SURRENDER EFFECTS ON POLICY RESERVES: A SIMULATION ANALYSIS OF INVESTMENT GUARANTEE CONTRACTS

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ABSTRACT

The assumption of dynamic lapse behavior is path-dependence related to the performance of underlying assets. This causes the pricing and reserving of investment guarantee products to be more difficult to deal with. The lack of actual experience of such policyholders' behavior is also an essential problem when launching such guarantee products. The purpose of this paper is to attempt to measure the impact of dynamic surrender assumptions on policy reserves of investment guarantee contracts. We consider a single-premium version of a variable annuity, deducted periodically by a fixed percentage of policyholders' account as margin offset, with six-year deferred maturity benefit. This deferred maturity benefit is a kind of investment guarantee. Utilizing two dynamic policyholders' lapse formula suggested by American Academy of Actuaries and the Swiss Reinsurance company, the simulation results show markets condition assumptions have a tremendous effects upon the magnitude of reserves. This implies that it is a crucial part of risk management considerations for such products. Reserves adequacy testing is necessary when market condition shifts dramatically. The numerical implementation of the simulation results allow us to identify some comparative statistical properties and to identify the appropriate reserving routine of variable annuity with investment guarantee.

JEL: G22; C50

KEYWORDS: Policyholders' Behavior; Dynamic Lapse; Variable Annuity; Guaranteed Minimum Accumulation Benefit (GMAB)

INTRODUCTION

An accurate analysis of policyholder behavior is one of the main challenges in the business of investment guarantee products. Surrender behavior of policyholders, also called lapse, happens if the premium is not paid by a policyholder within a grace period. From a conventional viewpoint, there are several reasons why life insurance business actively seeks to encourage timely premium payment. First, surrendering policies makes the insurance companies unable to fully recover their initial acquisition expenditures. Second policyholders who have poor health tend to lapse less than the healthy ones. More voluntary termination of healthy policyholders worsens the adverse selection issue. Under such circumstances insurance companies receive more claims and incur more losses than expected. Third, insurance companies face a liquidity constraint due to early surrender. They are forced to adopt a short term investment strategy which generates lower returns to meet surrender demands. During the early 1980s, most U.S. life insurance companies suffered from disintermediation resulting from the negative cash flows and excessive surrenders. Focused on traditional insurance products, many previous researchers note that lapse rates have a substantial effect on life insurance prices (e.g., Albizzati and Geman, 1994).

This study uses investment guarantee products as example to describe the relationship between policy reserves and surrender behavior. Policy reserves which are the largest liability item on the balance sheet are critical to risk management and solvency of life insurance companies. The uncertainty in reserves arises from uncertain cash flow which are contingent upon factors like mortality, disability, and early surrender. In actuarial practice, calculation of GAAP reserves and Canadian statutory reserves require two decrements with use of mortality and rate of surrender. The challenge arises when these contracts contain provisions which allow the policyholder to surrender the policy early at his discretion. The policyholder's option to demand the policy's cash value at any time before policy termination can have considerable impacts upon life insurers. Consequently, the accurate modeling of lapse behavior becomes crucial to valuation. However, pricing this kind of surrender option is difficult as it involves modeling lapse decisions which may be contingent on market conditions. Furthermore, the fact that policyholders may not act rationally make modeling policyholders behavior more ambiguous.

The objective of this study is to construct a simulation analysis to explore the effect of dynamic surrender behavior on policy reserves. The paper is organized as follows. In Section 2 we discuss earlier relevant studies about modeling surrender effects, most focused on traditional insurance products. Next, taking a pseudo case of variable annuity with investment guarantees, we consider two dynamic lapse functions to model dependencies between lapse behavior and market conditions which could explain how the lapse decisions can be linked to market innovations. In Section 4 we present numerical results of policy reserves under various combinations of market conditions which clearly demonstrate the importance of modeling such relations. Section 5 we conclude the paper and provide some suggestions for further studies.

