A STUDY OF RISK MANAGEMENT OF JAPANESE NON-LIFE INSURANCE COMPANIES

Kunimasa Horigome

Mitsui Sumitomo Insurance Company Limited, Japan

Abstract. In general, Japanese non-life insurance companies carry large catastrophe risks such as typhoons and earthquakes due to geographical features. In addition, they also carry large investment risks, one reason for which is that they are selling long-term insurance contracts such as saving type insurance. In this paper, I will discuss future subjects of risk management of Japanese non-life insurance companies, mainly focusing on investment risks.

Key-words: Fair value and fair value based risk, ALM enforcement, Embedded derivatives

1 Introduction

Currently, international solvency standards are being discussed by International Association of Insurance Supervisors (IAIS) and International Actuarial Association [IAA] etc, and International Accounting Standards Board (IASB) is developing insurance International Financial Reporting standards [IFRS] (Phase2). Japanese non-life insurance companies have strengthened their risk management and balance sheet management in the sight of these developments. If the ideas discussed in insurance IFRS or international solvency standards (especially concepts of fair value valuation of insurance contracts and measurement of risks in terms of fair value valuation) are introduced, it may affect Japanese non-life insurance companies dramatically. So actuaries of non-life insurance in Japan continue to play great roles in risk management.

In this paper, first I will introduce the developments of insurance IFRS (Phase2) and international solvency standards, and second explain the features and circumstances of Japanese non-life insurance business. Finally I will discuss the present conditions and future subjects of risk management of Japanese non-life insurance companies including case studies, mainly focusing on investment risks.

2 Developments of Insurance IFRS and solvency standards

2.1 Insurance IFRS (phase 2)

After developing IFRS4 (phase1), IASB resumed discussing insurance IFRS (Phase2) last year. The position of IASB is to reconsider insurance IFRS (Phase2) from the beginning, and IASB listed up following topics.

- model
- measurement
- discounting

- Asset/Liability interaction
- Risk/Service adjustment
- Gain or loss on initial measurement/liability recognition
- Policyholder behavior
- Acquisition costs
- Participating contracts
- Unbundling
- Credit Standing

IASB has brought up 4 accounting models (model A, B, C, and D) as non-life insurance contracts, and continued to discuss mainly 2 models (model C and D). 2 model have some similar aspects. But model D is so-called prospective fair value model, and there is possibility to adopt fair value model as insurance IFRS (Phase2).

Characteristics of 2 models are described below.

Figure 1. Characteristics of Model C and D

	Model C	**Model D**
Feature	Modified current approach	Consistent with revenue recognition project
Risk Margin	Reflected	Reflected
Discounting	Reflected (Risk free rate basis)	Reflected (Risk free rate basis)
Liability adequacy test	Needed	Not needed (Direct measurement of liability)
Asset backing insurance contracts	IAS39	IAS39

Note: Information of this section is referred to documents of IASB meeting in May 2005[1].

2.2 International solvency standards

As described below, development of international solvency standards have much to do with that of insurance IFRS (phase 2).

2.2.1 Solvency standards by IAIS

In October 2004, IAIS released "A new framework for insurance supervision (towards a common structure and common standards for the assessment of insurer solvency)", and in February 2005 it also released "(Draft version) Towards a common structure and common standards for the assessment of insurer solvency (cornerstones for the formulation of regulatory financial requirements)" [2]. In the latter paper, IAIS picked up 9 cornerstones and some of them are expressed below.

- Cornerstone II: the solvency regime is sensitive to risk, and is explicit as to which risks, individually and in combination, lead to a regulatory financial requirement and how they are reflected in the requirement.

- Cornerstone IV: the solvency regime requires a valuation methodology which makes optimal use of and is consistent with information provided by the financial markets and generally available data on insurance technical risks.

- Cornerstone V: the solvency regime includes the definition of technical provisions. Technical provisions have to be prudent, reliable, and objective and allow comparison across insurers. The regime should require as a minimum that sufficient assets are available to cover the technical provisions and other liabilities.

- Cornerstone VI: the solvency regime requires the determination of a "best estimate" of the costs of meeting the obligations arising from the insurance portfolio, taking into account the time value of money. The discount rate for this calculation is determined by reference to the relevant risk free interest rates on the financial markets.

2.2.2 Insurance accounting

In June 2005, IAIS released " Issues arising as a result of the IASB's Insurance Contracts Project – Phase II". In this paper, IAIS expressed "The IAIS believes that it would be most preferable if the methodologies for calculating items in public financial reports are able to be used for, or are substantially consistent with, the methodologies used for regulatory reporting purposes, with as few changes as possible to satisfy prudential reporting requirements."

This paper dealt with policyholder behavior, some form of fair value type model, marketability of insurance liabilities, asset/liability consistency, initial recognition of liabilities, discounting, and acquisition costs.

2.2.3 Other developments

ALM

IAIS seems to be developing paper regarding ALM (Asset Liability Management) of insurer. So IAIS may also be interested in ALM in addition to solvency standards and insurance accounting.

IAA support to IAIS

IAA has been supporting IAIS. Regarding solvency matters IAA developed report "A global Framework for Insurer Solvency Assessment" and submitted this report to IAIS last year. IAA continues to support IAIS especially in sight of actuarial profession.

