A new method for price and volume measurement of non-life insurance services: A statistical approach

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Abstract. The use of actual claims and loss data in price and volume measurement of non-life insurance services may give rise to negative nominal values (turnover) and inconsistent behaviour of production volume and nominal value. The new method relates premiums to expected loss and expected investment income. Yearly expectations of loss and investment income are estimated from Dutch data. Expected loss and its 'relative handling cost' are used to characterise insurance services, which take different values over different types of non-life insurances, thus giving rise to 12 product groups. Numbers of insurance policies in each product group are chosen as volume measures. A policy represents the handling part of risk (e.g., administration). The amount of assumed risk itself is excluded from the service, following the SNA-guidelines. The Dutch data show an average annual volume growth of about 0.97 percent during 2006-2009, while nominal value ('net premium') shows an increase of 1.21 percent. The results are robust to variations in uncertain parameter values. The method is compared with the 'gross premium' approach and with other approaches. The proposed method is preferred because of better model fits to data, while the gross premium approach evidences disputable behaviour in some cases.

Keywords: Non-life insurances, risk, nominal value, volume index, national accounts, maximum likelihood, information criteria.

1. Introduction

Price and volume measurement of insurance services is a complex field of national accounting. The first challenge is to characterise the services that insurance companies provide to policy holders. A notion of insurance service or 'product' needs to be developed before price and volume measurement can be undertaken. Another major problem is how to define nominal value of production. While for other service sectors, such as health care, expenditures are taken to represent nominal value of production, different views exist in the literature on the definition of nominal value for insurance services (SNA, 1993; Sherwood, 1999; SNA, 2008). As a consequence, a concept of 'price' is not readily available. Are premiums appropriate, some cost measure, or something else? Price and volume measurement of insurance services is so complex, because all its components need to be defined.

Two main concepts of production have been proposed for insurance services. The first is described by Sherwood (1999) as "the activities carried out by the industry to maintain the capacity for pooling risks". This view is supported by Hirshhorn and Geehan (1977, 1980). The second concept is described by Sherwood (1999) as "the assumption of (a certain quantity of) risk". Amongst others, Denny (1980) and Hornstein and Prescott (1991) support this concept. Denny (1980) argued that the output of the insurance industry is the quantity of risk shifted to the industry by those who purchase insurance. Policy holders and the industry contract for risk coverage, not for the performance of certain activities.

Different definitions of nominal value have been proposed for the two concepts of production. The nominal value for the activity-based approach is roughly premiums minus claims (or benefits, for life insurances). The netting out of claims reflects the main idea behind the first production concept: the margin left ensures that the service can be delivered, as it covers the costs of carrying out activities like administration. The nominal value for the risk assumption concept is basically premiums. In

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Hornstein and Prescott's (1991) interpretation, claims are considered as intermediate purchases ("replacement capital goods") and premiums cover both risks and costs of activities.

Premiums and claims/benefits are not the only components of nominal value. Insurance companies earn income from the investment of reserves and set premiums in relation with their expectation about investment income (also termed "premium supplements" in the literature). There is an ongoing debate on what types of investment income should be included in nominal value (SNA, 1993; Fixler, 2002; Lal, 2003; SNA, 2008). Should only 'direct income', such as rent, interest and dividend, be included, or also holding gains and losses?

Another topic that has received a lot of attention in national accounting is how claims should be dealt with for non-life insurances. The System of National Accounts (SNA) prescribes that nominal value should be measured as premiums plus investment income minus claims. However, nominal value may become negative in years with large claims, when the actual sums of claims incurred are used in the calculations. The most recent revision of the SNA, which appeared in 2008, speaks of "adjusted claims incurred", which gives national accountants more freedom in defining the claims term (SNA, 2008, par. 17.27). For instance, Chen and Fixler (2003) propose a weighted moving average model as an expression for expected claims.

The possibility of negative nominal values in years with large claims is not the only potential problem. When actual claims are also used in volume measures, like claims handled in the "direct service method" (Eurostat, 2001, pp. 95-96), this will lead to inconsistencies between nominal value and volume. Volume increases as a function of number of claims, while nominal value decreases. Nominal value should increase when production volume increases (when keeping prices fixed). We will give an illustration of this problem in Section 2.

The rest of this paper deals with a new method for price and volume measurement of non-life insurance services, which is now used at Statistics Netherlands. In Section 3, we first give a different characterisation of insurance services and counting measures of production volume. We abandon the 'single activity line of thought' followed in the past, as expressed by the direct service method.

In Section 4, a model for nominal value is derived. For the purpose of national accounting, we use the definition of the SNA 2008 as a starting point. In line with recent discussions in the literature, we also propose the use of expected values for investment income and loss, but we follow a different route in this respect. Expectations for investment income and loss, which are proposed in Section 4, are integrated into a mechanism that relates premiums and expected investment income to expected loss. Setting premiums is an essential part of the service provided by insurance companies to policy holders, so that we wanted this aspect to be captured by the new methodology.

Setting premiums is a complex matter in practice, which is simplified here. The parameters in the relation between premiums, expected loss and investment income make insightful how the two main sources of income, that is, premiums and investment income, are distributed over risk and 'handling cost' (i.e., the 'margin', nominal value). This approach gives rise to a parametrised form for nominal value. Different model versions for premium setting and nominal value are compared by using a statistical method and the best fitting model version is eventually selected. The parametrisation of nominal value and the model selection procedure are new contributions to this field of national accounting. Model fits to loss and investment income data are shown in the second part of Section 4.

Expressions for value and volume indices are derived in Section 5. Results are shown by distinguishing five groups of insurance services. The results are discussed in Section 6, which will be compared with other methods. We also show the results for a refinement to 12 product groups, under additional model assumptions. The main findings are summarised in Section 7.

2. The direct service method

At Statistics Netherlands, volume indices for life and non-life insurance services were calculated with the direct service method in the national accounts. Direct service methods quantify periodic changes in production volume by setting up quantity measures for three main activities: (1) administration of policies, (2) acquisition of new policies, and (3) handling of claims. The quantity indices are weighted and summed to an overall volume index.

The basic expression for the overall volume index can be written in the following compact form:

$$(1) \quad V = w_A V_A + w_N V_N + w_C V_C.$$

The overall volume index is denoted by V, and the volume indices for administration, new policies and claim handling are denoted by V_A, V_N and V_C respectively. The notation for time is left out for ease of exposition. The weights of the volume indices for the three activities are denoted as w_A, w_N and w_C, which sum to 1. The weights are assumed to have the same value every year in the method that was implemented at Statistics Netherlands.