LITERATURE REVIEW

Despite the importance of policy surrenders, most insurance companies do not have reliable surrender models and have not yet tracked or organized their lapse data in a manner that allows them to accurately predict surrendering dynamics (Santomero and Babbel, 1997). The classic survey of Richardson and Hartwell (1951) is the first study to consider the relationship between surrender behavior and macroeconomic effects. They note that termination behavior in later years have more severe economic impact than the first two policy years since it accumulates more cash values as policy matures. For empirical models, Outreville (1990) finds consistent support for the relationship between unemployment and surrender behavior in both the United States and Canada. Similar results are found by Kuo et al. (2004) and Kim (2005). Furthermore, higher lapse rates also erode benefits of the remaining policyholders. Carson and Dumm (1999) find that insurance companies with higher surrender rates end up offering products with poor performance. Policyholders who carry participating policies would get lower bonuses when the lapse rate rises dramatically.

For traditional products, the forms of dependencies of the lapse decision on the current interest rate are intuitively obvious. The interest rate hypothesis, which says that higher interest rates will be a strong incentive for policyholders to lapse, has emphasizes on the arbitrage needs of policyholders at time of higher interest rates. (Schott, 1971; Pesando, 1974) When the market interest rate is lower than the policy credit rate, policyholders are not supposed to exercise surrender options because the fixed credit rate provision is valuable. When the interest rate is higher than the credit rate, policyholders should surrender their policies to take advantage of the higher-yield alternatives in the financial markets. Such interest-rate-induced surrender induces a serious ALM problem. Interest-rate-induced surrender and prepayment of assets raise the sensitivity of duration mismatch between assets and liabilities. When the interest rate goes down, so does the surrender of liabilities, but the asset prepayment rate stays high. In this case the duration of liability cash flows increases, but that of asset cash flow decreases and causes a mismatch problem.

Grosen and Jorgensen (2000) assume that policyholders optimally exercise their surrender options in accordance with changes in the interest rate. They also demonstrate that the surrender option would account for more than 50% of the contract value if exercised optimally with changes in the interest rate. However, policyholders may not act in an optimal way to lapse depending on interest rate movements.

Based on an empirical model of lapse rates rather than theoretical optimal interest-rate-induced surrender, Tasi et al. (2002) incorporate early surrender into the distribution estimation for policy reserves. They find that early surrender reduces the risk for policy reserves due to surrenders in low interest rate periods. Their findings also imply that minimizing the lapse rate might not be optimal because early surrender could benefit insurers in reducing the risk of reserves, which is different from the conventional view.

Compared with traditional insurance products, surrender effects become more explicit for investment products because insurance companies directly provide protection of underlying funds rather than a pre-specified insurance amount. Capital market risk is not diversifiable as insurable risks. The dynamic lapse behavior due to market innovation, which is more critical than an implicit interest-rate-induced surrender mentioned above, become a crucial part of pricing and reserving issues for such products. Such a guarantee breaks the boundary between derivative and traditional insurance product and requires blending financial engineering and actuarial techniques. Dynamic lapse behavior path-dependency is similar to MBS prepayment on the asset side. This implies that the time of contract termination is not independent of market movement. Kolkiewicz et al. (2006) illustrate a marked point process approach by presenting a general framework for valuation of unit-linked products where terminations can be either due to death or caused by stochastic volatility of the underlying fund. They indicate that there was a strong relationship between insurance price and lapse behavior. In this study, we perform a simulation analysis to portray the surrender effect upon policy reserves under various market conditions. We consider a basic form of variable annuity. Specifically we consider a short-term annuity with a single premium paid at time zero. Only Guaranteed Minimum Accumulation Benefit (GMAB), which is a kind of living benefit at maturity date, has been discussed in this study.

CALCULATION OF POLICY RESERVES

The method to calculate policy reserves is presented in this section. To simplify the analysis, the only stochastic component in our analysis is the projections of underlying fund portrayed by standard geometric Brownian motion:

$$ds_t = \mu dt + \sigma dz \qquad (1)$$

where represents the underlying fund in policyholders' account balance. We assume the initial value of the underlying fund is 100 and a maturity guarantee, K, equal to 110:

$S_0 = 100$, and $K = 110$

The next step is to calculate the present value of the accumulated deficiency at each date. The accumulated deficiency at each date is determined as the negative of the net accumulated asset amount, which includes premiums received minus any benefits incurred during the coverage period. In this study, the only existing policy benefit is the maturity benefit and no death benefit (GMDB) implying that there would be only negative accumulated deficiency before maturity. In practice, mortality risk is much easier to manage by pooling large numbers. Living benefits are much more challenging such as our maturity benefit in this study.

