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Exchange Option Pricing Approach to Deposit Insurance Premium for Korean Life Insurance*

교환옵션가격결정모형에 근거한 예금보험료 합리화 방안에 관한 연구: 생명보험업을 중심으로

Jooho Sung**·Daehwan Kim***·Donghwa Lee****

This paper aims to investigate the risk-based premium rates of the Korea Deposit Insurance Corporation (KDIC), particularly focusing on life insurance firms. To accomplish this, we employ the exchange option model based on the assumption that assets and liabilities follow lognormal diffusion processes. Further, we incorporate the discount rate of expenses based on a purchase-and-assumption to consider the characteristics of the life insurance sector. To estimate premium rates between 2010 and 2017, we use the empirical data of Korean life insurance firms and asset indexes from 2000 to 2016. The result provides evidence that life insurance companies in Korea have been generally charged higher premium rates than they should be charged. The result also shows that most of the healthy life insurance companies aid a smaller number of risky companies in Korea. Finally, our result indicates that premium rates tend to be more sensitive to correlation between assets and liabilities under capital deficiencies.

Key words: Deposit insurance scheme, Risk-based premium, Option pricing model, Life insurance industry
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* This paper was supported by the Deasan Shin Yong Ho Memorial Society.
** first author: Professor in School of Management at Kyung-Hee University (jhsung@khu.ac.kr)
*** co-author: Associate Professor in Department of Economics at Dong-A University (kimdh@dau.ac.kr)
**** corresponding author: Ph.D. student in School of Management at Kyung-Hee University (ldhc9@khu.ac.kr)
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I. Introduction

As in many nations that have experienced a financial crisis, deposit insurance has attracted an increasing amount of attention in Korea. When the government set a premium rate for Korea Deposit Insurance Corporation(KDIC) in the Depositor Protection Act of 1997, it had neither experience nor data to offer a guideline regarding an appropriate premium rate. Although the rates have been subject to several adjustments, questions have been raised regarding the fairness of current deposit insurance premium rates. The main criticism is that the KDIC has not considered a risk-based premium rate. Park and Park(2014) argued that due to complex political issues as well as the huge costs involved in analyzing risks, a risk-based premium rate is not easy to practically implement.

Deposit insurance premium rates have been periodically revised since 1997(see table 1). At the beginning of the scheme in 1997, premium rate levels were kept relatively low in order to relieve the financial burden of companies. After the Asian financial crisis, however, the premiums were significantly increased, as massive government investments were injected to revive financial institutions. The biggest increase in premium rates occurred in 2000, through which the premiums were doubled for every financial sector. The premium rates have decreased since 2009, except for the mutual savings banks sector, which experienced a recent financial crisis in 2011. Although the KDIC has continuously attempted to set fair premium rates, questions have been raised regarding the methodology used for calculating the premium rates. In reality, the trend of historical premium rates shows that they have decided based on policy judgements rather than a risk-based valuation. Further, the KDIC has not considered the characteristics of each financial sector when deciding

premium rates, even if they charge differentiated premium rates for each financial sector.[1] Moreover, insurance premium rates have been unchanged since 2009, despite various changes in a financial environments.

〈Table 1〉 Historical Deposit Insurance Premium Rates for Each Financial Sector

(Unit: %)

Period	Banks	Insurance Companies	Investment Traders and Brokers	Merchant Banks	Mutual Savings Banks
~Nov. 1997	0.02	-	-	-	-
Nov. 1997~Apr. 1998	0.03	-	-	-	-
Apr. 1998~Jul. 1998	0.03	0.15	0.10	0.12	0.15
Jul. 1998~Jul. 2000	0.05	0.15	0.10	0.15	0.15
Jul. 2000~Jun. 2009	0.10	0.30	0.20	0.30	0.30
Jun. 2009~Nov. 2011	0.08	0.15	0.15	0.15	0.35
Nov. 2011~Present	0.08	0.15	0.15	0.15	0.40

Source: Korea Deposit Insurance Corporation.

A methodology to determine a fair deposit insurance premium has been offered by Merton(1977), who first suggests using the option-pricing model to evaluate the cost of guarantee by the Federal Deposit Insurance Corporation(FDIC). An extension of this methodology has been made by Ronn and Verma(1986), which additionally consider a capital forbearance. McCulloch(1985) and Pennacchi(1987) incorporate stochastic interest rates to calculate fair insurance values. A more appropriate model for property-liability insurers has been developed by Cummins(1988), who considers a stochastic liability with jump risk. Pennacchi(2005) suggests a moving average method for reducing the cyclicality of deposit insurance premiums.

1) Life insurance institutions are different from other financial institutions in terms of a business purpose, structural design of financial product, and risk exposure. However, in table 1, the trend of historical premium rates of the life insurance sector is similar with that of other financial sectors(Kim et al, 2018).

The use of the option pricing model gives two primary advantages. First, Marcus and Shaked(1984) argue that fair premium rates can be calculated by applying data collected over short time periods. This is important for nations in which the financial sector has a relatively short history. Second, Phillips et al.(1998) argue that the option pricing model explicitly incorporates default risk. This is also important given the increase in the volatility of life insurance companies.

