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A new method for price and volume measurement of non-life insurance services for the Dutch national accounts

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A new method for price and volume measurement of non-life insurance services for the Dutch national accounts

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Abstract. This paper presents a new method for calculating price and volume change for non-life insurance services in the Dutch national accounts. The previously used direct service method leads to inconsistent behaviour of nominal value and production volume, which is caused by the inclusion of actual claims in both components. In the new method, 'products' are characterised by type and size of insured risk. Counting units of production consist of bundles of insurance activities aimed at covering risk per time unit, instead of single activities. Policies are chosen to represent these counting units for five types of insurances. Nominal value is expressed in terms of expected loss (risk) and expected investment income, which are both linked to premiums. Volume increases at low yearly rates between 2006 and 2009 (0.52 percent on average), while nominal value shows a faster increase (up to 5 percent). Sensitivity analyses suggest limited effects of missing data on volume indices, which are hardly affected as well by different model choices for nominal value. CPI-deflated value indices indicate that some volume change could be missing due to possible shifts in risk within product groups. As the results of the previous method were volatile, one of the main conclusions is that the choice of production concept has greater effects on the results than other methodological choices. An extension of the ideas to life insurances and pensions is currently being studied.

1. Introduction

It is widely recognised that the insurance industry is one of the most difficult parts of the national accounts to deal with. This is reflected by the literature on the measurement of prices and quantities for insurance services. There are different views on what the insurance industry actually produces, while there is a range of different definitions regarding the nominal value of production (Schwartz and Fox, 2008; Sherwood, 1999; SNA, 1993; SNA, 2008).

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). An example of an 'activity-based' approach is the so-called "direct service method", which considers the acquisition of new policies, administration of policies and the handling of claims as separate 'products' (Eurostat, 2001, pp. 95-96).

The second concept of production 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 an amount of risk coverage, not for the performance of certain activities.

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Different definitions of nominal value have been proposed, which correspond to 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 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 Hornstein and Prescott's (1991) interpretation, claims are considered as intermediate purchases ("replacement capital goods") and premiums cover both risks and costs of activities (and profits).

Premiums and claims/benefits are not the only components of nominal value. Insurance companies earn income from the investment of (premium) 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 (Fixler, 2002; Lal, 2003; SNA, 1993; 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. 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 for expected claims.

Until recently, the direct service method was used at Statistics Netherlands for deriving price and volume indices for life and non-life insurance services. In Section 2, the method is illustrated for several types of non-life insurances. An evaluation of the method motivated the development of a new method for price and volume measurement. One of the reasons is that the direct service method leads to inconsistencies between nominal value and production volume, which are caused by the use of handled claims as one of the volume indicators.

In Section 3, the new method for non-life insurance services is presented. In Section 3.1, the 'products' of the insurance sector are characterised and counting measures of production volume are defined. The activity-based approach is followed, but here individual insurance activities are bundled into 'packages' to form counting units of production. This approach is in line with recent efforts at Statistics Netherlands on other service sectors, such as health care and education.

In Section 3.2, a model for nominal value is described. Nominal value consists of a model for expected investment income and of models for risk, or expected claims or loss, for five types of property-casualty insurances. The models link expected investment income and risk to premium. The results of model fits to data are shown. In Section 3.3, value and volume indices are derived.

The results are analysed in Section 4. Sensitivity analyses are carried out in order to quantify the effect of variations around base values for missing data on the value and volume indices. The results are also compared with other methods for price and volume measurement, amongst others with a deflation method. The main findings will be formulated in Section 5. Particular attention will be given to possible adjustments to Dutch GDP when the proposed method will be used instead of the direct service method.

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) $V = w_A V_A + w_N V_N + w_C V_C.$

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 quantity 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 per vehicle, which is deflated by the CPI. More precisely, the volume index is calculated as follows:

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

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. Changes in the product mix are assigned a weight of 0.2.

The volume indices for administration and claim handling are calculated in the same way. The volume index V_C for claim handling consists of a quantity index for the number of claims incurred and a deflated value index for the average damage per claim. The latter index is given a weight of 0.2, as in (2), and also here the CPI is used for deflation.

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 our 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. The behaviour indicated does not arise for all years, since nominal value also depends on yearly changes in premium supplements, which can be volatile.

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. Risk is an *ex ante* notion, while actual claims are measured *ex post*. 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.

In the next section, a different methodology for calculating nominal value is proposed, which links premiums to risk. The method also uses a different concept of insurance service.

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[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).

Motor vehicles

Property/fire
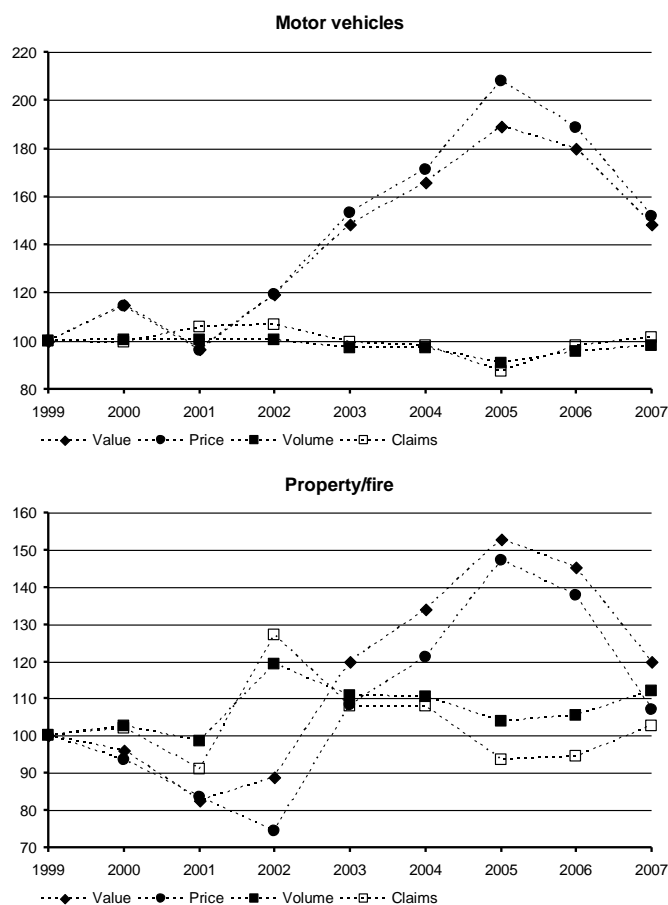
3. New method for price and volume measurement

3.1 Service types and quantity measures

In recent years, advances have 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 measure quantities directly, while volume indices were previously obtained by deflating value indices with some price index. The approaches toward 'direct volume measurement' were motivated by recommendations in the Eurostat handbook of 2001.

