

Insurance Premium Optimization: Perspective of Insurance Seeker and Insurance Provider

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ABSTRACT: The paper proposes a utilitarian and newfangled design of life insurance premium payment. Insurance companies provide insurance to the policy holders and in turn the policy holders have to pay insurance premium periodically. In this paper, we study the important factors to be considered at the time of selecting the term of premium payment of insurance. The intention is to extend this study to a method which can machinate and assist users in deciding the term and amount of premium payment. Our aim here is twin-fold; one, to evoke a novel way to policy holder to decide the least premiums to be paid and second, to devise a manner for insurance provider to collect maximum premiums. With this twofold aim, we propose a hybrid soft computing optimization model using Neuro-Fuzzy approach and Particle Swarm Optimization.

Keywords: Stress quotient; Stress stimulants; peer pressure; stress factors; parental expectations.

1. INTRODUCTION

People usually go for life insurance products with no external analysis on how much premium should be paid for a policy. Every perspective policy owner should be a little cautious of choosing a policy. There is a popular saying about health insurance: "*Buy health insurance when you don't want it, because you may not get it when you want it.*" Many companies render the facility of group insurance to their employees to counter their health contingencies but buying a personal insurance is always advisable. Buying a personal insurance policy is not only cost-efficient, but also provides with tax benefit.

The insurance companies have numerous policies with various schemes for different age groups, but opting for right insurance and choosing right premium is of interest to every insurance seeker. Insurance companies proffer different attractive options to a perspective insured, sometimes diverting him from choosing and paying an insurance premium amount which is not the best option for him thereby increasing their own collection. This may possibly increase the profitability of insurance company. If the insurance seekers understand the terms and conditions and premium calculation of insurance policy properly before buying it, it may lead to slenderized total payment made to the insurance company. The aim of this paper is to look from the perspective of both; the insurer and insurance seeker and to suggest a model by which an insured can choose the best option for paying premium and an insurer can increase his insurance premium amount. Basically, gross premium is calculated as the total money of the policy, which is penned of net premium and extra premium. Net premium is calculated on the basis of mortality rate and interest rate. Extra premium is calculated on the ground of the scheduled expense rate. The three factors used in pricing the life premium are mortality rate, interest rate and expenses rate [27].

The mortality rate is computed from national life table and is generally stable. The expenses rate is controllable with the use of proper management while the interest rate changes with different insurance periods [26]. For detailed discussion of how insurance premium is calculated, [3] can be consulted.

Neural networks have initiated in mathematical biological environment and have come out as a generalized technique for solving real time applications. The applications can be found in number of areas ranging from management, marketing, decision making to finance. One thing common in all these areas, worth noticing, is uncertainty. To deal with vagueness in the environment, fuzzy logic has been introduced as an additional technique giving rise to neuro-fuzzy approach. A lot of research is going on applicability of neuro-fuzzy techniques on real world problems like bankruptcy prediction [2],[5],[12],[25],[33], stock market prediction [1],[6],[11],[18], biometric applications [9],[28],[37] and insurance underwriting [3],[4],[10],[23],[30].

The application of neuro-fuzzy network in insurance underwriting process has proved to considerably reduce the time and insurance losses of the insurance companies. An effort has been made in this paper to extend our previous approach [3], in order to incorporate a methodology for optimizing effective premium amount. Computational experiments are carried out using the Soft Computing approach by considering both sides of insurance viz. insurer and insured. Since two parties are involved in the agreement called insurance, it has two viewpoints; one of insurer and the other of insured. At one end, where the insurance company aims at collecting more and more amount in the form of premium, at the other end, insurance seekers want to choose that term of premium payment which can relieve them off from the burden of paying more premiums.

The insurance companies provide risk cover by considering the portfolio of insurance seeker. Each portfolio is treated differently for charging extra premium, applying waiting periods to restore the necessary risk etc. The ultimate goal of any company is to gain profits out of the business. The insurance companies try to maximize the profits earned by providing insurance cover to individuals or groups. At the same time, a person seeking insurance tries to choose a premium payback method which can possibly minimize his total premium paid to the insurance company. The paper works in the benefit of both the parties. The rest of the paper is structured as follows: Section 2 explores the related work in insurance using various methods; Section 3 discusses the concept and types of insurance and in Section 4, a discussion about insurance premium is presented. Section 5 throws light on the proposed method which combines Neuro-fuzzy approach with Particle Swarm Optimization while Section 6 describes the results of experiments.

