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Dynamic lapse risk in an era of quantitative easing

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DYNAMIC LAPSE RISK

For insurers exposed to un-hedged guarantees on their variable[1] books, the financial crisis offered a rude awakening. The risk was material and should have been more systematically managed. Many companies have improved their variable block hedge protocols in recent years. Yet one of the most valuable options commonly offered by insurers still requires closer scrutiny: book value withdrawals on general account products.

In this paper, we examine the risk associated with book value guarantees in the context of the products and economic environment of Japan. We show that this risk can be material. This conclusion should remain valid for similar books of business in the United States and many other markets.

Our analysis is developed using a market-consistent framework. Although our conclusions have some implications for practitioners of market-consistent reporting, our primary objective in presenting these results is simply to promote a discussion of the modeling and management of dynamic lapse risk on general account business.

While Japanese insurers are not unaware of the risks associated with book value guarantees, decades of gradually declining interest rates may have led to some degree of complacency. Unfortunately, given many years of low interest rates and recent central bank interventions, the risk may now be particularly acute. This likely is increasingly true in other markets around the world. If interest rates rise suddenly–as could happen, for example, if quantitative easing is tapered too quickly or if easy money ultimately leads to inflation–insurers that have accumulated large blocks of business offering book value withdrawals may have exposed themselves to significant risk.

The path of interest rates will depend on a multitude of factors–for example, central bank policy, fiscal policy, and trends in globalization and technology. Although interest rates are impossible to forecast, risk managers should operate under the following assumptions:

- Significantly higher interest rates are a possibility
- In any rising rate scenario, lapse rates are likely to increase

For many typical blocks of business sold in Japan, the value of embedded options, and therefore the best estimate liability reflecting option costs, depends materially on policyholder behavior assumptions.

Quantifying the option cost

This analysis focuses narrowly on the option cost that arises as a result of a book value guarantee. Policyholder behavior, of course, has broader implications, for example, for the aggregate profitability of a book of business, the recoverability of acquisition costs, and the management of liquidity risk.

The ultimate cost of the book value withdrawal option will depend on the evolution of rates and on policyholder behavior. While neither can be predicted with accuracy, it is possible to make plausible hypotheses; reasonable estimates can be made of a potential range of option costs. Given the potential for material exposure, it is critical that insurers undertake this analysis.

Evaluating the cost of dynamic lapses in market-consistent framework

As noted above, in this paper, we examine the cost of book value surrender options in a market-consistent framework. Market-consistent frameworks attempt to place a value on the cash flows associated with insurance liabilities in a manner consistent with the way financial markets value cash flows generated by widely traded assets such as bonds or CMOs. Similar to the case of a CMO, the cash flows associated with many insurance liabilities depend on market environment. This dependence–the *dynamic lapse behavior*–can have a material impact on the market-consistent value of an insurance liability.

[1] Unit-linked.

In the case of the products examined in this analysis, the option value is driven substantially by the time value of financial options and guarantees (TVFOG) as it is calculated under CFO Forum Market Consistent Embedded Value Principles©. TVFOG is a measure of the option value that arises due to uncertainty in the course of future financial markets.[2] In the context of a general account guarantee, a TVFOG arises because policyholders may lapse policies if interest rates rise, allowing them in effect to trade their existing policies for new policies or other financial instruments offering a higher yield.[3]

Under alternative dynamic lapse assumptions, we calculate TVFOG for several hypothetical blocks of non-participating business. Each policy pays either a fixed, recurring premium or single premium. For the products under consideration, all benefits, including surrender benefits, are fully specified at the time of policy issue. In each case, because we are determining TVFOG for a single generation of business having a single, low interest guarantee, we assume that future lapse rates are a function only of future interest rates.

Our goal is to gain intuition into the extent to which the cost of the option, as measured primarily by TVFOG, varies as the assumed dynamic lapse sensitivity varies. To the extent that a material sensitivity exists, further analysis is warranted. Clearly there are implications for product design, financial reporting, and risk management.