The direct measurement approach forces one to think about counting units for production. For instance, these efforts have led to the notion of "complete treatment" as counting unit, which refers to the entire pathway that an individual takes through different health care institutes (Berndt et al., 2001; Aizcorbe et al., 2008; OECD (2008, p.72)). A relaxed version of this notion is used at Statistics Netherlands. A "health care package" has been proposed as counting unit, which bundles a set of health care activities, such as laboratory experiments, surgery and nursing in hospital care (Chessa, 2009).

Different choices regarding counting units may lead to significantly different results for volume indices. Chessa (2009) discusses the differences between counting units based on health care packages and on single health care activities. As an example, he mentions the implications of substitution of clinical treatments by day treatments in hospital care. Substitution implies less hospitalisation days and fewer activities, but does this also mean less hospital care delivered? Quantifying volume for single activities would lead to an affirmative answer. But using packages of activities as counting units would lead to the same volume, for a given diagnosis treated, and ignoring differences in 'quality' of care between clinical and day treatments. The importance of this example can be illustrated by the

following figures: hospitalisation days decreased with 0.4 percent per year on average between 2000 and 2007, while the volume of inpatient hospital care, measured by patient discharges, increased with 5.4 percent per year in the same period in the Netherlands.

The choice between single activities and packages of activities as counting units not only has implications for volume, but also for derived measures such as productivity. These considerations have inspired us to extend the recently developed ideas about volume measurement to insurance services as well. The following choices regarding counting units have been made:

- Packages, or bundles of insurance activities, such as collection of premiums, administration and investment of reserves, are used as counting units of production;
- The number of policies in portfolio, which comprise both existing and new policies, forms the actual counting measure of production volume. A policy is thus chosen to represent a package of insurance activities.

Policies should not be simply aggregated over different portfolios. Counting units should be linked in some way to product or service types. A characterisation of product types is therefore needed. For instance, it is suggested to characterise and differentiate hospital care by health state, such that a diagnosis serves as an indicator for a patient's initial health state (Chessa, 2009). Health care packages are then counted for different diagnoses. Similarly, we could speak about the 'state' of an insurance policy and identify risk insured as a main component of this state. Ideally, we would then count policies by risk covered during a certain period, for instance, per quarter.

However, detailed information about risk at policy level is not available. A less detailed subdivision of policies into different groups of risk was therefore made. A total of 10 risk or product groups are created, which are characterised as follows:

- The available data contain five types of insurance: health and accident,[3] motor vehicles, fire, transport, and a group termed "other insurances", which contain insurances for legal aid and liability;
- For each of the five types of insurance, a distinction is made between reinsured and non-reinsured risks.

Reinsured risks often cover larger risks, although this depends on the type of reinsurance contracted between insurers. We consider reinsured and non-reinsured risks as two different size groups of risk.

The choice of characterising non-life insurance services in terms of type of insurance and size of risk has a twofold implication. First, shifts of policies to higher risk classes, within insurance types, lead to higher production volume. An interpretation of this effect could be that higher risk policies require greater care by insurers in establishing adequate coverage, and could therefore be considered as 'heavier' types of service. Second, shifts of policy numbers among different types of insurance may also lead to changes in production volume. Two policies belonging to different insurance types may give different contributions to production volume, even if the sizes of risk covered are equal. In this case we could argue that certain types of insurance may be more sensitive to large claims than other types, and thus require greater care in establishing appropriate coverage.

Numbers of policies for the 10 product groups are combined to volume indices in Section 3.3. Nominal values for each product group are needed for these calculations. A model for nominal value is set up and estimated in the next section.

3.2 A model for nominal value of production

As was stated previously, risk instead of actual claims is used in this paper in order to derive nominal value. Insurers set premiums according to expected loss, to which they may add their expectation

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[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.

about investment income. Premiums are available to us from data, while risk and expected investment income are unknown and have to be reconstructed in some way. For this purpose, we develop models for expected loss and expected investment income, which are described below. Next, the method for estimating the model parameters will be described.

Expected loss

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. Let ES_t denote the expected investment income to premium ratio in year t, which is a notion that was already used by Chen and Fixler (2003). For product group i, premiums plus expected investment income in year t can be expressed as $P_{i,t}(1 + ES_t)$.

In our model, we take the sum of premiums and premium supplements to cover risk. Expected loss equals a fraction of this sum, as insurers retain a margin for covering different costs. Risk for product group i in year t can thus be expressed as

$$(3) \quad \mu_i P_{i,t}(1 + ES_t),$$

where $0 < \mu_i < 1$ is a parameter that will be estimated from data. The parameter μ_i is the risk that insurers are willing to cover, on average, for product group i per monetary unit of premiums plus supplements.

We make the following assumptions about model (3):

- The μ_i are allowed to take different values for the 10 product groups. But for each product group we assume that μ_i has the same value in time;
- We assume that ES_t has the same value for the 10 product groups, for every year t.

The first assumption, regarding constant values in time for every μ_i, is made in order to limit the total number of parameters to be estimated. A new methodology for price and volume measurement of insurance services is presented here, so we intend to develop a kind of benchmark model for nominal value as a first step. When parameter estimation and model fitting are carried out, it can be decided to develop and compare refined models at a later stage. Data about investment income are not specified by product group; only total amounts are available for every year during the period 1995-2009. This has motivated the second assumption. The values of ES_t may vary from year to year.

Expected investment income

Chen and Fixler (2003) used a weighted moving average model for the expected investment income to premiums ratio. We will consider their model in Section 4.2, where the results of our approach will be compared with alternative approaches. We suggest a more 'behavioural' model to expected investment income. The idea is to 'reconstruct' the expected ratio from a relationship that expresses the strength of interaction between premiums and investment income. Premiums could be set at higher levels than originally planned by insurers when the expectation about investment income to premiums ratio is lower in the next year.