2. RELATED WORK

In recent years, researchers have considered the application of computers to the process of insurance underwriting. Originally developed in the 1940's, Artificial Neural Networks were designed to replicate and study the thought process of the human brain [13]. Bakheet [8] used the back-propagation form of the feed forward NN as the pattern classification tool in construction bond underwriting. Vaughn *et al.* [36] used a multilayer perceptron network to classify applicants for whole life insurance into standard and non-standard risk. They then used a knowledge discovery method to identify the significant, or key, inputs that the network uses to classify applicants. The recent use of Artificial Neural Networks represents what may result in the most accurate application of computers in the underwriting process. A study was designed to predict losses on individual

policies using Artificial Neural Networks [22]. Brockett *et al.* [10] used a kohonen self-organizing feature map (SOFM) to uncover automobile bodily injury claims fraud in the insurance industry and a feed forward Neural Networks using a back propagation algorithm to validate the feature map approach.

Rocio *et al.* [29] considered the design of life insurance participating policy by maximizing the profit of policy. They build an optimization model to decide the minimum guarantee, participating rate and premium. Steffensen [34] applied quadratic optimization approach to financial decision making to the problem of life insurance by adjusting regulative payments. [7] analyzed fair pricing of a life insurance endowment policy with a minimum return guarantee and participation rate. She considered mortality risk and financial elements and evaluated premiums paid either by a single amount at the initiation of the contract or by periodical premiums.

Fuzzy Set Theory has been used successfully applied in insurance price problems that require much actuarial subjective judgment and those for which measuring the embedded variables is difficult [31]. The first application of fuzzy Logic to the problem of individual insurance underwriting was given by De Wit [14]. Lemaire [24] extended DeWit to a more extensive agenda for Fuzzy Logic in financial aspects of business between two parties based on the degree of risk and premium estimated as exactly as possible. Young [40] used fuzzy sets to model the selection process in group health insurance. Young [41] described how fuzzy logic can be used to make pricing decisions in group health insurance that consistently consider supplementary data, including vague or linguistic objectives of the insurer, which are ancillary to statistical experience data. Horgby *et al.* [17] provided underwriting application with the application of fuzzy logic to medical underwriting of life insurance applicants. Li-Hua Lai [22] used fuzzy CAPM and fuzzy ICAPM models to investigate underwriting systematic risk and profit margin of aviation transportation with triangular fuzzy number as membership function parameter. As pointed out by [3], a number of software for insurance underwriting are available in the market which can quickly and easily deploy intelligent automated processes for efficiency perform the job of an underwriter for determining the amount of premium to be paid by insurance seeker. Jia *et al.* [19] studied the life insurance model with the stochastic interest rate modeling as a reflected Brownian motion and a reflected Brownian motion combined with Poisson process.

Recently new technology integration is becoming focus of researchers to solve optimizations problems and that is frameworks of fuzzy neural network (FNN) and particle swarm optimization. Such work can be seen in for daily load forecasting [38], network intrusion detection [35] etc. The next section throws light on significance of insurance premium on the two involving parties i.e. insurer and insured.

3. INSURANCE PREMIUM

Insurance is a way of abbreviating your potential financial loss or hardship. Insurance is taken up by an insured to transfer his risk to another entity called insurer. Insurance is a contract between two parties whereby one party called insurer in exchange for a fixed sum called premium, promise the other party, called insured, to pay, a fixed amount of money on the happening of a certain event. Insurance policy, a contract between the insurer and the insured stipulates all the details of the agreement between the insurer and the insured such as, risks assumed by the insurer, premium amount, term of the contract, and the sum of money the insurer agrees to pay on the occurring of a particular event.

All insurers have to follow life insurance underwriting guidelines which are prescribed by IRDA. Their approach may differ slightly from each other. When an individual apply for a life insurance policy, the file is reviewed by an underwriter of the insurance company. The underwriter evaluates applicant's medical history, family medical history and lab results including height, weight, medical conditions, medications, lifestyle, parents or siblings who died of severe diseases like cancer, heart disease etc. The applicant is expected to provide honest details while applying for an insurance policy for a fair evaluation of the policy holder and thereby determining amount of insurance premium.