In terms of the issue of KDIC premium rates, there are very few empirical studies that use the option pricing model (Joh(2008); Kang et. al.(2011)). In particular, there are no empirical studies for Korean life insurance firms. Thus, the main purpose of this paper is to investigate a risk-based premium rate of deposit insurance, particularly focusing on life insurance companies.

Our model fundamentally follows the Cummins(1988) model based on an assumption that assets and liabilities follow lognormal diffusion processes. In addition, to consider a characteristic of the life insurance sector when estimating premium rates, we apply a purchase-and-assumption(P&A) effect. Unlike other financial sectors, in the insurance sector, an insurance run is not likely to occur.[2] Thus, the KDIC is likely to arrange P&A rather than liquidation and deposit payoff when insurance firms go bankrupt. In reality, during the Asian financial crisis from 1997 to 1999 in Korea, most remaining claims of distressed insurance firms were successfully transferred to solvent companies without the insurance run(see table 2). By arranging P&A, the KDIC could cut down on expenses over the period(see table 3).

2) International Association of Insurance Supervisors(2011).

〈Table 2〉 Restructuring of Life Insurance Companies during the Asian Financial Crisis

Failed Company	Restructuring method	The date of restructuring	Acquisition Company
Kukjei Life	Purchase-and-assumption	Aug. 1998	Samsung Life
BYC Life	Purchase-and-assumption	Aug. 1998	Kyobo Life
Taeyang Life	Purchase-and-assumption	Aug. 1998	Heungkuk Life
Coryo Life	Purchase-and-assumption	Aug. 1998	Cheil Life
Doowon Life	Purchase-and-assumption	Dec. 1999	Daehan Life

Source: Korea Life Insurance Association.

〈Table 3〉 The Expense of P&A during Asian Financial Crisis

(Unit: one million KRW)

Failed Company					Acquisition Company	Expense of P&A[1)]
Name	Asset (①)	Liability (②)	② - ①			
Kukjei Life[1)]	265,386	570,550	305,164		Samsung Life	68,833
BYC Life[1)]	242,335	396,475	154,120	⇨	Kyobo Life	42,877
Taeyang Life[1)]	296,836	443,699	146,863		Heungkuk Life	76,471
Coryo Life[1)]	194,889	313,769	118,880		Cheil Life	40,563
Doowon Life[2)]	238,418	478,119	239,701		Daehan Life	30,000

Source: Korea Life Insurance Association, Korea Deposit Insurance Corporation.
Notes: 1) We obtain data from 1997 financial statements.
2) We obtain data from 1998 financial statements.

Therefore, the valuation of deposit insurance has yet to be fairly priced in terms of standard option pricing model. Shown in table 2 and 3, the KDIC would be likely to cut down the P&A expense when dealing with failed companies because P&A is determined largely by the government judgement. Without loss of generality, we assume that the KDIC will estimate premium rates incorporating the P&A effect.

The remainder of the paper is organized as follows. The section 2 presents a valuation formula for the deposit insurance premium rate. The section 3 describes the data and result. In the section 4, we present our conclusions.

II. An option-pricing framework

1. Design for valuation

We assume that insurers enter into a contractual arrangement and pay the KDIC deposit insurance premiums at the beginning of a specific contract period whose length is generally one year. At the end of the year, the KDIC examines insured financial institutions. If the audits reveal that assets exceed liabilities, the companies continue to operate and a new premium is calculated on the basis of assets and liabilities for next year. On the other hand, in a case where liabilities exceed assets, the KDIC guarantees insured policyholders against losses resulting from the failure of the companies.

The following additional assumptions are made:

(A1) The insurer has attained a steady-state position. This means that premium inflows, claims outflow, and the incidence of new claims during the contract period are equal.

(A2) Insurer assets consist of marketable securities such as stocks, government bonds, deposits and real estates, and are assumed to follow geometric Brownian motion processes:

$$dA = \mu_A A dt + A\sigma_A dz_A \,, \tag{1}$$

where A is the insurer's assets, μ_A is the instantaneous expected rate of return on assets, σ_A is the instantaneous standard deviation of return on assets, and z_A is the vector of a standard Brownian motion process for assets.

(A3) Insurer liabilities are the reserve built up over time through the

collection of premiums and held until claims are paid. We also assume that the liabilities follow a geometric Brownian motion and are determined by

$$dL = \mu_L L dt + L\sigma_L dz_L , \tag{2}$$

where L is the insurer's liabilities, μ_L is the instantaneous growth rate of liabilities, σ_L is the instantaneous standard deviation of growth rate on liabilities, and z_L is the vector of a standard Brownian motion process for liabilities.

(A4) Our model allows for correlation across the assets and liabilities as follows:

$$dz_A dz_L = \rho_{AL} dt, \tag{3}$$

where ρ_{AL} is a correlation between assets and liabilities.