As a point of departure, we take expression (3) in order to set up a relation between premiums and expected investment income to premiums ratio ES_t. Consider the expected loss ratio for successive years $t-1$ and t based on (3), which we rewrite as follows for product group i:

$$(4) \quad \frac{\mu_i P_{i,t}(1 + ES_t)}{\mu_i P_{i,t-1}(1 + ES_{t-1})} = \alpha_{i,t}\left(\frac{P_{i,t}}{P_{i,t-1}}\right)^{1-\beta}.$$

The parameter $\alpha_{i,t}$ may contain different types of information, such as the numbers of policies in years $t-1$ and t, in order to eliminate their influence on ES_{t-1} and ES_t.[4] The parameter β is real-valued and is

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[4] We originally preferred to use an expression for expected investment income to premiums ratio, with average premiums per policy instead of total premiums. Unfortunately, this was not possible, as policy numbers are available only since 2006.

taken to be independent of i and t. This parameter controls the strength of the relationship between expected investment income to premiums ratio and premium, as will be illustrated below. The idea behind (4) is that risk may increase at a higher or lower rate than premiums, depending on the yearly changes in ES_t.

A compact expression for ES_t, containing total premiums for all product groups, can be obtained by taking geometric averages of the left-hand and right-hand side of (4). We then obtain:

$$(5) \qquad \frac{1 + ES_t}{1 + ES_{t-1}} = \alpha \left(\prod_{i=1}^{N} \frac{P_{i,t}}{P_{i,t-1}} \right)^{-\beta/N},$$

where $\alpha > 0$ and $N = 10$ is the number of product groups. The parameter α is a simplification of the geometric average of the $\alpha_{i,t}$ in (4), in the sense that α is taken to be independent of t. The relation between yearly changes in ES_t and the geometric average of premiums can be shown for different values of β. Let α be equal to 1. If $\beta > 0$, then a decrease of ES_t leads to an increase of average premiums, which will increase at a higher rate as β tends to zero. If $\beta < 0$, then a decrease of ES_t also leads to a decrease of average premiums.

Expression (5) can be simply rewritten into the following recurrence relation:

$$(6) \qquad ES_t = \alpha \left(\prod_{i=1}^{N} \frac{P_{i,t}}{P_{i,t-1}} \right)^{-\beta/N} (1 + ES_{t-1}) - 1,$$

in which we use $s_0 := ES_{1995}$ to denote the expected investment income to premiums ratio for 1995, which is the first year of the sequence in our data. The initial expectation s_0 is an additional parameter, beside α and β, that will be estimated from the data.

Data and model fitting

We now describe the procedure that was used for estimating the parameters of expressions (3) and (6). The following data were used, which are available from De Nederlandsche Bank (DNB), the Dutch central bank:

- Claims incurred for each of the 10 product groups, for every year in the period 1995-2008;
- Premiums earned for each of the 10 product groups, for every year in the period 1995-2008;
- Investment income for every year in the period 1995-2009. This is an aggregate value over the five types of insurances and is not restricted to direct premium supplements, such as interest and rent. It may therefore also contain holding gains and losses. An aggregate value for premiums earned is also available for 2009, so that an investment income to premiums ratio can also be calculated for 2009.

Expressions (3) and (6) contain a total of 13 parameters: μ_i for each of the 10 product groups, and the parameters α, β and s_0 in the model for expected investment income to premiums ratio. The parameters were estimated by maximising a likelihood function under the following assumptions:

- Investment income to premiums ratios are normally distributed with means given by (6). The error terms are assumed to be identically and independently distributed for different years t;
- The ratios of claims incurred to premiums earned are assumed to be normally distributed with mean $\mu_i(1 + ES_t)$ for product group i and year t. The error terms are assumed to be identically and independently distributed for different product groups and years, and are also assumed to be independent of the error terms for the investment income to premiums ratios. The variances for the two types of error terms are allowed to be different.

At the end of Section 4.2, we consider an alternative to the second set of assumptions. More precisely, independence of losses between reinsured and non-reinsured risks for the same year is dropped.

For every product group, we use only one parameter to model expected loss over time and three parameters for expected investment income. The total number of parameters used is thus rather small. Nevertheless, it is still interesting to ask whether it is necessary to treat each of the 13 parameters as a free parameter. For instance, could we obtain 'better' model fits by setting α equal to 1, or by setting the μ_i for reinsurance equal to the μ_i for non-reinsured risks? If so, then we could reduce the number of free parameters to seven in this example. 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. In this paper we use the Akaike Information Criterion (AIC), which is one of the classical information criteria in statistical literature (Claeskens and Hjort, 2008). We write the AIC as follows:

$$(7) \quad \text{AIC} = 2\ln(L) - 2k,$$

where L denotes a maximised likelihood function for a model with k parameters. AIC thus acts as a penalised likelihood function, which strikes a balance between a good fit (high log-likelihood value) and complexity (complex models are penalised more than simple ones). We intend to find a value of k for which AIC is maximised.

Under the above distributional assumptions, AIC can be written as:

$$(8) \quad \text{AIC} = -n_1\left(1 + \ln(2\pi \text{RSS}_1 / n_1)\right) - n_2\left(1 + \ln(2\pi \text{RSS}_2 / n_2)\right) - 2k,$$

where $n_1 = 14$ and $n_2 = 140$ denote the number of observations for investment income to premiums ratio and the claims incurred to premiums ratios for the 10 product groups, respectively. RSS_1 and RSS_2 are the corresponding residual sums of squares for the error terms. The year 2008 was left out of the model fit for investment income to premiums ratio because of the exceptional events that led to the financial crisis. This means that we used $n_1 = 14$ instead of $n_1 = 15$.

The best fits were obtained with $\alpha = 1$ fixed and by setting the μ_i for reinsured risks equal to the μ_i for non-reinsured, or unceded, risks for four insurance types, that is, for all types except for health and accident insurances. This means that the number of free parameters $k = 8$. The parameter values are shown in Table 1. The value of AIC for the corresponding model fit is 190.8.

Table 1. Parameter values for the models for expected loss and expected investment income to premiums ratio.

Risk parameter μ_i	Unceded	Reinsured
Health and accident	0,776	0,665
Motor vehicles	0,716	0,716
Transport	0,668	0,668
Fire	0,575	0,575
Other insurances	0,544	0,544

| Parameters investment income model	
α	1
β	0,035
s_0	0,078

The following observations can be made about the parameter values. The μ_i have different values across the five types of insurance. Insurers of healthcare/accident and motor vehicles seem to be willing to accept higher risks per unit of premium and supplements earned than for other types of insurance. This could be due to a higher probability of large claims for fire and liability, so that insurers charge relatively high premiums in order to provide coverage against loss. We emphasise that

this is only a possible explanation at this stage, which should be investigated and supported with evidence in the future. In any case, the parameter values show that risks are dealt with in a different way across insurance types.

