INDUSTRY-WIDE SCENARIO MODELLING FOR MEDICAL SCHEMES BASED ON STATUTORY INDUSTRY DATA

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This paper discusses a number of modelling techniques and algorithms specifically designed to infer detailed results on an industry-wide basis from limited, aggregated statutory data submitted to regulatory bodies by medical schemes. These techniques are proposed to address the challenges faced in collecting appropriate data to populate a model to be utilised as a scenario testing tool on an industry-wide basis.

Unlike the detailed demographic and claims data that individual schemes have available to populate their own scheme-specific models, publicly available statutory data tends only to be available in an aggregated (high-level) form. Recognising that more detailed data cannot realistically be obtained on an industry-wide basis in a developing country such as South Africa, the techniques described in this paper are suggested as a means to superimpose relationships and structures prevalent in detailed samples of medical scheme data over available aggregated statutory data.

The resulting information can be imported into a model such as the Health Monitor computer model, a stochastic computer-based actuarial risk management model that was developed to assist medical schemes to model and monitor, on an ongoing basis, the risks facing these schemes within the South African regulatory environment. The model enables the projection of contributions, claims, underwriting results and solvency levels with the ability to incorporate real or hypothetical changes in demographic composition, benefit structure and underlying claim patterns.

Populating an industry-wide model through these techniques provides the user with a credible and representative basis from which scenarios can be generated.

1. INTRODUCTION

The National Healthcare Financing debate in South Africa has begun to materialise towards the establishment of a Social Health Insurance (SHI) system with:

- Risk cross subsidies by means of a Risk Equalisation Fund (REF) and reformed benefit design imperatives;
- Proposals for income cross-subsidies being developed;
- Mandatory membership being contemplated in the middle and higher income groups;
- Developments regarding a Low Income Medical Schemes (LIMS) process that aims to create a (possibly demarcated) financing environment for previously uncovered, low income employees; and
- An imperative to drive costs down so that health care can become affordable to more South Africans.[1]

The implications of any combination of these initiatives on the healthcare financing industry are complex and may involve, amongst others, significant changes to the demographic profile of lives being covered and the way these lives cross-subsidise one another.

The understanding and quantification of proposals of this nature present a number of challenges. In order to quantify and measure the impact of proposals of this nature across the industry, it would be necessary to develop:

- A central repository of industry data; and
- The technical capacity to perform scenario modelling on such data (i.e. a model).

Whilst actuaries are generally familiar with the characteristics of the latter, the collection of adequate data at a sufficient level of detail presents the most significant challenge in achieving this aim. Medical schemes in South Africa are administered under a number of different systems. In addition to issues of confidentiality, the extraction and evaluation of detailed medical schemes data is a complex and intensive process that differs significantly from one system to the next.

This paper focuses on the techniques that are proposed to collect and/or infer the data required to populate such a model, on an industry-wide basis, through the examination of publicly available (but abbreviated) statutory information periodically submitted by South African medical schemes to their regulators. Combined with more detailed data from a limited number of individual medical schemes, it is possible to draw more detailed conclusions from statutory information than would be possible through consideration of statutory returns in isolation.

2. MODEL CONSIDERATIONS

The focus of this paper is on the collection (or generation) of data for modelling rather than modelling itself. It is however appropriate to consider the generic components of a model for projecting medical schemes' claims, since these components ultimately inform the model's data requirements.

A medical scheme model should have at its core the capability to describe a demographic profile and relate it to the gross claim propensities of individual beneficiaries in the profile. Such a demographic profile is typically described by means of rating factors such as age, gender, chronic condition, etc.

The capability of the model to project expected *gross* claims (i.e. before application of a scheme's benefit structure) for a demographic profile should draw from a statistical analysis of claim frequencies (or frequency distributions) and claim severities (or severity distributions). The model would normally distinguish between different types of claims (be it on a procedural or diagnostic basis) and assign appropriate frequencies and severities to each of these. The parameters of the frequency and severity distributions will in turn be a function of the rating factors of the population being considered.