The direct service method is illustrated below for motor vehicle insurances. The overall volume index for motor vehicles has the following weights in expression (1): $w_A = 0.25$, $w_N = 0.3$ and $w_C = 0.45$. The method thus puts the biggest weight on claim handling.[2]

The volume indices for administration, acquisition and claim handling all consist of two volume indices: an index for the number of policies or claims, and a deflated index for insured value or sum claimed. For instance, the volume index V_N for acquisition consists of a quantity index for the total number of new policies for motor vehicles and an index for average purchase value of vehicles, which is deflated by the CPI. More precisely, the volume index is calculated as follows:

$$(2) \quad V_N = Q_N (0.8 + 0.2 W_N),$$

where Q_N denotes the quantity index for the total number of new policies and W_N is the deflated index for purchase value. If the deflated average purchase value does not change in two successive years, so that $W_N = 1$, then it follows that $V_N = Q_N$. The index W_N can be considered as a factor that accounts for changes in the 'product mix', that is, shifts in insured risks for new policies. The volume indices for administration and claim handling are calculated in similar ways.

The direct service method has several weaknesses. One of the main points of criticism emerges from the use of the number of claims as one of the volume components. The method implies that volume increases (decreases) when the number of claims increases (decreases), while keeping all other factors fixed. In general, a higher volume gives a higher nominal production value, as value is equal to price times quantity. However, the direct service method violates this equality.

Nominal value of production is calculated in the direct service method according to the old definition, as was proposed in the SNA 1993 and the Eurostat handbook of price and volume measurement. Nominal value was defined as premiums earned plus premium supplements minus claims incurred. Actual claims were used in the old method. An increase in the number of claims leads to a higher volume by that method, but also to a higher value of claims incurred. Since premiums are fixed in advance, nominal value will decrease. This causes a contradictory behaviour of nominal value and production volume.

The behaviour of nominal value, volume and number of claims is shown in Figure 1 for insurance services regarding motor vehicles and fire. Indices for the number of claims are added in both subfigures in order to illustrate the opposite behaviour of nominal value and production volume, which is clearly visible for most years. This behaviour does not arise for all years, since nominal value also depends on the behaviour of premiums and investment income beside claims.

The old SNA-definitions of nominal value contain conflicting terms: premiums are set in advance to cover risk, that is, expected loss, not actual loss. The use of actual claims has another severe drawback, as it may cause nominal value to become negative in years with huge claims. This was one of the reasons for revising the SNA-section on insurance services in 2008.

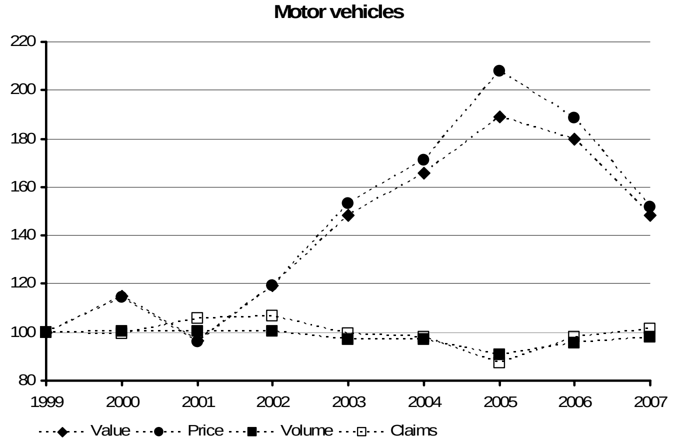
3. Service types and quantity measures in the new method

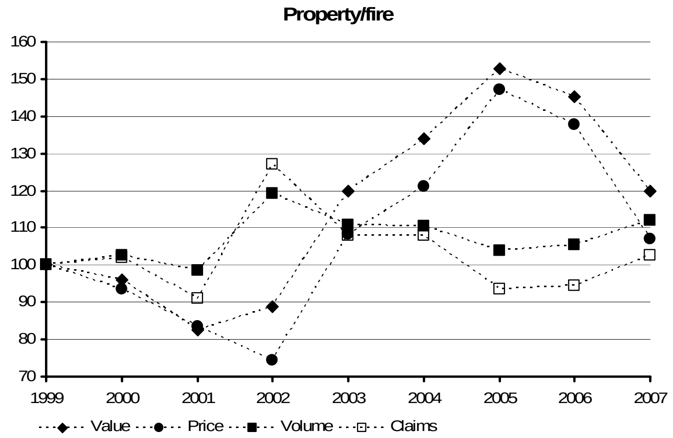
Characterisation of non-life insurance services

In recent years, progress has been made at Statistics Netherlands on volume measurement for public service sectors, in particular on health care and education. A transition has been made to methods that

[2] Unfortunately, the estimation method for the weights is not well-documented. The weights seem to be based on partial information about expenditures and 'expert opinion'.

Figure 1. Chained value, price and volume indices for two types of non-life insurances and for the number of claims incurred (1999 = 100).





measure quantities directly, while volume indices were previously obtained by deflating value indices with some price index. ‘Direct volume measurement’ seems to be an appropriate starting point also for insurance services, since nominal values and prices are not directly observable. Direct volume measurement is one of the recommendations in the Eurostat handbook (2001) for price and volume measurement.

Before setting up quantity measures, we first need a characterisation of insurance services in order to distinguish different ‘product types’. We suggest to distinguish non-life insurance services according to expected loss (‘risk’) and the ‘handling’ of risk by an insurer. So, we could imagine services to be characterised by pairs (r, μ), say, where r denotes expected loss, or risk, and μ is a parameter, or a set of parameters, which determine the handling cost of risk in order to cover the costs of administration, acquisition and claim handling, amongst others. We will work out and relate risk and handling cost in Section 4.

Reasons for distinguishing services according to pairs (r, μ) could be that expected loss r is an indicator of the extent of the liability of insurers to policy holders, while μ represents the way in which risks are handled. Certain types of risks require greater care by insurers in establishing adequate coverage, for instance because of a higher probability of occurrence of large claims. This is reflected in our model in Section 4 by setting μ at smaller values. Smaller values of μ lead to larger handling costs and thus larger margins for an insurer. This has a positive effect on production volume (‘heavier’ types of service have larger weights).

In Section 4, we present a simple model expression, which combines expected loss, premiums and handling cost parameters μ, and a method for estimating expected loss and μ for five lines of insurance:

- Health and accident;[3]
- Motor vehicles;
- Fire;
- Transport;
- A group termed "other insurances", which contain insurances for legal aid and liability.

Counting measures of production volume

Next, a characterisation of counting units for production is needed, so that volume can be quantified for every product type. For instance, in health care the notion of "complete treatment" has been proposed as counting unit, which refers to the pathway that an individual takes through different health care institutes (Berndt et al., 2001; Aizcorbe et al., 2008; OECD (2008, p.72)), or a sequence of health care activities leading to dismissal from a health care institute.

