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# Decreasing Classification Risk in Term Life Insurance Considering the Interest rate and Period of Contract

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## Abstract

Term life insurance is a type of life insurance policy that provides coverage for a certain period of time. If the insured dies during the time period specified in the policy and the policy is active, a death benefit will be paid. One of the basic problem in insurance company is that insurers cannot classify high level risk individual from low level risk individual and cannot offer different premium to each individual. Therefore, the aim of this study was to show how insurers can decrease risk classification and increase demand of low level individual for insurance. We used Mahdavi's model and it was expanded with contract duration, interest rate and individual's age parameters. We found that if contract duration or interest rate increases, demand for insurance and risk classification also increase. However, if age of the individual or cost of claim increases, demand for insurance decreases. In additional, when cost of claim goes up, risk classification declines

## Keywords

Term life insurance, Risk classification, adverce selecion, Risk aversion, Conventional theory, Interest rate.

## 1. Introduction

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Term life insurance is a type of life insurance policy that provides coverage for a certain period of time. If the insured dies during the time period specified in the policy and the policy is active, a death benefit will be paid. In term life insurance contract same as other type of life insurance, insurers involve with three important effects which include risk level, risk aversion level and asymmetric information. Risk level shows the histoty of involvment with risk. There are different risk level groups but for simplicity we assume that there are two groups of high risk individuals and low risk individuals. In life insurance, high level risk individuals does not pay attentoin to their health and also, some of these persons have had hiden dangerous diseases before the contract is executed. Risk aversion is the behavior of individuals regarding risk and uncertainty. Asymmetric information occurs when one party has more information from other party in one transaction. The subject of asymmetric information includes adverse selection and moral hazard. Adverse selection is related to characteristic of risk of agent. In life insurance, when insurers do not have any information about status of health and risk of policyholders, adverse selection occures. In other words, moral hazard explains action of agent. On the basis of conventional theory and adverse selection problem, mostly high level risk individuals purchase insurance and demand more but low level risk individuals demand less. The reason behind this purchasing is that the low level risk individuals realize that their mortality rate is low and they are subsidizing high level risk individuals so will be reluctant to insure, (Mahdavi. 2005).

However, in real word, this theory does not work. In 2006, Ghadir Mahdavi studied conventional theory and advantageous selection. He mentioned that the conventional theory ignores relationship between risk aversion and the level of riskiness. Also, he gave some examples and proved that the conventional theory does not work in reality. Furthermore, he demonstrated that low level risk individuals purchase insurance policy more than high level risk individuals in some conditions (Mahdavi & Rinaz. 2006). Different studies discussed the long term insurance and asymmetric information. In 1999, Volker studied why young agent postpones providing long term insurance contract until their retirement. He used two-period model without observation of moral hazard. He considered probability of surviving in the first period and proved that because of administrative costs, low probability of disability, young agents postpone providing long term insurance contact (Meier. 1999). In 2013, Bardey and De Donder introduced genetic test for long term insurance in condition of moral hazard and without moral hazard. The result showed that if cost of effort is low, genetic test will be done in condition of moral hazard (Bardey and De Donder. 2013). In 2017, Bourlès (2017), studied the two-period model in long term insurance contract under moral hazard and without moral hazard. In first period, agent can do some actions (for example exercising) in order to decrease his risk in second period. In fact, some agents will be low risk and some of them will be high risk in second period. These actions can be observable or not observable by insurer. He proved that by decreasing cost of effort, risk classification decreases (Bourlès. 2017). In 2019, S. Hun Seog and Jimin Hong found that life settlement may lead to an increase in the insurance demand and a decrease in financing costs. The insurer will have a higher profit when the decrease in financing costs or the increase in demand is sufficiently large (Seog and Hong. 2019).