The projection of gross claims instead of net claims allows for a scheme's benefit structure to be positioned as a parameterised component of the model. This component should incorporate the application of levies, co-payments, thresholds, limits, tariff structures and other instruments of this nature used to determine which benefits are paid. It should, however, be noted that the level of benefits to which a beneficiary has access may well in itself become a demographic *rating factor*, for two reasons:

- Traditional benefits (where beneficiaries lose unclaimed benefits from one year to the next) give rise to a "use it or lose it" approach to benefit utilisation, with higher benefits attracting higher utilisation (all other rating factors being equal); and
- Beneficiaries tend to (anti-)select benefit options based on their state of health, with healthier beneficiaries generally preferring lower options and *vice versa*; all other rating factors being equal.

Stochastic models should make provision for appropriate correlation between components within the three dimensions within which modelling is executed, being

- time (one month's claims may be dependent on previous months' claims);
- claim types (a visit to the GP may well be followed by an acute medicine script); and
- rating factors within the population (a catastrophe or epidemic might emerge in a particular region, giving rise to certain claims propensities for all beneficiaries within that region).

The Health Monitor computer model is a risk management model that was specifically designed and developed to assist medical schemes to, on an ongoing basis (monthly), model and monitor the risks facing these schemes. This model, developed and used by the authors, broadly conforms to the characteristics outlined above. Any similar model would be suitable for the application of the techniques described below.

3. COLLECTING DATA TO POPULATE AN INDUSTRY-WIDE MODEL

The collection of data required to populate an industry-wide model presents a number of challenges. Generally speaking, more detailed data only tends to be available for investigations limited to a small number of schemes/administrators. Data collected on an industry-wide basis tends to be in a high-level, aggregated form. A number of approaches to overcoming these challenges and populating an industry-wide data repository are considered below.

3.1 Collect detailed scheme information

The most complete means of populating a repository of industry-wide data would be to collect detailed claims and demographic information from each medical scheme. This could be done through mandatory regulatory submissions.

Currently in the South African environment, each medical scheme is required to submit high-level, aggregated information to the regulator on a quarterly basis. This data, considered in isolation, does not provide sufficient information for scenario modelling purposes (see section 3.4 below). It is unlikely that regulators would wish to impose the requirement for schemes to submit information in the level of detail required given the administrative complexity surrounding such a requirement. This is therefore not considered a feasible option.

3.2 Utilise sample data from willing administrator(s) or scheme(s)

A second possibility would be to utilise detailed medical scheme data obtained from willing participant(s), normally from one or more of the larger medical schemes/administrators, and use this as a sample from which national demographic and claims patterns can be inferred. This option would give access to a large body of detailed and credible data over a reasonable period of time. There is however no guarantee that any administrator will be prepared to supply the data at the level of detail required.

In addition, this solution presents a number of limitations that may introduce a measure of bias into the sample and hence into the results. In particular, when obtaining data from one administrator, one would typically gain access to only a limited number of benefit design characteristics and managed care dispensations.

The possibility of a bias becomes even more pronounced when data is requested with the stated or perceived intention of being used for industry research in a particular area, especially when the findings of such research can be expected to be incorporated in national policy debate. Industry stakeholders may elect to either submit or withhold their own data based on how they would expect its inclusion to influence the outcome of the research. Such behaviour could *systemically* introduce some measure of participation bias in the sample.

3.3 Utilise data from a data repository not specifically linked to an administrator or area of research

The potential for bias raised in section 3.2 above could, to some extent, be mitigated by obtaining data from sources that span over multiple industry stakeholders, especially if this data was primarily collected for reasons other than conducting research. Actuarial consultants to medical schemes, for one, would typically have access to detailed medical scheme information of its clients. Recognising that confidentiality constraints may need to be addressed, one could expect this data to be more representative and credible than the data sources mentioned above.

The authors, through their involvement in the Health Monitor Company, consider the collective data of all schemes currently utilising the Health Monitor to be an example of such a dataset. On a monthly basis, the database on which the model runs accumulates detailed demographic and claims data for each scheme. This has given rise to a considerable repository of detailed medical scheme data from both open and closed medical schemes spanning different:

- administrators;
- managed care systems;
- benefit design philosophies (e.g. saving accounts vs. fully cross-subsidised schemes);
- income/socio-economic groups of covered lives; and
- industries.

This data has been extensively analysed to populate a statistical model that relates claims experience to demographic rating factors. This statistical analysis provides claims frequencies and severities for different parts of a demographic population along the lines of the requirements set out in section 2 above.