Different choices regarding counting units may lead to significant variations in volume indices. Chessa (2009) discusses the differences between counting units based on packages of health care activities and on following single health care activities.[4] We extend the notion of health care package to insurance services, and propose packages, or bundles of insurance activities, as counting units of production. We follow the SNA-concept of 'net output', which focuses on the handling of risks. Policies are taken here to represent packages of insurance activities, such as policy administration, which are financed by the handling costs of risks.

Counting policies as volume units can be justified by the fact that policies denote the 'support' of insurance activities. That is, there are no insurance activities when there are no policies. We will thus count policies for the aforementioned five lines of insurance. With such a small number of product groups, we could miss volume growth when the groups are not homogeneous in terms of expected loss covered and handling cost parameters μ. We therefore decided to study the effects on price and volume change for a refinement to 12 product groups, although we had to make additional model assumptions (Section 6).

4. A model for nominal value

The aim of this section is to find a characterisation of the five product groups in terms of expected loss and their handling risk, or cost, parameters μ introduced in the previous section. Expected loss and μ are estimated on the basis of a simplified model for premium setting, which relates premiums to expected loss and handling cost. We first describe this model and afterwards we present the estimation method.

Expected loss

In the model below, premiums are set according to expected loss, to which insurers may add their expectation about investment income. Premiums are set at higher levels when risk increases. But increasing levels of investment income give the possibility to set lower premiums. We intend to set up an expression that captures these interactions between premium, risk and investment income.

Let $P_{i,t}$ denote total premiums earned for product group i in year t, that is, summed over all policies within the product group.[5] Let $\mathrm{E}S_t$ denote the expected investment income to premium ratio in year t, which is a notion that was also used by Chen and Fixler (2003). Premiums and expected

[3] The execution of the obligatory 'base' insurance for primary and curative care (*basisverzekering* in Dutch) is a government activity in the Dutch national accounts and is therefore not part of insurance services. The health care insurance services in this paper apply to supplementary insurances, which persons may conclude for care that is not covered by the base insurance.

[4] The volume of inpatient hospital care, measured by patient discharges, increased with 5.4% per year during 2000-2007 in the Netherlands, while hospitalisation days decreased with 0.4% per year on average. Patient discharges represent packages of health care delivered. This difference can be partly explained by the substitution of clinical treatments by day treatments.

[5] Premiums also include reinsurance premiums. Previous calculations showed that a distinction of risks between unceded and reinsured risks did not affect value and volume indices. This could be explained by the fact that a large part of reinsured risks falls under *quota share* contracts. This means that the reinsurer will receive a stated percentage of premiums and will pay the same percentage of losses. In this paper, we therefore combine premiums and loss for unceded and reinsured risks.

investment income, which is denoted as $P_{i,t}\mathrm{E}S_t$ for product group i, are distributed in some way over risk and handling cost. For this purpose, we introduce parameters μ_i^P and μ_i^S, which take values between 0 and 1. The parameters μ_i^P and μ_i^S denote the fractions of premiums and expected investment income, respectively, that cover total expected loss for product group i. We thus use the following expression for expected loss for product group i in year t:

$$(3) \qquad \mu_i^P P_{i,t} + \mu_i^S P_{i,t}\mathrm{E}S_t .$$

The parameters μ_i^P and μ_i^S are allowed to take different values. For instance, μ_i^P is expected to take some value smaller than 1, while μ_i^S could be equal to 1. In that case, investment income is entirely used to cover expected loss, so that handling cost exclusively consists of (a fraction of) premiums. In this model version, different sources of risk arising from loss and investment income are combined and premiums are set through the handling cost parameter μ_i^P. The idea behind this model version is that investment income is used to compensate (a part of) losses incurred. Model versions where the μ_i^S are equal to zero imply that investment income is assigned to handling cost and that a part of the premiums is used to cover losses.

We make the following assumptions about model (3):

- For each line of insurance i, we assume that μ_i^P and μ_i^S are constant in time;
- We assume that $\mathrm{E}S_t$ has the same value for each line of insurance, for every year t.

The first assumption follows from the objective of constructing homogeneous product groups, as the μ's are used as a characteristic of product groups. Time dependent μ's imply that product groups are non-homogeneous and therefore incomparable over time. This could be caused by shifts among different types of insurances within a product group, having different (hidden) values of μ_i^P and/or μ_i^S. We will come back to this in Section 6, where we consider a more detailed subdivision of insurance services into a larger number of product groups.

The available data about investment income gave rise to the second assumption. These data are not specified by product group; only total amounts are available for every year. The values of $\mathrm{E}S_t$ are allowed to vary from year to year.

Expected investment income

We suggested a simple model, where investment income is related to indicators like rent. We relate the yearly change in expected investment income to the yearly change in rent, which we denote by R_t for year t. Also R_t could be considered as an expected value, since some extrapolation of its behaviour until year t – 1 to year t is needed. In order not to make the model more complicated, with yet another set of parameters, we relate $\mathrm{E}S_t$ to R_{t-1} rather than to R_t. So, in order to make a statement in year t – 1 about expected investment income in year t, we look at the value of R_{t-1} and the amount by which it changed with respect to year t – 2.

We consider the following model form for $\mathrm{E}S_t$:

$$(4) \qquad \mathrm{E}S_t = \alpha \left(\frac{R_{t-1}}{R_{t-2}} \right)^{\beta} s_{t-1},$$

where $\alpha > 0$ and β is a real-valued parameter.

Different choices can be made for the components of this model. In this paper, we look at different choices for s_{t-1} in (4). It could be defined as the expected investment income to premiums ratio $\mathrm{E}S_{t-1}$ in year t – 1. But it could also be defined as the investment income to premiums ratio observed in year t – 1, so that $\mathrm{E}S_t$ is in fact a conditional expectation. We considered direct investment income, which involves rent, interest and dividend. As we noted that the inclusion of indirect investment income hardly affected the results for value and volume indices, we will only consider direct investment income here. Actual values of direct and total investment income to premiums ratio can show large differences, but the differences between the estimated expected values were more contained.

Data and model fitting

The parameters in models (3) and (4) give us the possibility to define different model versions. The parameter estimation method summarised in this subsection enables us to compare model versions and to select the one that gives the best fit to loss and investment income data. Why is it important, in our opinion, to compare model fits? Expression (3) relates expected loss to premiums, and can be read as a tool for setting premiums. As this is an essential part of insurance services, the focus should be on relating premiums, expected investment income and expected loss as closely as possible, in a certain statistical sense, thus providing a solid basis for price and volume index calculations.

