuously on life insurance policy conditions and prices in order to enable them to make comparisons and well-founded choices. For a minority of the consumers this is sufficient to take out a life insurance policy as direct writer or at bank or post offices.

As products remain complicated and come in a great variety of properties (type, age, and so on), the majority of consumers are not able to take out policies themselves, or willing to take the effort, and call upon services of insurance agents. However, recent research reveals that the market of financial advice does not function properly. Evidence emerges that insurance agents do not help their clients sufficiently, probably due to wrong financial incentives (Bijlsma et al., 2005).⁹ A third indicator is the degree to which consumers can take out life insurance policies collectively. Collective contracts are usually based on thorough comparisons of conditions and prices by experts, are often negotiated via the employer and contribute substantially to consumer power. Of course, many people are unable to take advantage of this instrument to add to consumer power. Finally, the number of suppliers is an important factor. As we have seen above, this number is sufficiently large. All in all, we conclude that buyer power is low as the life insurance market is opaque, but that this problem has been reduced in part by various types of cooperation in favour of consumers.

⁷ Acquisition costs are marketing costs and sales costs, which include commissions to insurance agents.

⁸ See Consumentenbond, 2004, Consumentengeldgids (Personal finance guide), September, pp. 34-37.

⁹ Incidentally, a new Dutch Financial Services Act (Wet Financiële Dienstverlening) will come into force soon, pressing for more transparency in this market, which may also work to improve competition in this submarket.

3.3 Conclusions

The supply side characteristics of the market for life insurance suggest limited supplier power. The number of firms is quite large, the level of concentration is not particularly high and entry opportunities are relatively large. However, at the demand side we find factors high search costs and high switching costs, few substitution possibilities, limited consumer power due to the opaque nature of life insurance products and substantial product differentiation. The demand side conditions may impair the competitive nature of the life insurance market and call for further analysis

4 Measuring scale economies

In the present market, we expect that scale economies that are not realised by firms would reduce under heavy competition.¹⁰ The existence of non-exhausted scale economies is an indication that the potential to reduce costs has not been employed fully and, therefore, can be seen as an indirect indicator of (limited) competition. This is the first reason why we investigate scale economies in this paper. A second one is that we will correct for (potential) distortion by possible scale economies in a subsequent analysis based on the Boone indicator. This correction can be carried out using the estimation results of this section.

We measure scale economies using a translog cost function (TCF). The measurement and analysis of differences in life insurance cost levels is based on the assumption that the technology of an individual life insurer can be described by a production function which links the various types of life insurer output to input factor prices. Under proper conditions, a dual cost function can be derived, using output levels and factor prices as arguments. In line with most of the literature, we use the translog function to describe costs. Christensen et al. (1973) proposed the TCF as a second-order Taylor expansion, usually around the mean, of a generic function with all variables appearing as logarithms. This TCF is a flexible functional form that has proven to be an effective tool for the empirical assessment of efficiency. A traditional Cobb-Douglas function is regarded by many as too simplified (as it ignores non log-linear effects), whereas a Fourier transformation would be unnecessarily complicated. The TCF reads as follows:

$$\ln c_{it} = \alpha + \sum_j \beta_j \ln x_{ijt} + \sum_j \sum_k \gamma_{jk} \ln x_{ijt} \ln x_{ikt} + v_{it} \quad (4.1)$$

where the dependent variable c_{it} is the cost of production of the i^{th} firm ($i = 1, \dots, N$) in year t ($t = 1, \dots, T$). The explanatory variables x_{ijt} represent output or output components ($j, k = 1, \dots, m$) and input prices ($j, k = m + 1, \dots, M$). The two sum terms constitute the multiproduct TCF: the linear terms on the one hand and the squares and cross-terms on the other, each accompanied by the unknown parameters β_j and γ_{jk} , respectively. v_{it} is the error term.

A number of additional calculations need to be executed to be able to understand the coefficients of the TCF in Equation (4.1) and to draw conclusions from them. For these calculations, the insurance firm-year observations are divided into a number of size classes, based on the related value of premium income. The marginal costs of output category j (for $j = 1, \dots, m$) for size class q in units of the currency, $mc_{j,q}$, is defined as:

$$mc_{j,q} = \partial c / \partial x_j = (c_q / x_{j,q}) \partial \ln c / \partial \ln x_j \quad (4.2)$$

¹⁰ This interpretation would be different in a market with only few firms. Further, this interpretation would also change when many new entrants incur unfavourable scale effects during the initial phase of their growth path.

where $X_{j,q}$ and c_q are averages for size class q of the variables. It is important to check whether marginal resource costs are positive at all average output levels in each size class. Otherwise, from the point of view of economic theory, the estimates would not make sense.

Scale economies indicate the amount by which operating costs go up when all output levels increase proportionately. We define scale economies as:¹¹

$$SE = \sum_{j=1, \dots, m} \partial \ln c / \partial \ln x_j \quad (4.3)$$

where $SE < 1$ corresponds to economies of scale, that is, a less than proportionate increase in cost when output levels are raised, whereas $SE > 1$ indicates diseconomies of scale. Fecher *et al.* (1991) applied translog cost functions to estimate scale economies in the French insurance industry. They find increasing returns to scale. However, it is unclear whether this effect is significant. An increase of production by one per cent increases costs by only 0.85 per cent in France's life insurance industry. Grace and Timme (1992) examine cost economies in the US life insurance industry. They find strong and significant scale economies for the US life insurance industry. Depending on the type of firm and the size of the firm an increase of production by one per cent will increase costs by 0.73% to 0.96%.

This paper applies two versions of the TCF. The first is used to estimate the scale effects and marginal cost which will also be taken as input for the Boone-indicator model. In this version, production is proxied by *one* variable, namely premium income. Particularly for marginal costs, it is necessary to use a single measure of production, even if that would be somewhat less accurate (see Section 8.1). The second is the stochastic cost approach model of the next section, which is used to estimate X-inefficiencies. Here it is essential that the multi-product character of life insurance is recognised, so that a set of five variables has been used to approximate production (see Sections 5, 8.2 and 8.3).

¹¹ Note that sometimes scale economies are defined by the reciprocal of Equation (4.3), see, for instance, Baumol *et al.* (1982, page 21) and Resti (1997).

5 Measuring X-inefficiency

It is expected that heavy competition forces insurance firms to drive down their X-inefficiency. Therefore, X-efficiency is often used as an indirect measure of competition. X-efficiency reflects managerial ability to drive down production costs, controlled for output volumes and input price levels. X-efficiency of firm i is defined as the difference in costs between that firm and the best practice firms of similar size and input prices (Leibenstein, 1966). Errors, lags between the adoption of the production plan and its implementation, human inertia, distorted communications and uncertainty cause deviations between firms and the efficient frontier formed by the best-practice life insurers with the lowest costs, controlled for output volumes and input price levels.