The values of μ_i for reinsured risks only differ from the parameter values for unceded risks for health and accident insurances. The value of μ_i is lower for reinsured risks, which means that insurers charge higher premiums on average for those risks. The DNB-data show that reinsurance hardly occurs for supplementary health insurances, so the smaller value of μ_i can be attributed to reinsured risks for accidents. A possible explanation for a lower value of μ_i could be found in a higher probability of large claims for reinsured accidental risks than for unceded health and accident risks.

The small value of β in the expected investment income to premiums ratio implies that average premiums are rather sensitive to changes in expected investment income to premiums ratio. The ratio $(1 + \mathrm{ES}_t)/(1 + \mathrm{ES}_{t-1})$ on the right-hand side of expression (5) is close to 1 for all years t, so that yearly changes in premiums remain limited. The fit of the model for the expected investment income to premiums ratio to the data is shown in Figure 2.

Figure 2. Model fit for expected investment income to premiums ratio.
(Data are from DNB)
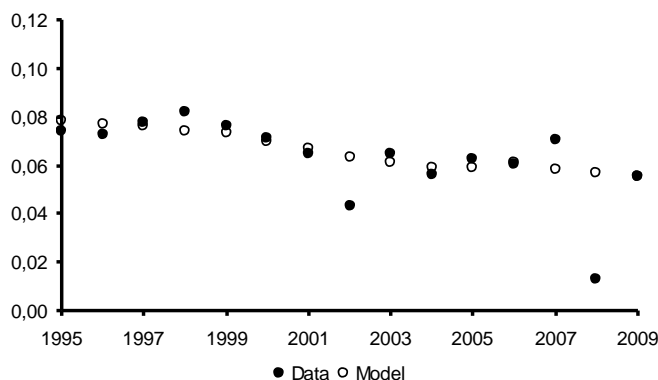
The fits of expected loss to claims data are shown in Figure 3. The fits are obtained with one risk parameter μ_i for unceded risks per product group, while a separate μ_i for reinsurance was needed only for health and accident insurances. This means that 6 free parameters were used for 10 fits. The fits are satisfactory, although one could argue whether μ_i for motor vehicles should be made time dependent. There is a discrepancy between the model and data for the period 2004-2007. On the other hand, the difference between model and data is much smaller for 2008. We decided to keep the models as they are specified now. We will consider possible refinements of the expected loss models when data for more years become available.

Finally, we note that 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.[5]

3.3 Value and volume index

The models specified in the previous section for expected loss and expected investment income to premiums ratio were used to derive value and volume indices for non-life insurance services. Nominal value for product group i in year t is equal to the following expression, when we follow the definition of SNA 2008:

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[5] 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 changed.

Figure 3. Model fits of expected loss to claims data for the five insurance types separately and aggregated. Results for unceded and reinsured risks are combined in each subfigure. Claims are in millions of euros. (Data are from DNB)
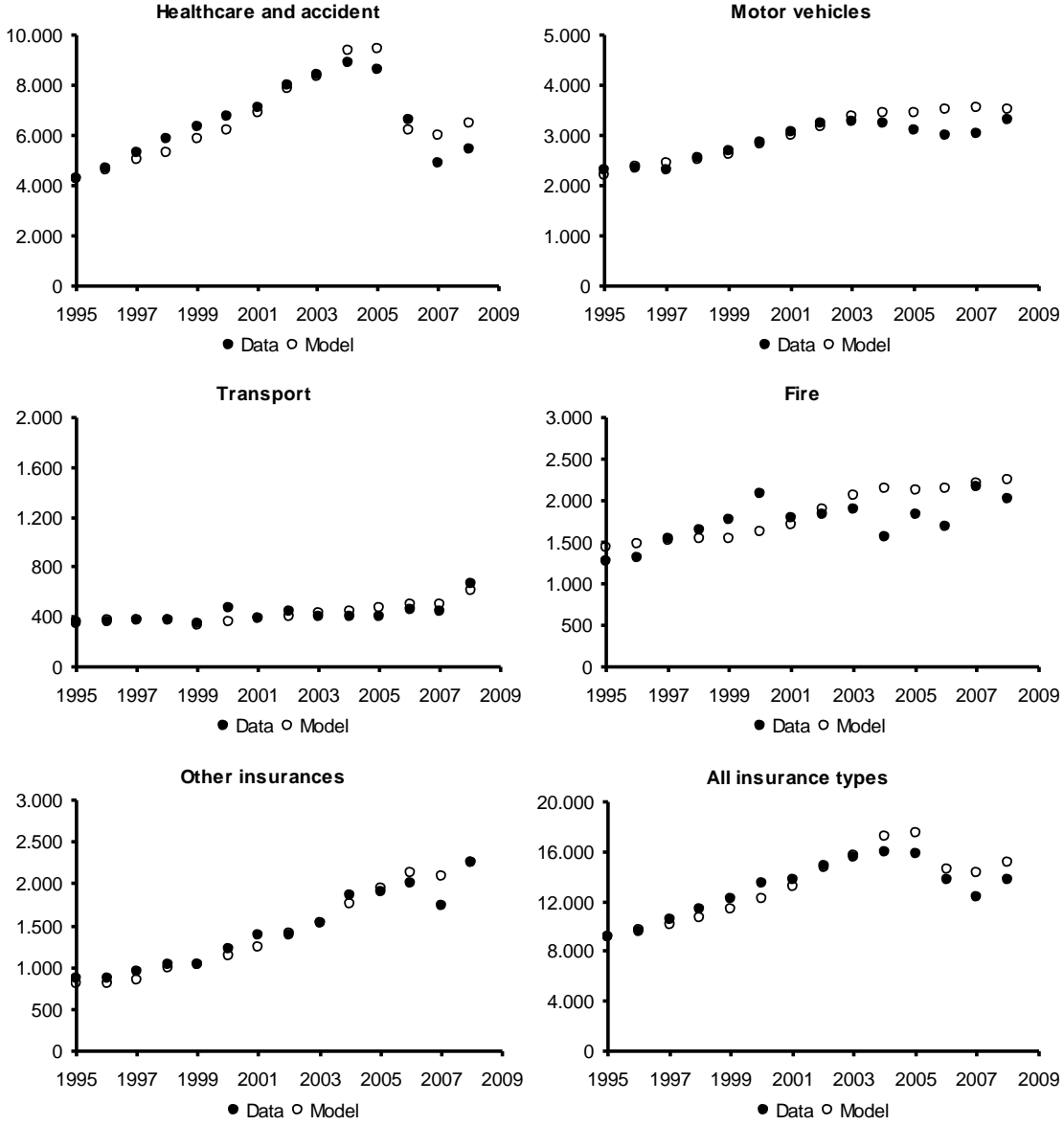
$$(9) \quad P_{i,t}(1 + \mathrm{E}S_t) - \mu_i P_{i,t}(1 + \mathrm{E}S_t) = (1 - \mu_i) P_{i,t}(1 + \mathrm{E}S_t).$$