The following data were used for estimating the parameters of (3) and (4), which are available from De Nederlandsche Bank (DNB), the Dutch central bank:

- Loss incurred for each of the 5 product groups, for every year in the period 1995-2009;
- Premiums earned for each of the 5 product groups, for every year in the period 1995-2009;
- Direct investment income for every year in the period 1995-2009. Only aggregate values over the five lines of insurance are available.

The parameters were estimated by maximising an adjusted likelihood function, which is based on normal distributions for loss and direct investment income to premiums ratio, with expectations given by (3) and (4).

The expectations (3) and (4) contain a total of 12 parameters. In addition, it is possible to set up to 6 different variances (one for investment income and one for loss in each of the five lines of insurance). There is a risk of overfitting when every parameter is freely estimated. It is therefore important to investigate which parameters should be treated as free parameters. For instance, could we obtain 'better' model fits by setting α equal to 1, or by setting the μ_i^P or the μ_i^S equal for different lines of insurance? Making models more complex by adding parameters increases their maximum likelihood, but this may lead to overfitting. Information criteria resolve this problem by introducing a penalty term for the number of parameters in a model.

There are different types of information criteria, with different forms of the penalty term for the number of model parameters (Claeskens and Hjort, 2008). We chose the Bayesian Information Criterion (BIC), since it gives more stable parameter estimates than the classical Akaike Information Criterion (AIC).[6] The BIC has a more severe penalty for model parameters, for sample sizes $n > 7$, and can be written as follows:

$$(5) \qquad \mathrm{BIC} = 2\ln(L) - (\ln n)\,p,$$

where L denotes a maximised likelihood function for a model with p parameters and n is the sample size ($n = 90$).

The number of free parameters can be strongly reduced. The following results were obtained:

- The best fits were obtained with s_{t-1} in (4) being the direct investment income to premiums ratio actually observed in year $t - 1$;
- The parameters of the direct investment income model are fixed at $\alpha = 1$ and $\beta = 0$;
- We do not have data on direct investment income in 1994, so we treated s_{1994} as an additional parameter. The value estimated is $s_{1994} = 0.106$;
- The values of the handling cost parameters regarding investment income in (3) are all fixed at 1, that is, $\mu_i^S = 1$ for all product groups;

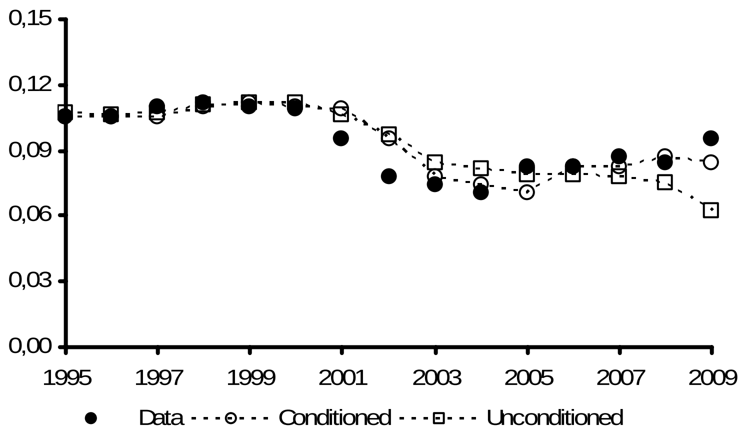
[6] An important question from a national accounts perspective is whether parameter estimates undergo substantial changes when future data are added. Refitting the models with new data could then lead to changes in the value and volume indices obtained until present. However, index numbers cannot be adjusted until the next national accounts revision. Parameter values should be left unchanged when computing value and volume indices for future years.

- The handling cost parameters μ_i^P regarding premiums have the following values: 0.721 for health and accident, 0.630 for both motor vehicles and transport, and 0.496 for both fire and "other insurances".

We thus have four free parameters in the expectations (3) and (4) (and two variances estimated from the data, one for investment income and one for loss). The maximum BIC-value obtained is 289.2.

The parameter values for direct investment income imply that the expected direct investment income to premiums ratio for year t is set at the value observed in year $t - 1$, that is: $\mathrm{E}S_t = s_{t-1}$.[7] This gives the model fit in Figure 2. The fit can be compared with the fit when using the expectation $\mathrm{E}S_{t-1}$ instead of s_{t-1}. This unconditional expectation results in a lower BIC (267.1), even with two additional free parameters (i.e., α and β).

Figure 2. Fits of expected direct investment income to premiums ratio (4) to data. Fits are shown for the expectation conditioned upon the value of the preceding year and for an unconditional expectation. (Data are from DNB)



The handling cost parameters μ_i^S with regard to investment income are all equal to 1. This means that investment income is entirely used to cover risk, so that it does not enter nominal value.[8] The handling cost parameters μ_i^P regarding premium have different values for three lines of insurance. Insurers of healthcare and accident charge the lowest handling cost, namely $1 - \mu_i^P = 0.279$ per unit premium. The highest handling costs are found for fire and "other insurances" (0.504). This could be due to a higher probability of large claims for fire and liability, so that insurers charge relatively higher premiums in order to provide coverage against loss. The parameter values show that risks are dealt with in a different way across insurance types.

The fits of expected loss to data are shown in Figure 3. The rapid decrease of expected and actual loss for health care and accident insurances in 2006 can be explained by changes in the Dutch healthcare insurance system, which was reformed in 2006.[9]