Various approaches are available to estimate X-inefficiency (see, for example, Lozano-Vivas, 1998). All methods involve determining an efficient frontier on the basis of observed (sets of) minimal values rather than presupposing certain technologically determined minima. Each method, however, uses different assumptions and may result in diverging estimates of inefficiency. In the case of banks, Berger and Humphrey (1997) report a roughly equal split between studies applying non-parametric and parametric techniques. The number of efficiency studies for life insurers is small compared to that for banks and a similar extensive survey is not available for the former sector.¹² Non-parametric approaches, such as data envelopment analysis (DEA) and free disposable hull (FDH) analysis, have the practical advantage that no functional form needs to be specified. At the same time, however, they do not allow for specification errors, so that such errors if they do exist may be measured as inefficiency, raising the inefficiency estimate. The results of the DEA method are also sensitive to the number of constraints specified. An even greater disadvantage of these techniques is that they generally ignore prices and can, therefore, account only for technical, not for economic inefficiency.

One of the parametric methods is the stochastic frontier approach, which assumes that the error term is the sum of a specification error and an inefficiency term. These two components can be distinguished by making one or more assumptions about the asymmetry of the distribution of the inefficiency term. Although such assumptions are not very restrictive, they are nevertheless criticised for being somewhat arbitrary. A flexible alternative for panel data is the distribution-free approach, which avoids any assumption regarding the distribution of the inefficiency term, but supposes that the error term for each life insurance company over time is zero. Hence, the average predicted error of a firm is its estimated inefficiency. The assumption under this approach of – on average – zero specification errors for each company is a very strong one, and, hence, a drawback. Moreover, shifts in time remain unidentified. Finally, the thick frontier method does not compare single life insurers with the best-practice life insurers on the frontier, but produces an inefficiency measure for the whole sample. The 25th percentile of the life insurer cost distribution is taken as the ‘thick’ frontier and the range between the 25th

¹² See Bikker and Bos (2005) for a short survey

and 75th percentile as inefficiency. This approach avoids the influence of outliers, but at the same time assumes that all errors of the 25th percentile reflect only specification errors, not inefficiency. All approaches have their pros and cons. All in all, the stochastic frontier approach, which has been applied widely, is selected as being – in principle – the least biased. This paper will also use this approach. Berger and Mester (1997) have found that the efficiency estimates are fairly robust to differences in methodology, which fortunately makes the choice of efficiency measurement approach less critical.

The first stochastic frontier function for production was independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977). Schmidt and Lovell (1979) presented its dual as a stochastic cost frontier (SCF) function. This SCF model elaborates on the TCF, splitting the error term into two components, one to account for random effects due to the model specification and another to account for cost X-inefficiencies:

$$\ln c_{it} = \alpha + \sum_j \beta_j \ln x_{ijt} + \sum_j \sum_k \gamma_{jk} \ln x_{ijt} \ln x_{ikt} + v_{it} + u_{it}. \quad (5.1)$$

The subindices refer to firms i and time t . The v_{it} terms represent the specification errors of the TCF, which are assumed to be identically and independently $N(0, \sigma_v^2)$ distributed and the u_{it} terms are *non-negative* random variables which describe cost inefficiency and are assumed to be identically and independently half-normally ($|N(0, \sigma_u^2)|$) distributed and to be independent from the v_{it} s. In other words, the density function of the u_{it} s is (twice) the positive half of the normal density function.

Cost efficiency of a life insurer relative to the cost frontier estimated by Equation (5.1) is calculated as follows. X is the matrix containing the explanatory variables. Cost efficiency is defined as:¹³

$$EFF_{it} = E(c_{it} | u_{it} = 0, X) / E(c_{it} | u_{it}, X) = 1 / \exp(u_{it}) \quad (5.2)$$

In other words, efficiency is the ratio of expected costs on the frontier (where production would be completely efficient, or $u_{it} = 0$) and expected costs, conditional upon the observed degree of inefficiency.¹⁴ Numerator and denominator are both conditional upon X , the given level of output components and input prices. Values of EFF_{it} range from 0 to 1. We define inefficiency as: $INEFF = 1 - EFF$.¹⁵

The SCF model encompasses the TCF in cases where the inefficiencies u_{it} can be ignored. A test on the restriction which reduces the former to the latter is available after reparameterisation of the model of Equation (5.1) by replacing σ_v^2 and σ_u^2 by, respectively, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\lambda = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$, see Battese and Corra (1977). The λ parameter can be employed to test whether

¹³ This expression relies upon the predicted value of the unobservable, u_{it} , which can be calculated from expectations of u_{it} , conditional upon the observed values of v_{it} and u_{it} , (see Battese and Coelli 1992, 1993, 1995).

¹⁴ Note that the $E(c_{it} | u_{it}, X)$ differs from actual costs, c_{it} , due to v_{it} .

¹⁵ An alternative definition would be the inverse of EFF_{it} , $INEFF_{it} = \exp(u_{it})$, which is bounded between 1 and ∞ .

an SCF model is essential at all. Acceptance of the null hypothesis $\lambda = 0$ would imply that $\sigma_u = 0$ and hence that the term u_{it} should be removed from the model, so that Equation (5.1) narrows down to the TCF of Equation (4.1).

An extensive body of literature is devoted to the measurement of X-efficiency in the life insurance market. Bikker and Bos (2005) provide a comprehensive overview. Most studies estimate efficiency on a single country base, using different methods to measure scale economies and X-efficiency of the life insurance industry. Furthermore, the studies employ diverging definitions for output, input factors and input factor prices. Key results of the insurance economies studies are that scale economies exist, that scope economies are small, rare or even negative and that average X-inefficiencies vary from low levels around 10% to high levels, even up to above 50%, generally with large dispersion of inefficiency for individual forms. The studies present contrary results with respect to the relationship between size and inefficiency. The stochastic cost frontier approach is generally seen as more reliable than the non parametric methods, which appear to provide diverging levels and rankings of inefficiencies.

6 The Boone indicator of competition

Recently Boone has presented a novel approach to measuring competition.¹⁶ His approach is based on the idea that competition rewards efficiency. In general, an efficient firm will realise higher market shares and hence higher profits than a less efficient one. Crucial for the Boone indicator approach is that this effect will be stronger, the more competitive the market is. This leads to the following empirical model:

$$\pi_{it} / \pi_{jt} = \alpha + \beta_t (mc_{it} / mc_{jt}) + \gamma \tau_t + \varepsilon_{it} \quad (6.1)$$

where α , β_t and γ are parameters and π_{it} denotes the profit of firm i in year t . Relative profits π_{it} / π_{jt} are defined for any pair of firms and depend, among other things, on the relative marginal costs of the respective firms, mc_{it} / mc_{jt} . The variable τ_t is a time trend and ε_{it} an error term. The parameter of interest is β_t . It is expected to have a negative sign, because relatively efficient firms make higher profits. In what follows we will refer to β_t as the Boone-indicator. Boone shows that when profit differences are increasingly determined by marginal cost differences, this indicates increased competition. The Boone indicator can be used to answer two types of questions. The first focuses the time dimension of β_t ‘how does competition evolve over time?’ and the second the potential cross-section nature of Equation (6.1) ‘how does competition in the life insurance market compares to competition in other service sectors?’ Since measurement errors are less likely to vary over time than over industries the former interpretation is more robust than the latter one. For that reason, Boone focuses on the *change* in β_t over time within a given sector. Comparisons of β_t across sectors are possible, but unobserved sector specific factors may affect β_t . An advantage of the Boone indicator is that it is more directly linked to competition than measures such as scale economies and X-inefficiency, or frequently used (both theoretically and empirically) but often misleading measures as the concentration index. The Boone indicator requires data of fairly homogeneous products. Although some heterogeneity in life insurance products exists, its degree of homogeneity is high compared to similar studies using the Boone-indicator (e.g. Creusen et al., 2005)

