Analysis of Stochastic Model and Life Insurance Premiums Allocation for Insurance Development in Indonesia

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Abstract. Indonesia has a very high level of disaster and accident prone. Based on state mortality risk data, one of the financial instruments capable of reducing the risk of death and helping victims and their families is life insurance. The life insurance business in Indonesia is quite large, starting from March 2017, the total assets of all insurance companies in Indonesia, both life insurance and general insurance, reached 981 trillion rupiah, with the distribution of 3.38% of sharia insurance assets and the rest non-sharia insurance. In writing this paper, it discusses the life insurance model using a stochastic process, especially for insurance without using savings. The method in this study uses a monte carlo insurance premium simulation with the processed data is data taken from the financial services authority in the form of Indonesian Insurance Statistics. Based on the review, it can be concluded that the coverage period and administrative costs are very influential in determining the portion of the premium that is included in the participant's savings. Period of coverage or proportion of administration is inversely proportional to portion of the premium that is put into customer savings and the investment situation does not really have an effect on the allocation of premiums for the participants.

Keywords: *Life Insurance; Monte Carlo; Simulation; Stochastic Model.*

1 Introduction

Indonesia is a developing country that is prone to disasters and accidents at a very high rate. Based on geographic location, Indonesia is traversed by Pacific and Mediterranean Circum which causes earthquakes in certain areas frequently and also accidents due to the population density increase. Based on the data and information about Indonesian disaster in 2016, the number of natural ones were 1985 which caused 522 people dying and 3.05 million people being displaced. In addition, based on accident data for the last 5 years, an average of 27000 people dying each year due to motorbike accidents [10]. Based on data from 2004 to 2015, the normal death rate for Indonesians is around 7.2-7.3 people per 1000 people each year. It means that if the total population in Indonesia is 260 million people, it is estimated that there will be approximately 1,872,000 people die every year [13]. If it happens to the head of the family so there will be impact both on emotional and financial conditions.

Based on the data above, life insurance is one of the financial instruments that is able to reduce the risk of death and help victims or their families. Insurance is an agreement, a person binds himself to an insured, the existing contract is called a policy. The main principle of life insurance is to collect funds in the form of premiums from its participants which are then used to overcome unexpected losses that experienced by the participants who were caused by accidents or died [12]. The life insurance business in Indonesia is quite large, starting from March 2017, the total assets of all insurance companies in Indonesia, both life insurance and general insurance, reached 981 trillion rupiahs, with the distribution of 3.38% sharia insurance assets and non-sharia insurance for the rest [11]. However, for life insurance, the number of users in Indonesia has only reached 11.8% of the population in Indonesia.

In this study, the focus is on life insurance. There are several reasons for choosing an insurance topic because insurance is very important to support participant finances. Another reason for choosing the topic is because it is needed more than the others so that it will be easier to implement the proposed strategies. In previous studies [1], [4], and [5] regarding insurance, it only discusses about the calculation of premiums with simple arithmetic both for products that use elements of savings and without savings [12]. In this research renewal is to calculate a model using a stochastic process, especially for insurance without savings usage.

2 Three Steps of Proposed Insurance Development Strategies

Related to the problems about insurance in Indonesia, the insurance development strategies in Indonesia proposed by the authors are as follows:

First Stage

The flow in the first stage of the proposed insurance development in Indonesia is as follows: Human Resources Input → Insurance Companies ←→ Indonesian Society. Based on data from Indonesian Actuary Association, the number of actuaries in Indonesia until 2016 is 400 people. Several colleges in Indonesia in the recent years are increasingly preparing mathematics/statistics graduates to become actuaries, but have not met the target.

Besides that, the quality of actuaries needs to be improved by carrying out various intensive studies. One of the problems that often arise in actuarial is determining the premium value and managing risk. A mathematical modeling that will be discussed in this paper is built to allocate funds for insurance companies, especially life insurance companies.

To increase public knowledge and awareness of insurance, especially life insurance, insurance companies need to conduct socialization and educate the public about the various insurance products offered and improve public financial literacy skills through CSR (Corporate Social Responsibility) and its agents. In addition, insurance companies need to improve the service commitment and public satisfaction in order to attract the unreached share of the life insurance market in Indonesia.

Second Stage

The flow in the second stage of the proposed insurance development in Indonesia is as follows: Government → Insurance Companies ←→ Indonesian Society ←→ Government. So far, insurance is less attractive to the public because premiums tend to be higher so that it is less attractive to the middle to lower class. A good insurance company should look at the market and segment the market, meaning that everyone should be offered according to their income. If their income is small, the premium paid is small and vice versa.