5. Nominal value and volume indices

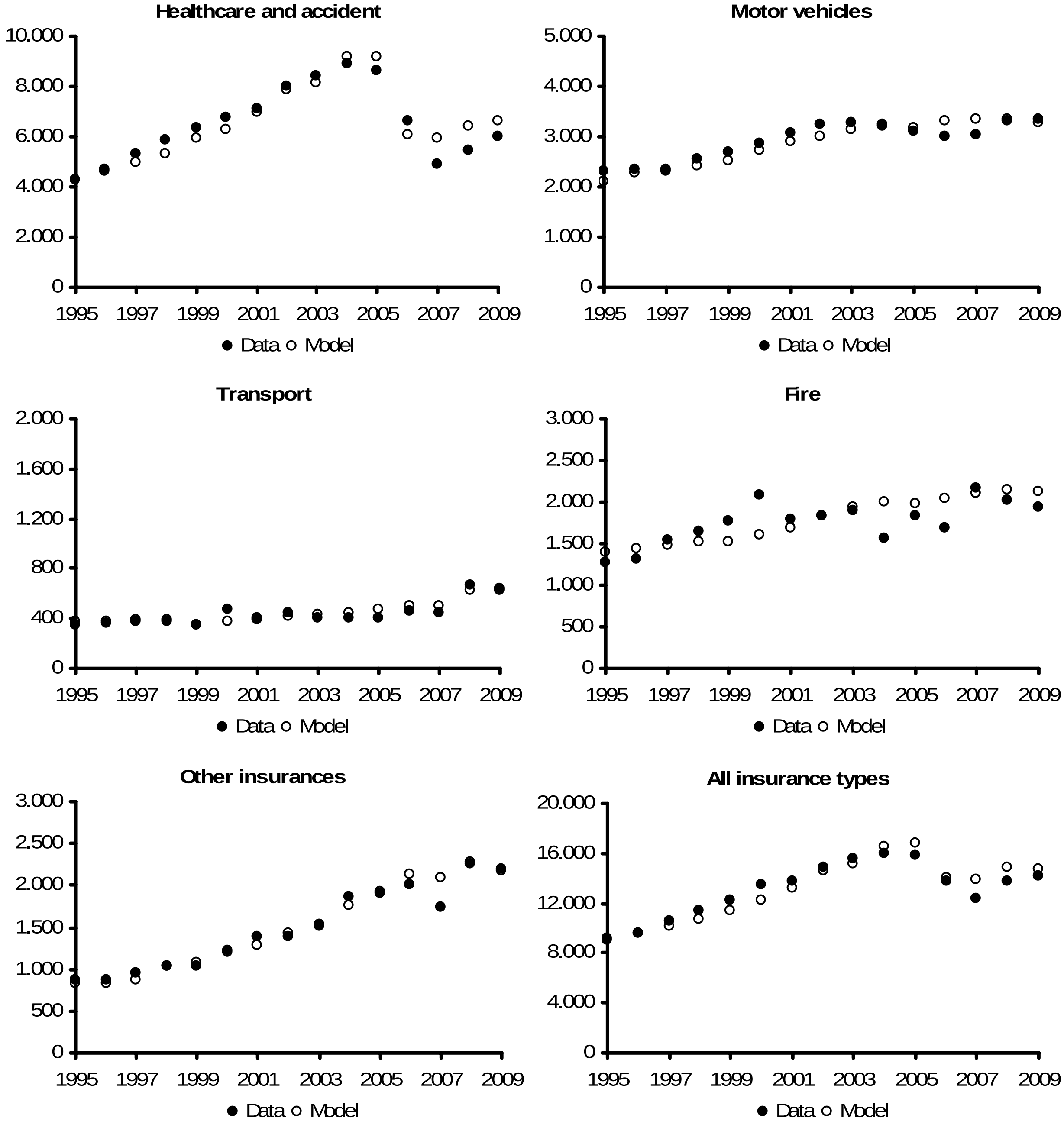
The models for expected investment income and expected loss, and the parameter estimates obtained for these models in the previous section, allow us to calculate the nominal values of the product groups

[7] Application of the moving average model of Chen and Fixler (2003) instead of (4) gives the same result.

[8] These handling cost parameters stay equal to 1 when leaving out years from the time series and refitting models (3) and (4). This strengthens the result that investment income is fully used to cover risk.

[9] The distinction between base and supplementary insurances for health care, as referred to in footnote 3, is one of the main novelties of the reform. The distinction between public and private insurances, which existed before 2006, was different. Persons with an income exceeding a certain threshold could only take a private insurance. Insurance services for health care in the Dutch national accounts shifted from private to supplementary insurances in 2006. The boundary between government and insurance activity has shifted.

Figure 3. Model fits of expected loss to data for the five insurance types separately and aggregated. Loss is in millions of euros. (Data are from DNB)



and index numbers for nominal value and production volume. Before presenting the expressions for value and volume indices and the results, we first summarise the data needed to calculate both.

Data for production volume

As was stated in Section 3, policy numbers are suggested as counting measures of production volume. These are grouped according to line of insurance. We have N = 5 of these 'product groups', with numbers of policies $q_{i,k,t}$ in product group i in quarter k of year t. These data are made available by the Verbond van Verzekeraars, the Dutch Association of Insurers. Policy numbers are available from year 2006 per line of insurance.

Data for nominal value, or turnover

The five product groups are characterised by expected loss and the handling cost parameters μ_i^P and μ_i^S. These characteristics are estimated and then used to calculate nominal value. The following data are required for this purpose:

- Premiums earned;
- Loss incurred;
- Investment income;
- Possibly also one or more indicators of investment income, such as rent, but this depends on the type of model used for expected investment income. (For instance, no additional data are required when a moving average model is used.)

Premium and loss data should be available for every product group and per year. If data are available on a finer time scale, for instance, per quarter, then the data at this level are preferred. Investment income data should be available per year and preferably also per line of insurance.

In the next subsection, we use the notation $P_{i,k,t}$ for total premiums in product group i in quarter k of year t, and $P_{i,t}$ for total premiums in product group i summed over the quarters of year t.

Value and volume indices

The results of Section 4 imply that nominal value only depends on premium and its handling cost. Nominal value for product group i in year t is equal to $(1 - \mu_i^P)P_{i,t}$. This leads to the following value index for non-life insurance services, over N = 5 product groups, in year t with respect to year t – 1:

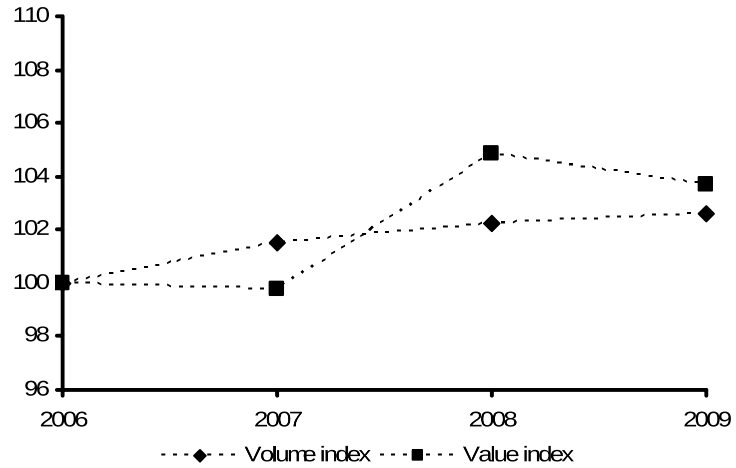
$$(6) \qquad \frac{\sum_{i=1}^{N}(1-\mu_i^P)P_{i,t}}{\sum_{i=1}^{N}(1-\mu_i^P)P_{i,t-1}}.$$

Laspeyres volume indices are used by convention at Statistics Netherlands. The volume index for year t with respect to year t – 1 is calculated as follows:

$$(7) \qquad \sum_{k=1}^{4}\sum_{i=1}^{N}\frac{(1-\mu_i^P)P_{i,k,t-1}}{\sum_{m=1}^{4}\sum_{j=1}^{N}(1-\mu_j^P)P_{j,m,t-1}}\frac{q_{i,k,t}}{q_{i,k,t-1}}.$$

Year-on-year volume indices have been derived on a quarterly and yearly basis. Figure 4 shows the value and volume indices on a yearly basis. Nominal value increased with 1.21 percent per year on

Figure 4. Volume and value index for non-life insurance services. Index numbers are multiplied by 100, by convention (2006 = 100).



average during 2006-2009. Production volume for non-life insurance services increased with 0.86 percent per year on average, so the average yearly price increase is 0.35 percent. The change in overall volume is contained, but this does not necessarily hold for the individual product groups. For instance, volume for motor vehicles increased with 2.1 percent in 2008 compared to 2007, while volume for healthcare and accident decreased with 1.9 percent in 2008. Overall volume increased with 0.7 percent in 2008.