This leads to the following value index for non-life insurance services, over all $N = 10$ product groups, in year t with respect to year $t - 1$:

$$(10) \quad \frac{(1 + \mathrm{E}S_t)\sum_{i=1}^{N}(1 - \mu_i)P_{i,t}}{(1 + \mathrm{E}S_{t-1})\sum_{i=1}^{N}(1 - \mu_i)P_{i,t-1}}.$$

Volume indices were computed by making use of quarterly data on numbers of policies, which are made available by the Verbond van Verzekeraars, the Dutch Association of Insurers. Quantities are available from the year 2006 per type of insurance, except for transport. Data on reinsurance contracts are not available either. We used a set of assumptions for the quantities that are missing, which will be formulated after giving the expression for the volume index. The base values regarding these assumptions will be varied in a sensitivity analysis in Section 4.1, in order to study the effects of variations on the volume indices.

Laspeyres volume indices are used by convention at Statistics Netherlands, which will be used in this study as well. We denote the number of policies for product group i in quarter k of year t by $q_{i,k,t}$ and total premiums by $P_{i,k,t}$. The nominal value given by (9) is used to derive value shares of the quantity indices for every product group i. The Laspeyres volume indices for year t with respect to year $t-1$ are calculated from the quantity indices per product group by quarter:

$$(11) \quad \sum_{k=1}^{4} \sum_{i=1}^{N} \frac{(1-\mu_i)P_{i,k,t-1}}{\sum_{l=1}^{4}\sum_{j=1}^{N}(1-\mu_j)P_{j,l,t-1}} \frac{q_{i,k,t}}{q_{i,k,t-1}}.$$

The expected investment income to premiums ratio drops out from the volume index, since ES_t was assumed to have the same value for every product group. Here we make the additional assumption that ES_t has the same value within every year t.

We make the following assumptions about the missing quantities:

- The number of policies for insurances regarding transport is taken to be some factor of the policies for motor vehicles. The factor is assumed to be constant over time;
- A similar assumption is made for reinsurance contracts. The number of contracts is a time-independent factor of the number of original policies for each of the five insurance types. The factors may differ across insurance types.

Transport insurances encompass, amongst others, loss or damage of ships, aircrafts and cargo, and liability. Quarterly data are available at Statistics Netherlands for the number of marine and road transports, but only until the last quarter of 2008, as the statistics have not yet been updated until 2009. The data could be used instead of policy numbers but show high volatility, so that extrapolations to the year 2009 prove to be difficult. The assumption listed first was therefore made. It leads to the same quantity indices as for motor vehicles, which will be varied in the sensitivity analysis of Section 4.1.

The second assumption implies that the quantity indices for reinsurance contracts are equal to the indices for the original contracts (unceded risks), which seems intuitively acceptable. Also this assumption will be varied in the sensitivity analysis.

Total premiums $P_{i,k,t}$ for product group i per quarter are calculated by distributing total premiums $P_{i,t}$ per year according to the share of the number of policies $q_{i,k,t}$ for quarter k in the sum of the policy numbers over the four quarters. We thus assume that the average premium per policy in a year is the same for every quarter within a product group.

The Laspeyres volume indices can now be calculated. Year-to-year volume indices have been derived on a quarterly and yearly basis. The value and volume indices are shown in figures 4 and 5. Nominal value increased with 2.8 percent per year on average during 2006-2009. Production volume for non-life insurance services increased with 0.52 percent per year on average. The largest part of the value increase therefore represents a price increase (2.3 percent per year on average).

The change in overall volume is small, but this does not apply to each individual product group. For instance, volume for motor vehicles increased with 3.5 percent in quarter 1 of 2007, with respect to the same quarter in 2006, while the volumes for healthcare/accident and fire decreased with 1.4 and 2 percent, respectively, in the same quarter. Overall volume increased with 0.8 percent in that period, which results after weighting the quantity indices of the product groups with the respective value shares. Volume indices also differ by quarter, as Figure 4 shows, which average out over an entire year. This has an additional smoothing effect on the volume changes calculated on a yearly basis.

The yearly increase in nominal value is almost equal to the yearly increase in total premiums (the average rates differ only by 0.02 percentage points for 2006-2009). This is clearly visible in Figure 6. Expected investment income has a small effect on the value index. As we stated earlier, the ratio $(1 + ES_t)/(1 + ES_{t-1})$ is close to 1 for all years, so that the value index for each of the 10 product groups is almost equal to the index for premiums. Average premium per policy is therefore the dominant factor in the price indices of the product groups. The results thus have a simple and economically plausible interpretation.

Figure 4. Year-to-year volume and value indices per quarter for non-life insurance services. Index numbers are multiplied by 100, by convention.
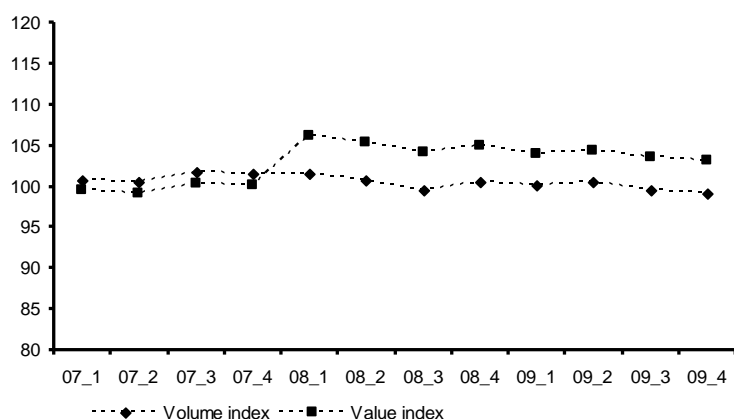