Present value of accumulated deficiency, $PV_t(AD)$, at date t' could be shown as follows $PV_t(AD) = -\sum_{t=0}^{i-1} cS_t(1-c)^t \, {}_t p_x^{(t)} v^t \quad \forall t^t < T$ and

$$PV_i(AD) = (K - S_T(1-c)^T)^+{}_T P_x^{(t)} v^t - \sum_{t=0}^{T-1} cS_t(1-c)^t\, p_x^{(x)} v^t \text{ for } t^t = T \tag{2}$$

where T represents the maturity date and c represents margin offsets. According to the actuarial equivalence principle, the margin offsets, c, has to be set to satisfy the following equation:

$$E_Q[(K - S_T(1-c)^T)^+{}_T p_x^{(x)} v^T] = E_Q[\sum_{t=0}^{T-1} cS_t(1-c)^t{}_t p_x^{(x)} v^t \tag{3}$$

For each projection, we have to find out the largest present value of accumulated deficiency for each date t, $GPVAD^{(i)}$, as the scenario reserves:

$$\mathrm{GPVAD}^{(i)} = \max\{\mathrm{PV_t(AD)}^{(i)} |\ t = 1,2,...T\} \quad \text{for each projection i} \tag{4}$$

In this study, the simulation analysis generates 100,000 paths for the underlying fund which means there are 100,000 projections (i=1, 2… 100,000). Finally, the policy reserves for an x-year-old policyholder, ${}_0\mathrm{V}_x$, is derived by averaging the highest 35% of scenario reserves, which is the CTE (Conditional Tail Expectation) measure at 65%.

Assume that policyholders have two contingencies: death and surrender. The survival effects in equation (2), ${}_tP_x^{(x)}$, is composed of mortality and surrender effects:

$${}_t p_x^{(\tau)} = (1 - {}_t q_x^{(d)})(1 - {}_t q_x^{(e)}) \tag{5}$$

where ${}_tq_x^{(d)}$ represents the mortality effect and ${}_tq_x^{(l)}$ represents the surrender effect. The surrender problem is essential in running an insurance business hence modeling the surrender behavior properly is a crucial task.

The surrender effect, ${}_tq_x^{(l)}$, in which we are interested, is expressed as a base lapse rate multiplied by a specified lapse multiplier λ_t:

$${}_{t|}q_x^{(e)} = {}_{t|}q_x^{(e)base} \lambda_t \tag{6}$$

The base lapse rate, ${}_tq_x^{(l)base}$, is usually constructed by insurance company's own experience. In this paper, we use two different lapse multiplier formula constructed by American Academy of Actuaries (AAA) and Swiss Reinsurance Company (Swiss Re) separately:

AAA model:

$$\lambda_t = \min\{1, \max[0.5, 1 - 1.25 * (ITM_t - 1.1)]\} \tag{7}$$

Swiss Re model:

$$\lambda_t = \min\{1.2, \max[0.2, (ITM_t - 1) * e^a]\}$$

where $a = 1$ when $ITM \le 1$, and $a = 0.22$ when $ITM \le 1$ (8)

and $$\text{ITM}_t = \frac{AccountValue_t}{GuaranteeValue_t}$$

In-the-moneyness (ITM) formula, which is the ratio of account value to guarantee value, are used to describe the degree of "moneyness" for investment guarantee. As ITM increases, surrender rates fall, as the value of the guarantee becomes significant to more policyholders. Notice that the guarantee value at each date is used for any cash out flow at each date such as GMDB. In our case, we determine guarantee value at each date as the present value of maturity benefit at each date. This implies interest rate movement is inherent. In the next section, policy reserves are calculated for various combinations of market conditions as well as some comparative static properties are tackled.

NUMERICAL ILLUSTRATIONS

In this section discuss reserves effect of variable annuity with investment guarantees in different market conditions. The relation of expected return and volatility is utilized to describe various market conditions. As mentioned above, the lapse rate of variable annuity with investment guarantees could change when market conditions shift. And, the surrender effect is affects the policy reserves of variable annuity with investment guarantees. In order to describe the relationship between market conditions, lapse behavior, and the policy reserves, this research uses two type dynamic lapse models: AAA dynamic lapse model and Swiss Re dynamic lapse model. These two dynamic lapse models have a similar framework, however, the models have discrepancy between parameter sensitivity. It helps to understand the influence of the lapse rate when market conditions shift.

