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Simulation as a Tool for Risk Management in Health Insurance

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Abstract
Risk is measured in terms of probability and managing risk is all about managing system variables to keep the probability within desired limits. Sensitivity of probability with respect to changes in system variables is not uniform. Somewhere a small change in system variable value may change the probability of some peril significantly fast whereas it may be just the other way somewhere else where even a big change in system variable may not change the probability significantly.
Changing the system variables and observing their impact on risk in reality is not desired because it will be quite time consuming, costly and may even be disastrous. Simulation can be used as a tool to understand the impact of changes in decision variables values on probability of desired or undesired result and hence can help in better risk management. This paper applies Simulation technique in a typical health insurance scenario and observes the impact of changing system variables on the performance of the insurance product.

Keywords: Risk Management, Simulation, Health Insurance, Scientific Underwriting, Probability, Handling Uncertainties, Insurance Product Design.

Introduction
Risk comes with uncertainty. If something is certain to happen or not happen then one can decide accordingly and eliminate risk. If something is certain to happen, the probability is 1. Similarly, if something is certain not to happen then probability of that happening is 0. Probability values on extremely high or low side represent close to certain situations and decision making are relatively easier in such cases. But, probability values in the middle are quite risky because things can go in any direction. Insurance service is all about risk management where various risks are insured based on certain evaluations and claims are paid in cases when risk happen. If the probability of some risk (peril) is high then the probability of claim happening is high. Such risks are either not insured or insured with some exclusions to keep the probability within desired limit. In a typical health insurance product, various diseases and related expenses are covered by charging certain premium amount. Inclusion of a disease in the insurance will increase the probability of claim happening depending on the chances of that disease happening to the kind of people for which this insurance is being offered. Similarly, if a disease is excluded from the insurance coverage the probability of claim is likely to reduce. In case of claim, the claim amount is decided based on the provisions of the policy. However, the main components are related to various expenses that are covered under the policy. Claim amount too varies and have some kind of probability distribution for various claim value ranges. There can be various mathematical models to describe the probability of claim and claim amount distribution. But these probabilities and their distribution depend

on the diseases being covered, expenses being covered, lifestyle of the people affecting the probability of disease, expense pattern in various treatment associated with the disease and similar factors. Insurers charge some premium amount to cover these risks. If the premium amount is lesser than what it should be then the insurance company has the risk of getting into loss. Similarly, if the premium amount is more than what it should be then there is likely to be some good profit. Though any business would like to keep the probability of profit as high as possible but such insurance product may not be attractive enough for the customers. Hence, it is required to create a win-win situation for both, the insurers as well as insured, by working with the system variables like premium amount, probability of claim, claim amount distribution, sum assured etc.

The most accurate way of understanding the impact of changes in system variables may be to make the changes and observe the impact. This takes time and involves huge cost. Also, to reach to any conclusion, it has to be sufficiently large number of times. So, this approach cannot be implemented. Here, Simulation provides a powerful alternative to experiment and understand the system to almost the same detail that can be obtained by actually observing the system for a long time.

Simulation is experimenting with a model that represents a real system. Simulation is done on a model and not the real system itself. But results of simulation are considered as good as the results obtained by actually observing the system. For this, the model need to be a valid model. There are various statistical tests to test the validity of a model. If the data obtained from the model and the data obtained from the real system are not significantly different then the model can be considered a valid model. If these two sets of data don't pass the validity test then the model is invalid. Some of the assumptions made during the modelling exercise may be invalid. So, one can rework on assumptions, prepare the model and test the validity of the model till a valid model is obtained. This task is much easier than what it looks.

Monte Carlo Simulation is one of the most popular Simulation technique in which random numbers are generated and then associated with the real system variables depending on their distribution. System variables, their relationships and distributions are modelled in the mathematical model. Data obtained using this kind of experimentation are as good as data obtained from the real system if the model on which the experiment has been done is a valid model representing the real system. These data can be analysed in similar way as done with the data obtained through insurance operations. In Simulation, output keeps changing. In real life too, the output doesn't remain constant. Hence, it is useful to conduct the simulation run large number of times to reach to a dependable conclusion.

A Health Insurance Model

Simulation and modelling go together. Simulation is an experiment conducted on a model. Hence, a model is prepared considering various system variables and their relationships. This model is validated to be sure that it represents the real system. Simulation can be done once a valid model is obtained. The model being given here is assumed to be a valid model related to a health insurance product. There are assumptions related to various variables in this model and initially it may look like a bad product for insurance company. That creates requirement for experimenting by changing the system variables. Various changes are experimented here to create a situation that may be liked by both – insurers as well as insured.

This health insurance product is designed especially keeping in mind the requirements of people working in Software Industry. Their lifestyle offer certain health hazards and a suitable health insurance product may be a necessity. At the same time it should be attractive enough to the insurance companies to continue in the business with this product. An Insurance Company has come out with this product and targets to have corporate tie-up with software companies to provide risk coverage to all their employees by charging premium per employee per year.