4. INSURANCE PREMIUM OPTIMIZATION

The traditional approach of calculating insurance premium based on costs is not enough to optimize a company's growth and profits. The refined methodology as suggested by [4] can be employed for calculating insurance premium in the same way as underwriters do. The criteria of optimizing premium differ from insurance provider to policy holder. At one end, the insurance provider, who is in business, seeks to increase the collection amount from every policy holder whereas on the other hand, the policy holder tries to opt for the payment option by which he can reduce his overall payment done to the company in the form of premiums.

A. Optimization Parameters: Insurance Provider/Insurer

Life insurance companies can be in terrible situation if they don't pay right attention while collecting the premium from the policyholders. A company can increase the per-policy profitability by charging more premiums for a given risk profile. An appropriate price optimization technique can be used for deciding the pricing of the policy. But this can be done only after gaining and analyzing information about competitors' policies and customer's demand and behavior. For this purpose, they employ underwriters to evaluate the portfolio of insurance seekers and to decide the amount of insurance premium by considering various personal and family factors of perspective applicants. They also adapt the premium based on market competitiveness to attract new customers. Once the premium is decided and the customer turns into policy holder, the insurer provides him various alternative ways of making premium payment based on the term. The insurer wants the customer to choose that payment method which can possibly increase his collection.

B. Optimization Parameters: Policy Holder/Insured

People buy insurance but usually they are not aware about the correct way of buying and handling it. The choice of preferences by policy holder on the same insurance plan can cost policy holder differently. These preferences include mode of payment, number of policies, etc. To optimize the amount of payment done to the insurance company in the form of premium, the policy holder has to be little vigilant about few simple factors. First, it is always good to have one policy with the highest coverage amount instead of multiple policies splitting the coverage amount. Buying many different plans can cost the insurance seeker more. Clubbing plans together may result into insurance company reducing the premium amount. Second, it is always better to buy insurance in the best of health. This will automatically reduce the payback premium to the insurance company as the portfolio shows the current condition of insurance seeker's health. At the time of calculating the insurance premium to be paid by every insurance seeker, the underwriters consider the individual's

personal details like age, health, medical condition along with the family history like heart disease or smoking/drinking habits. It is advised to the insurance seeker to opt early; normally at the age of 35. If some health problems are expected in near future, it is better to take the insurance cover before time to reduce the premium. At the time of application for life insurance, if the applicant is having a minor health problem, it gives a chance to the insurer to ask for additional premium above the normal premium called mark-up premium. Even normal fever can give a bad impression to the insurer. Third, insurance premium is paid to cover life against risk. Underwriters consider a morality chart for charging the applicant which is called mortality charges. Anything above these mortality charges increase the amount of life insurance premium. As a matter of fact, all additional benefits come with additional charges. To lower down the amount of insurance premium, one should opt for only those riders which are actually required. At the time of purchasing insurance policy, the policy holder is given multiple alternatives by the insurer to choose one of the payment methods for the premium. Policy holder should be cautious enough to choose a payment method which can possibly minimize his total payments made in exchange to the risk with the insurance company.

5. NEURO-FUZZY NETWORK FOR INSURANCE UNDERWRITING

Artificial Neural Networks were first developed in the 1940's as a mathematical model used to study the human thought process [13]. While considering the portfolios for possible insurance, the underwriter has to confront with lot of uncertainties in the inputs given by the prospect. A Neuro-fuzzy system can best deal with such imprecise inputs by taking up the entire burden from underwriters to refer the risk assessment manuals. The unique abilities of a Neuro-fuzzy system can improve the underwriting process. Arora & Vij [3] have provided a detailed discussion on the method of insurance underwriting whose implementation and results have been presented to show the application of Neuro-fuzzy networks in [4].

6. PARTICLE SWARM OPTIMIZATION

A number of approaches are available for solving optimization problems, such as genetic algorithms (GA), evolutionary programming (EP), simulated annealing (SA), and so on. GA has some drawbacks like long computation time, premature convergence leading to the local minima problem, complicated process in coding and decoding, etc. Although, EP is found to be more efficient mechanism than GA in computation time having capability to generate a quality solution with less calculation, the problem lies in its slow convergence to a good near optimal solution [39].