Whilst datasets of this nature could be expected to exhibit less of a bias than those considered above, the data ultimately remains a sample and may still exclude key sectors of the medical schemes industry. The authors believe that this potential bias may be further addressed through the techniques described later in this paper.

3.4 Utilise statutory returns in their unaltered form

A fourth potential method for collecting industry data, requiring the least additional effort, would be to utilise the statutory returns in their unaltered form, as submitted by medical schemes. This data is in the public domain and provides the ability to collect full information without encountering any biases.

However, data collected by statutory bodies tends to be of an aggregated nature and does not provide sufficient information regarding the linkages and interactions between different components of the data. For example, statutory data may provide us with some details of demographics and (separately) with some details of claims, without any mechanism to *link* the demographics to claims.

In order to construct a sufficiently detailed model that allows us to perform complex scenario modelling, it is therefore unlikely that aggregated statutory information on its own will provide us with adequate information. Assumptions of uniform distribution over respective components, or linear interpolation between visible data points, are unlikely to fill the gaps in these datasets sufficiently for purposes of scenario modelling.

4. PROPOSED SOLUTION

After considering each of the options outlined in Section 3 above, the authors attempted to develop an amalgam of the approaches outlined in sections 3.3 and 3.4. This process involves developing algorithms to utilise the substantial body of medical schemes' demographic and claims data amassed by the Health Monitor computer model's underlying database to "de-aggregate" the statutory data submitted by medical schemes.

4.1 Superimposing relationships from a sample onto aggregated data

Broadly speaking, the process of "reconstructing" or "de-aggregating" the information contained in statutory information can be categorised into three phases.

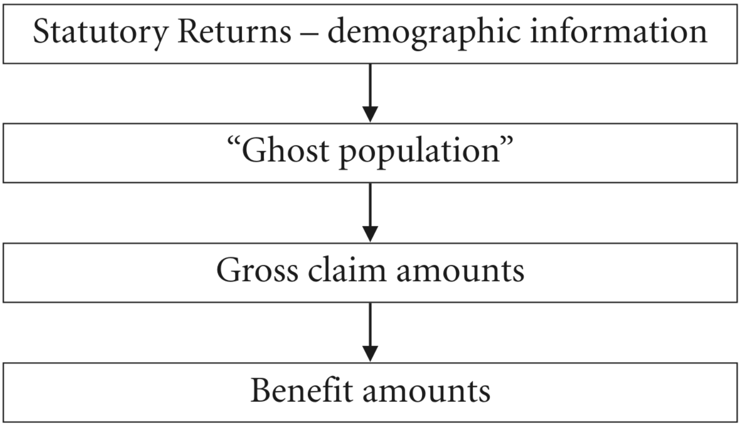
The first phase is the construction of a demographic profile that exhibits all the characteristics visible in statutory returns *and* simultaneously reflects dependencies between factors that are not visible. The relationships required to build the latter can be assembled from a detailed sample of the nature described in section 3.3. The authors adopted the approach of generating a list of hypothetical beneficiaries (or "ghosts") that conform to these characteristics. Section 4.3 describes in more detail the process followed in the South African environment, given the industry-wide statutory data available.

The second phase would be to project the claims experience expected of the "ghost" population generated. This can be achieved by applying claims propensities observed in the detailed sample to the generated demographic profile. The authors aimed to achieve this by projecting claims that the generated population would be *expected* to incur using the Health Monitor, based on a statistical analysis of the collective claims experience observed in the Health Monitor's underlying database.

The third phase involves the application of an appropriate benefit structure to the gross claims to calculate the net claims paid out by the schemes and is described in section 4.5.

These net claims can then be compared to actual claims data in statutory returns, on the levels of aggregation that are available. If the comparison points to discrepancies, the model basis for the particular scheme may need to be adjusted.

The process can be illustrated in diagrammatic form as follows:



4.2 Data available in the South African context

The relevant data included in statutory returns submitted quarterly by all medical schemes to the Council for Medical Schemes consists of three components

1. Demographic data showing the number of beneficiaries broken down by:
- age, gender and medical scheme option; and
- chronic prevalence
2. Net claims paid broken down by claim type (discipline), but crucially not by benefit option.
3. Financial data showing, per benefit option:
- contribution income;
- claims incurred; and
- administration and other expenses.