We are not aware of any empirical application of the Boone model to the life insurance industry. Boone and Weigand in CPB (2000) and Boone (2004) have applied their model on data from different manufacturing industries. Both papers approximate a firm’s marginal costs by the ratio of variable costs and revenues, as marginal costs can not be observed directly. CPB (2000) uses the *relative* values of profits and the ratio of variable cost and revenues, whereas Boone *et al.* (2004) consider the *absolute* values. To obtain a comparable scale for the dependent variable (relative profits) and the independent variable (relative marginal costs) and to avoid that outliers have too much effect on the estimated slope, these variables are both expressed in logarithms. Consequently, all observations of companies with losses – instead of

¹⁶ See Boone and Weigand in CPB (2000) and Boone (2001, 2004).

profits – have been deleted, introducing a bias in the sample towards profitable firms. Boone realises that this introduces a focus towards profitable firms, but states that the competitive effect of firms with losses is still present in the behaviour and results of the other firms in the sample.¹⁷

Finally, we adjust the Boone model also by replacing often-used proxies for marginal costs, such as average variable cost, by a model-based estimate of marginal cost itself. We are able to do so using the translog cost function from Section 4. Moreover, this enables us to correct the marginal cost for the effects of scale economies. The correction is based on an auxiliary regression wherein marginal costs are explained by a quadratic function of production. The residuals of this auxiliary regression are used as adjusted marginal costs.

¹⁷ Suppose that the negative profit firms are price fighters. In a well functioning market the price fighters will influence profitability of the other firms.

7 Description of the data

This paper uses data of the former Pensions and Insurance Supervisory Authority of the Netherlands, which recently merged with the Nederlandsche Bank. The data refer to Dutch life insurance companies over 1995–2003 and consists of 867 firm-year observations. In our dataset, the number of active companies in the Netherlands was 84 in 2003 and 105 in 1998. A number of insurance firms are owned by a holding company and, hence, not fully independent. The average size of a life insurance company in terms of total assets on its balance sheets is around € 2.5 billion. This firm has around half a million policies in its portfolio, insures a total endowment capital of 7 billion euro and current and future annual rents of almost 400 million euro. Profits are defined as technical results, so that profits arising from investments are included, and are taken before tax. Profits of an average firm amount to 5.5% of their premium income. An average firm uses five percent of its gross premiums for reinsurance. Roughly 63% of premiums are from individual contracts, the remainder is of a collective nature. More than half of the insurance firms have no collective contracts at all. Two-thirds of the contracts are based on periodic payments. Annual premiums reflect both old and new contracts. Because on average 48% of the premiums paid are of the lump sum type, whereas, on average, 15% of the periodic premiums refer also to new policies, the majority of the annual premiums stems from new business. Note that also cost and profit figures are based on a mixture of new and old business. Balance-sheet and profit and loss data for new policies only is not available. So called unit-linked fund policies, where policyholders bear the investment risk on their own deposits (that is, premiums minus costs), have become more popular: 44% of premiums are related to this kind of policies. Endowment insurance is the major product category, as 57% of all premiums are collected for this type of insurance. This type of insurance policy is often combined with a mortgage loan. The total costs are around 13% of the total premium income, half of which consists of acquisition (or sales) costs. The medians and the differences between weighted and unweighted averages reflect skewness in the (size) distributions. Larger firms tend to have higher profit margins and relatively lower acquisition cost, lower management cost, less individual contracts, less periodic payments, more unit-linked funds policies and less endowment policies.

Table 7.1 Description of the data on dutch insurance firms, 1995-2003

	Median	Mean	Standard deviation	
		Weighted	Unweighted	
	* 1000 euro			
Total assets	521 497	.	2472 521	6991 594
Annual premiums	66 041	.	247 707	588 867
Annual costs, total	18 187	.	32 788	63 168
Annual profits	2 550	.	15 650	47 558
	number			
Number of policies	168 672		522 421	973 601
	mln euro			
Total endowment capital	2 229		7 376	13 483
Amount of annuity rent ^a	9		387	1 397
Total unit-linked capital	67		246	589
	ratios			
Profit / premiums	0.05	0.08	0.06	0.25
Reinsurance	0.01	0.03	0.05	0.11
Acquisition costs / total costs	0.53	0.34	0.53	1.86
Individual contracts	1.00	0.63	0.90	0.21
Periodic payments	0.72	0.52	0.67	0.27
Unit-linked funds	0.25	0.44	0.33	0.32
Endowment premium	0.93	0.57	0.82	0.26
Acquisition costs	0.09	0.06	0.16	0.29
Management costs	0.18	0.13	0.23	0.22
	number			
Number of observation per year				
1995	94			
1996	103			
1997	104			
1998	105			
1999	101			
2000	94			
2001	93			
2002	89			
2003	84			
Total	867			

^a Annual payment

8 Empirical results

8.1 Scale economies

This section estimates scale economies using the translog cost function (TCF). In a later section of this paper, the TCF is used also to calculate marginal costs (see Sections 4 and 8.4). For these two purposes, the TCF explains the insurance company's cost by (only) one measure of production, namely premiums. As both scale effects and marginal costs are obtained from the first derivatives of the TCF to production, we will disregard other production measures here. Inclusion of more measures of components of production or proxies would be common practice in the case of a multi-product approach, such as for the X-efficiency models applied in Sections 8.2 and 8.3.

In the literature, measuring output in the life insurance industry is much debated. Where in many other industries, output is equal to the value added, we can not calculate this figure for insurances.¹⁸ Most studies on the life insurance industry use premium income as output measure. Hirschhorn and Geehan (1977) view the production of contracts as the main activity of a life insurance company. Premiums collected directly concern the technical activity of an insurance company. The ability of an insurance company to market products, to select clients and to accept risks are reflected by premiums. However, premiums do not reflect financial activities properly, as e.g. asset management represented by the returns on investment is ignored.¹⁹ Despite shortcomings, in this section we use also premium income as output measure.

As our model reads in logarithms, we cannot use observations where one or more of the variables have a zero or negative value. Insurance firms may employ various sales channels: own sales organisations, tied and multiple insurance agencies, and other channels, such as banks, post offices, etc. We have to drop observations of firms that do not use insurance agencies and report zero acquisition costs. In this sense, we clearly are left with a subsample of firms.

Table 8.1 presents the TCF estimates. We assume that costs are explained by production (in terms of total premiums), reinsurance and acquisition, so that these variables also emerge as squares and in cross-terms. To test this basic model for robustness, we also add four control variables in an extended version of the model. Periodic premium policies go with additional administration costs, whereas unit-linked fund policies save costs. The bottom lines of Table 8.1 shows that life insurance companies, on average, enjoy scale economies of 18%. After correcting for differences in the product mix or the share of unit-linked funds and so on, we find a similar average of 21%. We also calculated

¹⁸ Some insurance firms can approximate their value added by comparing their embedded value over time. These data are not publicly available.