Volume index ···◆··· Value index ···■···

Figure 5. Volume and value indices for non-life insurance services (2006 = 100).
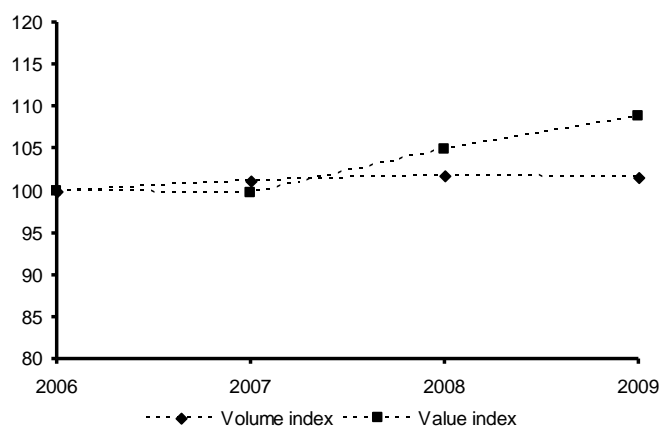

Volume index ···◆··· Value index ···■···

Figure 6. Nominal value of non-life insurance services according to model (9) and the data, compared with total premiums. Premiums are rescaled, such that their sum in 1995 is set equal to the model value of nominal value in that year.
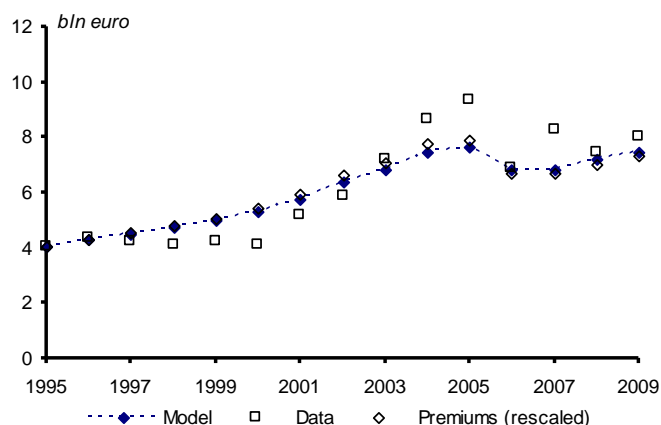

···◆··· Model   □ Data   ◇ Premiums (rescaled)

Figure 6 also compares nominal value as modelled according to expression (9) with nominal value calculated with actual investment income and claims data. Nominal value according to the data shows in fact the result when the old SNA-definition of nominal value would be used. It is much more volatile than the modelled nominal value. Although the data version of nominal value is positive for every year shown in Figure 6, it cannot be used for calculating value and volume indices. Nominal value is negative for two product groups when it is calculated according to the investment income and claims data.

4. Discussion

4.1 Sensitivity analysis

The assumptions on missing quantities formulated in the previous section are subjected to a sensitivity analysis in order to quantify the effects of deviations from these assumptions on the volume indices. In Section 4.2, we compare the results of Section 3.3 with other methods, so that we in fact extend the sensitivity analysis to different methodological choices. In one of the alternative methods, volume indices are obtained by deflating the value indices of the product groups with CPI's.

We introduce the following notation. Let $q_{tr,k,t}$ and $q_{mo,k,t}$ denote the number of policies in quarter k of year t for transport and motor vehicle insurances, respectively. Next, let $q_{r(i),k,t}$ denote the number of reinsurance contracts for insurance type i in quarter k of year t, where $r(i)$ is the product group that corresponds with insurance type i under reinsurance. We make the following assumptions in the sensitivity analysis:

- The base assumption for transport in Section 3.3 was $q_{tr,k,t} = uq_{mo,k,t}$, for any $u > 0$, for all k and t. We extend this assumption as follows: $q_{tr,k,2006} = uq_{mo,k,2006}$, for all quarters k, and for subsequent years we take $q_{tr,k,t} = (q_{mo,k,t}/q_{mo,k,t-1})(1 + v)q_{tr,k,t-1}$ for all k, where v is real-valued;
- The base assumption for reinsurance for the five types i of insurance was $q_{r(i),k,t} = c_i q_{i,k,t}$, for any $c_i > 0$, for all k and t. We extend this assumption in a similar way as for transport: $q_{r(i),k,2006} = c_i q_{i,k,2006}$, for all quarters k, and for subsequent years we take $q_{r(i),k,t} = (q_{i,k,t}/q_{i,k,t-1})(1 + d_i)q_{r(i),k,t-1}$ for all k, where the d_i are real-valued.

The factors u and c_i can be set at arbitrary values. These are time-independent scaling factors, which do not affect the volume indices. The factors v and d_i are also taken to be time-independent, but the d_i can be set at different values for different product groups. These factors allow us to deviate from the quantity indices for motor vehicles and for non-reinsured risks.

The influence of variations in v on the volume indices is small. The value of v under the base assumptions is zero. Setting $v = 0.01$ means that the quantity indices for transport are one percent larger than for motor vehicles. Under this value for v, volume for non-life insurance services increases with 0.56 percent instead of 0.52 percent on average per year.

It seems reasonable to assume that the quantity indices for reinsurance contracts will not differ substantially from the indices for the original contracts (unceded risks). If we allow the quantity indices for reinsurance contracts to be 0.5 percent larger than for non-reinsured risks, so that $d_i = 0.005$ for all insurance types i, then volume for non-life insurance services increases with 0.61 percent instead of 0.52 percent on average per year. If the values for d_i are combined with $v = 0.01$ for transport, then volume increases with 0.65 percent per year. Of course, taking negative values for v and the d_i will decrease the volume indices by the same amount as for the corresponding absolute (positive) values.

The deviations from the base assumptions show that the effects on the volume indices are small as a first indication. However, more research is needed in order to obtain a better idea of the range of realistic values for v and d_i.

4.2 Comparisons with other methods

In this section, we compare the results of Section 3.3 with two other methods. We consider this as an addition to the above sensitivity analysis in order to gain more insight into the robustness of our results. We consider the following methods:

- In the first method, volume indices of the 10 product groups are calculated by deflating the respective value indices with CPI's. The rest of the method is the same as the one in Section 3;
- In the second method, we replace the models for expected investment income to premiums ratio and expected loss by models described in Chen and Fixler (2003). The rest of the method is the same as described in Section 3.