We will examine the implications of three different lapse formulae. In addition, we will adjust the formula parameters so that each formula can be used to model a range from moderate to severe lapse sensitivity. Commenting on the appropriateness of specific formulae is beyond the scope of this paper.

In the course of this analysis, we demonstrate the following: For many typical blocks of business sold in Japan, the value of embedded options, and therefore the best estimate liability reflecting option costs, depends materially on policyholder behavior assumptions.

Dynamic lapse drivers

Policyholder behavior is tied to a complex array of factors, including:

1. The policyholder's financial circumstances
2. The policyholder's evolving savings and protection needs
3. The policyholder's health
4. The policyholder's relationship with the insurance company and the company's agents
5. Company reputation
6. State of the economy
7. Level of interest rates
8. The policyholder's alternative investment and protection opportunities
9. The degree to which policyholder behavior may be viewed as *rational*, from an economic perspective

Policyholder behavior may vary significantly depending on each company's circumstances. For a given company, behavior may vary significantly from block to block, depending especially on product type and channel. For example, single-premium business written through a bank channel is likely to exhibit materially different lapse behavior than recurring-premium business written through a company's tied agents.

[2] In contrast to the intrinsic option value that exists in a static scenario.

[3] It is worth noting that while many Japanese insurance products offer book value surrenders, some Japanese products allow surrenders only with a market value adjustment; this of course reduces the value of the surrender option to the policyholder and the cost to the insurer.

Three formulas

In this analysis we test three different lapse formulas reflecting different views of a policyholder's response to rising interest rates:

1. Step rate increase
2. Linear increase
3. Arctangent

In each case there is a base level of lapses which is assumed to occur in the absence of an interest rate rise.

Step rate increase

The step rate model assumes that policyholders are insensitive to small changes in interest rates. However, after interest rates reach a certain level, the following will occur:

- Due to a combination of financial news and word of mouth, policyholders will become aware of a material change in rates.
- Policyholders will be motivated by economic self-interest to lapse in increasing numbers.

Under the step rate model, once interest rates have risen to a point above which customer awareness has been raised, further interest rate increases have no impact on the propensity to lapse.

Linear increase

In contrast to the step rate model, under the linear model, lapse rates increase gradually and continuously as interest rates increase.

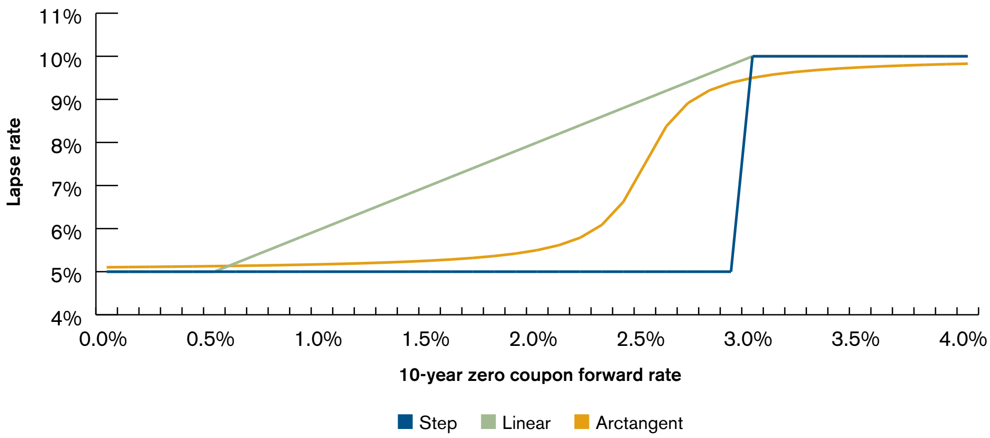
Adherents to this model believe that as rates increase, there is likely to be ever more frequent news about interest rates; further, as rates continue to increase, competitors will more aggressively market alternative investment vehicles and the incentive for individuals to lapse will increase.

Arctangent increase

The arctangent approach has characteristics of both the step rate and the linear increase.