As shown in the literature (e.g., Merton(1977) and Cummins(1988)), demand-deposit guarantees and put options have an isomorphic relationship. Thus, the deposit insurance can be valued using option pricing techniques. We can define the value to the insurer of the guarantee when the length of time until the end of the year ($T = 1$), P, as

$$P(A, L, T) = \max(0, L - A). \tag{4}$$

That is, the deposit insurance pricing model has a structure whereby the insurer purchases the put option from the KDIC, where in equation (4), promised payment L corresponds to the exercise price, and the value of the insurer's asset A corresponds to the underlying asset.

Utilizing procedures consistent with those employed in Margrabe(1978) who develops an option pricing model for an exchange option to exchange one risky asset for another, a differential equation for deposit insurance premium is obtained (see Margrabe(1978)):

$$P_T + \frac{1}{2}\left[A^2\sigma_A^2 P_{AA} + L^2\sigma_L^2 P_{LL} + 2AL\sigma_A\sigma_L P_{AL}\right] = 0\ . \tag{5}$$

The boundary condition for equation (5) is as follows:

$$0 \le P(A, L, T) \le A. \tag{6}$$

The function $P(A, L, T)$ is the solution to the differential equation (5), subject to the boundary conditions (6) and the initial condition (4):

$$P(A, L, T) = L \times N(-d_2) - A \times N(-d_1)\ , \tag{7}$$

where $N(\bullet)$ represents the normal cumulative density function, the parameters d_1 and d_2 are given by

$$d_1 = \frac{\log(A/L) + (v^2/2)T}{v\sqrt{T}}$$
$$d_2 = \frac{\log(A/L) - (v^2/2)T}{v\sqrt{T}} = d_1 - v\sqrt{T},$$

where A is the insurer's asset at the beginning of the year, L is the insurer's liability at the beginning of the year, and $v = \sqrt{\sigma_A^2 - 2\rho_{AL}\sigma_A\sigma_L + \sigma_L^2}$ is the volatility of the portfolio relative to the liability.

Then, following Ronn and Verma(1986), we scale down the value of deposit insurance by the proportion of policy reserve to total liability. Therefore, we

can rewrite the deposit insurance premium, P^*, as

$$P^* = P \times \frac{L_1}{L_1 + L_2} = L_1 \times N(-d_2) - \frac{A \times L_1}{L} \times N(-d_1) \quad (8)$$

where L_1 is the value of the policy reserve, and L_2 is the value of all liabilities other than the policy reserve. Equation (8) is consistent with the formula for a put option with exercise price L_1 on an underlying asset with current value A. The implication of equation (8) is that the deposit insurance gives policyholders an option to sell their deposits on financial institutions to the KDIC at price L_1.

2. Low possibility of full contract terminations

Although we calculated the value of the deposit insurance from the option pricing model, it is likely to be overpriced. In the option-pricing model, policyholders must exercise a put option if the liability exceeds the asset at the maturity. However, insurance policyholders tend not to easily terminate their contract by withdrawing deposits from an insurer whose financial condition has deteriorated.[3] That is, policyholders do not generally exercise their option that is already in the money. Further, the KDIC prefers to arrange P&A rather than liquidate failed companies' assets and pay off policyholders. This is analogous to the approach taken by other deposit insurance institutions (e.g. FDIC and Assuris) as they attempted to cut down on expenses. Thus, liquidation and deposit pay offs hardly ever happen in the life insurance sector. For this reason, P&A is a crucial factor which we should consider for estimating premium rates. We incorporate the discount rate of expenses as follows[4]:

3) International Association of Insurance Supervisors(2011).
4) During the Asian financial crisis, the KDIC successfully transferred all assets

$$P^{**} = P^{*} \times \eta, \tag{9}$$

where P^{*} is the calculated premium from equation (8) and η, the discount rate of expenses by P&A, is given as

$$\eta = \frac{c}{(L - A) \times \frac{L_1}{L}},$$

where c is the P&A expenses and $(L - A) \times L_1 / L$ is the pay-off expenses payable from the KDIC: that is, η means a ratio of the P&A expenses to liquidation expenses. Equation (8) is a special case of equation (9): in particular, two equations are equal when $\eta = 1$.

Finally, in Korea, the deposit insurance premium rate, π, is based on the premium income and policy reserve as follows[5]

$$\pi = \frac{P^{**}}{(I + L_1) \times 0.5}, \tag{10}$$

where I is the value of the premium income.

and remaining claims of insolvent life company to solvent life company(see table 2). Actually through arranging P&A, the KDIC could cut down on expenses(see table 3).

5) In Korea, the deposit insurance premium for life insurance firms are calculated as follows: Deposit Insurance Premium=(Policy reserve+Premium income)/2×15/10,000

Ⅲ. Empirical application

1. Sample life insurance firms

The Financial Supervisory Service(FSS) provides a financial statement and life insurance firms listed on the Korea Life Insurance Association(KLIA). The FSS contains financial data for financial sectors. We estimate premium rates since the last modification of 2009. Therefore, Our sample consists of every life insurance firm presented by the FSS and ALIA from 2009 to 2016. The sample includes nearly all insurance firms in Korea over the period, with only several firms excluded(see Table 4).