A progression of field tests were led to assess the nature of guidance gave by life insurance specialists in India (Anagol et al., 2017). A novel procedure was created which would assist administrative specialists with building up an appraisal approach for interconnectedness in the worldwide reinsurance organization and help the execution of guarantor stress tests for default disease (Kanno. 2016). The variables that impact the improvement of extra security on the protection market are broke down and described (Melnychuk et al., 2019). A group of researchers tended to the hole identified with wide dissimilarity in dimensionality and structure of administration quality and adds to the discussion on whether the impact of administration quality on conduct goals is just roundabout or both immediate and backhanded (Gera et al., 2017). A strategic relapse model was utilized to explore the impacts of monetary education, monetary counsels, and data sources on life coverage interest. It was proposed that individuals with high monetary proficiency are bound to buy life coverage and that discussions with monetary counselors and discussions with relatives and companions are both decidedly connected with the interest for disaster protection (Lin et al., 2017). Rough information recovery systems and fluffy measures were utilized for investigating the collaboration consequences for monetary execution. This methodology is required to help guarantors to methodically improve their monetary exhibition (Shen et al., 2017). BWM is utilized to ascertain the model loads and TOPSIS to rank the other options. The arrangements discovered are steady with the genuine pieces of the pie of the insurance agencies (Akyüz et al., 2020).

Insurance company cannot classify high level risk individuals from low level individuals and offers different premium in each group. Therefore, we present a model with important factors in order to decrease classification of risk or demand for low level risk individuals to increase more. In this paper, we used Mahdavi's model but we expanded it with three important factors including age of individual, interest rate and contract duration. In next part, we introduce model and explain it in details. In second part, we give a numerical example in order to show what happens on demand of high level risk individuals and low level risk individuals if factors of the model change. In last part, we have conclusion.

## 2. Model

In our model, we assumed two different groups: a group of low level persons L who are assumed to be very risk averse with low probability of death, and a group of high level persons H who are assumed to be less risk averse with high probability of death. tp_x^i ,i∈{L,H},was defined probability of surviving of a person who has x years old and survives at least t years. tq_x^i, i∈{L,H},was defined probability of death of a person who has x years old and less than t years survival. We will denote e_i, i∈{L,H}, for the effort made by each group. This effort which was related to improving his or her health, for example, exercise, test, healthy food and so on. U_i, i∈{L,H}, represents utility function and we devoted a expersion with parameter a_i∈[0,1] for this utility function as following:

∀i ∈{L,H} ,∀ X ∈ R^+,U_i=X^(1-a_i ) (1)

We assume that individual has same behavior during the whole contract. It means that if a person is high level risk, this person will be high level risk in the whole contract. Probabilty of surviving tp_x^i= tp_x^ij (e) is increasing function with increasing of effort and risk aversion parameter a_i= a_i (e) is an increasing function of the effort e.We have these constraints as following:

$$e_H < e_L \quad (2)$$

$$0 < tp_x^H < tp_x^L < 1 \quad (3)$$

$$0 < e_H < e_L < 1 \quad (4)$$

Since insurance company can not divide customer in two risk groups, we devoted the same permium in each unit $q$.where $x_i(q), n, i'$ was defined by the amount of demand in each group, contract duration and interest rate. We assumed that the interest rate is constant in whole of the contract. Each group of individuals will maximize its own expected utility, and thus will solve the following problem:

$$\max_{x_i} EU_i = \sum_{t=0}^{n-1}(tp_x^i U_i(w_i + y_i - qx_i(1+i')^{-(t)}) + tq_x^i U_i(w_i + x_i(1+i')^{-(t+1)}))\qquad(5)$$

Subject to

$$x_i > 0;\ qx_i < y_i \qquad(6)$$

$$i>0 \qquad(7)$$

$$and\ x_i < y_i \qquad(8)$$

Where $w_i$ and $y_i$ , $i \in \{L, H\}$ , are respectively the initial wealth and expected income of each groups. Condition (5) represents the fact that policyholder can not sell insurance in period of the contract. Condition (6) explains that individuals are not willing to pay more than their expected income in premiums. Condition (7) shows that interest rate is positive. Last condition states that insurers will not allow policyholder to cover more than the maximum possible incurred loss. The premium $q$ should be less than one. Therefore, condition (6) is satisfied if condition (8) is satisfied. Equation (1) inserts to problem (5) and changes as following:

$$\max_{x_i} \sum_{t=0}^{n-1}(tp_x^i(w_i + y_i - qx_i(1+i)^{-(t)})^{1-a_i} + tq_x^i(w_i + x_i(1+i)^{-(t+1)})^{1-a_i})\qquad(9)$$

