Session 6B, Dynamic Lapse Modeling Using Korean Insurance Industry Data

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Dynamic Lapse Modeling

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Introduction

- (Needs) In order to predict the future cash flow, not only are the risk rate, business expense, interest rate but also the policyholder behavior has become a significant variable
  - ► Solvency II, IFRS 17, and MCEV regulation requires explicitly that policyholder behavior has to be taken into account

- (At present) Research on policyholder behavior assumptions for liability valuation has not been actively carried out
  - **Changki Kim,** "Policyholder Surrender Behaviors under Extreme Financial Conditions"(2010)
  - **Jintae Hwang·Kyunghee Lee,** "Estimation and Prediction Model of Lapse Rate about Life Insurance Product"(2010)
  - **Changsu Oh,** "A Study on the Valuation of Interest Rate Guarantees under IFRS with Dynamic Lapse Rates"(2016)

- (KIDI) Policyholder Behavioral Assumptions Including Dynamic lapse
  - A study on the dynamic lapse due to changes in the financial environment (2011, 2013)
  - Operation of policyholder behavior assumptions TF in FY2016 (dynamic lapse , additional payment · partial withdrawal)

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1. Definition of Dynamic Lapse

In a larger sense, applying the lapse rate differently depending on the level of a dynamic variable is called a dynamic lapse.

- In practice, factors affecting the lapse rate can be divided into two types : market-related variables and the market-independent variables(i.e. variables related to the contract itself)

  ※ Calculating the lapse rate in consideration of market-related variables is the dynamic lapse rate.

< Contract variables>

- Elapsed period
- Product type
- Single/non-single
- Channel
- Full payment
- …

< Dynamic variables>

- Interest rate
  - Interest rate spread *

    * market reference –crediting rates
- Stock market index
  - Moneyness**

    ** policyholder reserve against minimum guarantee
- Macroeconomic variables
  - Price index, economic growth rate, etc.

2. Importance of Dynamic Lapse

The lapse rate assumption is a key factor essential to predicting future cash flows and insurance liability, and can have a significant financial impact on insurance company depending on the level of the assumption

- Policyholder‟s lapse behavior is closely linked to external variables other than contract characteristics
  - This can be discovered by studying correlations between lapse rate and the external variables, and by researching articles on lapse rates written at home and abroad
- It is essential to capture relevant variables for lapse rates in order to accurately predict future cash flows
- Current research on dynamic lapse rate exists sporadically and the detailed analysis of calculation methodology is insufficient

  - Continued research in the insurance industry is needed

3. Example of Dynamic Lapse Application – Variable Guarantee

Variable Guarantee is one type where dynamic lapse is often applied in practice

- Assume that policyholder lapse behaviors will vary depending on the value of the guarantee option.
- If policyholder reserve is less than the minimum guaranteed amount, the value of the option will increase, making the contractor less likely to terminate the contract.
- In the opposite case, the policyholder is more likely to terminate the contract, which would be reflected on the base lapse rate
- Accordingly, policyholder reserve against minimum guaranteed amount, (i.e. dynamic lapse rate based on Moneyness) is important

< Moneyness level and Terminology >

Moneyness (Reserve / Minimum guarantee)	Greater than 100%	Less than 100%
Terminology	Out-of-Money	In-the-Money

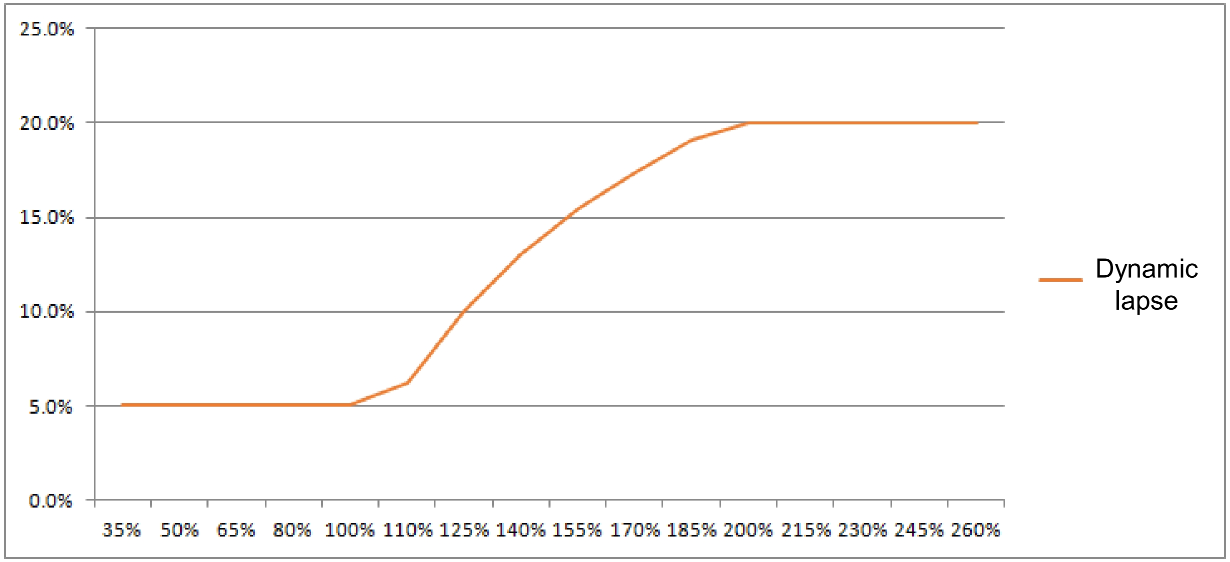
3. Example of Dynamic Lapse Application – Variable Guarantee