The idea of Particle Swarm Optimization (PSO) is under study by several scientists. PSO is widely known to be a method of computational simulation of the movement of organisms like flock of birds. These simulations are basically worked out on the manipulations of distances between individuals, i.e., the synchrony of the behavior of the swarm was seen as an effort to keep an optimal distance between them. Socio-biologist Edward Osborne Wilson outlined a link of these simulations for optimization problems [16]. PSO is similar to genetic algorithm (GA) in that the system is initialized with a population of random solutions. It is unlike a GA, however, in that each potential solution is also assigned a randomized velocity, and the potential solutions, called particles, are then flown through the problem space [15]. Each particle keeps track of its coordinates in the problem space which are associated with the best solution (fitness) it has achieved so far.

Particle Swarm Optimization (PSO) falls under the category of population-based evolutionary algorithms. The PSO has particles driven from natural swarms with communications based on evolutionary computations. PSO, originally developed by Kennedy and Eberhart in 1995, is a population-based swarm algorithm [14], [20]. In PSO computational algorithm, population dynamics simulates bio-inspired behavior, typically a bird flock's behavior, which involves social sharing of information and allows particles to take profit from the discoveries and previous experience of all the other particles during the search for food. Each particle in PSO has a randomized velocity associated to it, which moves through the problem space. Each particle in PSO keeps track of its coordinates in the problem space, which are associated with the best solution (fitness) it has achieved so far. The particle itself finds optimal solution, namely the individual extreme value personal best (pbest). Another best value tracked by the global version of the particle swarm optimizer is the overall best value. The whole population finds an optimal solution, known as the global extreme value (gbest). This can be obtained by any particle in the population. The past best position and the entire best overall position of the group are employed to minimize or maximize the solution.

The PSO algorithm consists of changing the velocity (acceleration) of each particle toward its pbest and gbest locations at each time step. Acceleration is weighted by a random term, with separate random numbers being generated for acceleration toward pbest and gbest locations. Each individual called a particle represents a potential solution [15], [21]. In the continuous space coordinates, PSO algorithm is described mathematically as:

Set for the D-dimensional search space, N^{th} particles compose a population, and the i^{th} particle position is $x_i = (x_{i1}, x_{i2}, \dots, x_{id})^T$ the i^{th} particle velocity vector is $v_i = (v_{i1}, v_{i2}, \dots, v_{id})^T$. Fitness value of each particle in the current position (measure the merits by the function value for each particle) is described as $fitness_i = fitness(x)$, the best previous position of particle i is represented by $P_i = (P_{i1}, P_{i2}, \dots, P_{id})^T$, and the best position among all particles in the population is $P_g = (P_{g1}, P_{g2}, \dots, P_{gd})^T$. Each particle adjusts its speed dynamically according to the comprehensive analysis individual and population flying experience, and fly to the best position that it experienced and other particles have. Each particle updates its speed and position according to (1).

$$\begin{aligned} v_{id}(t+1) &= wv_{id}(t) + c_1r_1[P_{id}(t) - x_{id}(t)] + c_2r_2[P_{gd}(t) - x_{id}(t)] \\ x_{id}(t+1) &= x_{id}(t) + v_{id}(t+1) \end{aligned} \quad (1)$$

Where, t is iteration time, $v_{id}(t+1)$ represents particle's moving speed; $v_{id}(t)$ is the former particle's moving speed; $x_{id}(t+1)$ is present particle's position; $x_{id}(t)$ is the former particle's position; w is inertia factor; r_1, r_2 are random between 0 and 1, and c_1, c_2 are nonnegative constants, called learning factors mostly with value $c_1 = c_2 = 2$ and to adjust each iteration step length. Learning factors are used to control the relative influence among particle own memory and companions'.

In finding the optimal solution of problem in hand, inertia weight is used to balance the global and local search ability. The inertia weight has characteristics that are reminiscent of the temperature parameter in the simulated annealing [32]. A large inertia weight facilitates a global search while a small inertia weight facilitates a local search. By changing the inertia weight dynamically, the search ability is dynamically adjusted.