2.3 Common features

Both insurance IFRS [phase 2] and international solvency standards have just begun to discuss, so it is possible that both directions will be changed in the future. But now both seem to have some features in common. In my own pinion, both may have thrown the common subjects to insurance companies as expressed below.

a. Measurement of fair value and fair value based risk

If IASB adopts fair value model as insurance IFRS (Phase2), of course insurance companies have to try to measure fair value of liability. In addition, Cornerstone IV

refers present value of best estimate by risk free interest rates. Besides, as expressed in section 2.2.2, IAIS thinks it would be most preferable if the methodologies for calculating items in public financial reports are able to be used for regulatory reporting purposes with few changes. So it will be possibly required to measure fair value of in terms of solvency.

Of course measurement of fair value is not only applied to liabilities, but also to assets. IAS39 requires that most of financial instruments are measured at market value or fair value.

Moreover in terms of solvency, it might be implicitly required to measure market value or fair value based risks in accordance with measurements of market value or fair value of assets and liabilities. For example, it is preferable to measure fair value based credit risk (fair value falling due to credit rating downgrade) of corporate bonds, if possible even loans, not to measure only default risks.

b. ALM enforcement

In both fair value accounting of insurance liability and international solvency standards, discount may have to be taken into account. So measurement of liability expects to be substantially effected by fluctuation of interest rates. Furthermore, Both IASB and IAIS seem to be interested in asset/liability interaction or consistency. So the importance of ALM is getting larger.

Japanese non-life insurance companies have been selling long-term insurance contracts such as saving type insurance, so it is very important for them to enforce interest rate ALM.

Not only interest rate ALM, but also exchange ALM and even credit ALM are important.

c. Introducing concepts of valuation method in finance (ex. embedded derivatives)

IAS 39 requires to separate some embedded derivatives from their host contract and to measure them at fair value. IFRS4 also requires separate derivatives embedded in an insurance contract unless the embedded derivative is itself an insurance contract.

IAIS have not clearly commented these matters, but Cornerstone IV implies a valuation method, which makes optimal use of and is consistent with information provided by the financial markets. And generally value of embedded derivatives is included in price of a financial instrument.

So it is desirable for insurance companies to study valuation of embedded derivatives in insurance contracts.

In financial markets, some valuation models of derivatives such as option pricing models are generally used, but these models are based on the assumption that the market is efficient. But there is a hot argument that whether this assumption should be applied to insurance products. So in valuation of embedded derivatives in insurance contracts, characteristics of insurance market may have to be taken into consideration.

3 Survey of Japanese non-life insurance Industry

3.1 Characteristics of Japanese non-life insurance companies

Following figures are total numbers of financial statements of Japanese non-life insurance companies which are members of The General Insurance Association of Japan (GIAJ).

Figure 2. Balance sheet of Japanese non-life insurance companies

Item	Fiscal2003 Amount (bil yen)	Fiscal2003 Share (%)	Item	Fiscal2003 Amount (bil yen)	Fiscal2003 Share (%)
Deposits	1,516	4.7	Underwriting Funds	22,713	70.8
Call Loans	822	2.6	(Outstanding Loss Reserves)	(2596)	(8.1)
Receivalbles under Resales Agreements	44	0.1	(Underwriting Reserves)	(20117)	(62.7)
Monetary Recivables Bought	238	0.7	(Other Reserves)	(-)	(-)
Money Trust	229	0.7	Other Liabilities	2,992	9.3
Securities	22,370	69.7	Total Liabilities	25,705.3	80.1
(National Government Bonds)	(3674)	(11.4)	Capital	853	2.7
(Local Government Bonds)	(1020)	(3.2)	Suspense Receipts on CapitalSubscriptions	-	-
(Corporate Bonds)	(4045)	(12.6)	Additional Paid in Capital	423	1.3
(Stocks)	(9065)	(28.2)	Earned Aurplus	1,966	6.1
(Foreign Securities)	(3984)	(12.4)	(Profits for the Current Year)	(326)	(1.0)
(Other Securities)	(582)	(1.8)	Land Revaluation Excess	-2	0
Loans	3,080	9.6	Unrealized gain on other Securities Net of Income Taxes	3,238	10.1
Real Estate	1,393	4.3	Treasury Stock	-89	-0.3
Other Assets	2,403	7.5	Total Equities	6,389	19.9
Total Assets	32,094	100.0	Total Liabilities and Equities	32,094	100.0

Figure 3. Income statement of Japanese non-life insurance companies

Item		Fiscal2003 Amount (bil yen)
Ordinary Income and Expenses	Underwriting Income	9,058.7
	(Net Premiums Written)	(7,437.2)
	(Savings Portion of Maturity-refund type)	(1,208.6)
	Underwriting Expenses	7,595.7
	(Net Claims Paid)	(3,781.3)
	(Loss Adjustment Expenses)	(332.8)
	(Agency Commissions and Brokerage)	(1,253.3)
	(Maturity Refunds to Policyholders)	(1,999.7)
	(Net Provision for /Net Reversal of Outstanding Loss Reserves)	(-12.5)
	(Net Provision for /Net Reversal of Underwriting Reserves)	(64.7)
	Investment Income	669.2
	Investment Expenses	184.0
	Operating and General Administrative Expenses	1,306.3
	Other Ordinary Income and Expenses	17.7
	Ordinary Profits	659.6
Net of Special Profits and Losses		-151.9
Profits for the Current Year before Corporate Taxes		507.7
Corporate Income Taxes and Corporate Resident Taxes		63.3
Adjustments in Corporate Income Taxes, etc.		88.7
Net Profits for the Current Year		325.8

(Source) The General Insurance Association of Japan (http://www.sonpo.or.jp)

[Note: Figure 2]
"Other Assets" is composed of 1) Cash in hand, 2) Furniture and fixture, 3) Construction in progress, 4) Amounts due from agency business, 5) Amounts due from other domestic companies for reinsurance, 6) Customer's liability for acceptance and guarantee.