¹⁹ The definition of production of life insurance firms is discussed further in Section 8.2.

Table 8.1 Estimation results of the translog cost function^a

	Basic model		Extended model	
	Coefficient	T-value ^b	Coefficient	T-value ^b
Premium income (production)	0.50	5.5**	0.16	1.3
Reinsurance ratio	0.26	2.6**	1.13	0.9
Acquisition ratio ²	-0.18	-1.3	0.05	0.2
Premium income ²	0.01	2.6**	1.03	4.9**
Reinsurance ratio ²	0.04	0.6	1.01	0.9
Acquisition ratio	-0.03	-1.9*	-0.02	-0.7
Premium income * reinsurance ratio	-0.03	-3.0**	-0.01	-1.1
Premium income * acquisition ratio	0.03	1.7*	0.02	0.9
Reinsurance ratio * acquisition ratio	0.01		0.06	2.5**
Individual premiums ratio			-0.09	-0.7
Periodic premium ratio			0.27	7.9**
Unit-linked fund ratio			-0.05	-3.1**
Endowment insurance ratio			0.15	2.1*
Intercept	2.24	4.4**	4.10	5.5**
Adjusted R ²	0.89		0.89	
Number of observations	607		456	
Economies of scale	0.82		0.79	
Idem, small firms (25%)	0.72		0.58	
Idem, small to medium-sized firms (50%)	0.77		0.68	
Idem, medium-sized to larger firms (75%)	0.80		0.74	
Idem, large firms (100%)	0.87		0.90	

^a All terms are expressed in logarithms

^b *: level of confidence is 95%; **: level of confidence is 99%

average scale economies for various size classes with size measured as the companies' premium income. Scale economies appear to be larger for the smaller size classes. According to the extended model, small firms – in the lowest 25 percentile class – may realise average scale economies of 42%, where large firms – in the highest 25 percentile class – enjoy just 10% economies of scale. Decreasing scale economies with firm size have also been found by Fecher et al. (1993) for the French life insurance industry. The comparison between the basic model and the extended model makes clear that the average scale economies per size class depend (only) slightly on the model specification. Although the average economies of scale for both models are rather similar, the dependency of the scale economies on size classes in the basic model is less than in the extended model.

The optimal production volume in terms of gross premium is defined as the volume where an additional increase would no longer diminish marginal costs, so that the derivative of marginal costs is zero. According to the basic model, the optimal size can be calculated as far above the size of all actual life insurance firms.²⁰ This implies that (almost) all firms are in the

²⁰ Of course, the accuracy of this optimal size is limited, as its calculated location lies far out of our sample range.

(upper) left-hand part of the well-known U-shaped average cost curve. This suggests that consolidation in the Dutch insurance markets is still far from its optimal level.

The TCF estimates make clear that average scale economies of around 20% are an important feature of the Dutch life insurance industry. These scale economies are generally higher than those found for Dutch banks (e.g. Bos and Kolari, 2005), but not uncommon in other sectors. Similar figures were found in other countries. Fecher et al. (1991) find 15% for France and Grace and Timme (1992) observe 4% to 27% for the US, depending on type and size of firm. The existence of substantial scale economies might indicate a moderate degree of competition, as firms have so far not been forced to employ all possible scale economies.

8.2 Cost X-inefficiency

This section applies the stochastic cost frontier model (5.1) to data of Dutch insurance firms. Costs are defined as total operating expenses which consist of two components, acquisition cost and other costs. The latter includes management costs, salaries, depreciation on capital equipment, and so on. A further split of 'other cost' in its constituent components would be highly welcome, but is regrettably unavailable. The price of the two input factors, acquisition costs and other costs, has been estimated as the ratio of the respective costs and the total assets. Such a proxy is fairly common in the efficiency model literature, in the absence of a better alternative.

As said, the definition of production of life insurance firms is a complicated issue. Insurance firms produce a bundle of services to their policy holders. Particularly for life insurances, services may be provided over a long period. Given the available data, we have selected the following five proxies of services to policyholders, together constituting the multiple products of insurance firms: (1) annual premium income. This variable proxies the production related to new and current policies. A drawback of this variable might be that premiums are made up of the pure cost price plus a profit margin. But it is the only available measure of new policies; (2) the total number of outstanding policies. This variable approximates the services provided under all existing policies, hence the stock instead of the flow. In particular it reflects services supplied in respect of all policies, irrespective of their size; (3) the sum total of insured capital; (4) the sum total of insured annuities. Endowment insurances and annuity policies are different products. The two variables reflect the different services which are provided to the respective groups of policy holders; and (5) unit-linked funds policies. There are two types of policies regarding the risk on the investments concerned. These risks may be born by the insurance firms or by the policy holders. The latter type of policies are also known as 'unit-linked'. As the insurance firm provides different services in respect of these two types of policy, we include the variable 'unit-linked funds policies'. Note that these five production factors do not describe the production of separate services, but aspects of the production. For example, a unit linked policy

may be of either of an endowment insurance type or an annuity type, so that two variables describe four different types of services.

The five production measures and the two input prices also appear as squares and cross-terms in the translog cost function, making for a total of 35 explanatory variables. Such models have proven to provide a close approximation to the complex multiproduct output of financial institutions, resulting in an adequate explanation of cost, conditional on production volume and input factor prices. In our sample, this model explains 94.0% of the variation in the (logarithm of) cost.²¹

The set of suitable (non-zero) data consists of 105 licensed life insurance firms in the Netherlands over the 1995–2003 period, providing a total of 689 firm-year observations. This panel dataset includes new entries, taken-over firms and merged companies. The dataset is unbalanced as 256 observations are missing or incomplete.

Table A.1 in Appendix I provides the full set of estimation results (see cost column). Due to the non-linear nature of the TCF it is difficult to interpret the coefficients of the individual explanatory variables. As indicated by γ , 91% of the variation in the stochastic terms (σ^2) of the cost model is attributed to the inefficiency term. A test on the hypothesis that inefficiency can be ignored ($\gamma = 0$) is rejected strongly. The essential results are the cost efficiency values calculated according to Equation (5.2). Table 8.2 provides average values of cost X-efficiency per year and for the total sample (see cost column).

The average cost *X-efficiency* is 72%, so that the *inefficiency* is, on average, 28%. That implies that costs are, on average, 28% higher than for the best practice firms, conditional on production composition, production scale and input prices. The average cost X-efficiencies fluctuate irregularly over time, so that apparently no clear time trends emerge. The inefficiencies are assumed to reflect managerial shortcomings in making optimal decisions in the composition of output and the use of input factors.

Table 8.2 Average cost and X-efficiency in 1995-2003

Year	Cost
1995	0.716
1996	0.727
1997	0.741
1998	0.724
1999	0.725
2000	0.710
2001	0.729
2002	0.728
2003	0.718
Total	0.724

²¹ This figure is based on the OLS estimates, which provides the starting values of the numerical optimisation procedure. As OLS minimises the errors terms and maximises the degree of fit, the latter will be lower in the SCF model.