This research analyzes the policy reserves of a single premium six-year variable annuity with maturity investment guarantees. We assume that all the policy of prospects account values is $100 initially without any cash surrender charge. There is an addition rider GMAB guarantee that the investor could get minimum 110 dollar account values at the expiration date. This research considers a 45 years old with no sex distinction. To simplify the subject, the discounting procedure in this analysis utilizes a determined term structure at a specific date rather than projecting a series of short rates. Yield curve data in March, 2009 is utilized for discounting purpose. Further, we must determine an appropriate margin offset, to satisfy equation (3). The margin offset is set to be 252 bps by specifying Monte Carlo simulation. The following are the summary of relevant parameters used.

Table 1: Summary of Assumptions

Initial account value: $100				**Surrender charge: $0**		
Minimum maturity benefit: $100				**Margin offset: 252 bps**		
Policy year	1	1	2	3	4	5
Base lapse rate	2%	2%	3%	5%	5%	5%
Mortality rate	0.241%	0.241%	0.263%	0.282%	0.298%	0.319%
Yield rate	0.67%	0.67%	0.98%	1.36%	1.62%	1.87%

Note: This table shows the assumptions utilized for simulation in this paper.

The performance of the underlying fund will affect the accumulate rate of account value. If the underlying fund performs well, the accumulate rate of account value will increase faster. If the accumulate rate of account value is over the original account value in the short time, the policyholders will rescind ahead of time, and apply the cash surrender value. The reserves for future risk in an ordinary insurance company might be reduced. To measure the lapse effect on reserves, we firstly calculate the slope between each adjacent pair of cells in the following tables. For each level of μ and σ, we average out the slopes as the sensitivity measure, $\frac{\partial_0 V_x}{\partial \sigma}$ and $\frac{\partial_0 V_x}{\partial \mu}$, separately. Table 2 and Table 3 show the policy reserves in two different dynamic lapse models.

Figures provide clearer descriptions of the findings in Table 2 and Table 3. Figure 1 shows that at the same level of volatility, if the expected returns of underlying funds is high, the reserves is lower. We also find if expected returns higher the trend will get smoother. It means, when volatility increases one unit, if the expected returns of underlying fund is high, the policy reserves will reduce. One the other hand, if the expected returns of underlying funds are lower, the reserves will increase.

Table 2: Policy Reserve of AAA Dynamic Lapse Model

μ σ	0.05	0.1	0.15	0.2	0.25	$\frac{\partial_0 V_x}{\partial \sigma}$
0.1	4.99	4.64	4.19	4.14	3.86	-4.53
0.2	5.76	5.31	4.76	4.65	4.46	-5.22
0.3	6.50	5.89	5.65	5.26	4.88	-6.50
0.4	7.40	6.74	6.39	5.90	5.40	-7.98
0.5	8.23	7.55	7.02	6.51	6.07	-8.65
$\frac{\partial_0 V_x}{\partial \mu}$	6.48	5.81	5.66	4.73	4.42	

Note: This table describes policy reserves estimate when using AAA dynamic lapse model. When expected return gets higher, the policy reserves estimates gets lower because it becomes less risky. On the other hand, when volatility go higher, the policy reserves estimates gets higher because it becomes more risky.