On the liability side, underwriting reserves is 20,117 billions which is much larger than 2,569 billions of outstanding loss reserves. The main reason is underwriting reserves for long-term insurance contracts such as saving type insurance in addition to catastrophe reserves.

On the asset side, 22,370 billions of securities share about 70% of total assets, and 3,080 billions of loans (about 10%) follow. Regarding securities, Japanese non-life insurance companies have sold a lot of stocks to reduce high market risk of stocks. But there are still 9,095 billions of stocks [about 28% of total assets] which is even higher than total equities. It means that for some companies, received premiums of long-term insurance contracts (generally with assumed interest rate) are invested to stocks and there exists ALM mismatches.

3.2 Accounting and solvency regulation in Japan

3.2.1 Accounting of non-life insurance in Japan

Current Japanese GAAP for non-life insurance companies, which is based on Statutory Accounting Principles, employs basically deferral-matching approach. In detail, most of ordinary underwriting reserves (excluding reserves for refunds of saving type insurance) is based on unearned premium, and regarding saving type insurance, reserves for maturity repayment (refunds) are calculated by assumed interest rates without few exceptions. Recently several revisions of accounting standard for underwriting reserves (which might include some concepts of IFRSs) have been considered in accordance with changes of circumstance.

On the other hand, Japanese GAAP have already employed substantially similar accounting principles to IAS39 for financial instruments, and most financial instruments are measured at market values or fair values. So if fair value accounting of insurance liabilities is introduced, most of assets and liabilities are measured similarly at fair values. Therefore if so, not only in terms of risk management, but also in terms of financial reporting, it is very important for Japanese non-life insurance companies to enforce ALM.

3.2.2 Solvency regulation in Japan

The solvency margin standard of Japan which was developed by referring to the US standard are based on Risk Based capital. Japanese non-life insurance companies are required to have more than 200% solvency margin ratio, which is calculated by following formula.

$$Solvency\ M\arg in\ ratio = \frac{Total\ of\ Solvency\ M\arg in}{(\sqrt{R1^2 + (R3+R4)^2} + R2 + R5)\times 1/2}$$

R1: Ordinary Insurance Risks
R2: Major Catastrophe Risks
R3: Assumed Interest Rate Risks
R4: Asset Management Risks
R5: Business Management Risks

The current solvency margin standard seems to include some concepts of "Cornerstones" by IAIS, for example, "Cornerstone II: the solvency regime is sensitive to risk".

Revisions of the current solvency margin standard have started to be discussed and in the future there seems to be possibility to introduce some concepts which have been developed by IAIS.

4 Analysis of required risk management

4.1 Measurement of fair value and fair value based risk

Basic framework of risk management is to keep sufficient solvency to cover total risk of the company. For this purpose, first, measurement of solvency is expected to be based on fair value valuation of assets and liabilities as far as possible.

4.1.1 Development of fair value measurement of liabilities

Regarding fair value measurement of liabilities, GIAJ (the General Insurance Association of Japan) has been researched it from various aspects. Especially in terms of accounting practice, last year IFRS Business Practice Sub-Project Team Of GIAJ reported "International Financial Reporting Standard On Insurance Contracts -Business Practice and Necessary Data In General Insurance Companies- (Interim Report)" (3).

This report is based on presuppositions as follows and addresses some practical methods for measuring underwriting reserves:

- Insurance IFRS [Phase 2] is based, fundamentally, on the "DSOP".
- However, it will be supplemented by the tentative conclusions in the IASB meeting in January 2003.

So, in this paper, regarding fair value measurement of liabilities, I will later describe mainly embedded options and guarantees which above report does not address so much. And later in this section, I will focus on fair value measurement and fair value based risk measurement of assets.

4.1.2 Fair value measurement of loans

As described in section 3.1, Japanese non-life insurance companies invest about 10% of assets on loans in average. Although it is not required to measure loans at fair value in current accounting, solvency requirement in Japan, or even resent development of international solvency standards explicitly, it is desirable to measure fair value of assets in addition to liabilities as far as possible in terms of risk management.

Actually, Japanese non-life insurance companies may have not been researched fair value valuation method of loans so much, but as the secondary loan market in Japan is getting larger gradually, so it may become important to develop fair value valuation method of loans. Moreover, broadly speaking, fair value valuation methods of personal loans have much to do with those of insurance liabilities and practice of ALM, especially valuation method of prepayment.

General loans (excluding policyholders loan) are divided into 2 categories, corporate loans and personal loans.

a. Corporate loans

The basic valuation method of fair value of corporate loans is discount of estimated future cash flows (usually decided by the loan contract) with adjustment of investment yields curve of corporate bonds for corresponding periods. If the borrower issues corporate bonds, applied yield is based on that of corporate bonds which the borrower issues. If the borrower does not issue corporate bonds, applied yield may be based on that of corporate bonds which the company with same credit rating and in same industry issues.