A possible reduction of cost by at least one quarter does not seem plausible in a competitive market. However, it should be remembered that these inefficiency figures set an upper bound to the measured inefficiencies, because they may partly be the result of imperfect measurements of production and input factor prices. Particularly in the financial sector, production is difficult to measure, while our data set also suffers from none-too-exact information on input prices. Instead of drawing very strong conclusions regarding competition, it is better to compare these results with benchmarks. In the literature, the insurance inefficiency figures in other countries range from 10% to 65%. This implies that our inefficiencies are quite common and even lie earlier towards the lower end. They are similar to the inefficiencies that have generally been found in the banking literature, which spread – widely – around 20% (Berger and Humphrey, 1997; Altunbas et al., 2000). Bikker (2004, p.218) reports an average X-inefficiency for Dutch banks in 1997 of 26%, remarkably similar to the figure for insurance firms.

Table 8.3 Average cost and profit X-efficiency over size classes

Size class	Cost	Average size 1000 euro
1	0.747	13 261
2	0.763	94 907
3	0.731	277 937
4	0.693	548 474
5	0.696	936 795
6	0.701	2 107 749
7	0.742	14 479 608
Total average	0.724	2 447 891
Median		519 970

Table 8.3 shows average cost X-efficiency for seven size classes. Here we observe a clear U-curve for cost efficiency: higher efficiency for small insurance firms lower efficiency for medium-sized companies and, again, increasing efficiency for larger firms. A possible explanation could be that smaller firms generally profit from their orderly structure and neatly arranged composition of products, so that differences in managerial inability across smaller firms are limited (as has also been found for banks, see Bikker, 2004, p. 209 ff.). This leaves unexplained why the largest companies seem to be more efficient than medium-sized firms. This U-shaped pattern is the opposite of what is often found for scale effects, where rising economies are found for smaller firms and constant returns or even declining economies after a certain optimum is exceeded.

8.3 Profitability

A straightforward measure of competition is the profit margin. Supernormal profits would indicate insufficient competition.

A traditional measure of profitability is the price-cost margin.²² We cannot calculate the price-cost margin for life insurance companies, as we do not know the output prices and market shares of all insurance products per firm. However, we are able to calculate the average profit margin, defined as the ratio of profits before taxes and gross premium written. Using figures on consolidated life insurance firms from the ISIS dataset, we compare the Netherlands with some major European economies (see Table 8.4).²³ We are aware that profits could be influenced by differences in accounting rules, products, distribution channels, maturity or other characteristics of the markets.²⁴ However, we draw some conclusions from the remarkable profit margins in the Netherlands (around 9%) compared to those in other EU countries like France, Germany, Italy and the UK, with respective profit margins of around 7%, 2%, 5% and 4%. The higher profits in the Netherlands suggest less competition than in the other countries.²⁵ The Dutch profit margins may be exaggerated, because the ISIS dataset does include less smaller life insurance companies, but this phenomenon also holds for the other countries. We also have data published by De Nederlandsche Bank (DNB, the Dutch supervisory authority on insurance companies), which includes all licensed firms and refer to domestic activities only. Also these figures point to high Dutch profit margins of around 7%.

Table 8.4 Average profit margins of life insurance firms in various countries^a

	ISIS ^b				DNB	
	Germany	France	UK	Italy	The Netherlands	The Netherlands
	%					
1995	2.2	.	5.0	.	.	8.1
1996	2.3	12.9	4.2	.	10.2	8.1
1997	2.6	6.3	4.9	7.2	8.1	7.3
1998	2.9	5.6	5.1	5.3	10.0	6.6
1999	3.0	5.8	3.9	4.2	12.6	7.1
2000	2.0	6.9	3.1	6.1	12.0	7.3
2001	1.3	6.2	2.4	4.7	10.9	6.8
2002	1.6	2.1	1.0	2.8	2.2	3.2
2003	8.9

^a Weighted averages.

^b Sources: Own calculations based on ISIS (first columns) and DNB (last column).

²² This measure can be defined as $PCM = \sum_{i=1}^n s_i (p_i - mc_i) / p_i$ where p_i denotes the firm's equilibrium output price and mc_i its marginal cost.

²³ ISIS data concern both domestic and foreign activities. Pure domestic figures would be more precise but are not available

²⁴ For instance, firms in the Netherlands use more agents as selling channel than those in other countries (CEDA, 2004, page 144).

²⁵ A similar picture emerges from figures of CEDA (2004), page 198.

Of course, these figures largely reflect profit margins on past production, as profit stems from the existing portfolio of policies and not only from new business.²⁶ Sources at hand of specialised on-site supervisors indicate that profit margins of domestic production have declined strongly in recent years. Where Table 8.4 concludes that in the past competition in the Dutch market has been weak, this probably has changed in recent years.

Table 8.5 Fixed effects estimates of the Boone model for profits^a

	Average variable cost		Marginal cost		Adjusted marginal cost ^b	
	Coefficient	T-value ^c	Coefficient	T-value ^c	Coefficient	T-value ^c
β						
1995	-0.52	-2.7**	-0.53	-2.5**	-0.32	-1.4
1996	-0.42	-2.2*	-0.38	-1.8*	-0.20	-0.9
1997	-0.43	-2.0*	-0.32	-1.3	-0.05	-0.2
1998	-0.69	-3.2**	-0.70	-2.9**	-0.23	-0.9
1999	-0.34	-1.7*	-0.35	-1.5	-0.08	-0.3
2000	-0.43	-2.1*	-0.38	-1.5	-0.10	-0.4
2001	-0.55	-2.7**	-0.42	-1.7*	-0.15	-0.6
2002	-0.17	-0.9	0.14	-0.5	0.39	1.3
2003	-0.37	-1.7*	-0.18	-0.7	-0.35	1.2
ratios						
Individual premiums	1.71	3.0**	1.46	2.4**	1.42	2.3*
Periodic payments	0.34	0.9	0.26	0.6	0.14	0.4
Unit-linked funds	0.22	0.6	0.34	0.8	0.34	0.8
Endowment insurance	-0.27	0.4	-0.25	-0.3	-0.52	0.7
Intercept	6.76	8.1**	7.48	7.4**	8.15	11.5**
σ_u	2.01	.	1.97	.	0.25	.
σ_e	0.66	.	0.67	.	0.11	.
P	0.90	.	0.89	.	0.84	.
Overall R ²	0.01	.	0.01	.	0.00	.
Within / between R ²	0.26	0.04	0.28		0.26	0.08
number						
Observations	500	.	444	.	444	.
Groups	.	89	.	85	.	85

^a Profits and marginal costs are in logarithms

^b Adjusted for scale economies;

^c *: level of confidence of 95% ; **: level of confidence of 99%.

²⁶ This lagging adjustment of profitability does not disturb the international comparison, as this limitation holds also for the foreign data.