Table 3: Policy Reserve of Swiss Re Dynamic Lapse Model

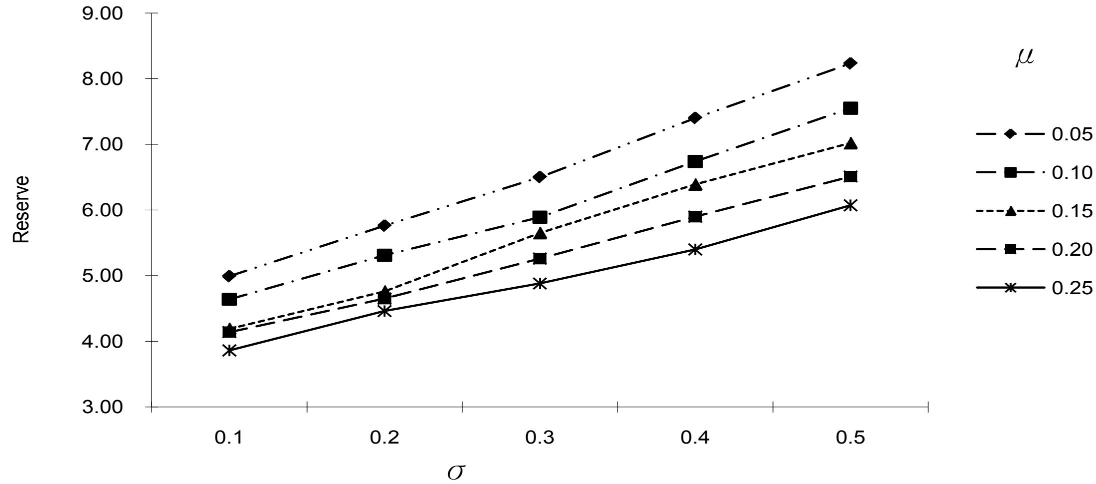
μ σ	0.05	0.1	0.15	0.2	0.25	$\frac{\partial_0 V_x}{\partial \mu}$
0.1	5.03	4.52	4.36	3.89	3.79	-6.19
0.2	5.55	5.16	4.81	4.58	4.24	-6.52
0.3	6.32	5.98	5.63	5.26	4.77	-7.78
0.4	7.41	6.79	6.28	5.86	5.40	-10.06
0.5	8.24	7.68	7.02	6.52	6.03	-11.04
$\frac{\partial_0 V_x}{\partial \sigma}$	8.02	7.90	6.65	6.58	5.60	

Note: This table describes policy reserves estimate when using Swiss Re dynamic lapse model. When expected return gets higher, the policy reserves estimates gets lower because it becomes less risky. On the other hand, when volatility go higher, the policy reserves estimates gets higher because it becomes more risky

In Figure 2, we also find at the same level of volatility, if the expected returns of underlying funds are higher, the policy reserves will reduce. Higher expected returns make the trend smoother. This implies that, when expected returns is higher, the influence of volatility on the reserves is smaller.

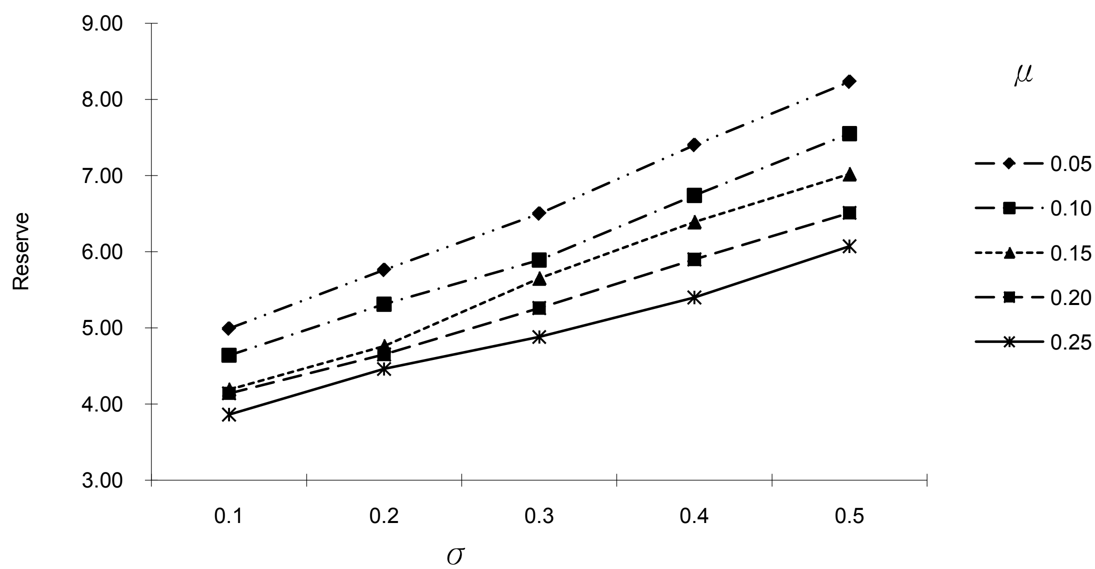
High volatility of the underlying fund means that the performance of the underlying fund has instability as well as higher risk. The account value of a variable annuity with investment guarantees is associated with the performance of the underlying fund. If the performance presents well, the accumulated account value will increase. The insurance company which issued the variable annuity with investment guarantees assures quota reward guarantees. Therefore, the insurance company has damage risk. This research assumes that investors could receive at least 110% of the premium (capitalization) when the policy expires. If the account value reduces to the original capitalization 110%, the insurance company shouldbe able to afford this damage. So the risk of volatility will affect the policy reserves.