The first order condition (9) is as following:

$$\sum_{t=0}^{n-1}(qtp_x^i(1+i')^{-(t)}(w_i + y_i - qx_i(1+i')^{-(t)})^{-a_i} + tq_x^i(1+i')^{-(t+1)}\big(w_i + x_i(1+i')^{-(t+1)}\big)^{-a_i}\big) = 0 \qquad(10)$$

So, optimal demand for each groups is equal to:

$$x_i^* = \frac{\sum_{t=0}^{n-1}(k_t^i(q)\,(w_i+y_i)-w_i)}{\sum_{t=0}^{n-1} k_t^i(q)q(1+i')^{-t}[(i'+1)^{-1}+1]} \qquad(11)$$

Where

$$\left[\frac{tp_x^i}{tq_x^i} q(1+i')\right]^{\frac{-1}{a_i}} = k_t^i(q) \qquad(12)$$

Furthermore, insurance company wants to increase it's profit by obtainig premium. In this paper, we assumed this premium is obtained from policyholder at beginning of each year. Also, if policy holder dies, the benefit is paid to beneficiaries of policyholder at the end of the year. Since, survival of individual is probabilistic, we use expected present value of premium $q$, expected present value of benefit $x_i$ and expected present value of cost of claims C. Hence, insurance company wants to maximize this problem as following (Dickson et al., 2013).

$$\max_q \sum_{i=L,H}[\sum_{K=0}^{n-1} qx_i v^k kp_x^i - \sum_{K=0}^{n-1}(x_i+c)v^{k+1}kp_x^i q_{x+k}^i] \qquad(13)$$

Where

$$v = (\frac{1}{1+i}) \qquad(14)$$

We put optimal demand in problem (13) in order to maximize profit. So we have:

$$\sum_{i=L,H}[\sum_{K=0}^{n-1} (\frac{\sum_{t=0}^{n-1}(k_t^i(q)\,(w_i+y_i)-w_i)}{\sum_{t=0}^{n-1} k_t^i(q)q(1+i')^{-t}[(i'+1)^{-1}+1]})(qv^k kp_x^i\ \ v^{k+1}kp_x^i) - cv^{k+1}kp_x^i q_{x+k}^i]=0 \qquad(15)$$

And so, we have:

$$[\sum_{K=0}^{n-1} (\sum_{t=0}^{n-1}(k_t^L(q)\,(w_L + y_L) - w_L))(qv^k kp_x^i\, v^{k+1}kp_x^L) - (\sum_{t=0}^{n-1} k_t^L(q)\, q(1+i')^{-t}[(i'+1)^{-1} + 1])cv^{L+1}kp_x^L q_{x+k}^L] + [\sum_{K=0}^{n-1} (\sum_{t=0}^{n-1}(k_t^H(q)\,(w_H + y_H) - w_H))(qv^k kp_x^H\, v^{k+1}kp_x^H) - (\sum_{t=0}^{n-1} k_t^H(q)\, q(1+i')^{-t}[(i'+1)^{-1} + 1])cv^{k+1}kp_x^H q_{x+k}^H]=0 \quad (16)$$

See Figure 1 for an example of solving equation (16) graphically. For simplicity, we assume $tp_x^i$ is equal to:

$$tp_x^L = (0.99 - 0.005(x))^t \quad (17)$$

$$tp_x^H = (0.85 - 0.008(x))^t \quad (18)$$

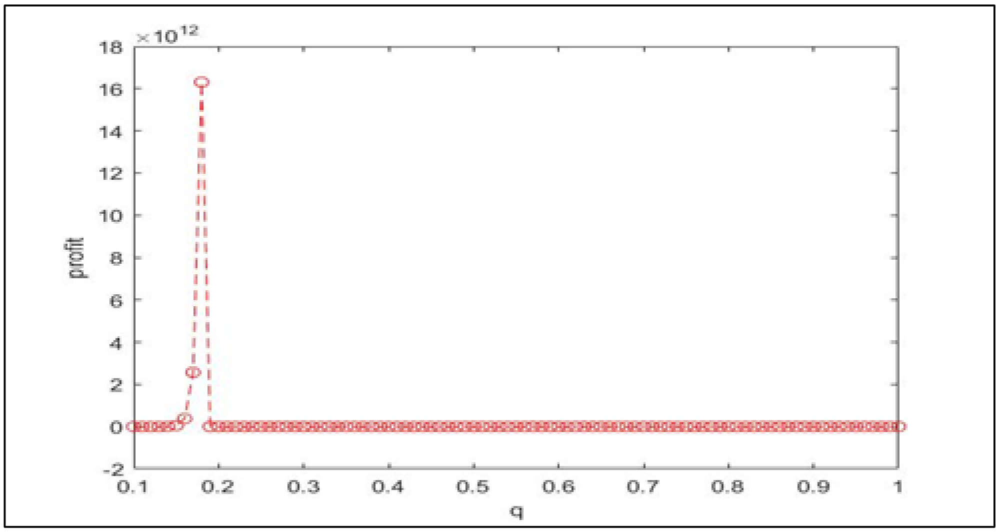


**Fig.1.** profit of insurer with different premiums

In Fig.1, profit of insurer when the parameters of two groups are as follows: $w_L = w_H = 0, y_L = y_H = 100, x = 20, n = 10, i = 0.01, c = 1, a_L = 0.9, a_H = 0.2$. So, optimal q is equal to 0.18. In next part, we gave a numerical example in order to show how changing contract duration, interest rate and cost of claim affect the demand of low level risk group and high level risk group.

## 3. Changing period of contract

In this part, we want to know what will be happen in demand insurance of each group of period of contract increases. Also, we change initial age of policy in order to show how it affects on demand of insurance. Therefore, we have plotted the optimal demand levels for both groups as well as the corresponding optimal pooling equilibrium price for 1000 units of insurance. For plotting Figure 2 and Figure 3, we gave number to parameters of model as follows: $w_L = w_H = 0, y_L = y_H = 100, x = \{20{,}40\}, n = [2{,}15], i = 0.1, c = 1, a_L = 0.9, a_H = 0.2$. So, Figure 2 and figure 3 show that with increasing duration of contract, risk classification increases more and more. The reason behind this result is the the high risk individuals know the probability of death increases as long as their age goes up. Therefore, insurer should execute short period contract. Optimal premium with increasing duration of contract was not changed much. With comparing Fig. 2 and Fig. 3, we found that demand of high level risk and low level risk group decrease with increasing age of individuals.

## 4. Changing interest rate

Here, we studied if interest rate increases how it affects on demand of two groups. For understanding this issue, we gave number to parameters of model as follows: : $w_L = w_H = 0, y_L = y_H = 100, x = 20, n = 10, i = [0.1,0.9],\ c = 1, a_L = 0.9, a_H = 0.2$. In Fig. 4, we found that if interest rate goes up, demand of both groups increase but demand of high risk group increases more. The reason behind this result is when interest rate goes up, the present value of premiums decreases and utility function for both groups increases. In addition, since probability of death for high risk group is high, the expected utility function for high risk group increases more than low level risk group.