The role of the government in this stage is to provide subsidies to low-income people, so that the sum insured earned when he dies will be greater than expected, so that the families left behind can still meet their living needs at least for the next few years. Other subsidies can also be made between the upper middle class and the lower middle class. Some of the premiums paid by the middle to upper class can be used to help the middle to lower class, if needed, so that insurance can dominate the middle to lower market share.

Third Stage

The flow in the third stage of the proposed insurance development in Indonesia is as follows: Investors → Insurance Companies ←→ Indonesian Society. After successfully carrying out the second stage, it is hoped that the life insurance market in Indonesia will have a significant increase in the number of participants compared to the current number of participants. The increasing number of participants will attract investors to invest their funds in insurance companies. In addition, insurance companies are attractive to investors because of Indonesia's pyramid-shaped demographics, where the number of productive age (66.5% between 25 and 65 years) is more than the number of non-productive age (27.3% under 25 years and 6.2% over 65 years). That is, Indonesia has the potential to develop rapidly in the future because it has so many human resources compared to the developed countries which in fact already lack many resources, such as Japan and South Korea.

This will encourage insurance companies to expand beyond Indonesia, especially since the enactment of the AEC (ASEAN Economic Community) in 2015. Thus, it is hoped that the insurance market in Indonesia will not be controlled by foreign companies.

Life insurance companies in Indonesia can develop rapidly as the time goes by utilizing their own resources and attracting investors. In addition, the existence of advertisements regarding life insurance is also necessary to attract consumers and can form the public's mindset that insurance is a basic and important need because of the benefits it provides. The advertisements used can be in the form of television advertisements, social media and others.

3 Premiums for Indonesian Life Insurance Companies Allocation

Based on the data obtained, life insurance in Indonesia allocates premiums for administrative costs, participant savings, and special savings that are the same for every age, period of coverage, and investment situation. Mathematical modeling that will be reviewed in this paper is to evaluate the current insurance policies, where this modeling concludes that age and insurance period are very influential. As a result, life insurance companies need to update their premium allocation policies in order to benefit both life insurance companies and policyholders/participants.

Suppose a policy holder is registered at the age of x years with the coverage period of k years. Based on the insurance business process, the premium paid is used for administrative costs, customer savings, and special savings. Suppose the division is as follows:

- $\theta\%$for administrative costs
- $\omega\%$ for customer savings
- $(100-\theta-\omega)\%$ for special savings

From the description above, it can be interpreted that if the policyholder pays a premium of p, then $p\theta\%$ is an administrative fee, $p\omega\%$ is for customer savings and the remaining $p(100-\theta-\omega)\%$ is for special savings. For customer savings and special savings invested in the company, the insurance company benefits from the investment. The profits are then divided into those of the insurance company and those of the policyholders according to a certain proportion.

Suppose that the rate of return obtained by the participant in year$-t$ is r_t, it means that 1 piece of money at the beginning of year$-t$ will be $1+r_t$ at the end of the year$-t$. The profit earned by policyholders varies each year, adjusted to the

performance of the company where the insurance company invests so that it is $1 + r_t$ can be assumed to be *Brownian Geometry Motions* with *drift parameter* μ and variance σ^2. Obtained:

$$1 + r_t = e^{\mu - \frac{1}{2}\sigma^2 + \sigma Z_t}, Z_t \sim N(0,1).$$

Based on the life insurance business process with a savings element, if a person dies during the coverage period, the claim earned at the end of the year of death is as much as the money in the savings account with the amount of unpaid premiums, whereas if the person does not die until the end of the coverage period, that person gets as much money as the money in his savings account.