Figure1: The Relationship between the Volatility and Reserves under AAA Dynamic Lapse Model



This figure describes policy reserves estimate in Table 2. Every path denotes policy reserves under different level of expected return. When volatility goes higher, the policy reserves estimates gets higher.

Figure2: The Relationship between the Volatility and Reserves under Swiss Re Dynamic Lapse Model

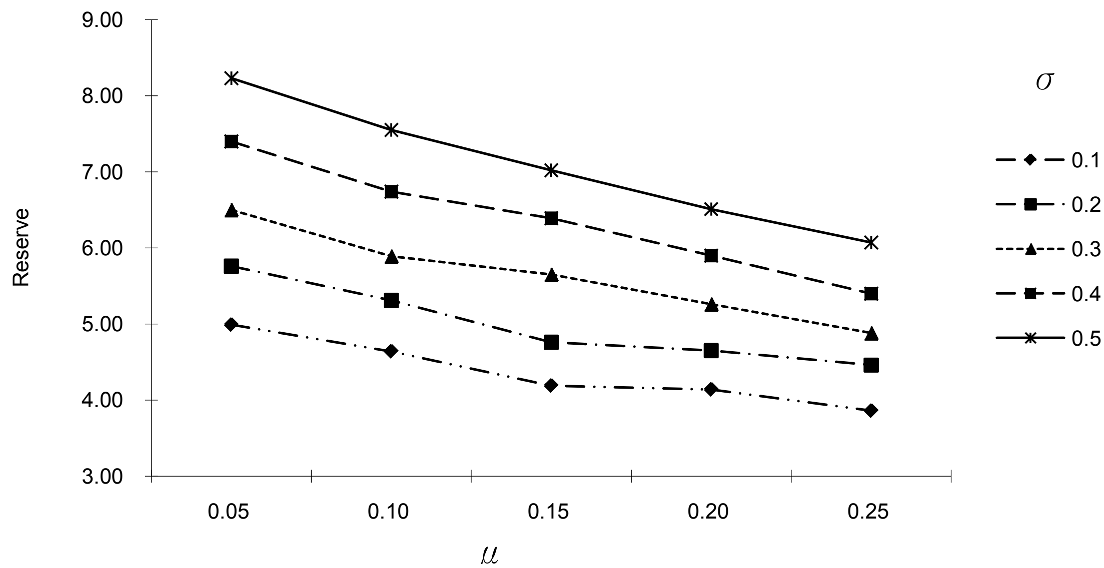


This figure describes policy reserves estimate in Table 3. Every path denotes policy reserves under different level of expected return. When volatility goes higher, the policy reserves estimates gets higher.

We also find the opposite relation between expected returns and reserves from Figure 3. If the underlying fund performs much better, the policy reserves will reduce. This relationship is similar to the one between expected returns and reserves. With the same expected returns, when volatility increases, more reserves are required. This implies, the risk of the underlying fund is high. Thus, it need more reserves at the same level of expected returns. We find that the lower the volatility, the smoother the trend presented. Figure 4 shows the results of the Swiss Re dynamic lapse model is similar to the AAA dynamic lapse model. It shows an opposite relation between reserves and expected returns. Higher expected returns of underlying fund require fewer reserves. At the same level of expected returns, higher volatility of underlying funds need more reserves. At different expected returns, the lower the volatility of the underlying fund, the smoother the trend presented. It means that increases in each unit of expected return could require fewer policy reserves.