In this case, we may consider additional liquidity premium arising from the fact that liquidity of loans is lower than that of bonds. And if a loan is with collateral we may also consider discount premium because generally bond is without collateral. Above concepts are described as below.

$$Fair\ value\ of\ a\ \ loan = \frac{C_1}{(1+y_1+lp_1-dp_1+op_1)} + \frac{C_2}{(1+y_2+lp_2-dp_2+op_2)^2} + \cdots + \frac{C_n}{(1+y_n+lp_n-dp_n+op_n)^n}$$

$k(=1,2,\ldots,n)$: *time period*(*years*) *from present time*

C_k : *future cash flow*

y_k : *correspoding investment yield*

lp_k : *additional liquidity premium*

dp_k : *discount premium for collateral*

op_k : *premium for other factors*

b. Personal loans

Generally speaking, it is considered that fair value valuation of personal loans is more difficult than that of corporate loans due to constraints of similar bond market. So it need further study.

But, similar to insurance contracts, personal loan portfolio consists of thousands of individual contracts though the amount of each personal loan is rather small. Moreover long-term personal loans such as residential mortgage loans have the prepayment risk which long-term insurance also generally have. So developing valuation method of fair value of personal loans is also useful for considering fair value valuation of insurance liabilities and for practicing ALM.

4.1.3 Measurement of fair value based risk

Corresponding to measurement of fair value of assets and liability, it is of course desirable to measure risks based on fair value. I will describe measurement of credit risk based on fair value in section 5.2 as a case study.

4.2 ALM enforcement

4.2.1 General analysis of interest rate ALM

Japanese non-life insurance companies carry long-term interest risk arising from long-term insurance contracts such as saving type insurance. But there are several characters in interest rate risk.

a. Non-option risk

This risk means that present value of future cash flow of assets and liabilities varies due to interest fluctuation. Furthermore non-option risk is classified into two.

a-1. On-balance risk

This risk is fluctuation risk of present value of assets and liabilities in relation to premium which the insurance company has already received. This risk is typically caused by duration mismatch between assets and liabilities. Usually, insurance products with single premium carry only this risk among non option risks.

a-2. Off-balance risk

This risk is caused by future premium which the insurance company has not received yet and insurance products with installment premium carry this risk. In other words, this risk appears when the market interest rate drops after selling products, and this risk can be hedged by derivatives (ex. interest rate forward swap).

b. Option risk

Typically, when cancellation of a insurance product is done during policy term, the surrender value is paid. But if the surrender value is based on policy reserve in cancellation date which is calculated by assumed interest rate regardless of the market environment, the product contains option risk. In other words, this risk appears when the market interest rate rises after selling products and cancellation is done. This risk can be also hedged by derivatives (interest rate option or bond option)

Above discussion is summarized as below.

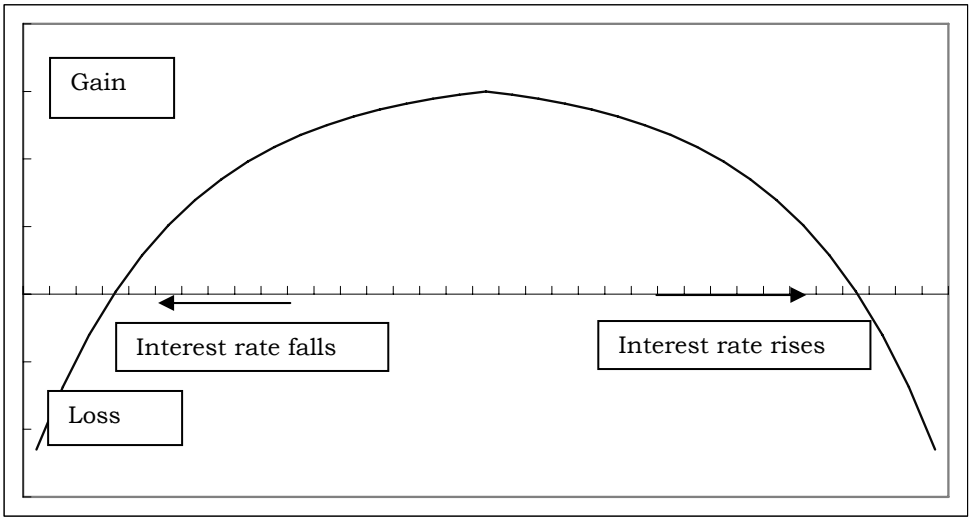
Figure 4. Types of interest rate risks

Types of Risks		**Risks Appear when**	**Hedge Methods**
Non-option risk	On-balance risk	If duration of A* exceeds L* -> interest rate rises If duration of L exceeds A -> interest rate falls	Bonds, loans Interest rate swap
	Off-balance risk	interest rate falls	Interest rate forward swap
Option risk		interest rate rises	Interest rate option or bond option

*Note: **"**A" stands for Assets, and "L" stands for Liabilities

As described in above, insurance companies generally carry interest rate risk to both upside and downside. In financial engineering, this position is called gamma short position. The image is described as below.