Similar to the step rate, the arctangent formula exhibits relatively low lapse sensitivity below and above certain interest rate thresholds. As interest rates increase, there is at first a gradual increase in lapse rates. After a certain threshold rate is reached, lapse rates begin to rise significantly. Above a certain point, further increases in interest rates lead to only moderate additional levels of lapsation.

The three lapse hypotheses are illustrated in the following graph:



Many other formulas or algorithms could be developed in an effort to model dynamic policyholder behavior. As a routine part of risk management, companies should reflect on the drivers of policyholder behavior for their own business and make an effort to develop appropriate models to quantify and monitor this risk.

The products

The lapse risk profile of any product depends on the size of the cash value accumulation subject to book value withdrawal, the level of gross premium compared to that currently available in the market, and the significance of protection elements, such as death benefits or health coverage. In general, we would expect lapse rates to be less sensitive to interest rate changes when protection elements are large. This is due in part to the fact that policyholders in need of protection coverage must be re-underwritten if they lapse a policy with the intent to purchase a new one.

Related to this, it is important to note that a severe increase in lapse rates will likely be coupled with anti-selection. Policies that persist in spite of high interest rates may exhibit unfavorable mortality and morbidity due to the underwriting requirement.

We will examine the ramifications of anti-selection in a follow-up paper.

In this paper, we limit our analysis to two products:

- Single-premium whole life (WL)
- Recurring-premium whole life paid-up at 60

We calculate liabilities for both products at the end of the first issue year and at the end of the 10th issue year, respectively.

The formula parameters

Within the general formula frameworks described above, there are of course many ways to choose formula parameters in order to vary:

- Minimum or *base case* lapse rates
- Maximum lapse rates
- The slope of lapse rates as interest rates change

With regard to the step formula, rather than *slope* we need to speak in terms of a threshold. In the arctangent case, the threshold is not a single rate but a range of rates through which lapse rates increase rapidly.

For all scenarios, we assume a minimum base case lapse rate of 5% per year. Maximum lapse rates vary between 10% and 30 % per year depending on scenario. The market interest rate (10-year Japanese government bond or JGB) at which the maximum lapse rate is reached varies between 2% and 6% depending on the scenario. This compares to a 10-year JGB zero-coupon forward rate of approximately 55 basis points at the time of this analysis.

The detailed dynamic lapse parameters are listed in Appendix A to this report.

Summary of results: Option costs by scenario

We ran scenarios reflecting four liability blocks,[4] the three dynamic lapse formulae, and 20 formula parameters, generating a total of 240 valuations.

For each valuation scenario, we calculated the ratio of the value of the embedded option to the total value of best estimate liabilities, including the option cost. The option value is calculated as the sum of its intrinsic value–the value that emergences under a single, deterministic interest projection–and the TVFOG, the amount emerging due to uncertainty in future interest rates.

For the recurring-premium whole life block during the first issue year, because the best estimate liability is near zero, this ratio is hard to interpret. Therefore, we summarize results only for the single-premium block at the end of the first issue year and the recurring-premium block at end of the 10th year after issue. Detailed results are presented in Appendix C to this report.

For each liability block/dynamic lapse formula combination, ratios are as follows:

LIABILITY BLOCK/DYNAMIC LAPSE FORMULA	MINIMUM OPTION COST AS % OF TOTAL OF BEL[5] + TVFOG	MAXIMUM OPTION COST AS % OF TOTAL OF BEL + TVFOG	MEAN OPTION COST AS % OF TOTAL OF BEL + TVFOG
SINGLE-PREMIUM WL/STEP LAPSE (YEAR ONE)	2.2	11.7	6.9
SINGLE-PREMIUM WL/LINEAR LAPSE (YEAR ONE)	4.8	11.4	8.9
SINGLE-PREMIUM WL/ARCTANGENT LAPSE (YEAR ONE)	4.9	10.7	8.2
RECURRING-PREMIUM WL (YEAR 10)/STEP LAPSE	3.1	16.8	9.9
RECURRING-PREMIUM WL (YEAR 10)/LINEAR LAPSE	7.1	16.6	13.0
RECURRING-PREMIUM WL (YEAR 10)/ARCTANGENT LAPSE	7.1	15.6	11.9

Even under quite mild assumptions as to dynamic lapse, the option cost will raise the total cost of liabilities by about 5%.