〈Table 4〉 Life Insurance Firms: Summary Statistics

Year	The number of firms	Firm's Assets(one billion KRW)				
		Mean	Standard deviation	Median	Minimum	Maximum
2009	22	16,933	29,438	8,141	701	133,045
2010	22[1)]	18,925	32,089	9,228	825	146,354
2011	22[2)]	20,794	35,025	9,963	910	160,590
2012	22[2)]	23,831	40,198	11,393	997	185,475
2013	22[3)]	24,940	41,561	12,053	1,073	191,003
2014	22[3)]	27,639	45,924	13,407	1,200	211,204
2015	22[3)]	30,205	49,153	14,914	1,421	226,244
2016	22[3)]	32,560	52,395	16,539	1,560	241,904

Source: Korea Life Insurance Association.
Notes: To calculate the deposit insurance premium rate through the option-pricing model, sufficient data is required. For this reason, we excluded some life insurance firms with a history shorter than 10 years.
1) IBK Insurance has been excluded.
2) IBK Insurance and Nonghyup Life were excluded.
3) IBK Insurance, Nonghyup Life and Kyobo Lifeplanet Life were excluded.

2. Data

The model applied in the paper depends upon eight parameters: the insurer's asset (A), the insurer's liability (L), the insurer's policy reserve (L_1), the insurer's premium income (I), the variance for return of assets and liabilities (σ_A^2 and σ_L^2 respectively), the correlation of assets and liabilities (ρ_{AL}), and the discount rate of expenses according to the P&A (η).

To apply the insurer's asset, liability, policy reserve and premium income, we obtain financial data from the financial statements presented by the FSS. We use the annual data of each life insurance company as we assume that examination interval is one year.

To estimate the variance for return of the insurer's asset, we assume that life insurance firms invest their assets in stocks, government bonds, deposits and real estate.[6] The parameter is determined by each insurer's asset portfolio and the diffusion parameters of each asset class. Insurer's asset portfolios are estimated from data presented by the KLIA.[7] Parameters are estimated for stocks, government bonds, deposits and real estates over the period 2000 to 2016. Table 5 shows rates of return for each asset class.

6) We assume that non-invested assets have equivalent characteristics to bonds as in Cummins(1988).

7) As the insurers' asset portfolios are not available, we estimate the asset portfolios from annual statements provided by KLIA.

〈Table 5〉 Rates of Return for Each Asset Class(2000~2016)

(Unit: %)

	Stock[1)]	Government Bond (3 year)[2)]	Deposit[2)]	Real Estate[3)]
2000	-50.92	8.30	6.87	0.43
2001	37.47	5.68	4.86	9.87
2002	-9.54	5.78	4.90	16.43
2003	29.19	4.55	4.36	5.74
2004	10.51	4.11	3.43	-2.07
2005	53.96	4.27	4.09	4.01
2006	3.99	4.83	4.86	11.60
2007	32.25	5.24	5.82	3.14
2008	-40.73	5.27	3.93	3.11
2009	49.65	4.04	2.86	1.46
2010	21.88	3.72	2.80	1.89
2011	-10.98	3.62	3.55	6.86
2012	9.38	3.13	2.89	-0.03
2013	0.72	2.79	2.66	0.37
2014	-4.76	2.59	2.13	2.10
2015	2.39	1.79	1.67	4.42
2016	3.32	1.44	1.52	1.35

Sources: 1) Korea Composite Stock Price Index.
2) Bank of Korea.
3) KB Financial group.

Estimating the variance of liability growth rate, Cummins(1988) adopted the log of (L_t/L_{t-1}), where $L_t =$ total liabilities at t. We follows Cummins(1988) for estimating the variance. Each firms' correlation between assets and liabilities is calculated from each firms' rate of return for asset and liability.

The final parameter is the discount rate of expenses according to P&A. While parameter η can be estimated from historical failure cases where P&A was arranged, it is difficult to estimate empirically. This is because the P&A is determined by policy judgements. It is assumed here that the KDIC will behave in a manner consistent with past decisions, which are to arrange the P&A when dealing with failed firms. Actually, in Korea, there have been five

bankruptcies in the life insurance sector during the Asian financial crisis(see table 2). At that time, the KDIC successfully transferred all assets and remaining claims of insolvent life insurance firms to solvent firms, at little cost and without deposit payoffs. Thus, we assume that the KDIC will decide to arrange P&A whenever they deal with failed firms. From the historical data, we obtain the discount rate of expense by P&A ($\eta = 0.389$).

〈Table 6〉 The Discount Rate of Expense by P&A

(Unit: one million KRW)

Failed Company				P&A Expense (④)	The discount rate of expense by P&A (④/((②−①)×③/②))
Name	Asset (①)	Liability (②)	Policy reserve (③)		
Kukjei Life[1)]	265,386	570,550	567,551	68,833	0.2267
BYC Life[1)]	242,335	396,475	384,296	42,877	0.2870
Taeyang Life[1)]	296,836	443,699	434,592	76,471	0.5310
Coryo Life[1)]	194,889	313,769	310,030	40,563	0.3453
Doowon Life[2)]	238,418	478,119	471,768	30,000	0.1268
Daishin Life[3)]	902,845	1,111,791	973,725	139,254	0.7609
Hanil Life[4)]	66,816	165,853	97,431	26,248	0.4511
Average					0.3899

Source: Korea Life Insurance Association, Korea Deposit Insurance Corporation.
Notes: 1) data set from 1997 financial statements.
2) data set from 1998 financial statements.
3) data set from 2002 financial statements.
4) data set from 2003 financial statements.