Diseases covered in this product are such that probability of claim happening in a year for the kind of policy holders it is designed is 0.2. Such probability value can be obtained by studying the lifestyle of personnel working in Software Industry and the kind of diseases they are exposed to. Past data related to their health obtained from organizations or health service providers can help in estimating the probability data accurately. In claim cases, the claim amounts are uniformly distributed in various claim ranges with following probabilities:

Claim amount up to Rs. 80000 with probability of 0.6, claim amount between Rs. 80000 to Rs. 200000 with probability of 0.3 and between Rs. 200000 to Rs. 500000 with probability of 0.1. These claim amount ranges and their probabilities can be worked out based on various cost data related to the diseases being covered, some kind of clustering technique applied on claim data to make the claim amount ranges, data obtained from healthcare service providers etc.

The Insurance company accounts 20% of the premium collected for operations cost. It is targeting to provide this product to a software organization with 1000 employees by charging Rs. 8000 per person per year as premium.

This model has been kept simple here to demonstrate the power of Simulation technique in experimenting with various policy decisions related to the health insurance product. The technique is equally capable of doing similar experiments with very complex models as well.

Preliminary analysis suggests that;

Premium collected = Rs. 8000 * 1000 = Rs. 8000000

Net premium after deducting the operations cost = Rs. 8000000 *(1 - 0.2) = Rs. 6400000

Expected number of claims = 1000 * 0.2 = 200

Expected claim amount = ((200 * 0.6) * (80000 + 0) / 2) + ((200 * 0.3) * (200000 + 80000) / 2) + ((200 * 0.1) * (500000 + 200000)/2) = Rs. 20200000

Hence, expected profit = Rs. 6400000 – Rs. 20200000 = - Rs. 13800000. This is a huge loss.

Experimenting with the Model

It is expected that this health insurance product will be huge loss making and is not something to implement. The calculated loss of Rs. 13800000 is based on averages. In reality, if this product is implemented in 10 different software companies with 1000 employees each, the loss amount will not be same in all the cases. In fact, they will vary every time. It is a probabilistic situation and hence there will be always some probability of making loss or profit. In some case the loss amount may be much lower than expected. In some, it may be profit as well. So, this average based calculation doesn't give much idea about how frequently and in what ranges this product is likely to provide loss or profit.

Moreover, the system variables like premium, probability of claim, claim amount distributions etc. are obtained through some scientific underwriting process. One can change the probability of claim by including or excluding some diseases in policy cover. Similarly, claim amount distribution too can be changed by applying some exclusions or excess. Premium amount can definitely be fine-tuned to expect a desired result. In extreme competitive situation, even the operations cost too can be reduced if it doesn't affect the operations adversely. Also, there can be combination of these changes. It is important to see the impact of such changes in system variables on the profitability of the product and accordingly decide about the values that give the desired profitability. Though various profitability parameters can be applied in this process, the probability of profit can be the single most important parameter to get a fair idea in such uncertain situation.

So, the variables values are changed here and simulation is conducted for different values to get the pattern of profit or loss and finally come-out with such combination that can make this product win-win for both the insurers as well as insured.

Methodology

First, the given model is simulated using Microsoft Excel. For this purpose, a random number is generated between 0 and 1 and that is associated with the system variable claim amount. Random numbers are such numbers whose probability of getting selected are same. Since probability of claim happening is 0.2 as per the model, 0.2 fraction of possible random numbers are associated with claim. When claim happens, the probability that the claim amount lies between 0 and Rs. 80000 is given as 0.6 in the model. Hence, of the total population, the probability of claim being in this range is 0.2*0.6 = 0.12. Hence, if the random number generated is less than 0.12, another random number is generated between 0 and 80000 indicating the claim amount. Probability of claim amount in claim cases being between Rs. 80000 and Rs. 200000 is given as 0.3. This probability for the population becomes 0.2*0.3 = .06. Hence, the next 6% of the random numbers are associated with this claim range. So, if the random number generated is not less than 0.12 but is less than 0.18, then another random number is generated between 80000 to 200000 to get the claim amount in this range. If the random number is not less than even 0.18 but is less than 0.2 then it is representing a claim in the range of Rs. 200000 to Rs. 500000. In such cases, another random number is generated between 200000 and 500000 that gives the claim amount. If the random number is not even less than 0.2 then it is representing a no claim situation and hence the claim amount is zero. Since the distribution of claim amount in given claim amount range is uniform, a random number between the given ranges can represent the claim amount.

Since there are 1000 employees for which this insurance product is being offered, this step of generating random number and associating that with claim amount is done 1000 times. Data thus obtained is equivalent to implementing the product for one year and actually observing the claim amount for each and every individuals. Adding claim amounts provide the total amount paid in claims. Net premium is computed using the premium amount, number of customers and operations cost. The difference between net premium and total claim paid gives the profit or loss.

This is one simulation run. The result may be just a chance. Hence, to get a fair idea, this simulation has to be done large number of time. In this work, it has been done 500 times. This is equivalent to implementing this product on a set of customers and getting the result in one year. Implementing it again on another set of 1000 customers and getting the result after one year. Repeating this 500 times and observing the pattern of profit and loss.