6. Discussion

The value and volume indices presented in the previous section were obtained by making choices on different aspects of value and volume measurement: 1) product characterisation, 2) counting measures of production volume, and 3) models for expected loss and investment income used to derive nominal value. In this section, we compare the choices made with other choices and models. For instance, Chen and Fixler (2003) used other models for expected loss and investment income, so we could investigate how their models fit the data. We return to one of the main questions addressed in the literature, on whether the volume of insurance services should be measured according to the 'net' or 'gross' premium approach. We also try to shed some light on the question whether more refined product groups result in substantially different value and volume indices, although we need to make additional assumptions because of incomplete data.

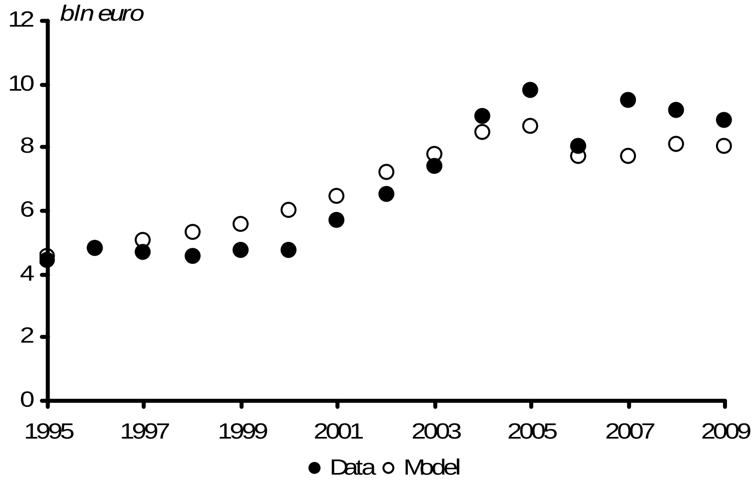
Different choices for nominal value

We consider three different choices: (1) nominal value calculated with the previous method at Statistics Netherlands, which fits the SNA 1993, (2) nominal value according to the 'gross' premium approach, and (3) nominal value estimated by using the models of Chen and Fixler (2003).

(1) Nominal value based on data

The previous method for price and volume measurement of non-life insurance services used at Statistics Netherlands calculates nominal value by adding the actually realised investment income to premiums earned and subtracting actual loss incurred. That is, data were used to compute nominal value instead of model estimates for expected investment income and expected loss. In Figure 5, nominal value as calculated in Section 5 is compared with nominal value according to the data. The 'data version' of nominal value is much more volatile than according to the model. Although the data version of nominal value has positive values for every year shown in Figure 5, it cannot be used for calculating value and volume indices. Apart from the fact that premiums are related to expected loss and not to actual loss, nominal value also becomes negative in six years for four product groups.

Figure 5. Nominal value of non-life insurance services according to the model and the data.
(Data are from DNB)



(2) Gross premium approach

We now compare the results of Figure 4 with the 'gross' premium approach. 'Gross' premium refers to the fact that expected loss is not subtracted from premiums in the calculation of nominal value. In this approach, nominal value is basically equal to total premiums. The underlying choice regarding services delivered in this approach is that both the handling of risk and the asssumption of risk itself are considered as services that contribute to production volume. In the net premium approach, which is followed here and in the SNA, only the handling of risk matters.

The following analysis could provide somewhat more insight into the choice between the net and the gross premium approach. The value share of the volume index for product group i in year t is proportional to $(1-\mu_i^P)P_{i,t-1}$ for our approach and to premiums $P_{i,t-1}$ for the gross premium approach. As we characterised non-life insurance services according to expected loss and handling cost parameters, it is instructive to rewrite the value shares in terms of these two components. For simplicity, we leave out investment income in expression (1) for expected loss, which we write as $\mathrm{E}L_{i,t-1}$ for year $t-1$. The value share for our approach is proportional to

$$(8) \qquad \frac{1-\mu_i^P}{\mu_i^P}\mathrm{E}L_{i,t-1}$$

and for gross premium to

$$(9) \qquad \frac{1}{\mu_i^P}\mathrm{E}L_{i,t-1}.$$

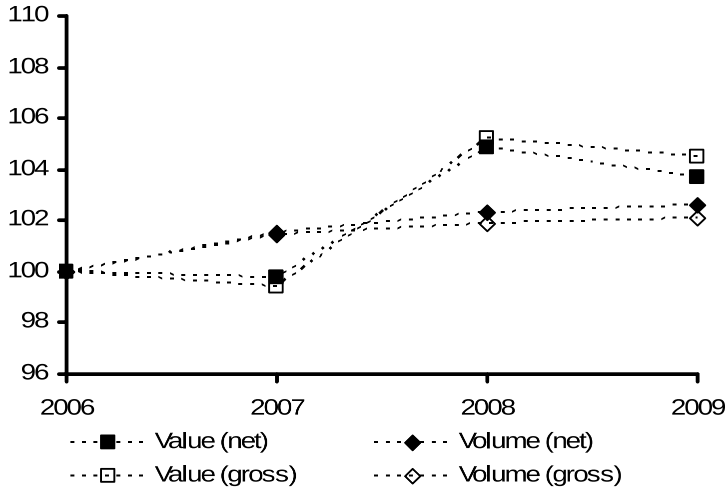
In both approaches, the value shares depend on both $\mathrm{E}L_{i,t-1}$ and μ_i^P. Expected loss and handling cost parameters affect volume change in the same direction for both approaches. For instance, a decreasing value of μ_i^P, or an increase of $\mathrm{E}L_{i,t-1}$, lead to a larger value share for product group i in year t, so that overall volume change will be influenced more by the volume change for product group i. Values of μ_i^P close to zero tend to produce the same behaviour of the volume indices for the net and gross approaches. This situation represents risks with large handling costs, where the service of risk assumption is negligible. These cases could be identified with complex risks, large variances in loss, which require more care in setting premiums.