Lastly, based on the year for which we want to calculate the premium rate, we use data from the past 10 years. For instance, in order to calculate the premium rate in 2010, we apply data from 2000 to 2009.

3. Empirical findings

For the overall life insurance sector and each life insurance firm we calculate deposit insurance premium rates for 2010 to 2017. Table 7 compares historical deposit insurance premium rates with premium rate estimates based on data for the overall life insurance sector. The premium rate estimates have been lower than historical premium rates over the period. The premium rate estimates increased sharply in 2017 as life insurance firms increased the stock portion in their asset portfolios and the debt ratio climbed, by and large. In the light of the risk-based premium, it is clear that life insurance companies in Korea have generally charged much higher premium rates than they should charge. In addition, it seems that the KDIC needs to adjust premium rates according to market conditions. Unlike premium rate estimates, historical premium rates were flat, irrespective of not only during recessions but also during expansions.

〈Table 7〉 Historical Premium Rates and Premium Rate Estimates (Overall Life Insurance Sector)

(Unit: %)

Year	Historical premium rates[1)]	Premium rate estimates[2)]
2010	0.15	0.04
2011		0.01
2012		0.03
2013		0.05
2014		0.06
2015		0.07
2016		0.05
2017		0.13

Notes: 1) data source from Korea Deposit Insurance Corporation.
2) By applying the sum of total life insurance sector data, we estimate the premium rate estimates of overall life insurance sector.

Meanwhile, the range of premiums paid by life insurance firms from 2010 to 2017 is also important. Figure 1 shows that the distribution of premium rate estimates is extremely skewed. The number of insurance companies rapidly decreases for the premium between 0 and 0.0010. It shows that probability densities exhibit long right-hand tails for the whole period. Moreover, the highest premium rates are generally greater than 0.02 over the period. Although the KDIC is currently applying the risk-based premium rate, the range of KDIC premium rates is quite narrow compared to the that of premium rate estimates. For example, in 2017, the range of KDIC premium rates is only 0.00015 even though the highest premium rate estimate is 0.0164. This means that most of the healthy life insurance companies in Korea are aiding the risky companies.

〈Figure 1〉 The Range of Premium Rate Estimates from 2010 to 2017

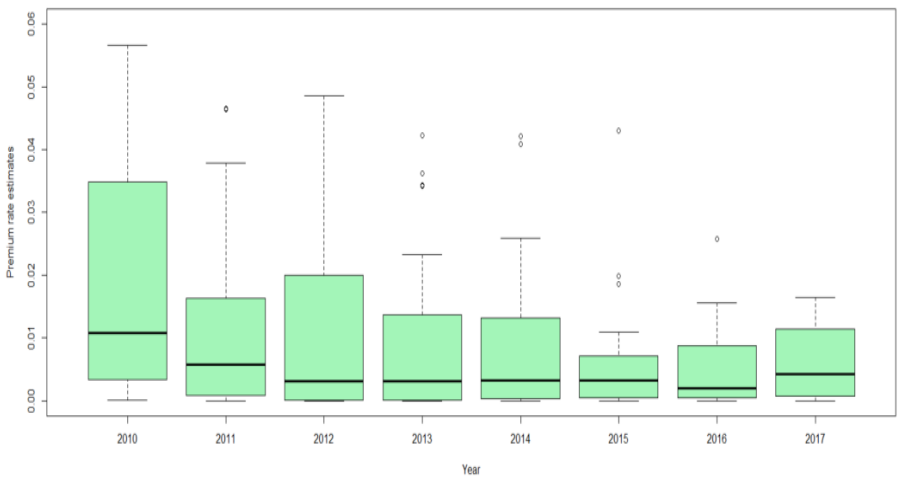


Table 8 shows more detailed statistics about deposit insurance premium rate estimates from 2010 to 2017. Mean and standard deviation have consistently declined since 2010. Life insurance firms experienced expansions over this

period, which leads to a decrease in the number of risky firms. Although gaps between minimum and maximum premium rate estimates have been narrowed gradually over 2010~2017 compared to the range of KDIC's risk-based premium rates, 0.00015. Therefore, it seems that the KDIC needs to classify life insurance firms in a more detailed way.