8.4 The Boone indicator

Table 8.5 presents estimates of the Boone indicator, based on an extended version of Equation (6.1) with profits and marginal costs in logarithms. Marginal costs are represented in three ways: average variable cost, defined as management costs as share of the total premium as in the traditional Boone model (see e.g. Boone, 2004; Creusen et.al., 2004), marginal cost, derived from the translog cost function of Section 8.1, and adjusted marginal costs, i.e. marginal costs adjusted for scale economies (see Appendix II).²⁷ Average variable costs have the advantage of being less complex, since they are not model based, but they are less accurate because we cannot distinguish between variable and fixed costs.

In practice, average variable costs are commonly proxied by average costs. We prefer the marginal cost derived from a translog cost function, as this is the most accurate measure. Adjusted marginal costs allow to distinguish between the effects of two components of marginal cost, namely scale economies and X-efficiency.

Following Boone (2004) and Creusen *et al.* (2004), we also introduce so-called fixed effects, that is, a dummy variable for each insurance firm (coefficients of these dummies are not reported here). The advantage is that these fixed effects pick up all company-specific characteristics, including scale, that are not captured by the other variables, so that part of the disturbances is eliminated. Around 10% of the variance in the error term of the model without fixed effects (unexplained variance: σ_u^2) can be explained by these fixed effects (explained variance: σ_e^2) when they are introduced, where ρ is equal to $\sigma_u^2/(\sigma_u^2 + \sigma_e^2)$. With respect to the control variables, we find a systematic, significantly positive contribution of individual policyholders to profits. The other control variables, policyholders with periodic payments, unit-linked fund policies and endowment insurances, do not affect profits.

As indicators of competition, the annual estimates of beta are, of course, pivotal in the analysis. The first two columns of Table 8.4 present estimates of beta based on average variable costs, which range from -0.2 to -0.7 and are significant in all years but one. The model-based marginal costs estimates are slightly higher and only significant in four out of nine years. Although the level of the indicator is difficult to interpret, its low degree of significance suggests moderate competition. When marginal costs are adjusted for scale economies, none of the betas are significant. This indicates that scale economies are an important component of the observed Boone indicator. Figure 8.1 shows that the coefficient β fluctuates somewhat over time in all three model versions. We observe an upward trend, indicating a (slight), but insignificant decline in competition over the respective years. Average variable costs and model-based marginal costs result into similar estimates. The third measure of marginal cost

²⁷ Note that the variable cost may change over the size classes due to scale efficiency (just as the marginal cost may do), so that the average variable cost may differ from the marginal cost. Apart from this theoretical dissimilarity, these variables are also measured differently in practice.

renders a comparable pattern over time, but – due to the eliminated scale economies – at a higher level.

In order to assess whether our estimates for the Boone indicator are high or low, we compare them with estimates for other Dutch industries. Creusen *et al.* (2005) estimated the traditional Boone model for the manufacturing and service industries and found elasticities between average variable costs and profits of around, respectively, -5.7 and -2.5, for the years 1993-2001. The Boone indicator of the life insurance industry is around -0.45. As noted in section 6, comparisons of the Boone indicator across sectors are problematic due to measurement error for example due to differences in accounting practices of profits and losses. However, the absolute value of the Boone indicator of insurances appears to be much lower (closer to zero) than in other service industries. Moreover, estimations using exactly the same definition for profit as in Creusen *et al.* (2005) render the same conclusion.²⁸ All in all, this implies that the life insurance industry is less competitive than the manufacturing and service industries.

Figure 8.1 Effect on profits of average variable costs and (adjusted) marginal costs



Due to the logarithmic specification of the Boone model all loss-making firms, including new entrants, have been ignored. This creates a potential bias because 20% of our observations concerned loss-making companies, as appears from estimations not presented here. Estimations of the Boone indicator in a model with ratios instead of logarithms using the full sample results in a significant more negative relationship between efficiency and profits. Solving this bias would at most add -0.5 to the Boone indicator. The conclusion remains that the Boone-

²⁸ The value of the Boone-indicator becomes for these estimations of around -0.85. Results can be obtained from the authors.

indicator is substantially smaller in the life insurance industry than in other service industries. Furthermore, the Boone indicator is subject to the same deficiencies as the profit margin in Section 8.4, as it is based on profitability of past business instead of only new production. The next section solves these issues by analysing another performance indicator: market shares. Note that similarly as described above for profits, market shares will react stronger on marginal costs, the more competitive the market is. Market shares are based on annual premiums and a significant part, 55% of these premiums, are due to new policies. Therefore, market shares reflect largely the current business. Furthermore, using market shares we can utilise information of the full sample, loss-making firms included .

8.5 Sensitivity analysis: the Boone indicator based on markets shares

Although the indicator as originally formulated by Boone is based on relative profits, the idea behind it – namely that competition rewards efficiency – implies that we could also use the intermediate magnitude relative market shares as our outcome variable. Therefore, as a check on the findings in the previous section, this section presents estimation results based on markets shares. Results are shown in Table 8.6. We find that average variable costs appear to have a significantly negative effect on market shares, see the first two columns. An increase of this marginal cost measure with one percent results in a market share loss of around 0.45%. Note that this value is similar to the Boone indicator based on profits in Section 8.5.

If we consider changes in β_i over time, we observe larger negative values in the years just before the major fiscal policy change-over of 2001 with respect to annuities, as described in Section 2 (see also Figure 8.2). This indicates that competition has intensified somewhat in these years, probably with respect to annuities, which is in line with the observed increase in advertising and sales. In the subsequent years, we see that the effect of marginal costs on market shares decreases, pointing to weakening competition.

Considering the other estimation results in Table 8.5, it is clear that the unit-linked funds appear to have been a major innovation in gaining market shares. Collective contracts are also favourable for gaining larger market shares. The year dummies are (almost) insignificant and, therefore, have not been shown in the table. When – as a second test on robustness – the four control variables are dropped, we find similar results for β_i (not reported here). The most important conclusion is that the central results – significant negative values for the β_i s and a (negative) peak in the β_i just before the fiscal reform of 2001 – appear to be robust for specification choices.

Table 8.6 Fixed effects estimates of the model for market shares

	Average variable cost		Marginal cost		Adjusted marginal cost ^b	
	Coefficient	T-value ^c	Coefficient	T-value ^c	Coefficient	T-value ^c
β						
1995	-0.36	-5.4**	-0.37	-7.0**	-0.18	-2.2*
1996	-0.45	-7.3**	-0.44	-7.5**	-0.26	-3.4**
1997	-0.50	-7.8**	-0.48	-7.1**	-0.25	-3.1**
1998	-0.47	-6.8**	-0.44	-5.5**	-0.19	-2.1*
1999	-0.57	-7.9**	-0.56	-7.2**	-0.11	-1.1
2000	-0.59	-8.3**	-0.59	-5.9**	-0.38	-4.1**
2001	-0.48	-6.6**	-0.42	-2.8**	-0.23	-2.3*
2002	-0.34	-5.2**	-0.34	-2.2*	-0.10	-1.0
2003	-0.33	-4.4**	-0.28	-1.9*	0.02	0.2
ratios						
Individual premiums	0.62	2.9**	0.74	3.0**	0.66	2.8**
Periodic payments	-0.71	-5.3**	-0.70	-6.2**	-0.82	-5.7**
Unit-linked funds	0.45	3.3**	0.56	4.3**	0.59	4.0**
Endowment insurance	0.63	2.9**	0.40	1.0	0.25	1.0
Intercept	-7.13	-25.7	-6.81	-21.5**	-6.03	-24.5**
σ_u	2.11	.	1.86	.	1.95	.
σ_e	0.30	.	0.29	.	0.31	.
P	0.98	.	0.98	.	0.98	.
Overall R ²	0.19	.	0.10	.	0.02	.
Within / between R ²	0.30	0.17	0.28	0.11	0.19	0.01
number						
Observations	651	.	581	.	581	.
Groups	.	101	.	96	.	96

^a Profits and marginal costs are in logarithms

^b Adjusted for scale economies;

^c *:level of confidence of 95% ; **: level of confidence of 99%.