In selecting our parameters for maximum lapse sensitivity, we tried to select lapse levels consistent with experience at some companies in the United States during the period of disintermediation that occurred in the early 1980s. The maximum annual lapse rate is 30%. For these more severe scenarios, the option cost rises to between 10% to 17 % of the total best estimate liability.

4 i.e., single and recurring premium at the end of Durations 1 and 10.
5 We are using best estimate liability (BEL) here and in the appendices to mean the present value of cash flows arising under a single, deterministic interest scenario derived from the yield curve on March 31, 2013. All figures shown in this table are on a pre-tax basis.

Although protection-oriented plans will show considerably less lapse sensitivity, we believe these results point to the following conclusions:

- The cost of embedded options can be material on investment oriented general account business.
- The cost of embedded options varies materially depending on dynamic lapse assumptions.
- Due to uncertainty over dynamic lapse behavior, market-consistent valuations need to be interpreted with care.

Clearly, these results need to be interpreted carefully and must be understood in a specific context. On the one hand, to the extent that general account savings products are only one segment of a diversified portfolio, one might suspect that the risks illustrated above are not highly material. On the other hand, because these option values are calculated as an average over many stochastic scenarios, the results of specific scenarios will be more severe than may be suggested by the TVFOG metric. Risk managers need to employ both stochastic and deterministic analyses in developing policy recommendations. As indicated at the outset, policyholder behavior has implications for risk management and profit that extend well beyond a focused analysis on the cost of embedded options.

Integration of market-consistent reporting with asset-liability management

Because the valuation of liabilities under a market-consistent approach is explicitly framed in the context of financial market theory and is conceptualized in terms of tradable assets, it is natural for practitioners to develop an integrated approach to embedded value reporting and asset-liability management (ALM). Although this offers a useful perspective, the comingling of insurance elements with investment guarantees and the uncertainty associated with policyholder behavior complicate the replication of liability cash flows. It is critical that companies appreciate both the potential value and the potential pitfalls underlying efforts to integrate reporting and ALM.

In the market-consistent framework, the cash flows underling a BEL are fixed, so that the BEL can be viewed as the cost of bonds that will replicated this fixed stream of cash flows. The TVFOG can be thought of in terms of the cost of the swaptions that will convert these bonds into an immediate payment. This is easiest to visualize in the case of a single pay product, where cash outflows from surrenders would typically dominate in the early years; these cash flows are substantially determined by the dynamic lapse assumption that emerges under the forward rates implied by the yield curve at the valuation date.

As an ALM strategy, the option granted to policyholders could be explicitly hedged through the purchase of swaptions. The appropriate strategy depends on our understanding of policyholder behavior. If we believe that policyholder behavior is highly sensitive to rising interest rates, this means that many policyholders will in fact exercise the right implied by the swaption. Because not all policyholders will in fact exercise the option, an effective hedging strategy requires careful analysis of an appropriate hedge ratio and potential purchase of out-of-the-money swaptions.

Summing up

As noted above, our primary goal in presenting this paper is to promote a discussion of policyholder behavior. Regardless of a company's approach to financial measurement and reporting, risk management protocols should include an ongoing analysis of dynamic lapse issues. Newly emerging techniques from areas such as predictive analytics, behavioral psychology, and Bayesian statistics can facilitate a better understanding of policyholder behavior than was possible in the past. For those companies reporting embedded values, we recommend that the implications of alternative dynamic lapse assumptions be tested as part of a broader review of embedded value sensitivity.

A note on the appendices

Appendix A describes the parameters used for each dynamic lapse scenario. Appendix B outlines the key economic and non-economic assumptions used in the analysis.

Appendices A and B are attached with this report.