The US Principle based Reserve (PBR, VM-21) applies the following dynamic lapse multiplier (λ) when calculating the cash surrender value of GMDB products:

$$\lambda = MIN[U,\ MAX[L,\ 1 - M \times (\frac{GV}{AV} - D)]]^{*}$$

* GV : guaranteed amount, AV : policyholder account value, U,L : upper·lower coefficient, M : sensitivity coefficient, D : adjustment factor

< Application of Dynamic Lapse Rate on the Variable Guarantee ① >



U : 200%
L : 50%
M : 3.5
D : 0.8

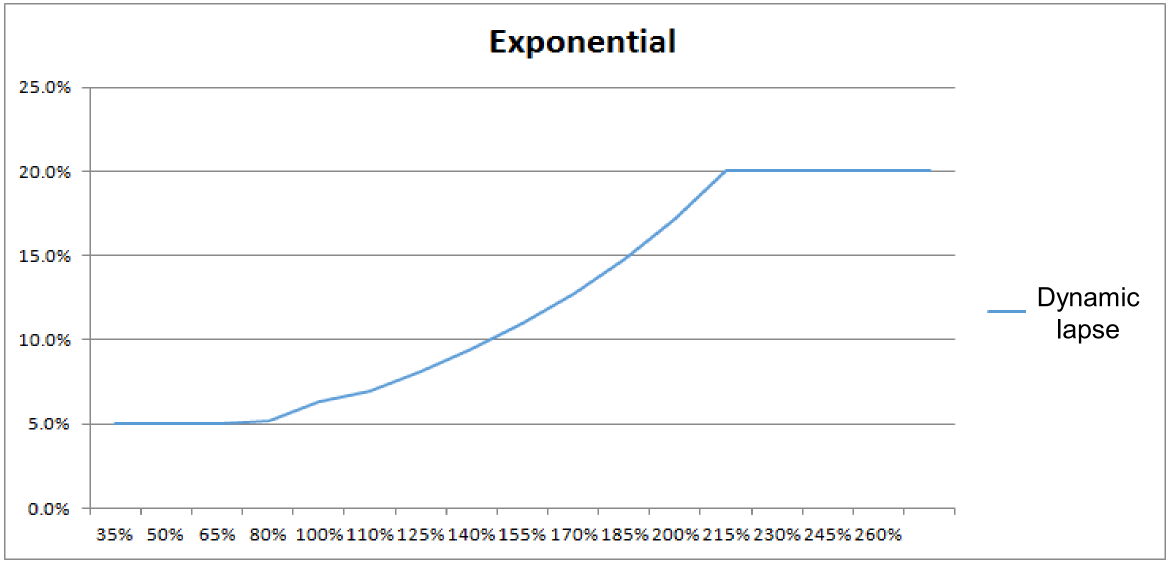
base Lapse rate: 10%

3. Example of Dynamic Lapse Application – Variable Guarantee

The ascending shape in lapse rate depends on the fitting model.
Consider, for instance, the rising curve in the form of an exponential function as follows :