7. OPTIMIZATION MODEL

As determined by underwriters, the insurance seeker is offered various options for paying the insurance premium in terms of payment term. Life insurance premiums may be paid quarterly, monthly or annually. Less amount of sum assured does not varies much in the total amount of premium paid and collected in any term by the insured and insurer resp., but bigger sums show a huge margin. Insurers usually do not give suggestions to insured about the choice of total policy tenure and payment term because in doing so, they may lose their profit margin. For modeling purpose, the demand is assumed to be a linear decreasing function of price which implies that, the higher the premium for a policy, the less people will demand that policy. When it comes to determining the profit for the insurance company, the following formula is used:

$$Max Profit = EP + II - L \quad (2)$$

Where, the income is assumed to be composed of total earned premiums (EP) and the income from investing (II) in the financial markets and the L denoted the value of payments. A basic criterion is considered in the optimization model for both the cases:

Case 1: Maximizing insurance company's premium collection

The insurer aims at maximizing the profit for the policy, which is achieved when $EP + II > L$

Case 2: Minimizing insured's premium payment

The insured tries to minimize the premium payment of the policy, which is achieved, when $EP + II < L$

8. EXPERIMENTAL RESULTS AND DISCUSSION

The input to the experiment consist of all possible premium payment options including monthly, quarterly, half-yearly and yearly. Table 1 shows the sample data for determining which premium payment mode is most desired for both the cases discussed above. As viewed from the insurer's end, a premium mode that yields him maximum premium from the insurer is most favorable whereas, from the viewpoint of insured, it is the one by which his total premium paid to the insurer is minimized. The dataset is prepared for combination of different sum assured values with various terms of insurance and different premium payment options.

Table 1: Sample Data for Determination of Premium Payment Model

Sum Assured	Payment Mode	Term	Premium	Annual Premium
2,00,000	Monthly	10	4521	54252
2,00,000	Monthly	15	4631	55572
2,00,000	Monthly	20	4741	56892
2,00,000	Monthly	25	4851	58212
2,00,000	Monthly	30	4961	59532
2,00,000	Quarterly	10	13500	54000
2,00,000	Quarterly	15	13800	55200
2,00,000	Quarterly	20	14000	56000
2,00,000	Quarterly	25	14500	58000
2,00,000	Quarterly	30	14800	59200
2,00,000	Half-yearly	10	26500	53200

Sum Assured	Payment Mode	Term	Premium	Annual Premium
2,00,000	Half-yearly	15	27000	54000
2,00,000	Half-yearly	20	28100	56200
2,00,000	Half-yearly	25	28900	57800
2,00,000	Half-yearly	30	29650	59300
2,00,000	Yearly	10	52000	52000
2,00,000	Yearly	15	53100	53100
2,00,000	Yearly	20	54300	54300
2,00,000	Yearly	25	55500	55500
2,00,000	Yearly	30	56700	56700

The parameters used for PSO are shown in Table 2. With the initial value of these parameters, PSO experiment is conducted.

Table 2: PSO Parameter Setting

Sr. No.	Parameter	Value
1	Swarm Size N	24
2	Inertia Weight	0.6
3	Number of iterations	2000

Calculation of premium is done and best premium payment option is determined using PSO algorithm in the experiment. The desired global best value for finding minimum/maximum premium is found from function named 'myInsuranceFunc' which takes two parameters. Parameter 1 is the calculated premium on choosing any one of the suggested options, whereas parameter 2 is the actual premium. The summary of statistics rendered which includes information about mean, standard deviation, min and max obtained for the value over all conducted tests is shown in table 3.

Table 3: PSO Experiment Statistical Information

Sr. No.	Variable	X stat	Y stat
1	Minimum	1	-5.3029e+111
2	Maximum	2000	-361.3589
3	Mean	1.0005e+03	-8.0902e+109
4	Median	1.0005e+03	-2.9853e+34
5	Mode	1	-2.7166e+14
6	Standard Deviation	577.4946	6.3365e+110

The algorithm is run a number of times to determine the consistency and uniformity of results due to the randomized nature of PSO. The results show the effectiveness of choice of parameters setting.

9. CONCLUSION

In this paper a study is carried out for various methods to slenderize insurance premium to be paid by insured. This paper has presented an extension of previous work by authors on determining the amount of insurance premium using a neuro-fuzzy system. The application of Particle Swarm Optimization strengthens previous method by bringing forth and raising better results in terms of optimized premium amount. The methodology introduced each for insurer and insured is believed to consider the most realistic situation for agreement called insurance policy between the two parties.

The suggested model is unmatched and novel in its approach as it has dual interface; one for the insured and the other for insurer. The model with two flip-sides is found to maximize the insurer profit for insurance policy collected in the form of premium and the same model has also resulted into minimizing the payment made for insurance policy in the form of premium. The system is relatively simple and elementary and supports creation of high-level buying-selling strategies.

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