Appendix C includes a more detailed presentation of the results. Results are shown for each dynamic lapse scenario. In addition, for each dynamic lapse scenario, we develop an analysis of the liabilities that emerge under each of the stochastically generated interest rate scenarios. Appendix D includes some observations on the detailed results. Milliman is happy to provide Appendices C and D upon request; please contact any of the authors in this regard.

APPENDIX A: DYNAMIC LAPSE PARAMETERS

For each of the three formula types (step, linear, arctangent), we tested 20 sets of parameters as described by the following tables:

Step Parameters

PARAMETER SET	MINIMUM LAPSE RATE (% P.A.) @ 10-YEAR JGB =0.5%	MAXIMUM LAPSE RATE (% P.A.)	10-YEAR JGB RATE (%) AT WHICH THE MAXIMUM LAPSE RATE IS REACHED
STEP 1-1	5	10	2.0
STEP 1-2	5	10	3.0
STEP 1-3	5	10	4.0
STEP 1-4	5	10	5.0
STEP 2-1	5	15	2.0
STEP 2-2	5	15	3.0
STEP 2-3	5	15	4.0
STEP 2-4	5	15	5.0
STEP 3-1	5	20	2.0
STEP 3-2	5	20	3.0
STEP 3-3	5	20	4.0
STEP 3-4	5	20	5.0
STEP 4-1	5	25	2.0
STEP 4-2	5	25	3.0
STEP 4-3	5	25	4.0
STEP 4-4	5	25	5.0
STEP 5-1	5	30	2.0
STEP 5-2	5	30	3.0
STEP 5-3	5	30	4.0
STEP 5-4	5	30	5.0

Linear Parameters

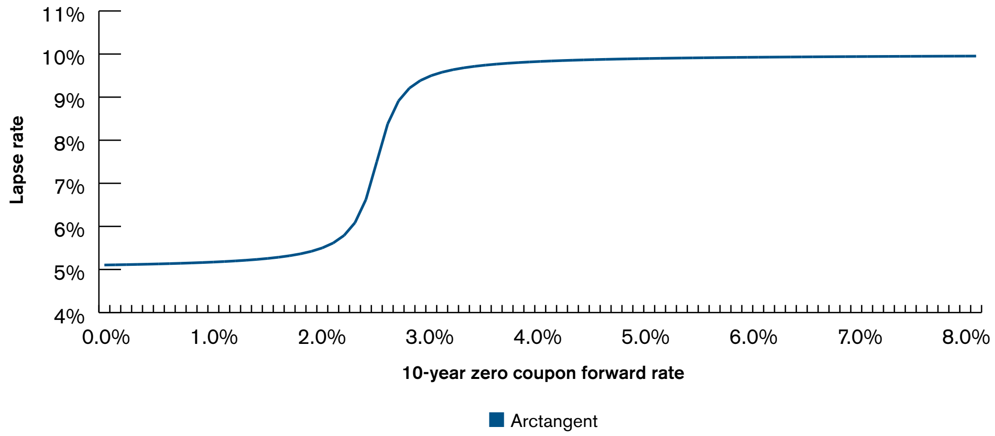
PARAMETER SET	MINIMUM LAPSE RATE (% P.A.) @ 10-YEAR JGB =0.5%	MAXIMUM LAPSE RATE (% P.A.)	10-YEAR JGB RATE (%) AT WHICH THE MAXIMUM LAPSE RATE IS REACHED
LINEAR 1-1	5	10	3.0
LINEAR 1-2	5	10	4.0
LINEAR 1-3	5	10	5.0
LINEAR 1-4	5	10	6.0
LINEAR 2-1	5	15	3.0
LINEAR 2-2	5	15	4.0
LINEAR 2-3	5	15	5.0
LINEAR 2-4	5	15	6.0
LINEAR 3-1	5	20	3.0
LINEAR 3-2	5	20	4.0
LINEAR 3-3	5	20	5.0
LINEAR 3-4	5	20	6.0
LINEAR 4-1	5	25	3.0
LINEAR 4-2	5	25	4.0
LINEAR 4-3	5	25	5.0
LINEAR 4-4	5	25	6.0
LINEAR 5-1	5	30	3.0
LINEAR 5-2	5	30	4.0
LINEAR 5-3	5	30	5.0
LINEAR 5-4	5	30	6.0

For the linear rule, lapse rates are assumed to vary linearly between the minimum lapse rate and the maximum lapse rate as interest rates increase from 0.5% to the interest rate threshold shown in the last column in the table above.