Figure 5. Imagination of gain and loss by interest rate fluctuation



Japanese non-life insurance companies have been making efforts to exercise interest rate ALM focusing on non-option risk, especially in saving type insurance. But, in general, as Japanese market of long-term bonds is small, ALM mismatch (duration of liabilities is longer than that of assets) still seems to exist. In addition, a lot of work may be still needed to practice ALM to control option risk. This will be treated in section 5.1.

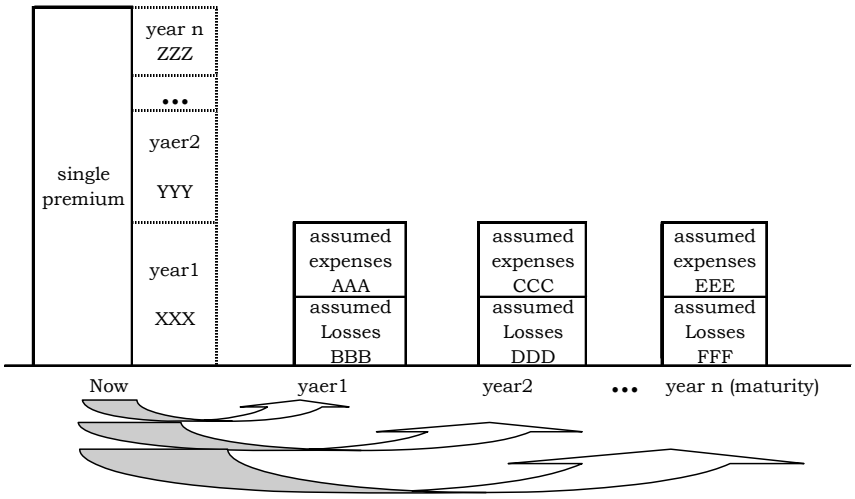
4.2.2 Interest rate ALM for non-saving type insurance

There is also another type of interest rate risk for Japanese non-life insurance companies. Recently general products with long-term compensating function such as long-term fire insurance and medical insurance have been increasing. In these general long-term insurance (non-saving type insurance), premium is also discounted by assumed interest rate. So it is necessary to enforce ALM corresponding to these products.

If rating assumptions of the target insurance have not been changed, in other words, the latest rating assumptions are same as the target sold insurance, basic technique of ALM in general long-term insurance is following. We estimate future cash flows of liabilities based on assumed losses, expenses, interest rate etc and invest in assets in accordance with estimated future liability cash flows.

But for example in long-term fire insurance, the actual future cash flows is substantially fluctuated by natural disasters, then it may be more challenging to exercise ALM corresponding to these products compared to saving type insurance.

Figure 6. Future cash flows of liability in long-term insurance with single premium



estimating future cash flows of liabilities by considering assumed interest rate

4.3 Embedded derivatives

In Japanese accounting principles for financial instruments, some embedded derivatives are required to be measured by separating from their host financial instruments. But regarding embedded derivatives in insurance contracts, there are not clear standards of separate measurement.

It is thought that insurance contracts have embedded options or guarantees in various ways. But in many cases it may be difficult to measure them by separating from host insurance contracts. However whether required to separate or not in accounting, it is very beneficial for pricing and still risk management in insurance companies to estimate values of embedded options or guarantees, even rough value.

For Japanese non-life insurance companies, valuation of embedded options or guarantees have not been studied yet. We would consider a concrete example in section 5.1 as a case study.

5 Case Studies

5.1 Valuation of surrender option in saving type insurance

5.1.1 Overview

In Japanese non-life insurance industry, when a saving type insurance contract comes to the maturity date without cancellation or lapse, the maturity repayment which is based on assumed interest rate is paid to the policyholder. And if investment return during policy term exceeds assumed interest rate, policyholder dividend is paid in addition to maturity repayment.

When cancellation is done during policy term, the surrender value is paid. But in general, the surrender value is based on policy reserve in cancellation date which is based on assumed interest rate with fixed cancellation deduct regardless of the market environment.(there is also different type products, but the discussion will be continued with this assumption).

Therefore when cancellation is done at the time of interest rate rising, current price of the bond which the insurance company has invested fall, while surrender value based on assumed interest rate is paid to the policyholder. It means insurance companies have the prepayment risk and it is the same problem financial institutions faced when advance repayment of housing loan is done at the time of interest decreasing. This risk is caused by giving the right [option] of cancellation during policy term to the policyholders by insurance companies.

Now we suppose saving type insurance with single premium. (The compensating component is small in comparison with the saving component, and we can ignore compensating component.) In policyholder's view, we can regard this insurance as discount bond with put option in sight of economic effect. Therefore, in comparison with usual discount bond (without put option), value of saving type insurance with single premium is high due to embedded surrender (put) option.

5.1.2 Example of valuation of surrender option

As follows, we regard saving type insurance with single premium as the discount corporate bond with put option which the same insurance company issues. We will evaluate the surrender option value.