〈Table 8〉 Deposit Insurance Premium Rate Estimates: Summary Statistics

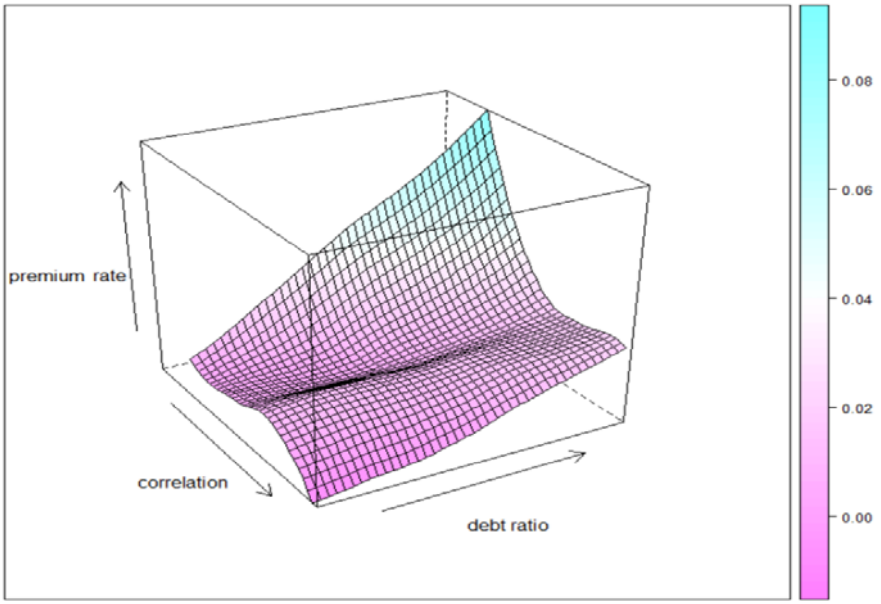
(Unit: %)

Year	The number of firms	Arithmetic Mean	Standard deviation	Median	Minimum	Maximum
2010	22	2.07	2.36	0.95	0.00	9.58
2011	22	1.20	1.49	0.56	0.00	4.65
2012	22	1.16	1.55	0.25	0.00	4.85
2013	22	1.01	1.38	0.20	0.00	4.23
2014	22	0.98	1.28	0.26	0.00	4.21
2015	22	0.66	0.97	0.30	0.00	4.31
2016	22	0.53	0.66	0.19	0.00	2.57
2017	22	0.61	0.59	0.35	0.00	1.64

Note: Arithmetic Mean, standard deviation and maximum have continuously been declined with decreasing the number of risky firms.

As shown in Figure 2, the debt ratio and correlation between assets and liabilities are important parameters in deciding premium rate levels. We identify that higher debt ratio generally bring about higher premium rate. Moreover, premium rates are more sensitive to correlation under capital deficiencies. Therefore, it is more important for capital-deficient firms to consider asset-liability management(so-called ALM). We expect that the correlation will increase in the near future as it is an important factor under the K-ICS(Korean-Insurance Capital Standard) which will be introduced in 2021. As a result, premium rate estimates are likely to become lower than they are currently.

〈Figure 2〉 Premium Rate Estimates Based on Correlation and Debt Ratio



4. Procyclicality

The option-pricing method is designed to have premium rates react rapidly to changes in financial conditions. As shown in Table 7, premium rate estimates have fluctuated heavily over the business cycle. In particular, the preceding analysis shows that premium rate estimates increase sharply during recessions, which would further pressure life insurance firms. Shaffer(1997) argues that fluctuating premiums causes profits to fluctuate, increasing the probability of failure. That is, the procyclicality effect under the option-pricing method is likely to worsen the financial stability of firms during recessions. Paradoxically, the deposit insurance system based on the risk-based method might increase the risk of default. Thus, smoothing premium rates over the business cycle is necessary for a steady-state deposit insurance system. Our model follows Pennacchi(2005), which attenuates the

procyclical impact of risk-based capital requirement through a moving average. We adapt it to decrease the volatility of premium rates over the business cycle; Premium rates are determined by a moving average (e.g. 3-year or 5-year) of past premium rates which are calculated without the moving average.

Table 9 shows premium rate estimates when periods of moving average are 1-year, 3-year and 5-year. Consistently with the previous literature, as the period of moving average increases, the volatility of premium rates decreases over the business cycle, since new financial conditions impact only a (1/n)th. This case is likely to be more realistic because it is difficult to accept strong fluctuation of premium rates as a feature of regulation for firms.

〈Table 9〉 Deposit Insurance Premium Rate Estimates by Moving Average

(Unit: %)

Year	Premium rates without moving average (n = 1-year)	Moving average	
		n = 3-year	n = 5-year
2010	0.04		
2011	0.01		
2012	0.03	0.03	
2013	0.05	0.03	
2014	0.06	0.05	0.04
2015	0.07	0.06	0.04
2016	0.05	0.06	0.05
2017	0.13	0.08	0.07
Standard deviation	0.03	0.02	0.01

Ⅳ. Conclusions

Within the deposit insurance system, estimation of the appropriate premium rates is one of most important issues. If the KDIC sets a premium rate that is

lower than fair value, the system cannot maintain steady state due to the huge expense. On the other hand, a higher premium rate might also increase the probability of failure. Although premium rates have been periodically revised, there are no guidelines for an appropriate premium rate in Korea.