Arctangent Parameters

PARAMETER SET	MINIMUM LAPSE RATE (% P.A.)	MAXIMUM LAPSE RATE (% P.A.)	THRESHOLD RANGE[6] (10-YEAR JGB RATE (%))
ARCTANGENT 1-1	5	10	2.0 – 3.0
ARCTANGENT 1-2	5	10	2.5 – 3.5
ARCTANGENT 1-3	5	10	2.0 – 4.0
ARCTANGENT 1-4	5	10	1.5 – 4.5
ARCTANGENT 2-1	5	15	2.0 – 3.0
ARCTANGENT 2-2	5	15	2.5 – 3.5
ARCTANGENT 2-3	5	15	2.0 – 4.0
ARCTANGENT 2-4	5	15	1.5 – 4.5
ARCTANGENT 3-1	5	20	2.0 – 3.0
ARCTANGENT 3-2	5	20	2.5 – 3.5
ARCTANGENT 3-3	5	20	2.0 – 4.0
ARCTANGENT 3-4	5	20	1.5 – 4.5
ARCTANGENT 4-1	5	25	2.0 – 3.0
ARCTANGENT 4-2	5	25	2.5 – 3.5
ARCTANGENT 4-3	5	25	2.0 – 4.0
ARCTANGENT 4-4	5	25	1.5 – 4.5
ARCTANGENT 5-1	5	30	2.0 – 3.0
ARCTANGENT 5-2	5	30	2.5 – 3.5
ARCTANGENT 5-3	5	30	2.0 – 4.0
ARCTANGENT 5-4	5	30	1.5 – 4.5

5 The threshold range is defined as the range over which the function moves from 10% above the base level to 90% above the base level. For example, for the first set of parameters, the formula 7.5 + (2.5/(0.5*3.14159))* arctangent (6.155346*(INT – 2.5)) has a value of 5 + 0.1 (10-5) at INT = 2.0, 3 + .9(10-5) at INT = 3.0, and is asymptotic to 5 and 10 as illustrated by the following graph:



APPENDIX B: MODEL ASSUMPTIONS

The assumptions used for this calculation are as below.

Economic assumptions

JGB yields as at the end of March 2013 are used as reference rates for risk free rates. They determine the investment yields and discount rates that underlie the calculation of the certainty equivalent present value of liability cash flows (i.e., the best estimate liability, which excludes TVFOG in our definition).[6] As there are no data available for interest rates beyond 40 years, it is assumed that 1-year forward rates in the 41st year and thereafter are equal to the 1-year forward rate in the 40th year. The JGB yield data were obtained from information vendors.

The 1-year forward rates are shown below.

PERIOD	YIELD	PERIOD	YIELD	PERIOD	YIELD	PERIOD	YIELD
1 YEAR	0.07%	11 YEAR	1.87%	21 YEAR	1.93%	31 YEAR	2.09%
2 YEAR	0.08%	12 YEAR	1.87%	22 YEAR	1.93%	32 YEAR	2.09%
3 YEAR	0.03%	13 YEAR	1.87%	23 YEAR	1.93%	33 YEAR	2.09%
4 YEAR	0.20%	14 YEAR	1.87%	24 YEAR	1.93%	34 YEAR	2.09%
5 YEAR	0.30%	15 YEAR	1.87%	25 YEAR	1.93%	35 YEAR	2.09%
6 YEAR	0.31%	16 YEAR	3.04%	26 YEAR	1.93%	36 YEAR	2.09%
7 YEAR	0.95%	17 YEAR	3.04%	27 YEAR	1.93%	37 YEAR	2.09%
8 YEAR	0.92%	18 YEAR	3.04%	28 YEAR	1.93%	38 YEAR	2.09%
9 YEAR	1.24%	19 YEAR	3.04%	29 YEAR	1.93%	39 YEAR	2.09%
10 YEAR	1.51%	20 YEAR	3.04%	30 YEAR	1.93%	40 YEAR	2.09%

The 10-year zero coupon forward rates used as a benchmark interest rate for dynamic lapses are shown below.

