

Actuarial Models Assignment 1

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Question & Answer

- 1. You have been commissioned to develop a model to project the assets and liabilities of an insurer after one year. This has been requested following a change in the regulatory capital requirement. Sufficient capital must now be held such that there is less than a 0.5% chance of liabilities exceeding assets after one year.**

The company does not have any existing stochastic models, but estimates have been made in planning process of “worst case” scenarios.

Set out the steps you would take in the development of the model

Ans. Following are the steps that are already taken by the company to develop a model:

- i. Develop a well-defined set of objectives that need to be met by the modelling process. The company has an objective of projecting the assets and liabilities of the company after one year
- ii. Plan the modelling process and how the model will be validated. This model will be validated when there is less than 0.5% chance of liabilities exceeding the assets. This change is to be brought to comply with the change in the regulatory capital requirement
- iii. Collect and analyse the necessary data for the model. The company would have the necessary data, that is the liabilities and assets of the company a year from now
- iv. Define the parameters for the model and consider appropriate parameter values. The company wants to know the worst-case scenario, hence, extreme parameters shall be taken

These are further steps that I shall be taking:

- v. Define the model initially by capturing the essence of the real-world system, i.e., to take the parameters or condition given today's data
- vi. Involve the experts on real-world system in order to get a feedback on the validity of the conceptual model. Ask a superior to overview the model made
- vii. Decide on whether a simulation package or general-purpose language is appropriate for the implementation of the model. If necessary, choose a statistically reliable random number generator that will perform adequately in the context and complexity of the model
- viii. Write the computer program for the model
- ix. Debug the program to make sure it performs the intended operations in the model definition
- x. Test the reasonableness of the output from the model
- xi. Ensure that any relevant professional guidance has been complied. For example, the Financial Reporting Council has issued a Technical Actuarial Standard on the principles of Technical Actuarial Work (TAS100), which includes principles for models used in technical actuarial work
- xii. Communicate and document the results of the model

2. An insurance company has a block of in-force business under which policyholders have been given options and investment-related guarantees.

A stochastic model has been developed which projects options and guarantee costs. You have used the model to estimate, for the Company Board, the probability of the insurance company having insufficient assets to honour the pay-outs under the policies. A Board member has asked whether there are any factors which could cause this probability to be inaccurate.

Outline the items you would mention in your response.

Ans. The factors that could cause the probability to be inaccurate are:

- i. The data that has been fed in may be inaccurate, which would lead to discrepancies in the result
- ii. The model may be sensitive to one or more inputs, and a change in value of one may lead to a significant change in the overall output
- iii. The data collected may not have been sampled appropriately and have a bias
- iv. As it is a stochastic model, the output is only a snapshot or an estimate of the characteristics of the model for a given set of inputs
- v. The model may not have passed tests of validity and verification.

3. The government of a small country has asked you to construct a model for forecasting future mortality.

Outline the stages you would go through in identifying an appropriate model

Ans. The steps I would take in identifying an appropriate model are:

- Set out the key objectives that the model must accomplish
- Determine the type of model that would be appropriate
- Determine the validity of the model to test for mortality rates
- Consider the validity of the data to be used in the modelling process, that is, usually when asked for the age, a person who is 39 but about celebrate his 40th birthday would say 40. Hence taking the exact data
- Consider the validity of assumptions that I would use to model the mortality
- Consider the impact of correlations between the random variables that drive the model such as age and sex
- Check the relevance of models made and used in the past to determine the mortality of the country, examples of models of other country with the same conditions can be taken to get a rough idea
- Check the credibility of the data source and cancel out any kind of biases that may have risen due to bad data
- Consider the ease with which the results of the model can be communicated to the government
- Consider the implications that a spuriously accurate result can have
- Check its sensitivity to change in factors such as age, living conditions etc.
- Ensure that the model adheres to any regulatory requirements that the government may have and have set out

- 4. You work for a consultancy which has created an actuarial model and is now preparing documentation for the client.**

List the key items you would include in the documentation of the model

Ans. The main objective of technical documentation is to minimize key person dependency for the model users/owners and to allow any reasonably competent modeler (including a new one) to understand its methodology. Comprehensive documentation should contain sections on model inputs, calculations, outputs, limitations, associated business processes, governance practices, application, and platform specifics.