If the person dies at the age of $(x + t)$, then the savings at the end of the year are as follows:

$$p\omega\% \times \sum_{i=0}^{t} \left\{ \prod_{j=0}^{i} \left(1 + r_{t+1-j}\right) \right\},$$

while the unpaid premium is $(k - t - 1)$ payment, so the total claims obtained at the end of the year of death are:

$$a_t = p\omega\% \times \left[p(k - 1 - t) + \sum_{i=0}^{t} \left\{ \prod_{j=0}^{i} \left(1 + r_{t+1-j}\right) \right\} \right].$$

If the person dies at the age of $x + t$ years, the savings at the end of the year are as follows:

$$a_k = p\omega\% \times \left((1 + r_k) + (1 + r_k)(1 + r_{k-1}) + \cdots + (1 + r_k) \ldots (1 + r_1) \right)$$

Thus, the present value of claims earned by participants can be calculated as follows:

$$\left(\sum_{t=0}^{k-1} \frac{a_t \, {}_{t|}q_x}{(1 + r_1) \ldots (1 + r_{t+1})} \right) + \frac{a_k \, {}_n p_x}{(1 + r_1) \ldots (1 + r_k)} = p\omega\% \left(1 + \sum_{i=1}^{k-1} \frac{{}_i p_x + (k - i) \, {}_{i-1}q_x}{(1 + r_1) \ldots (1 + r_i)} \right),$$

$$\left(\sum_{t=0}^{k-1} \frac{a_t \, {}_{t|}q_x}{(1 + r_1) \ldots (1 + r_{t+1})} \right) + \frac{a_k \, {}_n p_x}{(1 + r_1) \ldots (1 + r_k)}$$

$$= p\omega\% \left(1 + \sum_{i=1}^{k-1} \frac{(k - i) \, {}_{i-1}p_x - (k - i - 1) \, {}_i p_x}{(1 + r_1) \ldots (1 + r_i)} \right).$$

Then, the premium value deposited by participants at this time can be calculated as follows:

$$1 + \sum_{i=1}^{k-1} \frac{{}_ip_x}{(1+r_1)\dots(1+r_i)}.$$

However, only $(100-\theta)\%$ of the premium is invested. So that in order to be optimum, the present value of the premium invested must be the same as the present value of the claim received by the participant, and we obtain the following equation:

$$p\omega\% \left(1 + \sum_{i=1}^{k-1} \frac{(k-i)\ {}_{i-1}p_x - (k-i-1)\ {}_ip_x}{(1+r_1)\dots(1+r_i)} \right) = p(100-\theta)\%\ 1 + \sum_{i=1}^{k-1} \frac{{}_ip_x}{(1+r_1)\dots(1+r_i)}.$$

From the equation above, it is found that the portion of claims which are deposited into the customer accounts can be calculated using the formula:

$$\omega\% = (100-\theta)\% \times \frac{P}{Q}$$

where

$$Q = 1 + \sum_{i=1}^{k-1} \frac{(k-i)\ {}_{i-1}p_x - (k-i-1)\ {}_ip_x}{(1+r_1)\dots(1+r_i)}$$

$$P = 1 + \sum_{i=1}^{k-1} \frac{{}_ip_x}{(1+r_1)\dots(1+r_i)}.$$

Because the value of $r_1, r_2, \dots, r_k$ are unknown, with an assumption that $1 + r_t$ is *Geometric Brownian Motion*, we will obtain the possibility about the value of r_t. By doing *Monte Carlo* simulation, the value of ω will converge towards a value. It means that an estimate value of ω can be obtained by using *Monte Carlo* simulation. Thus, the optimal distribution of premium allocations can be determined between customer savings and special savings.

4 Conclusion and Recommendation

In this paper, there are several stages as a strategy in developing and increase the attractiveness of insurance to the public. In the stage, quality input is needed, one of which is in determining premiums and allocating appropriate funds for insurance companies. The role of the government and investors is also very much needed so that insurance companies in Indonesia can develop and be able to answer the needs of the public. Mathematical modeling carried out in this paper produces an empirical equation that can be used as an alternative for insurance companies in allocating their funds properly, the age factor when registering, the period of coverage, and administrative costs are very influential in allocating premiums from participants, while the investment factor is not very influential. It is hoped that this paper can support actuarial development in the field of insurance, by using appropriate modeling supported by the data obtained. it is

also hoped that the insurance industry in Indonesia can develop properly and be able to offer better products than insurance companies in other countries. In addition, strategies and modeling in this paper can be developed further more so that it can be applied to both sharia and other insurance life insurance such as health insurance, education, pension funds, etc.

There are also recommendations as follows:

1. It is necessary to have cooperation between the government, universities, and investors in order to implement the several stages above. In this case, Indonesian Actuary Association has a very important role in establishing cooperation.
2. Researches on insurance needs to be carried out more intensively to realize the government's mission to make Indonesia as the center of economic studies in the world.
3. Research on determining premiums and risk management can be used as material in establishing regulations to regulate insurance in order to achieve insurance objectives.

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