Deflation with CPI's

A point of criticism that could be raised against the method proposed in Section 3 is that the product differentiation into 10 product groups is still quite rough. Product groups contain a large number of policies and are likely to be heterogeneous in terms of risk covered per policy. Shifts may occur in the size of these risks from one year to another, in which case we could miss volume change within product groups.

The database StatLine of Statistics Netherlands contains CPI's for the five insurance types, which we used to deflate the value indices of the product groups for every quarter since 2007. It is thus interesting to compare the resulting volume indices with the results obtained in Section 3.3. However, the following remarks should be made in this respect:

- The CPI's are based on a sample of insurers;
- The price indices are based on a sample of policies;
- Only new (acquired) policies are considered.

The volume of insurance services applies to all policies, also existing ones, which form the greatest part of the policies in a portfolio. Because of this, the difference between the results of Section 3.3 and the CPI-deflated method should be considered only as an indication of the possible volume change that may not be captured by the base method of Section 3.3.

The CPI's of the product groups are calculated by making use of premiums. Price indices can be set equal to indices of premiums within our model by making the following assumptions:

- The risk parameters μ_i are independent of risk size, for all product groups i;
- The μ_i are also independent of time t, for all product groups i;
- ES_t is equal for all risk sizes and product groups.

We adjusted the CPI's with the ratio $(1 + ES_t)/(1 + ES_{t-1})$ in order to obtain price indices of the product groups. The volume index is shown in Figure 7. On average, the difference between the volume changes per year is small: 0.52 percent for the base method of Section 3.3 and 0.42 percent for the CPI-based method. The actual differences per year may be quite large, however, which is the case for 2007. As was stated earlier, the differences should be considered merely as an indication. The sample should be extended to cover existing policies as well in order to obtain a better basis for interpreting the results.

Figure 7. Value index and volume indices for the base method and the CPI-deflated method (2006 = 100).
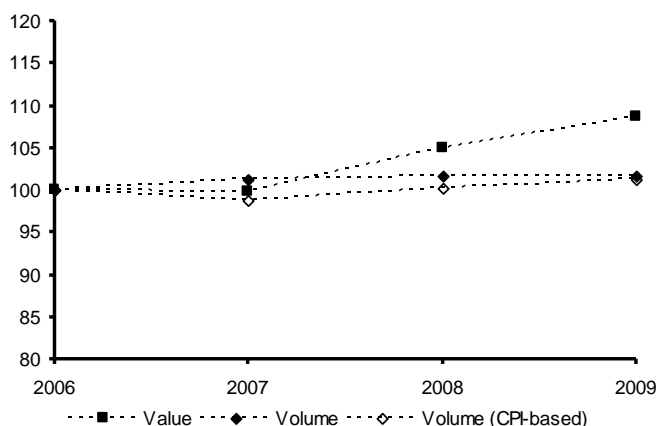
Alternative models for expected loss and investment income

We now consider a method for computing value and volume indices, in which the models for expected loss and expected investment income to premiums ratio of Section 3 are replaced by models proposed by Chen and Fixler (2003).

We first describe their model for expected loss, using a slightly different notation. Let $\lambda_{i,t}$ denote the expected ratio of incurred loss to premiums earned for product group i in year t, conditional on losses in preceding years, and let $P_{i,t}$ be premiums earned as in Section 3. Let $l_{i,t}$ be the actual, or observed, loss to premiums ratio in year t for product group i. Expected loss $\lambda_{i,t}P_{i,t}$ for product group i in year t is estimated by making use of the following model for $\lambda_{i,t}$:

$$(12) \quad \lambda_{i,t} = a_i l_{i,t-1} + (1 - a_i)\lambda_{i,t-1},$$

where $a_i \in [0, 1]$ is the so-called "smoothing constant" for product group i. The expected loss ratio for year t can thus be calculated as the weighted sum of the observed and expected loss ratio in year $t - 1$.

Chen and Fixler's model for expected investment income to premiums ratio is defined in a similar way as (12). Since we do not have data on investment income per product group, we use s_t to denote the expected investment income to premiums ratio in year t, given investment income in preceding years. Again, we assume that s_t is equal for every product group, for all years t. Let $b \in [0, 1]$ denote the smoothing constant and let i_t be the observed investment income to premiums ratio in year t, where investment income and premiums earned are aggregated over the five insurance types, as in Section 3. The expected investment income to premiums ratio in year t is modelled as follows:

$$(13) \quad s_t = b i_{t-1} + (1 - b)s_{t-1}.$$

We used the same model fitting procedure as in Section 3.2. Beside the smoothing parameters a_i and b, we used parameters for the initial values of $\lambda_{i,t}$ and s_t, that is, for $t = 1995$. Also here we omitted the data on investment income for the year 2008. Since $\lambda_{i,t}$ for $t = 2009$ depends on the observed investment income to premiums ratio $l_{i,t-1}$ in 2008, we replaced $l_{i,t-1}$ by the expectation $\lambda_{i,t-1}$ for 2008.

As in Section 3.2, we varied the number of free parameters in order to find out which combination of free and fixed parameters gives the highest AIC. The best fit was obtained by setting the smoothing parameters a_i at the same value for all 10 product groups, which resulted in $a_i = 0$ for all i. The smoothing parameter b is equal to 0.3. The initial values of $\lambda_{i,t}$ for reinsured risks are different with respect to unceded risks for health/accident and fire, and are equal for the other three insurance types. Ten free parameters were estimated in total. The AIC obtained was 178.9.

Although more free parameters are estimated than in Section 3.2 (eight in that case), the AIC is lower for models (12) and (13). The fits of the expected loss models give almost identical results, but the differences between the two expected ratios of investment income to premiums are larger. Model (6) gives better fits; the AIC obtained in Section 3.2 has a higher value (190.8).

Note that $a_i = 0$ for all i implies that $\lambda_{i,t}$ is independent of t for all i. The fits of Figure 3 to claims data in Section 3.2 already showed good results with constant μ_i in model (3). The fits of model (12) support the assumption of time independent μ_i's.

The value and volume indices are calculated as in Section 3.3. Nominal value of production for product group i in year t, under expressions (12) and (13), is equal to $(1 + s_t - \lambda_{i,t})P_{i,t}$. The same assumptions with regard to missing data and the distribution of premiums over quarters are made as in Section 3.3. Also here we assume that the value of s_t does not vary within year t, for all t.

The results show that the volume indices for the two methods hardly differ. For the method of Section 3.3, volume increases with 0.52 percent per year on average between 2006 and 2009, while it increases with 0.51 percent per year when using the above mentioned model fits of (12) and (13).