We estimate an actuarially fair risk-based premium rate employing the exchange option model based on the assumption that assets and liabilities follow lognormal diffusion processes. We also incorporate the discount rate of expenses by P&A to consider the characteristics of the life insurance sector. Finally, we apply the moving average method in order to dilute procyclical effects.

This study provides evidence that the life insurance firms are overpaying than their risk. Further, the distribution of premium rate estimates exhibits a long right-hand tail over the period from 2010 to 2017. It is possible to assert that life insurance firms with relatively higher financial stability have consistently assisted risky companies. Thus, even if the KDIC is currently implementing the risk-based premium system by assessing the risk profile of individual institutions, a more segmented system is needed to fairly impose the deposit insurance premium rates. In addition, our results indicate that premium rates tend to be more sensitive to the correlation between assets and liabilities in response to higher debt ratio. This fact supports the premise that risky firms must manage their risk by investing in their assets while considering their liabilities, and the KDIC also needs to consider the correlation as an important parameter for assessing firms.

The major limit of our methodology presented in this paper is the assumption that the insurer has attained a steady-station position. Although the assumption involves no loss of generality, incorporating the more realistic setting is an important next step. In reality, the life insurance market in Korea

has continuously expanded since the establishment of the KDIC. Thus, considering the incidence of new claims, premium inflow and claims outflow can help calibrate the model for the estimation of the premium rate.

Lastly, taking in account that the bankrupt would happen at any time of the year, an american option model could be more suitable than an european option adopted here. Then, we would like to leave this topic as a future development.

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Appendices

〈Appendix table 1〉 Standard Deviation Estimates for the Return of the Insurer's Asset

Life Insurer	Year							
	2010	2011	2012	2013	2014	2015	2016	2017
A	0.0384	0.0315	0.0210	0.0414	0.0328	0.0555	0.0486	0.0685
B	0.0136	0.0142	0.0137	0.0172	0.0196	0.0270	0.0216	0.0225
C	0.0873	0.0679	0.0714	0.0663	0.0606	0.0562	0.0461	0.0527
D	0.0659	0.0358	0.0372	0.0405	0.0362	0.0436	0.0497	0.0654
E	0.0483	0.0384	0.0330	0.0375	0.0403	0.0525	0.0520	0.0658
F	0.0088	0.0080	0.0162	0.0206	0.0098	0.0114	0.0123	0.0178
G	0.0623	0.0431	0.0607	0.0727	0.0512	0.0921	0.0869	0.0931
H	0.0863	0.0420	0.0397	0.0452	0.0385	0.0564	0.0584	0.0663
I	0.0695	0.0550	0.0492	0.0552	0.0762	0.0817	0.0913	0.1082
J	0.0350	0.0365	0.0292	0.0342	0.0301	0.0313	0.0396	0.0630
K	0.0093	0.0067	0.0068	0.0074	0.0100	0.0156	0.0188	0.0219
L	0.0099	0.0115	0.0106	0.0111	0.0124	0.0127	0.0137	0.0162
M	0.0198	0.0169	0.0178	0.0302	0.0313	0.0318	0.0308	0.0484
N	0.0087	0.0122	0.0161	0.0184	0.0315	0.0314	0.0303	0.0256
O	0.0101	0.0072	0.0073	0.0071	0.0084	0.0097	0.0116	0.0652
P	0.0100	0.0104	0.0071	0.0077	0.0092	0.0116	0.0123	0.0138
Q	0.0105	0.0178	0.0190	0.0267	0.0465	0.0403	0.0694	0.0514
R	0.0563	0.0364	0.0319	0.0450	0.0493	0.0258	0.0417	0.0406
S	0.0058	0.0216	0.0268	0.0283	0.0282	0.0310	0.0228	0.0135
T	0.0417	0.0327	0.0183	0.0130	0.0120	0.0123	0.0140	0.0377
U	0.0120	0.0071	0.0072	0.0073	0.0098	0.0106	0.0119	0.0169
V	0.0123	0.0164	0.0216	0.0184	0.0222	0.0411	0.0477	0.0537

〈Appendix table 2〉 Standard Deviation Estimates for the Growth Rate of Insurer's Liability