The key items that I would include in my model documentation are:

- i. The inputs, all the data, assumptions and parameters considered while building the model
- ii. Any special considerations take before running the model
- iii. The intermediate calculations and methodologies used to do the calculations
- iv. The final output, the interim calculated values, and the final output
- v. Results of verification and sensitivity testing

- 5. Ten years ago, a confectionery manufacturer launched a new product, the Scrummy Bar. The product has been successful, with a rapid increase in consumption since the product was first sold. In order to plan future investment in production capacity, the manufacturer wishes to forecast the future demand for Scrummy Bars. It has data on age-specific consumption rates for the past ten years, together with projections of the population by age over the next twenty years. It proposes the following modelling strategy:**

- Extrapolate past age-specific consumption rates to forecast age-specific consumption rates for the next 20 years
- Apply the forecast age-specific consumption rates to the projected population by age to obtain estimated total consumption of the product by age for each of the next 20 years
- Sum of the results to obtain the total demand for each year

Describe the advantages and disadvantages of this strategy

Ans. Following are the advantages:

- i. The data is segregated into strata (age), this would help give a clearer picture about the demand in the future and account for anomalies which would have risen because of normal random sampling
- ii. As sampling done is stratified, a smaller sample size would be enough to give a precise result
- iii. Population forecast is being taken into consideration; hence the results will be more accurate

Following are the disadvantages:

- i. Simple extrapolation may not match with actual rise/decline in demand for product over the next 20 years
- ii. Does not take into consideration shift in peoples tastes or changes in people's perception or eating habits in the future
- iii. The proposed model does not account for current trends in the market relying heavily on past data, this may result in the model not matching the actual demand and hence, over investment into the production capacity.

6. Following a review of the results of a stochastic model run, an actuary requests that a parameter is changed. The change is not expected to alter the results significantly, but results on the final basis are required in order to complete a report. Unfortunately, the actuarial student who produced the original model run is away on study leave, and so the revised run is assigned to a different student. When the revised results are produced, they are significantly different from the original results. Discuss possible reasons why the results are different.

Ans. The reasons for this variation can be:

- **Improper Documentation:** The model and its required parameters may not have been documented properly, this would mean that anyone other than the initial user that tries to run the model will have to figure out for themselves what the correct parameters and input are
- **Incorrect Inputs:** The inputs put in by the new student might not be in line with what the model expected, or they may have changed multiple parameters or inputs which the actuary did not propose leading to this discrepancy
- **Ineffective model creation:** The model created may be too complicated to understand and require specialised inputs that may not have been mentioned in the documentation
- **Lack of sensitivity testing and peer review:** The model must not have been put through the rigors of sensitivity testing and peer review. As a result, the model may be increasingly sensitive to changes in certain parameters and the outputs not verified by credible sources
- **Discrepancy in data used:** The data used might not have been checked/cleaned properly. Hence, there can be significant outliers in the data that can have a huge impact as and when the parameters are changed. Additionally, outliers may not have been accounted for while creation of the model.

7. A new town is planned in a currently rural area, a model is to be developed to recommend the number and size of schools required in the new town. The proposed modelling approach is as follows:

The current age distribution of the population in the area is multiplied by the planned population of the new town to produce an initial population distribution.

Current national fertility and mortality rates by age are used to estimate births and deaths

The births and deaths are applied to the initial population distribution to generate a projected distribution of the town's population by age for each future year, and hence the number of school age children.

Discuss the appropriateness of the proposed modelling approach.

Ans. This approach to the modelling process has flaws. It is considering the existing population distribution of that area; the area in question has not been developed yet and would not be a good indicator of how the population distribution would look in a new town. Building on this point, the model does not take into consideration immigration and emigration, this would greatly affect the estimates. Even though the planned population is being considered, the population of the new town can greatly vary from its plans. For example, the town may have to accommodate more people than planned and would fall short with regards to the number of schools that it needs to provide quality education to its citizens. Additionally, the mortality and fertility rates that are being considered are on a national level, even though this may be a good indicator, a better estimate would be obtained if state wise or local rates (from a nearby city) are used as these rates can vary greatly depending on the location, climate, and culture that people follow in a particular area.

8. A large company wishes to construct a model of sickness rates among its employees to use in evaluating the present and future financial health of its sick pay scheme. Outline factors which the company should take into consideration when developing the model.

Ans. The factors the company must consider are:

- **Demographic of the company:** Factors such as the age of people working, their sex, and their lifestyles will affect how healthy the employees remain on average
- **Locations in which it has business operations:** This would affect the rate at which people fall sick as disease spread varies from place to place. Additionally, there may be diseases that are region specific. Mortality rates may also vary from region to region
- **Data Sources being used:** The company must ensure that the data used for the model comes from credible sources or spend its own time and capital for data collection
- **The designation of employees:** Care must be taken to account for the difference in the sick pay scheme structure between various employees. Higher ranking employees may get greater benefits and may also be older and hence more susceptible to diseases. Conversely, higher earning employees may have access to better health care and hence be less at risk. All of this must be taken into consideration as well
- **Working and living conditions of employees:** Employees working in the office may be less prone to ill health when compared to employees working in factories or construction sites. Moreover, some employees may be living far away from their actual office location and hence will be prone to a separate set of diseases.