The differences between the volume indices for the two approaches become larger when the μ_i^P tend to 1. In the case of net premium, nominal value and production volume tend to zero. However, in the case of gross premium, the volume indices for the product groups are weighted according to their shares in total expected loss over all product groups. The nominal value for product group i is equal to its expected loss. The focus thus shifts towards the assumption of risk. Handling costs tend to be small, so premiums will get close to risk premiums. Cases where μ_i^P tends to 1 could be identified with risks that are easy to handle, where loss apparently has a small variance.

The thoughts expressed on cases where μ_i^P takes values close to 1 raise the question whether risk assumption should be part of a volume measure for non-life insurance services. Premiums tend towards risk premiums (expected loss). What merely happens is that risk is shifted from one party to another, with nothing else taking place. Expression (8) for the net premium approach shows that value shares combine expected loss with an odds ratio regarding μ_i^P. The odds ratio tends to zero when μ_i^P goes to 1, in which case product group i does not contribute to volume. The ratio expresses a 'need odds' for an insurance policy, which is small for large values of μ_i^P. Risks are easy to handle and loss has a small variance, so that the need for an insurance to cover risks can be questioned. These thoughts tend us to move towards a preference for the net premium approach.

Figure 6 shows the results for our method, as in Figure 4, and for the gross premium approach. As can be noted, the gross premium approach gives a smaller volume growth and a larger average increase of nominal value. The average annual volume growth is 0.69 percent (versus 0.86 for the net premium approach), while nominal value increases with 1.47 percent on average (versus 1.21 percent for our approach). The larger overall volume growth for the net premium approach indicates that the highest volume growth figures occur for the product groups with the larger handling costs.

Figure 6. Value and volume indices for our (net premium) approach and the gross premium approach (2006 = 100).



(3) Results for the Chen and Fixler (2003) approach

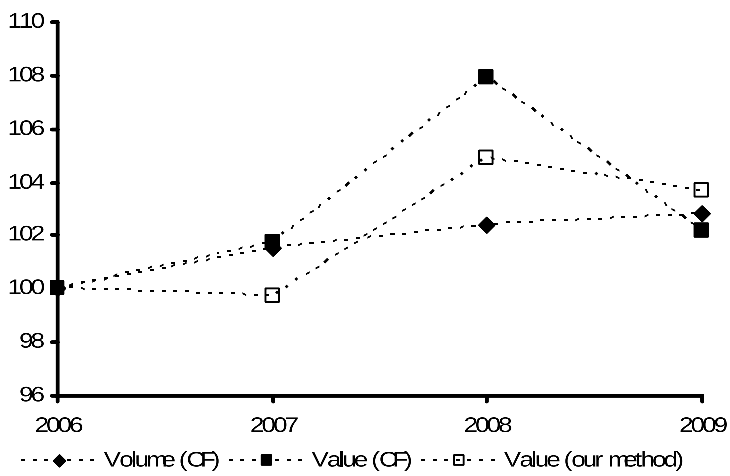
We also studied the impact on the value and volume indices by replacing the models for expected loss and expected investment income by the models proposed in Chen and Fixler (2003). These models specify expected loss to premiums ratio and expected investment income to premiums ratio in year t as weighted sums of the actual and expected ratios in year $t - 1$. Only the results are shown in this paper; the model expressions can be found in Chen and Fixler (2003).

Chen and Fixler's models give a lower BIC than our models, so that the data are fitted less well with Chen and Fixler's models. The fits for investment income are the same, so the difference in fits is completely explained by the fits of expected loss model (3) and Chen and Fixler's model.

A major difference between our expected loss model (3) and Chen and Fixler's model is that the latter model estimates expected loss from information of past years. Policies that are acquired in the present year may have different risk profiles, which would not be captured by moving averages. Our model considers the relation between expected loss, premiums and expected investment income for the same years, so it is updated. This could be a possible explanation for the better fits with our model (3). On the other hand, we should be cautious with such statements as we compared models for one data set. It would be interesting to consider other data sets in the future.

Information criteria, such as the BIC, enable us to make a selection among competing models. The importance of having such selection criteria is illustrated by the differences in the results between our model and Chen and Fixler's model. The latter gives a larger variability in the yearly nominal value indices than our model, as can be noted in Figure 7. Nominal value increases in 2008 with 6.0

Figure 7. Volume and value index for the 'Chen-Fixler approach' (CF) and the value index for our method (2006 = 100).



percent and decreases with 5.3 percent in 2009. The respective value changes of +5.1 and –1.1 percent for our model are much more contained. The volume indices show small differences, as can be seen in Figure 4 and Figure 7. Annual volume growth is 0.06 percentage points larger on average for the 'Chen-Fixler approach' during 2006-2009. But the differences in the price indices are much larger.

Results for refined product groups

We also calculated value and volume indices by refining the product groups to 12 groups. We have policy numbers and information on premiums for subtypes of insurances within some of the five lines of insurance. Unfortunately, we do not have loss data at a more detailed level than the five lines of insurance, so we had to make assumptions for the subtypes of insurances in order to calculate expected loss and nominal values. The 12 subtypes of insurance are composed as follows:

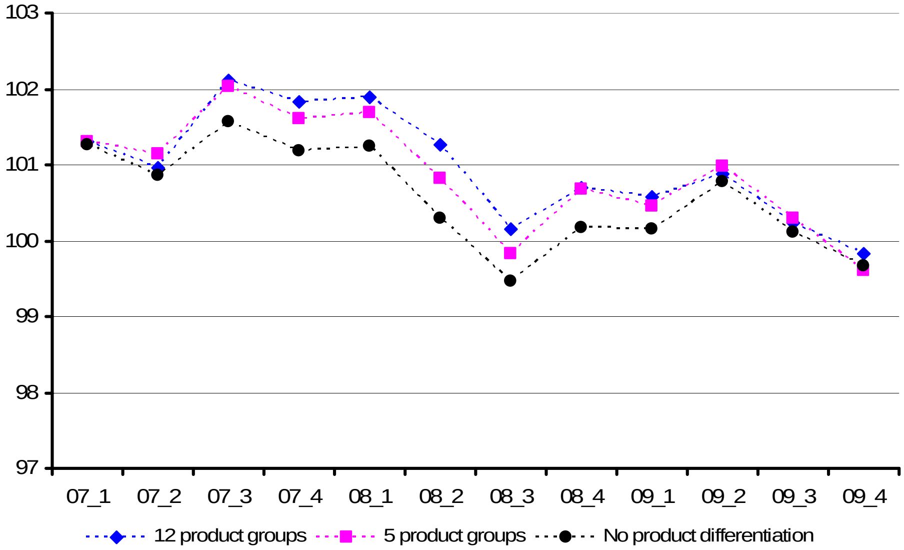
- Health and accident insurances is not refined, as there are not enough data to do this. So this line of insurance remains one product group;
- The group of motor vehicles is subdivided into insurances for private cars, company cars and a remaining category, which includes motorbikes and caravans;
- The group of fire insurances is subdivided into insurances for private houses, companies and a smaller, residual group consisting of insurances for technical aspects, such as machine failure;
- The group of "other insurances" is subdivided into insurances for liability, legal aid, travelling and a remaining category, which includes financial loss;
- The group of transport insurances is not refined because of incomplete data, but this group has a small value share.