Assumptions

Figure 7. Assumptions of surrender option of saving type insurance

Surrender option of saving type insurance [insurance term]	**In other words: Put option of corresponding discount bond [underlying asset] [financial terms]**	**sign**	**figure**
Surrender option value	Put option value	P	?
Single premium	Current value of underlying asset	S	86.07
Surrender value	Strike Price	K	87.37
Maturity of surrender(year)	Maturity of option(year)	T	1
Policy term(year)	Maturity of underlying asset(year)	t	5
Risk free rate	Risk free rate	r	3.0%
Assumed interest rate [continuous compound interest]	Original investment yield of underlying asset[continuous compound interest]	u_0	3.0%
-	Investment yield of underlying asset 1 year later	u_1	Variable
-	Average volatility of underlying asset	σ	4.0%
Maturity repayment	Face value	F	100

- Policyholders have the option that they can cancel the contracts just 1 year after contracting [only 1 time]. In other words, the potion is the European put option whose maturity is 1 year later.

- The surrender value (= strike price) when canceling is the amount based on investment return with assumed interest rate 3% during 1 year - cancellation deduct of 0.5 years
- As a result, it becomes the amount based on investment return with assumed interest rate 3% during 0.5 years.
- $K = S\exp(0.5u_0) = 86.07\exp(0.5\times 0.03) = 87.37$
- At the beginning, assumed interest rate (=investment yield of the discount corporate bond which the insurance company issues) is the same as the risk free rate 3% of 1 year period. But investment yield of discount corporate bond fluctuates after issuing (=selling insurance).
- We do not consider the credit risk of the insurance company.
- We suppose 4 types of functions of cancellation ratio to interest rate, in case that value of the discount corporate bond without put option is below the surrender value (i.e. Put option is "In The Money") 1 year later .
  a. Cancellation ratio is 100%. (100% policyholders exercise the option) This assumption is consistent with the assumption of financial market.
  b. Cancellation ratio has the liner function X.

     X = $\min(1,10(u_1 - u_0))$ where $u_1 > u_0$

  c. Cancellation ratio has the liner function Y which is as 2 times as X.

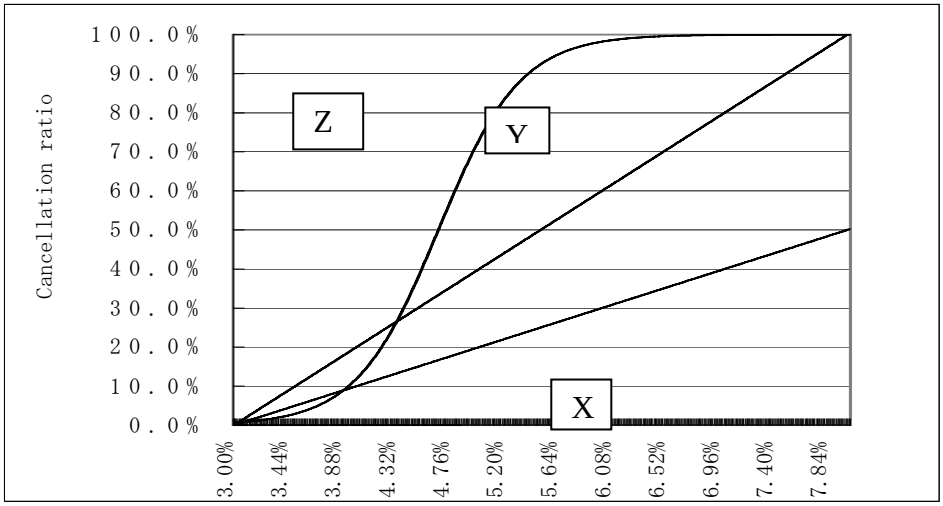
     Y = $\min(1,20(u_1 - u_0))$ where $u_1 > u_0$

  d. Cancellation ratio has logistic function Z.

     Z = $\dfrac{1}{1+\exp(-(-5+300(u_1-u_0))}$ where $u_1 > u_0$

- The underlying asset (discount bond) has the Ito Process.

Figure 8. Graphs of 3 Functions



Valuation method

- Cancellation ratio a Option pricing model (Black-Scholes model) is used.

$$P = \exp(-rT)KN(-d_2) - SN(-d_1)$$

$$d_1 = \frac{\ln(S/K) + (r + \sigma^2/2)T}{\sigma\sqrt{T}}, d_2 = d_1 - \sigma\sqrt{T}$$

where N is cumulative distribution function of standard normal distribution.

- Cancellation ratio b, c, and d.
  We will calculate present value of probability weighted gain of exercising the option in terms that the relation between value of the discount corporate bond 1year later and cancellation ratio.

Result

Figure 9. Price when issuing

	Cancellation Ratio Function			
	a(100%)	**b(liner):X**	**c[liner]:Y**	**d(logistic):Z**
Discount bond price without put option	86.07	86.07	86.07	86.07
Put option value	0.82	0.12	0.24	0.32
Discount bond price With put option	86.89	86.19	86.31	86.39

Put option value increases as b -> c -> d-> a. In other word, as the sensitivity of cancellation ratio to interest rate increases, put option value increases because sum of gains for policyholders (i.e. sum of losses for the insurance company) becomes larger by exercising put option.

Here, initial discount bond price with put option (i.e. surrender option) might be considered as initial fair value of saving type insurance with single premium amount with surrender option.