Life Insurer	Year							
	2010	2011	2012	2013	2014	2015	2016	2017
A	0.0354	0.0350	0.0214	0.0175	0.0198	0.0191	0.0189	0.0171
B	0.0405	0.0405	0.0437	0.0426	0.0477	0.0495	0.0471	0.0437
C	0.0329	0.0324	0.0240	0.0253	0.0282	0.0258	0.0253	0.0253
D	0.0555	0.0562	0.0429	0.0303	0.0235	0.0223	0.0239	0.0256
E	0.0189	0.0192	0.0158	0.0190	0.0204	0.0203	0.0202	0.0175
F	0.0684	0.1254	0.1377	0.1404	0.1208	0.1099	0.1101	0.1103
G	0.3077	0.0604	0.0508	0.0508	0.0510	0.0494	0.0517	0.0600
H	0.3972	0.0479	0.0483	0.0478	0.0493	0.0489	0.0488	0.0420
I	0.0843	0.0710	0.0656	0.0674	0.0816	0.0841	0.0681	0.0484
J	0.1264	0.0384	0.0224	0.0237	0.0400	0.0403	0.0414	0.0442
K	0.1106	0.0951	0.1160	0.1209	0.1273	0.1286	0.1021	0.0929
L	0.1896	0.1529	0.1150	0.0772	0.0663	0.0484	0.0395	0.0337
M	0.0752	0.0441	0.0312	0.0314	0.0384	0.0376	0.0346	0.0327
N	0.4039	0.4106	0.4111	0.3310	0.2642	0.2566	0.2083	0.1554
O	0.1528	0.1207	0.1412	0.1116	0.0968	0.0894	0.0732	0.0655
P	0.2541	0.1856	0.1830	0.1616	0.1401	0.1056	0.0874	0.0563
Q	0.2765	0.2436	0.2457	0.2590	0.2386	0.1395	0.1336	0.1339
R	0.2505	0.2538	0.2491	0.2467	0.2616	0.2650	0.1856	0.1417
S	0.1987	0.1724	0.1545	0.1414	0.1420	0.1369	0.1332	0.1364
T	0.0478	0.0484	0.0451	0.0429	0.0445	0.0365	0.0804	0.1109
U	0.1154	0.0815	0.0731	0.0693	0.0686	0.0750	0.0775	0.0764
V	0.3133	0.3315	0.2983	0.2782	0.2094	0.1497	0.1109	0.0840

〈Appendix table 3〉 Correlation Estimates between the Return of the Insurer's Asset and the Growth Rate of Liability

Life Insurer	Year							
	2010	2011	2012	2013	2014	2015	2016	2017
A	0.080	0.308	0.241	0.184	0.280	0.238	0.198	0.233
B	0.820	0.809	0.839	0.870	0.938	0.927	0.929	0.960
C	-0.080	0.077	-0.138	-0.086	0.020	-0.004	-0.129	-0.111
D	0.023	-0.201	-0.005	-0.234	0.107	0.077	0.139	0.179
E	-0.490	-0.404	-0.189	-0.242	-0.144	-0.166	-0.234	-0.256
F	0.285	-0.322	-0.392	-0.396	-0.415	-0.340	-0.060	0.143
G	-0.516	0.067	0.282	0.295	0.486	0.490	0.719	0.658
H	-0.569	-0.107	0.167	0.068	0.217	0.204	0.181	0.181
I	0.339	0.040	0.409	0.395	0.420	0.466	0.206	0.291
J	-0.531	-0.204	0.183	0.049	0.338	0.404	0.553	0.419
K	-0.276	0.387	0.613	0.646	0.822	0.937	0.927	0.976
L	0.464	0.455	0.327	0.418	0.540	0.838	0.783	0.800
M	0.221	-0.062	0.505	0.486	0.511	0.631	0.524	0.524
N	-0.122	0.181	0.522	0.663	0.684	0.772	0.672	0.891
O	-0.450	0.519	0.631	0.540	0.687	0.778	0.705	0.359
P	0.346	0.359	0.498	0.476	0.546	0.816	0.705	0.824
Q	-0.304	-0.079	0.330	0.389	0.386	0.776	0.690	0.741
R	0.447	0.428	0.527	0.523	0.554	0.679	0.397	0.556
S	-0.565	0.927	0.859	0.864	0.875	0.885	0.877	0.593
T	0.044	0.025	-0.033	0.058	0.283	0.119	-0.293	-0.158
U	-0.445	0.775	0.721	0.742	0.721	0.764	0.765	0.886
V	0.431	0.435	0.363	0.501	0.541	0.795	0.687	0.888

요 약

본 연구는 한국의 생명보험회사를 중심으로 예금보험의 위험보험료율을 산출하는데 그 목적이 있다. 이를 위해, 생명보험회사들의 자산과 부채는 lognormal diffusion processes를 따른다고 가정하였으며 Margrabe(1978)의 교환옵션 모형을 적용하여 위험보험료율을 산출하였다. 또한, 보험업권의 경우 회사의 재정상태가 좋지 않을 경우에도 insurance run이 잘 발생하지 않고 이에 따라 예금보험기관에서 계약의 청산보다는 보험계약이전을 선호하는 점을 고려하여 보험료율 산정에 반영하였다. 본 연구에서는 2010년부터 2017년까지의 보험료율을 산출하기 위해 2000년부터 2016년까지의 생명보험회사 자료와 자산 인덱스 자료를 사용하였다. 분석 결과, 한국의 생명보험업권은 보유하고 있는 위험수준보다 많은 예금보험료를 예금보험공사에 납입하는 것으로 나타났다. 또한 재정상태가 안정적인 다수의 생명보험회사들이 재정상태가 좋지 못한 일부 생명보험회사들의 위험까지 부담하는 것으로 나타났다. 마지막으로, 재정상태가 좋지 않을수록 자산과 부채의 상관관계가 예금보험료에 미치는 영향이 큰 것으로 나타났다.

※ 국문 색인어: 예금보험제도, 위험보험료, 옵션평가모형, 생명보험업권