In order to calculate expected loss for the subtypes of insurances within the groups of motor vehicles, fire and "other insurances", we assumed that μ_i^P and μ_i^S have the same values for the subtypes within each group. The parameter values are equal to the values given in Section 4.

Of course, the value indices are the same as in Figure 4 for the five main product groups. But the volume indices undergo slight changes: average annual volume growth increases with 0.97 percent under the refinement to 12 product groups, compared to the 0.86 percent under the coarser subdivision into 5 product groups. The additional volume growth of 0.11 percent is an overall effect, in which the larger volume growth occurs for subtypes of insurances with larger expected loss.

In Figure 8, year-on-year volume changes per quarter are compared for three situations: for the cases with 5 and 12 product groups, and in the case where no subdivision into different product groups is made. The latter case implies that volume indices are calculated by simply dividing the total number

Figure 8. Year-on-year volume indices per quarter, calculated for three situations: 12 product groups, 5 product groups, and without distinguishing different product types (year t – 1 = 100).



of policies over all product groups in year t by the total number of policies in year $t - 1$. Insurance services for policies with different expected loss and handling cost parameters, that is, with different pairs (r, μ) following the notation in Section 3, are considered to be equal. The average annual volume growth in that case is 0.56 percent, which thus produces larger deviations from the growth figures for the five product groups.

The volume indices based on 12 product groups were calculated by assuming equal handling cost parameters for the subtypes of insurances within each of the five main product groups. We could not estimate these parameters for the subtypes of insurances because we do not have data on incurred loss for the subtypes. We could therefore miss additional volume growth because we do not have proper estimates for the handling cost parameters. We performed sensitivity analyses in order to find out the effects of variations in handling cost parameters for the subtypes of insurances on value and volume growth. Variations until ±10 percent around the handling cost parameters turned out to have very small effects on the value and volume changes (up to 0.03 percentage points for the variations considered).

Although the refinement to 12 product groups has an additional average yearly effect of about one tenth of a percentage point to volume growth, it is worth carrying out volume and value index calculations at the most detailed level as possible when data are available. The above results show that the value and volume indices for five product groups are already close to the results for 12 product groups. The product heterogeneity captured by the five product groups is already substantial, as is indicated by the differences between the volume indices for five product groups and for the case where no product differentiation is made at all (Figure 8).

7. Summary

A new method for price and volume measurement of non-life insurance services was presented, which is built upon choices for: (1) service or ‘product’ characterisation, (2) counting units of production volume for each type of product, and (3) nominal value of production. With regard to nominal value and volume measurement we took the SNA 2008 as a point of reference, as the method was developed for use in the Dutch national accounts. It is being used since 2010 for calculating value and volume indices for both quarterly and yearly figures.

The method belongs to the category of ‘net premium approaches’, which means that volume measures merely consist of handling risks, and the administrative tasks concerning insurances, thus excluding the assumption of risk itself. A comparison of the net and gross premium approaches in Section 6 suggested a preference towards the net premium approach. But even when this choice is made, the functional form for nominal value is still to be decided. Different ways of calculating nominal value under the net premium approach were computed and discussed in Section 6.

We compared our model for nominal value, which arises from expressions (3) and (4), with nominal value calculated according to the data and with the moving average models for expected investment income and loss to premium ratios of Chen and Fixler (2003). The data-version of nominal value should not be applied for two main reasons: it may give negative values and premiums are linked to expected loss, not to actual loss. The Chen-Fixler models give good fits and the model results are perhaps easier to interpret than our models, but for the time being we prefer model (3)-(4) of this paper.

Model expression (3) is not merely a model for expected loss, it can also be read as a simplified mechanism for setting premiums, which are related to expected loss and expected investment income. Since setting premiums is an essential insurance activity, we should aim at obtaining a tight relation between premiums, expected loss and investment income. We therefore emphasised the importance of optimising the fits of expressions (3) and (4) with loss and investment income data. Expected loss and expected investment income to premiums ratios are fitted separately to the data with the Chen-Fixler approach, in a way that their interplay with premiums is not fully captured.

The parameterisation of model (3) for expected loss also expresses that premiums and expected investment income can be utilised in different ways for risk handling and administration and for risk coverage, depending on the values of the handling cost parameters. It is important to carefully estimate the handling cost parameters in order to separate the risk coverage, or assumption, part of insurance services from the handling of risks. The parameterisation therefore also gives insight into the allocation of financial sources to both types of activities. It turned out that expected investment income is fully assigned to risk coverage, so that nominal value is completely determined by premiums earned and their handling cost parameter.

The results in Section 6 also showed that much of the heterogeneity in insurance services is already captured by distinguishing five product groups. A more refined product differentiation with 12 product groups resulted in an additional volume growth of about 0.1 percentage point per year on average. Despite the lack of loss data for the more detailed types of insurance, the results for the 12 product groups were found to be robust. The 12 product groups are characterised by different expected loss per policy and/or different handling cost parameters, so they should be distinguished as different product groups according to our volume framework of Section 3. The results for the most detailed level of product characterisation should therefore be used.

Finally, it would be valuable to reproduce the analyses in this paper to other data and other countries as well and compare the findings with those reported here.

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Figure captions

Figure 1. Chained value, price and volume indices for two types of non-life insurances and for the number of claims incurred (1999 = 100).

Figure 2. Fits of expected direct investment income to premiums ratio (4) to data. Fits are shown for the expectation conditioned upon the value of the preceding year and for an unconditional expectation. (Data are from DNB)

Figure 3. Model fits of expected loss to data for the five insurance types separately and aggregated. Loss is in millions of euros. (Data are from DNB)

Figure 4. Volume and value index for non-life insurance services. Index numbers are multiplied by 100, by convention (2006 = 100).

Figure 5. Nominal value of non-life insurance services according to the model and the data. (Data are from DNB)

Figure 6. Value and volume indices for our (net premium) approach and the gross premium approach (2006 = 100).

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Figure 8. Year-on-year volume indices per quarter, calculated for three situations: 12 product groups, 5 product groups, and without distinguishing different product types (year $t - 1 = 100$).