The two middle columns of Table 8.5 repeat the results for marginal cost instead of average variable cost. The values of β_I are similar in level and development over time and slightly less significant.²⁹ Apparently, average (variable) costs do well as a proxy for marginal costs. The control variables have effects in line with earlier results.

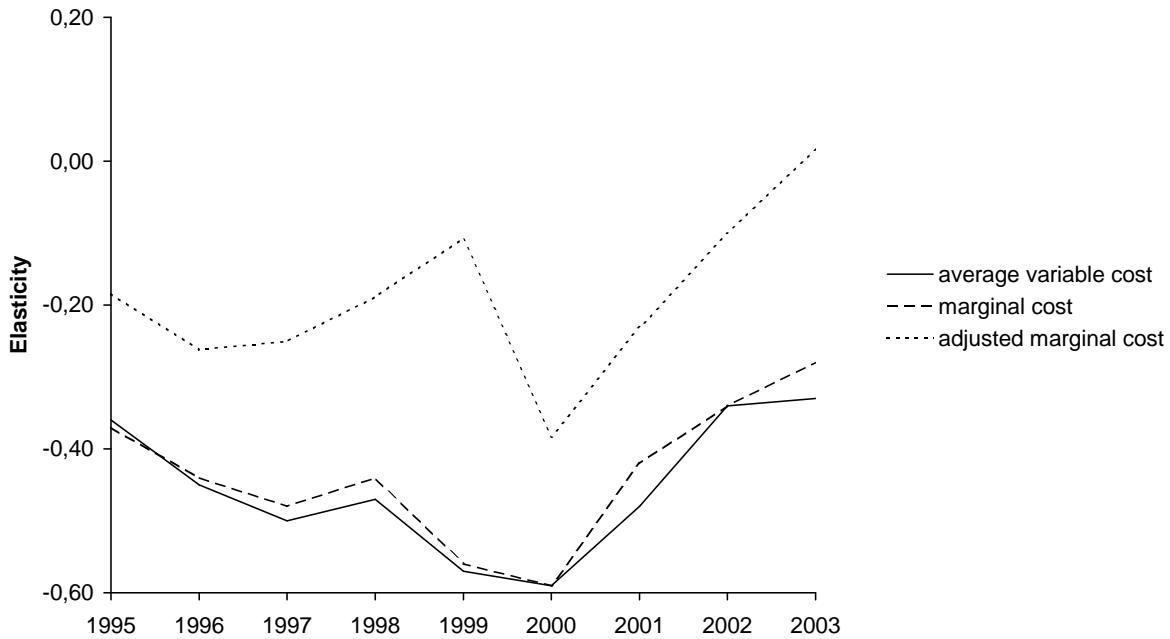
Although the results presented above uniformly indicate that efficiency gains lead to larger market shares, this could also fully or partly be due to scale economies, as observed in Section 8.1. Large firms enjoy these scale economies which reduce marginal costs and work to increase market shares. To avoid possible distortion due to this kind of endogeneity, we correct the marginal costs (mc) for scale economies as set out in Appendix II. This correction for scale

²⁹ In the basic model, the β_I values for mc are lower than for average variable costs (namely around -1) and for one year even not significant, see Table A.2 in the appendix.

economies yields the purest method of investigating the present relationship. The right-hand side columns of Table 8.5 present the estimates for the market share model based on marginal cost adjusted for scale economies. As in the earlier model versions, we find that higher marginal cost tend to diminish a firm's market share and *vice versa*. However, the value of β_I and its level of significance are much lower now (namely around -0.2), apparently due to the fact that the positive contribution of scale economies has been eliminated (see also Figure 8.2). Note that this coefficient may be affected by measurement errors. Nevertheless, if we estimate one single β_I for the whole period, this coefficient is significant (not reported). The control variable coefficients are similar to earlier results.

Figure 8.2 shows that the annual estimates of beta in each of the three model versions indicate no upward or downward trend. Higher negative values of β are found in the years just before the major fiscal policy change-over of 2001 with respect to annuities, as described in Section 2. This indicates that competition has intensified somewhat in these years with respect to annuities, which concern around 30% of the market. In the subsequent years, we see that the effect of marginal costs on market shares decreases, pointing to weaker competition. In these years, profit margins on annuities recovered (according to sector experts). Apparently, the level of competition changed somewhat over time.

Figure 8.2 Effect on market shares of average variable costs and (adjusted) marginal costs



9 Conclusions

This paper analyses competition and efficiency in the Dutch life insurance market. As competition cannot be observed directly, we use five indicators to estimate competition in an indirect manner.

The first indicator is of a qualitative nature. We investigated the structure of the insurance market using the so-called tight oligopoly analysis, yielding diverging results. For the supply side factors we find that supplier power is limited, due to the large number of insurance firms, and that ample entry possibilities exist, which in principle enable sound competition. However, on the demand side we observe that consumer power is limited, particularly due to the opaque nature of many life insurance products, and that few substitution possibilities exist for life insurance policies, which may rein in competition. In short, the resulting overall picture from these considerations is mixed.

The second indicator is the scale efficiency level. A translog cost function has been applied to measure scale economies in the Dutch life insurance industry. Estimates indicate that scale economies exist and amount to 20% on average, ranging from 10% for large firms to 42% for small firms. Such scale economies are substantial compared to what is usually found for other financial institutions such as banks, but still modest compared to other industries. All existing insurance companies are far below the estimated (theoretical) optimal size. This implies that further consolidation in the Dutch life insurance market would be beneficial. Apparently, competitive pressure in the insurance market has so far been insufficient to force insurance firms to employ the existing scale economies. Of course, consolidation could interfere with entry of new competitors.

The third indicator is the X-efficiency level. We find cost X-inefficiency estimates of around 25%, on average, a magnitude which would not be expected in a market with heavy competition. Incidentally, such inefficiencies are not uncommon for life insurance in other countries.

The fourth indicator is the profit margin. We observed that profit margins of the Dutch life insurance firms have been high compared to those of their peers in other European countries. This could indicate relatively less competitive pressure in the Netherlands. However, this result mainly reflects the competitive situation in the past rather than in the most recent years. Anecdotic evidence suggests that current profit margins in the domestic market are small, whereas, given the current low interest rates, the outlook for the (near) future is also not favourable.