PERIOD	YIELD	PERIOD	YIELD	PERIOD	YIELD	PERIOD	YIELD
1 YEAR	0.55%	11 YEAR	2.42%	21 YEAR	1.93%	31 YEAR	2.09%
2 YEAR	0.73%	12 YEAR	2.44%	22 YEAR	1.95%	32 YEAR	2.09%
3 YEAR	0.90%	13 YEAR	2.46%	23 YEAR	1.96%	33 YEAR	2.09%
4 YEAR	1.08%	14 YEAR	2.48%	24 YEAR	1.98%	34 YEAR	2.09%
5 YEAR	1.25%	15 YEAR	2.50%	25 YEAR	1.99%	35 YEAR	2.09%
6 YEAR	1.41%	16 YEAR	2.52%	26 YEAR	2.01%	36 YEAR	2.09%
7 YEAR	1.68%	17 YEAR	2.40%	27 YEAR	2.02%	37 YEAR	2.09%
8 YEAR	1.88%	18 YEAR	2.29%	28 YEAR	2.04%	38 YEAR	2.09%
9 YEAR	2.09%	19 YEAR	2.17%	29 YEAR	2.05%	39 YEAR	2.09%
10 YEAR	2.27%	20 YEAR	2.05%	30 YEAR	2.07%	40 YEAR	2.09%

To generate stochastic interest rate scenarios, we used the Heath-Jarrow-Morton interest rate model, calibrated to the market at the end of each year ending March 31. Parameters are estimated from the swap curve and the implied volatilities of interest swaptions with different option term and swap tenors as at the end of March 2013. We employed 1,000 scenarios derived from this interest rate model in calculating the time value of options and guarantees.

6 Many Japanese companies use JGB rates rather than swap rates as a proxy for risk free rates in their embedded value calculations.

Non-economic assumptions

Mortality assumptions are as below. The base mortality rates are the same as pricing assumptions, the Life Insurance Standard Table 2007 for regular deaths.

DURATION	MORTALITY SCALAR APPLIED TO BASE MORTALITY RATES
1	50%
2	60%
3	70%
4+	80%

The base lapse assumption is 5%.

Maintenance expense unit costs are show in the table below.

PER PREMIUM	3%
PROPORTIONAL TO SUM INSURED	0.2%

Model points

Model points are as below.

Single-premium whole life:

SEX	AGE	ISSUE YEAR	SUM INSURED	PREMIUM
MALE	20	OCTOBER 1, 2012	10 MILLION YEN	6.6 MILLION YEN
MALE	30	OCTOBER 1, 2012	10 MILLION YEN	7.0 MILLION YEN
MALE	40	OCTOBER 1, 2012	10 MILLION YEN	7.5 MILLION YEN
MALE	50	OCTOBER 1, 2012	10 MILLION YEN	8.0 MILLION YEN

Recurring premium whole life paid-up at 60:

SEX	AGE	ISSUE YEAR	SUM INSURED	PREMIUM (MONTHLY)
MALE	20	APRIL 1, 2003	10 MILLION YEN	17.6 THOUSAND YEN
MALE	30	APRIL 1, 2003	10 MILLION YEN	23.9 THOUSAND YEN
MALE	40	APRIL 1, 2003	10 MILLION YEN	36.6 THOUSAND YEN
MALE	50	APRIL 1, 2003	10 MILLION YEN	74.3 THOUSAND YEN

Assumed interest rate: 1% for both single-premium and regular-premium policies.

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