The fact that claims data is available either by claim type, or by benefit option, but not both, provides us with a pertinent example of the issues that tend to emerge when working with aggregated statutory data. Ideally, one would like to be able to analyse claims by both claim type and benefit option, and ultimately relate these claims to the beneficiaries that incurred them. The methodology described in this section aims to achieve exactly that.

4.3 De-aggregating demographic data into a "ghost" population

The process followed to generate beneficiaries ("ghosts") is described here. This process depends entirely on the dimensions of aggregation in statutory data, and the methodologies developed for the South African context is provided here, in broad steps, as a case study.

- **Age, gender and benefit option** – The statutory returns provide a picture of every scheme's demographic profile, broken down by age band, gender and benefit option. A list of "ghosts" can readily be created from this table. A date of birth is randomly generated for every beneficiary, within his/her age band. It is important that generated dates of birth are spread across an age band to ensure that "age creep" over brackets occurs smoothly over time when running model scenarios.
- **Dependent type** – Statutory returns provide a separate table with "dependent types" of beneficiaries, *i.e.* the number of principal members and dependents per benefit option. The table is used to update the generated list "ghosts" by assigning each the status of principal member, adult dependent or child dependent. An interaction is allowed for between age, gender and dependent type based on observed relationships in the detailed Health Monitor database. Specifically, for example, a higher percentage of adult dependents are female than male in the majority of age bands. This process also allocates all ghosts to family units, again allowing for interaction with age (with younger and older families generally having fewer dependents than middle-aged families).
- **Chronic status** – Statutory returns again provide a separate table with the chronic prevalence of certain conditions. This table is used as a basis when assigning chronic statuses to ghosts. Allowance is made for an interaction between age and benefit option and chronic status – with older beneficiaries and beneficiaries in higher benefit options more likely to be regarded as chronic.
- **Region** – Finally, a similar process is followed to assign every "ghost" to a geographical region. It is assumed for this purpose that all beneficiaries in a family reside in the same geographical region.
- **Beneficiary movements over time** – The above steps describe the process of creating a single "snapshot" of a medical scheme's demographic profile at a specific point in time. It is important to relate snapshots in one time unit to snapshots in adjacent time units, in order to track the development of a population over time. This can be done by attempting to link the generated family units and beneficiaries in a snapshot at time t to the beneficiaries in the snapshot at time t-1. Beneficiaries that cannot be linked back are regarded as new beneficiaries, and beneficiaries that are not present any more are regarded as beneficiaries that exited at time t.

Throughout the process described above, statutory data should be investigated and checked for reasonability and correctness before imported into the model. In some cases, it may be appropriate to replace statutory data that appears to be erroneous with appropriate assumptions.

When the process is complete, the generated list of "ghosts" is aggregated into the same dimensions as provided in statutory returns and checked to ensure that the "ghost" population conforms, in every available dimension, to that of the statutory returns.

4.4 Applying claims distributions to the population to generate claim amounts

Once a list of "ghosts" is generated, the gross claims that would be expected to be incurred by these "ghosts" are projected. Any actuarial model with characteristics similar those described in section 2 will be suitable for this purpose, provided that the rating factors required by the model have been generated for all "ghosts".

The authors employed the Health Monitor computer model, based on a statistical analysis of the collective claims experience observed in the Health Monitor's underlying database, for this purpose.

Gross claims cannot readily be compared to any of the claims information in statutory returns. The application of a benefit structure over the gross claims is the final step that needs to be performed before this comparison can be made.

4.5 Applying a benefit design model to the claims distribution to generate benefit payments

In order to successfully construct a model office, one requires the ability to relate gross claims (i.e. the total claims incurred, whether funded by the medical scheme or not) to net claims (i.e. claims actually paid by the medical scheme). While certain medical scheme benefit designs are relatively simple to model (e.g. co-payments and levies), others can be considerably more complex (e.g. limits and threshold benefits) as the latter develop in a non-linear fashion over time.

Furthermore, one must take into consideration that a scheme's benefit design has two subtle, but important implications:

- Higher benefits tend to introduce a *supply-induced demand* especially where benefits are in a risk pool (i.e. not a savings account). For this reason alone, *ceteris paribus,* beneficiaries in higher benefit options tend to claim more than those in lower benefit options; and
- In the South African environment, with open enrolment and community rating, beneficiaries may be forced to select benefit options based on their state of health. For this reason less healthy individuals tend to select higher benefit options and vice versa.