In the present shape, this health insurance product is highly loss making. So, certain changes are done in system variables and their effect on probability of profit is simulated. With every change, 500 simulation runs are done and the number of incidences of profit is used to get the idea about probability of profit. By making changes in combinations, this product could be made an attractive product.

Results

This product shows loss in all the 500 simulation runs. It continues to show loss in all simulation runs even when the premium amount is changed to Rs. 12000. When premium amount is changed to Rs. 20000, it started showing profit on 7 occasions out of 500. The probability of profit remains too low. When the premium is changed to Rs. 25000, the probability of profit improves to 0.466. But an Insurance organization will not like to do business with such probability of profit. At a premium of Rs. 30000, there were 485 simulation runs giving profit. That makes the probability of profit as 0.97. This is good for insurer. But it is interesting to experiment and see whether it is possible to make the probability of profit good keeping the premium amount somewhere around Rs. 10000. In such case, the product will be quite competitive and attract the customers.

If some excess is applied keeping rest of the variables same then even an excess of Rs. 30000 didn't change the scenario. In all the 500 simulation runs it was loss. Detail of various changes experimented in the simulation and their impact on probability of profit are shown in the table below. With a premium of Rs 12000 and operations cost remaining 20% of the premium, the probability of profit became 0.956 with an excess of Rs. 10000 and the probability of claim reduced to 8%.

System Variables	Change on the base product	Number of incidences of profit	Probability of profit
Probability of claim 0.2, Premium – Rs. 8000, Operations Cost 20%, No excess	NIL	0	0
Probability of claim 0.2, Premium – Rs. 12000, Operations Cost 20%, No excess	Premium changed to 12000	0	0
Probability of claim 0.2, Premium – Rs. 20000, Operations Cost 20%, No excess	Premium Changed to 20000	7	.014
Probability of claim 0.2, Premium – Rs. 25000, Operations Cost 20%, No excess	Premium Changed to 25000	233	.466
Probability of claim 0.2, Premium – Rs. 30000, Operations Cost 20%, No excess	Premium Changed to 30000	485	.97
Probability of claim 0.2, Premium – Rs. 8000, Operations Cost 20%, Rs. 30000 excess	Excess Rs. 30000	0	0
Probability of claim 0.2, Premium – Rs. 8000, Operations Cost 5%, No excess	Operations cost changed to 5%	0	0
Probability of claim 0.1, Premium – Rs. 8000, Operations Cost 20%, Rs. 10000 excess	Probability of claim changed to 0.1, Rs. 10000 excess	2	.004
Probability of claim 0.1, Premium – Rs. 10000, Operations Cost 20%, Rs. 10000 excess	Probability of claim 0.1, Premium – Rs. 12000, Rs. 10000 excess	69	.138
Probability of claim 0.1, Premium – Rs. 10000, Operations Cost 15%, Rs. 10000 excess	Probability of claim 0.1, Premium – Rs. 10000, Operations Cost 15%, Rs. 10000 excess	125	.25
Probability of claim 0.08, Premium – Rs. 12000, Operations Cost 20%, Rs. 10000 excess	Probability of claim 0.08, Premium – Rs. 12000, Rs. 10000 excess	478	.956

Conclusion

It is easy to conduct simulation runs for large number of times with existing computational tools. Results represent real system when the simulation is done on a valid model. Validity of a model can be tested hence getting a valid model is quite feasible.

Simulation is a powerful tool to experiment with the model. Hence, it facilitates changing the variables values and see their impact on the result. It becomes fast and involves practically no cost. Experimenting and gaining clear insights into various possibilities before taking important decisions is a good way of risk management.

In this health insurance product, the initial situation was hugely loss-making. The natural approach of increasing the premium could not improve the probability of profit. Increasing premium about four times to make the probability of profit in acceptable range for insurers may not be acceptable to the customers. Reduction in operations cost is a tough decision. However reducing it from 20% to 5% of the premium collected too could not improve the profitability of this product. This explains such situations where people take hard decisions to restrict the operations cost but the organization fail to make any significant improvement in business. Applying an excess of Rs. 30000 too could not improve the profitability. Excess of Rs. 300000 means that any claim amount in excess of Rs. 30000 only will be paid in case of claims. This is a hard provision for customers in health insurance but is not helping the insurers here. Reducing the probability of claim to 0.1 too did very little to the probability of profit as the simulation result suggested a probability of profit as .004. This is as bad as 0 for any business decision.

As experimenting with changes in variables becomes easy with the use of simulation technique, various combinations are tried. The simulation results show that if the probability of claim is kept at 0.08 and an excess of Rs. 10000 is applied then the probability of profit becomes 0.956 with a premium of Rs. 12000 per person per year and operations cost remaining at 20% of the premium. This is much preferable situation for insurers as the probability of profit is quite good and operations cost too is quite liberal. Also, for the customers, a premium of Rs. 12000 per year is not bad. Simulation technique can be used to observe the impact of various combinations of changes in system variable values on the risk being managed. Thus, the desired values of system variables can be obtained and such decisions can be taken to move towards these values.

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