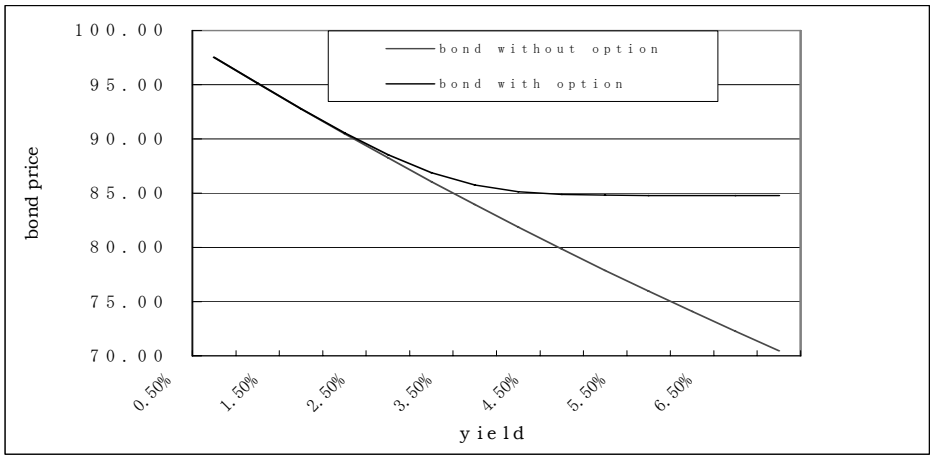
Further analysis

Next, We will analyze price of discount bond with put option, when investment yield of discount bond without put option (calling simply "yield" as followed) fluctuates just after issuing. The Result is described below.

As the yield rises, both bond Prices drop. But the difference between 2 bond prices becomes larger due to put option value. Because put value becomes larger as yield rises, i.e. as underlying asset price is far below strike price.

So, It is considered that the higher the market interest rate rises compared to the assumed interest rate, the more important recognition of the surrender option value is. Of course, in addition to valuation of the surrender option, it is also important to grasp option risk when analyzing liability risks.

Figure 10. Bond prices after yield fluctuates



Notice

- In general, the actual insurance product can be canceled throughout the policy term, the actual option value may be larger.
- The surrender value depends on the sensitivity of cancellation ratio to interest rate, but practically it may be usually difficult to estimate it due to data constraint.
- When we estimate cancellation ratio, we have to consider how the compensating component of actual insurance product effects the saving component.

5.1.3 Solution

As expressed in section 4.2, insurance companies can hedge risk of surrender option (in other words gamma risk called in financial engineering), by purchasing interest option or bond option. But, when it tries to hedge this risk completely, they have to purchase option whose strike price is around At The Money. Moreover if the market interest rate rises after selling insurance products, insurance companies have to purchase option whose strike price is In The Money. Those may need high costs.

Generally, insurance companies get profit if market interest rate fluctuates to a certain extent. Therefore there may be a choice for them to purchase option whose strike price is (deep) Out of The Money, to hedge risks that interest rate substantially rises. Strike price may depend on the risk capacity of each company.

And, as the surrender value depends on sensitivity of cancellation ratio to interest rate, it is very useful to analyze policyholders segments (ex. institutional investors, general corporations, individuals classified by age or income level). Then there may be a choice for insurance companies to vary commission rates in accordance with policyholders segments.

5.2 Credit risk measurement by the MTM method

5.2.1 Overview

Japanese non-life insurance companies have been working on measuring of credit risk mainly in investment assets in addition to market risk. General method of credit risk measurement is calculating VaR or Tail VaR of the portfolio, and VaR or Tail VaR is calculated as below

- Summing up investment amounts (if possible with market values or fair values) of each counter party.
- Setting up default rate or/and credit rating change rates and recovery rate of each counter party by referring current credit rating.
- Setting up credit correlation between counter parties.
- Doing Monte Carlo simulation to obtain credit losses of the portfolio

In this point, measurement methods of credit losses are mainly categorized to two.

a. DM (Default Mode) method: recognizing losses only when counter parties default.

b. MTM (Mark To Market) method: recognizing losses when market values go down due to credit ratings downgrade of counter parties in addition to defaults, in other words, measuring credit risk on market value basis.

It seems that in Japanese non-life insurance companies, some adopt MTM method but other still adopt DM method. To measure appropriate credit risk in terms of risk management, it is preferable to adopt MTM method. MTM method described as below is based on Credit Metrics™ [4].

Example

It is assumed that an insurance company invested in a discount corporate bond whose current credit rating is single A, maturity is 5 years, face value is 100

thousands, and market value is 90 thousands (spot yield of 5 years of this bond is nearly 2%). Probabilities of changes of credit rating within 1 year and market values after changes of credit rating are expressed in figure 11 as below. The results of loss recognition by DM method and MTM method after changes of credit rating are also expressed in figure 11. (In practice, Market value of discount bonds increase as the time passes, but to simplify the analysis we ignore that in this example.)