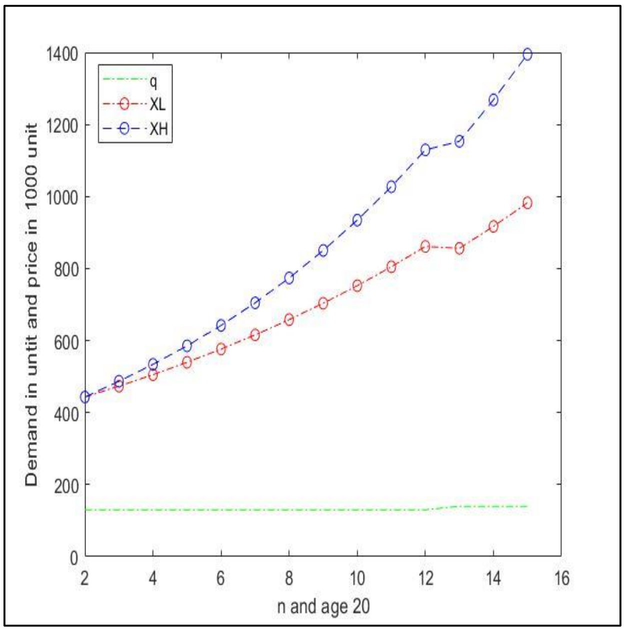


**Fig.2.** Demand insurance for each groups with different period contract (age=20)

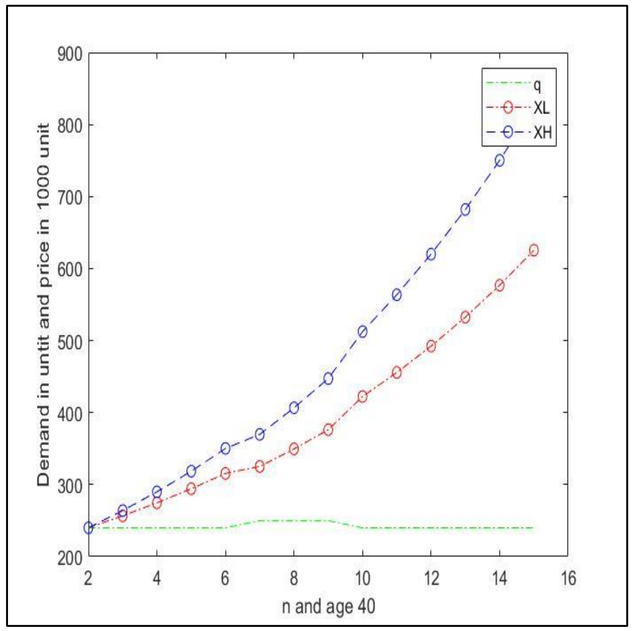


**Fig.3.** Demand insurance for each groups with different period contract (age=20)

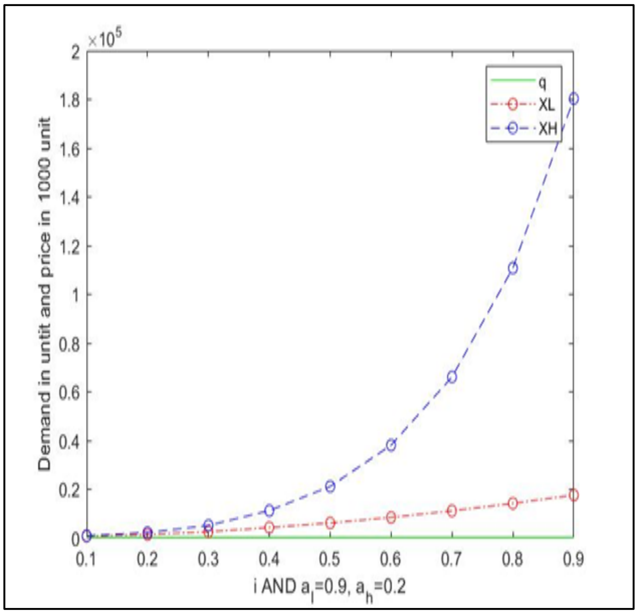


**Fig. 4.** Demand insurance for each groups Changing interest rate ($a_L = 0.9, a_H = 0.2$)

## 5. Changing cost of claim

In this section, we changed cost of claim insurance in order to find how it changes pattern of demand for both groups. Again, we gave number to parameters of model as follows: $w_L = w_H = 0, y_L = y_H = 100, x = \{25,35\}, n = 10, i = 0.1,\ c = \{1,200\}, a_L = 0.9, a_H = 0.2$. As you can see in Fig. 5 and Fig. 6, when cost of claim increases, demand of both groups decreases and also, demand of both group are close to each other. The reason behind this issue is that when cost of claim increases, the premium goes up, so expected utility funtion declines for both groups and also, demand decreases. In addition, because a large part of premium is related to the cost of claims, the demand of high risk group is close to the demand of low risk group. The other issue that we found by camparing Figure 5 and Figure 6 is that when age of individual increases along with cost of claims, the decreasing demand for both groups is more. The reason for this issue is when age of individual increases, then probability of death also increases and insurer have to get more premium for compensation of this risk. Therefore, that demand declines more.