$$\lambda = MIN[U, \ MAX[L, \ \exp(\frac{GV}{AV} - D) \times M]]$$

< Application of Dynamic Lapse Rate on the Variable Guarantee ② >



U : 200%
L : 50%
M : 0.7
D : 1.1

base Lapse rate: 10%

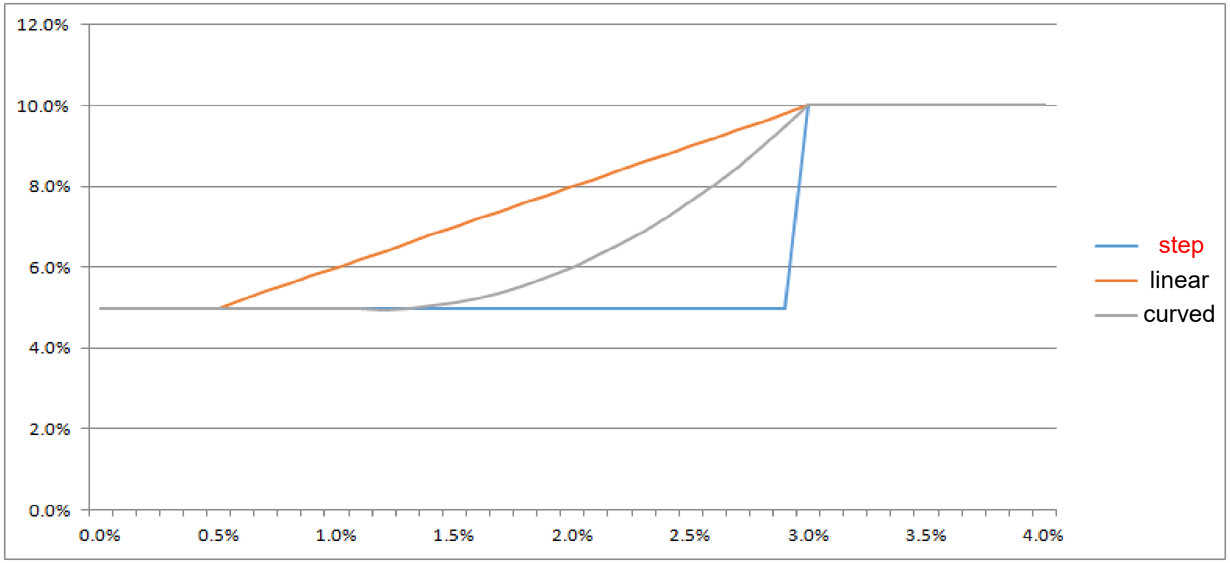
- Segment and point of reaching upper limit are almost similar but ascending shape changes in form of exponential function.

4. General Methodology for Estimating Dynamic Lapse

(1) The method where the multiplier(or the excess lapse rate) calculated based on the level of the dynamic variable is applied to the base lapse rate (Multiplier method)

- It is important to determine the type of ascending shape for this multiplier method.
- There are three main types of ascending shapes, and each presents different views on how policyholders react depending on the level of the dynamic variables

< Comparisons among ascending lapse rate shapes>



4. General Methodology for Estimating Dynamic Lapse

(2) Method which includes dynamic variables in a lapse model so that the dynamic effects can be reflected in the model (Modeling method)

※ „Time series model" and „Logit model" are widely used for the lapse rate modeling

Panel A: Focus on environmental variables

Authors	Dar and Dodds (1989)	Outreville (1990)	Kuo et al. (2003)	Kim (2005a)	Kim (2005b)	Cox and Lin (2006)	Kiesenbauer (2011)
Country	UK	US, Canada	US	South Korea	US		Germany
Lapse Data Provider	Industrial Life Offices' Association (ILOA)	American Council of Life Insurance (ACLI); Life Insurance and Market Research Association (LIMRA)	American Council of Life Insurance (ACLI)	One Korean company	Society of Actuaries' Risk Management Task Force (data on one US company)	Society of Actuaries' Risk Management Task Force (data on one US company)	German regulator BAFin and self-collected data
Type of Policy	Endowment policies	Whole-life and ordinary life insurance	All ordinary life insurance contracts*	Endowment, annuity, protection plan, education	Single premium deferred annuities	Single premium deferred annuities	Endowment, annuities including disability and long-term care, term life, group business, other
Time Period	1952-1985	1955-1979 (annually), 1960-1979 (semiannually)	1951-1998	1997-2000	1993-2003	1993-2003	1997-2009
Methods	Standard time series regressions	Standard time series regressions	Cointegration techniques	Logit and complementary log-log model	Logit	Tobit	Logistic regression
Variables for EFH and IRH	EFH: growth in the level of unemployment and the level of actual unemployment relative to time trend	EFH: yearly unemployment rate	EFH: yearly unemployment rate	EFH: Unemployment rate	EFH: Monthly annualized US unemployment rate	EFH: Monthly annualized US unemployment rate	EFH: Unemployment rate
	IRH: internal and external rate of return	IRH: real rate of return on alternative assets	IRH: market interest rates	IRH: reference market rate - crediting rate -surrender charges	IRH: Annualized five–year Treasury bond rate minus the policy credited rate	IRH: Annualized five–year Treasury bond rate minus the policy credited rate	IRH: Bond Performance, Stock Performance
Other variables	/	Real transitory income per capita, price of insurance, anticipated inflation rate.	/	Policy age, GDP growth, surrender charge	Policy age, GDP growth, surrender charge	Policy age, GDP growth, surrender charge	Buyer confidence, GDP, company age, distribution, legal form, company size, participation rate
Main Results	EFH +; IRH -	EFH +	EFH -, IRH +	Lapse depends on additional exogenous factors beyond interest rates and unemployment rates	Logit Model closely fit the experience of the data even under extreme financial conditions	Tobit model is better than logit model; poisson and the negative binomial regression model are more appropriate to model lapse	Factors beyond interest rates and unemployment influence lapse behavior, including company characteristics