The value indices show larger differences, as can be noted in Figure 8. Nominal value increases with 3.3 percent per year on average for models (12) and (13), which was 2.8 percent for the method of Section 3.3. The influence of investment income on price change is therefore stronger for the 'Chen-Fixler approach'. The variability in model values for investment income to premiums ratio is higher for the fit of model (13). Model (6) is based on an interaction between change in premiums and change in expected investment income to premiums ratio, which is not the case for model (13). The interaction between premiums and investment income has a slight downward effect on the value index.

Figure 8. Volume index and value indices for the model of Section 3 and for model (12)-(13) ('Chen-Fixler') (2006 = 100).
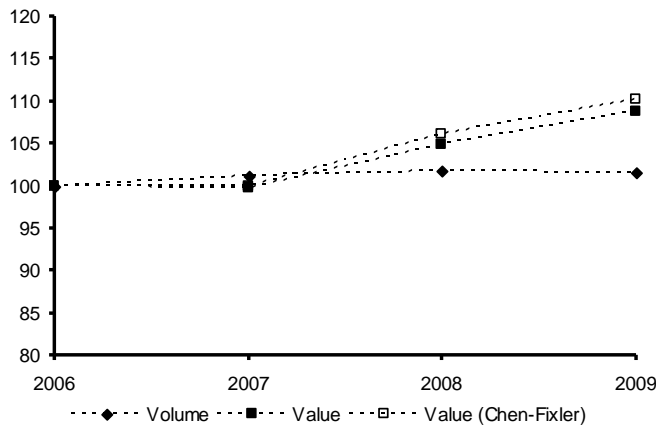
Dependence in loss data between reinsurance and non-reinsurance

In Section 3.2, we assumed, amongst others, that loss data for reinsurance and unceded risks are independent (see subsection "Data and model fitting"). This allowed us to fit expected loss model (3) to all 140 available data points on loss incurred. The independence assumption can be supported when considering different years. The assumption may also be sustained for the same year across different reinsured portfolios. But this assumption cannot be guaranteed when considering the same portfolio.

As a consequence, we re-estimated the parameters of expressions (3) and (6) by dropping the independence assumption for loss under reinsurance and non-reinsurance. We did not use an explicit relation between the two types of losses, but decided to leave this relation free. We modified the model fitting procedure of Section 3.2 by replacing the aforementioned independence assumption by the following set of assumptions:

- Loss for each of the five insurance types i is normally distributed with expectation $\mu_i(1 + \mathrm{E}S_t)P_{i,t} + \mu_{r(i)}(1 + \mathrm{E}S_t)P_{r(i),t}$ for every year t, where $r(i)$ denotes the product group regarding reinsurance for insurance type i;
- Loss is independent over different years and across insurance types;
- The error terms for total loss over premiums $P_{i,t} + P_{r(i),t}$ have the same variance, for every i and t.

Since we add both loss and premiums for reinsurance and non-reinsurance, we have that $n_2 = 70$ instead of 140 in (8).

The above assumptions lead to minor changes in the results. The only noteworthy change is that the parameters μ_i and $\mu_{r(i)}$ for unceded and reinsured risks have the same value (0.770) for health and accident. However, this change hardly affects the value and volume indices. The volume indices are the same as reported in Section 3.3, while the average value increase per year is now 2.7 instead of 2.8 percent. Because the effects are so small, we stick to the assumptions and parameter estimates of Section 3.2.

5. Conclusions

Price and volume measurement of insurance services is more complex than for other parts of national accounts. A notion of insurance service or 'product' needs to be developed and prices are not directly observed. 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. Price and volume measurement of insurance services is so complex, because all its components need to be defined.

According to the Eurostat handbook on price and volume measurement of 2001, characterising services or 'product types' and finding appropriate counting measures of quantities produced for each type should be the first step in price and volume measurement. Before addressing this issue in Section 3.1, we evaluated the direct service method that was previously used in the Dutch national accounts. The direct service method uses an activity-based approach towards production and volume. Handling claims is one of these activities. Losses incurred are subtracted in nominal value, while the number of claims is a component of production volume. This gives rise to inconsistencies between nominal value and volume. More precisely, nominal value is a decreasing function of the number of claims, and thus volume, which is inadmissible.

The problems with nominal value occur because premiums are not linked to expected loss, but actual loss is included in nominal value. In Section 3.1, we proposed to characterise 'products' in terms of the size and type of risk insured. Next, we proposed to consider bundles or packages of insurance activities as counting units of production volume. Single activities should, in general, not be seen as processes that give rise to distinct products. Less activity does not necessarily imply less production volume. The experiences with volume measurement for hospital care at Statistics Netherlands illustrate this.

The activity-based view on production and the approach proposed in Section 3.1 may lead to large differences in price and volume change. The use of actual claims in the direct service method may give rise to price and volume changes that are very volatile. The yearly changes in nominal value that are based on the data clearly illustrate this in Figure 6. Yearly volume changes of plus or minus five percent, or even up to ten percent, are no exception. The largest volume change for the method proposed in this paper is +1.2 percent in 2007. Although the yearly value shares of non-life insurance services in Dutch GDP are close to two percent, the adjustments to GDP when employing the method proposed here could still be several tenths of a percentage point. This discussion also applies to price change. In past years, price changes of more than 15 percent were obtained with the direct service method. The largest price change for the method proposed here is +4.5 percent in 2008.

The results may thus be quite sensitive to the choice of production concept. The effects of other methodological choices on price and volume change seem to be much smaller, at least, given the data used in this study. The sensitivity analysis of Section 4.1 shows that variations around the base values for missing data have limited effects on volume change. The use of alternative models for expected loss and investment income to premiums ratio lead to larger value changes in Section 4.2, but volume change remains almost the same. The volume indices that were calculated by deflating the value indices of the 10 product groups by CPI's suggest that some volume change may be missing, but considerable care is needed with these results. The CPI's are based on a sample of insurers, while only newly concluded policies are considered. Overall, it can be stated that the volume indices calculated in Section 3.3 are quite stable.

The ideas presented in this paper are being adapted and applied to life insurances and pensions. The concept of risk needs to be redefined for that purpose: claims are replaced by benefits and changes in technical provisions represent an essential additional component. The fact that technical provisions play a key role affects the characterisation of insurance services and the definition of nominal value. The models for expected loss and investment income will therefore undergo changes.

Acknowledgements

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