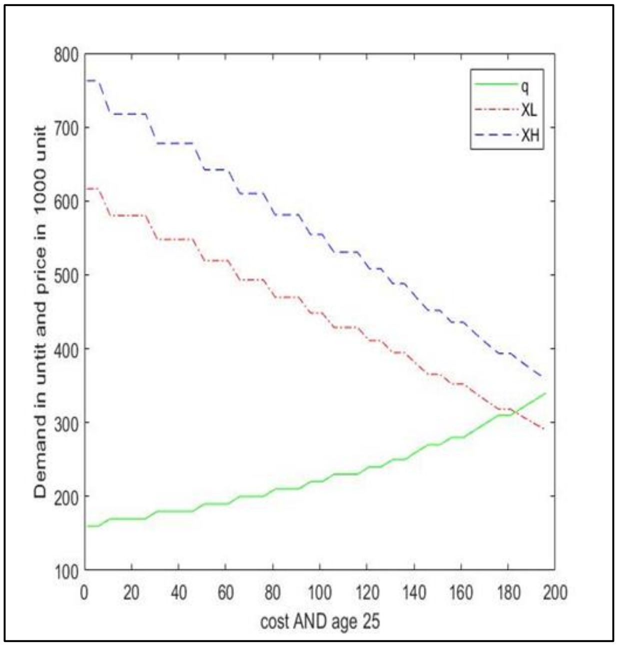


**Fig. 5.** Demand insurance for each groups with changing cost of claim (age=25)

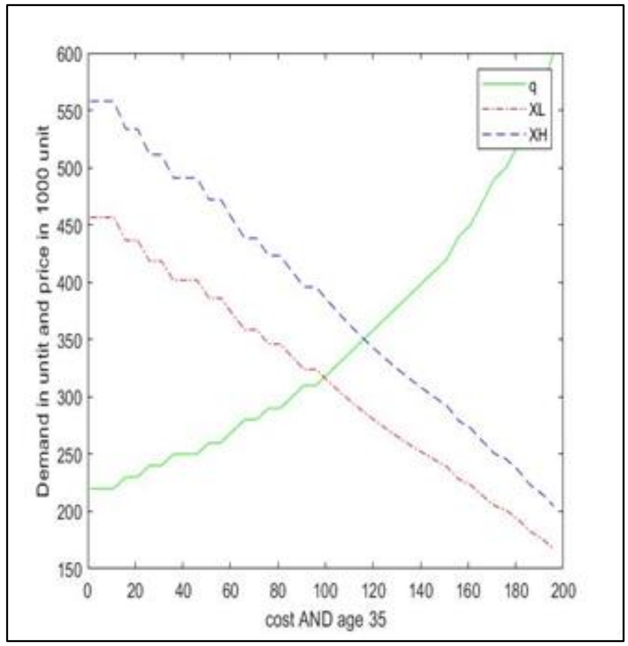


**Fig. 6**. Demand insurance for each groups with changing cost of claim (age=35)

## 6. Conclusion

The aim of this paper was investigating how interest rate, contract duration, cost of claim insurance and age of indiviual affect risk classification. Therfore, we added time period, interest rate and age of individual to the Mahdavi's model. We saw that when cost of claim increases, risk classification and demand of the insurance decreases. This result is same as result of Mahdavi & Rinaz. (2006). We found that when contract duration increases, the risk classification and demand for insurance also increase. Hence, insurance company have to execute short period contract as much as possible in order to declines risk classification. In pervious parts, we found that when age of individual goes up, the demand for insurane declines. Because probability of death increases with increment of the age, therefore, premium goes up and demand for insurance decreases. At end, when interest rate increases, risk classification and demand for insurance also increases.

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