Figure 11. Comparison of loss [DM] and loss [MTM]

Current Rating	Face Value	Current Market Value	(Spot yield)
A	100,000	90,000	(nearly 2%)

After change of Rating

Rating	Probability	Market Value	(Spot yield)	Loss(DM)	Loss(MTM)
AAA	0.10%	97,500	(nearly 0.5%)	0	-7,500
AA	2.00%	95,000	(nearly 1%)	0	-5,000
A	90.00%	90,000	(nearly 2%)	0	0
BBB	6.00%	86,000	(nearly 3%)	0	4,000
BB	1.50%	78,000	(nearly 5%)	0	12,000
Below B	0.35%	50,000	(nearly 15%)	0	40,000
Default	0.05%	0 *		90,000	90,000

* It is assumed that market value after default is zero (recovery rate is zero)

5.2.2 Example of credit risk measurement of portfolio

Assumption:

- An insurance company invested in 50 discount corporate bonds which were issued by different issuers.
- Current credit rating, maturity, and unit price of all bonds are same as described in 5.2.1.
- Market values of bonds are 90 thousands, 180 thousands, 270 thousands,..., 4,500 thousands. (in other words, face values are 100 thousands, 200 thousands, 300 thousands,..., 5,000thousands.) Sum of market values of portfolio are 114,750 thousands.
- Credit correlations between 50 bonds [companies] are uniformly 0.25.

Results:

Doing Monte Carlo simulation 10,000 times , then the results of credit risk by DM method and MTM method are obtained in figure12 as below.

Figure 12. Comparison of credit risk [DM] and credit risk [MTM]

	Credit risk (loss) (DM)		Credit risk (loss) (MTM)	
		Loss Ratio		Loss Ratio
Current Portfolio Value	114,750,000	-	114,750,000	-

Mean	53,244	0.05%	606,032	0.53%
VaR(0.98)	90,000	0.08%	4,740,000	4.13%
VaR(0.99)	2,700,000	2.35%	6,180,000	5.39%
VaR(0.995)	3,870,000	3.37%	7,490,000	6.53%
TVaR(0.99)	4,005,900	3.49%	8,310,930	7.24%

Comments:

As described in Figure XX, for example, VaR(0.99) of Credit risk by MTM method is 6,180 thousands while credit risk by DM method is 2,700 thousands. The former is more than 2 times of the latter. It is mainly because market value losses due to downgrade of credit rating are recognized by MTM method, while those are not recognized by DM method.

Difference of credit risk between DM method and MTM method depends on features of portfolios. But in general, as average credit rating is high, the difference may increases. Because frequency of default in portfolio tends to decrease while frequency of downgrade in portfolio tends to increase. (in other words, there is very little probability of upgrade)

Generally speaking, Japanese non-life insurance companies tend to invest high credit rated bonds (basically above BBB and BBB, or above A and A), so if adopting DM methods credit risk might be fairly underestimated. Then I believe it is very important to adopt MTM method.

If it is possible to estimate fair values, MTM method can be also applied to other assets such as loans and credit derivatives etc.

Supplement: summary of method of Monte Carlo simulation

a. Let 50 issuers of discount bonds be n=1,2, …, 50 .

b. Generate 50 independent standard normal variables, $\varepsilon_{1,}\varepsilon_{2,\ldots,}\varepsilon_{50}$ and generate another independent standard normal variable X to reflect credit correlation.

c. Let credit correlation be ρ (=025), and then correlation of Y_i and Y_j is also ρ by transformation described as below.

$$Y_i = \sqrt{\rho}X + \sqrt{1-\rho}\varepsilon_i,\ Y_j = \sqrt{\rho}X + \sqrt{1-\rho}\varepsilon_j$$

d. Now as ε_i and X have standard normal distribution, and $\sqrt{\rho}$ and $\sqrt{1-\rho}$ are constant, Y_i also has normal distribution with mean 0 and variance $\sqrt{\rho}^2 + \sqrt{1-\rho}^2 = 1$, i.e. standard normal distribution.

e. Then As described in Figure 13, let threshold (y) between 2 credit ratings be the number which is obtained when inserting cumulative probability into inverse function of cumulative distribution function of standard normal distribution.

Figure 13. Threshold between 2 credit ratings

	Probability	Cumulative Prob	Threshold(y)
AAA	0.10%	100.00%	
AA	2.00%	99.90%	3.090
A	90.00%	97.90%	2.034
BBB	6.00%	7.90%	-1.412
BB	1.50%	1.90%	-2.075
Below B	0.35%	0.40%	-2.652
D	0.05%	0.05%	-3.291
Sum	100.00%		

f. Therefore the result of credit rating change is obtained as below.

Issuer i defaults when $Y_i \leq$ -3.291

Credit rating of Issuer i downgrades to Below B when -3.291< $Y_i \leq$ -2.652

Credit rating of Issuer i upgrades to AAA when 3.090< Y_i

g. Same judgements are done regarding other 49 issuers as above f, and calculate each MTM loss. Then we can obtain MTM loss of portfolio in .one simulation.

6 Conclusions

- In general, Japanese non-life insurance companies carry huge investment risks, and they have been trying to develop new risk management methods and manage investment risks.
- But according to developments of international solvency standards and insurance IFRS [phase2], it seems to be needed that some further developments still has to be done in terms of risk management as well as management of impact on financial statements.
- Especially, they may have to develop some valuation methods of fair value and measurement methods of fair value based risk (regarding both assets and liability), to enforce ALM, and to develop valuation methods of embedded derivatives.
- Actuaries of non-life insurance in Japan continue to play great roles in this risk management.

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KUNIMASA HORIGOME
Mitsui Sumitomo Insurance Company Limited, Accounting Dept.
27-2, Shinkawa 2-chome, Chuo-ku, Tokyo 104-8252, Japan
Phone: 81-3-3297-4621 Fax: 81-3-3297-8463
E-mail: kunimasa.horigome@ms-ins.com