In Figure 3, we also could find the kinked phenomenon with the returns volatility and reserves. Consider the expected return, 0.15, as a benchmark. The left side of the line is steeper than the right side. The kinked phenomenon of reserves become clearer when volatility gets lower, and gets smoother at high return volatility. This implies, at different levels of volatility, changing expected returns have different influence on reserves. Therefore we know that there exists interaction effects between both variables. To sum up, when the volatility of underlying funds and expected returns are small, adding each unit of expected returns, the required reserves have substantial space to decline. In contrast, if the volatility of the underlying fund and expected returns gets higher, than adding each unit of expected returns gives reserves less space to reduce. Although we can find this phenomenon in the AAA dynamic lapse model, as shown in Figure 4, the Swiss Re dynamic lapse model does not show an obvious kinked phenomenon. It might mean that, in the Swiss Re dynamic lapse model, links between return volatility and reserves are more progressive than in the AAA dynamic lapse model, so it is not as sensitive to different changes of relevant variables.

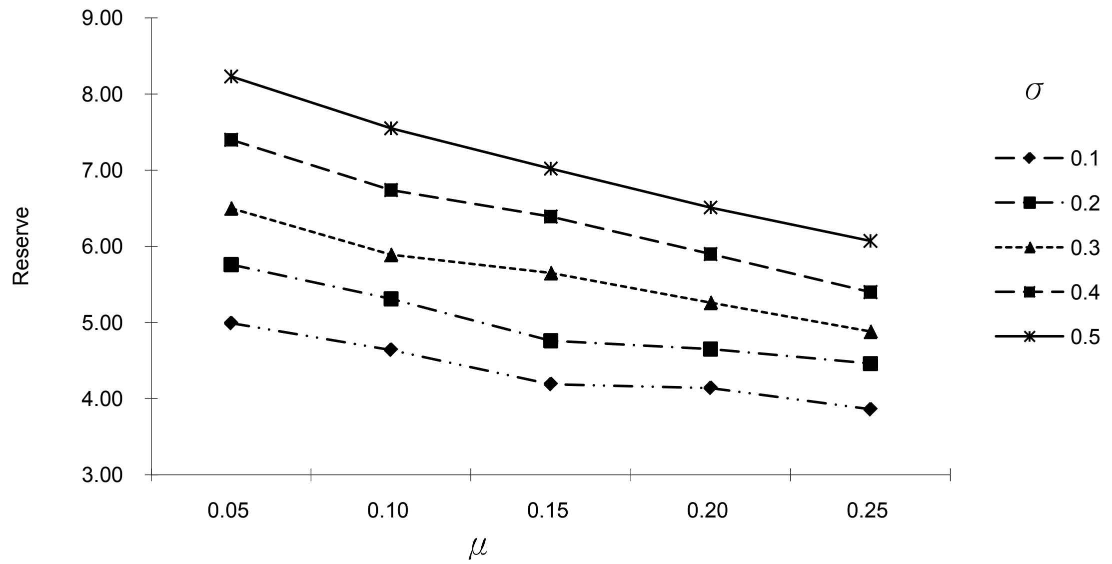
Figure 3: The Relationship of Expected Returns and Reserves under AAA Dynamic Lapse Model



This figure describes policy reserves estimate in Table 2. Every path denotes policy reserves under different level of volatility. When expected return goes higher, the policy reserves estimates gets lower.