Both these points can be addressed by making the benefit option (or at least the level of benefits provided by the benefit option) a demographic rating factor in itself. If statutory data does not provide sufficient indication of the level of benefits provided by a particular benefit option, this may be derived by interrogating the level of contributions and/or claims of the benefit option. The authors used a simple categorisation of benefit options into

- Traditional and new-generation (i.e. savings account) benefit options; and
- Low, medium or high level of benefits.

The application of the benefit structure to gross claims now follows. The projected benefit amounts are calculated by considering the exact benefit specification of each benefit option of each scheme. Details in a benefit specification can include, across various different claim categories:

- Annual limits (individual and family);
- Levies or deductibles;
- Co-payments as well as the application of a standard tariff structure based on procedure or diagnosis; and
- Above threshold benefits.

If this information is not available for some medical schemes, a "generic" benefit structure for certain types of options could be constructed, although the accuracy of such an approach should be carefully evaluated.

5. MODEL VERIFICATION AND SCALING

In order to ensure that the model provides accurate and reliable results, it is necessary to compare the model benefit payments with actual benefit payments reported in statutory returns. This comparison can only be performed on those levels of aggregation provided in statutory returns.

Should model results not conform sufficiently to actual results, appropriate adjustments to either the statistical bases or the model should be effected.

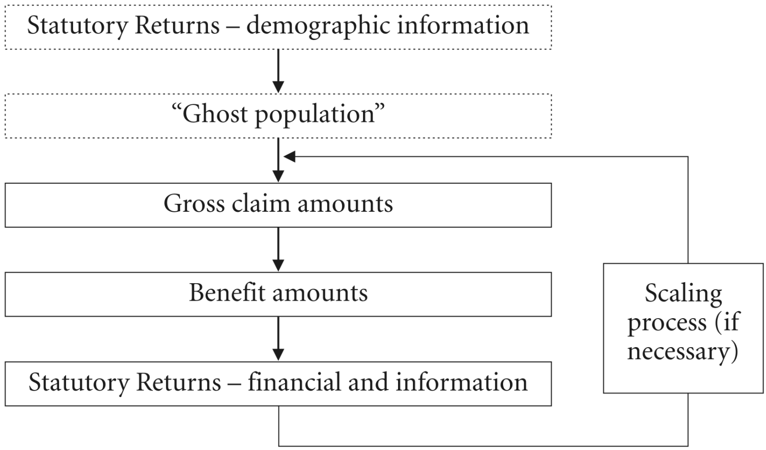
Scaling is particularly important where results are simulated over multiple years. For example, if possible when projecting results from 2004 the deviation between modelled and actual claims for 2003 should be considered. If the model has been properly calibrated on 2003 claims experience, it is likely (and has been found) to provide better estimates for 2004.

Such scaling is performed on at least three levels – type of claim, benefit option and medical scheme. Through an iterative process the adjustment factors required to bring model claims in line with actual claims for these dimensions is calculated until the best overall adjustment has been found.

The scaling process can be shown diagrammatically (see next page).

6. LIMITATIONS OF PROCESS

In the development of the processes described in this article, the authors have at many points considered the obstacles that exist in achieving its ultimate goal, i.e. the



creation of a tool to accurately model various scenarios that may unfold in the ever-changing medical schemes environment in South Africa. In reviewing the methods and processes followed we have felt it necessary to acknowledge certain technical limitations. Of particular concern initially was the fact that any bias present in the Health Monitor's collective database would be transferred to the generated data on some level (albeit to a limited extent).

Having noted that certain limitations may exist, the authors have produced results using this model and compared the results to actual experience. This process has given added measure of credibility to the data and models produced.

7. APPLICATION

The authors have tested inferred datasets (generated through these techniques) against actual detailed datasets and found a satisfactory level of correspondence for purposes of scenario modelling.

In applying these techniques to actually perform industry-wide scenario modelling in the South African context, specifically, it has been the authors' experience that scenarios generated from inferred datasets provide more credible and representative results than scenarios generated based on actual samples of data.

REFERENCES

[1] Report of the Committee of Inquiry into a Comprehensive System of Social Security for South Africa. (2002) *Transforming the Present – Protecting the Future*