The fifth indicator is the Boone indicator. Estimates of this indicator point to weak competition in the Dutch life insurance industry in comparison to indicator values in other service industries. All our empirical analyses are based on balance sheet and profit and loss data from both new and old business. Although the majority of annual premiums stems from new policies, the portfolio of policies is built up over the years. Hence, eventual improvement of

competition would show up in these figures only with some delay, depending on the approach. However, annual estimates of the Boone indicator for the most recent years find a weakening rather than a strengthening of competition.

The evidence in this paper does not allow us to draw strong conclusions on competition in the insurance market. The reason is that our analysis is on an aggregate level and potentially relevant institutional details are lacking. Yet, all five indicators point to limited competition.

Deliberations about possible policy measures to promote competition in the life insurance market should take into account the trade-off that exists between heavier competition, with the advantage of lower premiums and better services for consumers in the short run, and its downside, the possibility of a long-term deterioration in insurers' solvency, leading to less assured future insurance benefits. Further, possible policy measures should be aimed at the right submarkets or distribution channels. Due to data limitations, our analyses could not distinguish between life insurers and independent insurance agents. Recent research has revealed that the financial advice market does not function properly and may hamper competition. Given the fact that most consumers call in the services of insurance agents, this may be an important indication on where to start enforcing of competition.

Beside, it seems obvious that reduction of both X-inefficiency and scale inefficiency would be advantageous for all parties involved. Developments in information technology make further improvements in efficiency possible, as was recently demonstrated by some Dutch insurers. Our empirical research also suggests that consolidation would carry enormous cost savings. Comparison to other countries teaches that foreign markets are much more consolidated, so that scaling-up in the Dutch market is apparently lagging. From that perspective, further consolidation would be sensible.

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APPENDIX I Estimation results

Estimation results of the cost and profit X-efficiency models for insurance firms

Variables	Cost		Profit	
	Coefficients	T-values ^a	Coefficients	T-values ^a
Intercept	4.020	5.1**	- 4.235	- 4.2**
Premiums (1)	0.149	0.9	0.079	0.3
Unit-linked funds (2)	0.317	4.5**	- 0.160	- 1.4
Numbers of policies (3)	- 0.178	- 1.3	0.141	0.6
Endowment insurance (4)	0.305	3.4**	1.172	7.0**
Amount of annual annuities (5)	0.267	4.0**	0.021	0.2
Price of acquisition (6)	0.181	1.5	- 0.690	- 3.1**
Price of other cost (7)	1.630	8.0**	1.951	5.0**
Netput profit (8)			- 0.262	- 3.0**
Squares (1)	- 0.054	- 2.6**	- 0.025	- 0.7
Squares (2)	0.000	0.0	0.012	3.4**
Squares (3)	- 0.005	- 0.4	0.073	2.9**
Squares (4)	0.013	2.5**	0.044	5.4**
Squares (5)	0.004	1.5	0.018	4.1**
Squares (6)	0.038	5.3**	0.027	2.6
Squares (7)	- 0.058	- 4.0**	- 0.029	- 1.2
Squares (8)			0.131	13.3**
Cross-terms (1,2)	0.039	4.4**	- 0.006	- 0.5
Cross-terms (1,3)	0.084	3.4**	0.085	2.0*
Cross-terms (1,4)	- 0.018	- 1.3	0.021	0.8
Cross-terms (1,5)	0.014	1.0	- 0.039	- 1.7*
Cross-terms (1,6)	0.025	1.2	0.017	0.5
Cross-terms (1,7)	- 0.103	- 3.4**	0.051	0.9
Cross-terms (1,8)	- 0.028	- 3.9**	- 0.023	- 1.4
Cross-terms (2,3)			- 0.006	- 0.6
Cross-terms (2,4)	- 0.006	- 2.3*	0.012	2.3**
Cross-terms (2,5)	- 0.008	- 3.0**	- 0.002	- 0.5
Cross-terms (2,6)	0.020	3.7**	0.021	2.4**
Cross-terms (2,7)	0.032	3.9**	- 0.013	- 1.0
Cross-terms (2,8)			0.001	0.1
Cross-terms (3,4)	- 0.035	- 1.6	- 0.207	- 5.4**
Cross-terms (3,5)	- 0.021	- 2.6**	- 0.033	- 2.4**
Cross-terms (3,6)	- 0.019	- 1.2	- 0.020	- 0.7
Cross-terms (3,7)	- 0.105	- 4.6**	- 0.182	- 4.7**
Cross-terms (3,8)	0.009	1.1	- 0.055	- 4.8**
Cross-terms (4,5)			0.036	2.3*
Cross-terms (4,6)	0.020	2.5**	0.086	4.9**
Cross-terms (4,7)	- 0.022	- 1.1	- 0.024	- 0.7
Cross-terms (4,8)			- 0.061	- 5.1**
Cross-terms (5,6)	- 0.009	- 1.5	- 0.027	- 3.3**
Cross-terms (5,7)	0.052	6.1**	0.005	0.4
Cross-terms (5,8)			0.004	0.6
Cross-terms (6,7)	0.004	0.3	0.057	1.9*
Cross-terms (6,8)			0.019	1.7*
Cross-terms (7,8)			0.005	0.2

Estimation results of the cost and profit X-efficiency models for insurance firms (continued)

Variables	Cost		Profit	
	Coefficients	T-values ^a	Coefficients	T-values ^a
σ^2	0.952	8.0	5.960	5.2
γ	0.914	52.6	0.987	205.3
μ	- 1.865	- 7.1	- 4.852	- 3.9

^a :level of confidence of 95% ; **: level of confidence of 99%.

Appendix II Marginal costs adjusted for scale economies

Section 8.1 has confirmed the existence of substantial scale economies in the Dutch life insurance industry. To avoid possible distortion due to endogeneity, we correct the marginal costs (*mc*) for scale economies, based on a simple regression of *mc* on production, where *mc* occurs both in linear terms and squared, either as logarithms or in their natural form (the former for the market share model, the latter for the profit model). Table A.2 shows that a one per cent increase in production reduces marginal costs by, on average, 0.15% according to the log-based model and 0.17% in the second model.³⁰ These figures are in line with the scale economies of Section 8.1. The residuals of these auxiliary equations are interpreted as marginal costs corrected for scale economies.

Auxiliary regressions for marginal cost and scale economies corrections

Dependent variable: marginal costs	Model in logarithms		Model in natural values	
	Coefficients	T-values ^a	Coefficients	T-values ^a
Production	- 0.37	- 4.5**	- 1.34 ^a	- 6.03**
Production ²	0.01	2.7**	2.49 ^a	4.6**
Intercept	0.83	1.9*	0.20	31.5**
Adjusted R ²	0.19	.	0.07	.
Number of observations	607	.	607	.

^a *: level of confidence of 95% ; **: level of confidence of 99%.

^b In billions instead of thousands of euros

³⁰ The elasticity, the first derivative of the auxiliary equation in logs, is $-0.37+0.01*2*\text{average production in logarithms}$. For the auxiliary model in natural values it is equal to $\partial mc/\partial \text{production} * (\text{average production} / \text{average mc}) = (-0.134e-7 + (0.249e-14 * 247707.4*2) * 247707 / 0.18)$.