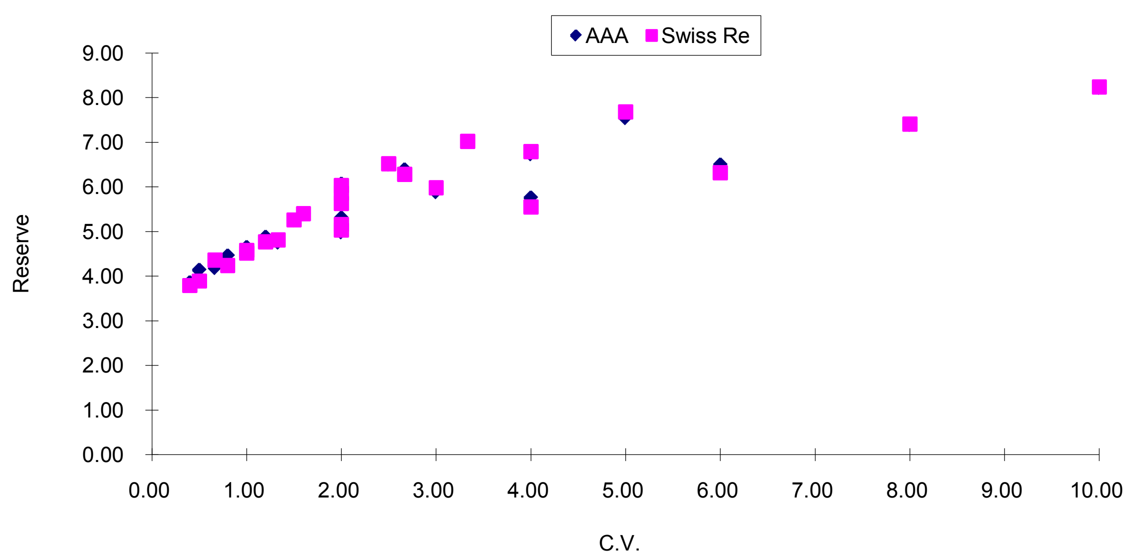
Finally, we examine the relationship between the coefficient of variation and policy reserves. As noted above, we find a positive relationship between reserves and volatility and a negative relationship between reserves and expected rate of return. When policyholders decide their choice of investments, they usually would generally consider both return expectations and volatility. Therefore it is necessary to understand the impact of reserves taking into account both the volatility and expectations of return. The kinked phenomenon discussed previously implicitly revealed the importance of taking into account the two variables. The coefficient of variation is used to simultaneously consider these two variables. Figure 5 shows the coefficient of variation and reserves relationship graphics. The coefficient of variation is positive between the policy reserves, which means that when the underlying fund has a greater coefficient of variation, the required reserves are increasing. At a similar coefficient of variation level, the reserves requirement shows little difference between the two dynamic lapse models. In addition, we take the coefficient of variation of 2.0 as the benchmark thereby dividing the graph into two parts. The results show that less fluctuation on left side of the graph. But, the right side shows larger fluctuate in the level of reserves requirements. This implies that when the coefficient of variation gets smaller, the variation of reserves requirements is smaller. In contrast, if larger coefficient of variations are present reserve requirement have greater fluctuations.

Figure 4: The Relationship of Expected Returns and Reserves under Swiss Re Dynamic Lapse Model



This figure describes policy reserves estimate in Table 3. Every path denotes policy reserves under different level of volatility. When expected return goes higher, the policy reserves estimates gets lower.

Figure5: The Relationship between the Coefficient of Variation and Reserves



This figure denotes two kinds of policy reserves (both AAA and Swiss Re) under different level of coefficient of variation. Policy reserves will go higher when coefficient of variation goes higher.

CONCLUSIONS

The value of investment products is connected with the performance of underlying funds and have an impact on the amount of reserves. This research utilizes two types of dynamic lapse models, which are frequently used in the insurance industry, to identify the impact of changing market conditions on reserves. Not surprisingly, the study finds a positive relationship between volatility and required policy reserve, and negative relationship between expected return and required policy reserve. However, at the fund selection time, policyholders likely consider both expectations returns and volatility. To take into account both the expected rate of return and volatility the coefficient of variation is calculated. We find positive relations between coefficient of variation with policy reserve. The greater the coefficient of variation, the more required reserves. Also, when the coefficient of variation is bigger, each unit change in the coefficient of variation implies larger variation in policy reserves than when the coefficient of variation is smaller. The numerical implementation of the simulation results allow us to show some comparative statistical properties of reserves and to address the problem of suitably reserving these investment products.

In this study, a pseudo six-year variable annuity with investment guarantees is taken as research example. Taking into account the general insurance policy with longer period, possible fluctuations in the account value and volatility might be increased enormously because the longer insurance period affects the amount of reserve requirements. In addition, this study uses a relatively simple GBM model to describe market conditions. Future research may consider more complex models such as the RSLN or SV models. Finally, this study considers only the assurance mechanisms in the maturity date, however in the real world, most insurance policies are accompanied by the death guarantee (GMDB). Investment guarantees are paid at the death thereby increasing the insurance company uncertainty.

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