Notes: EFH: Emergency fund hypothesis; IRH: Interest rate hypothesis; *: The covered policies include universal life, variable life, variable-universal life, and traditional whole life that includes limited payment, continuous premium, joint whole life, single premium, adjustable life, monthly debit, and other fixed-premium products), term insurance (including decreasing, level and other term, term additions), and endowment insurance.

4. General Methodology for Estimating Dynamic Lapse_continued

(2) Method which includes dynamic variables in a lapse model so that the dynamic effects can be reflected in the model (Modeling method)

Panel B: Focus on product and policyholder characteristics

Authors	Renshaw and Haberman (1986)	Kagraoka (2005)	Cerchiara et al. (2009)	Milhaud et al. (2010)	Eling and Kiesenbauer (2011)
Country	Scotland	Japan	Italy	Spain	Germany
Data Provider	Pool of 7 companies	1 company	1 company	1 company	1 company
Type of Policy	Endowment Whole-life Temporary insurance	Annuity-type personal accident	Saving	Endowment	Endowment Annuity Term life
Time Period	1976	1993-2001	1991–2007	1999–2007	2000-2010
Methods	Logistic regression model Binomial model	Poisson model Negative binomial model	Poisson model	Logistic regression model Classification and regression tree model	Poisson model Binomial model Negative binomial model
Variables	Policyholder age and sex Contract age Product type Company	Policyholder age and sex Seasonality Unemployment rate Heterogeneity	Policyholder age Contract age Product type Calendar year	Policyholder age Contract age Product type Sum insured Risk premium Saving premium	Policyholder age and sex Contract age Product type
Main Results	four factors identified as important (age at entry, duration of policy, office, type of policy); additionally, significant interaction between policy type and duration	surrender of the insurance contracts is explained by change of unemployment rates and time elapsed from contract date.	Shows the importance of policy duration, but also show the sensitivity of lapse rates to calendar year of exposure, to product class and policyholder age	Find that duration and profit benefit option are essential	Product characteristics such as product type or contract age and policyholder characteristics such as age or gender are important lapse drivers

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1. Data Used

(DB) Collected 14 life insurance company„s lapse rate data

- (Variables) Product type, payment type, crediting rate, minimum guaranteed interest rate, elapsed period (month), etc.
- (Product type) 4 product types: savings, annuity, annuity savings, and protection
- (Data range) CY2006 ~ CY2015 ; 10 years of monthly data in total*

  * The range of data submitted is slightly different by company
- (Calculation basis) Calculation of the base lapse rate in month using the number of in-force contracts at the end of month and the number of cancelled contracts during the month

- k th month lapse rate $= \dfrac{k \text{ th month number of lapse}}{k \text{ th month number of expsure}}$
- (year) maintanence rate $= \prod_{k=1}^{12} (1 - k \text{ th month lapse rate})$
- (year)lapse rate $= 1 -$ (year)maintanence rate

2. Multiplier Method – Principle

Determine the lapse multiplier(interest rate spread) by calculating the difference between the market reference and crediting rates of insurance contract

- (External market reference) Five-year treasury bond rate
  - Interest rate spread = Five-year treasury bond rate – crediting rate*
    * If the minimum guarantee rate exceeds the crediting rate, replace it with the minimum guarantee rate
- (Product type) 4 product types: savings, annuity, annuity savings, and protection
- (Spread section width) Calculate lapse multiplier in units of 50bp
- (Range of multiplier calculation) Consider the data sufficiency for each product type and determine the range for calculating the multiplier
  - The multiplier is the base data for model fitting → credibility is important
- (Elapsed period) Calculate one multiplier per spread section regardless of elapsed duration

2. Multiplier Method – Principle

< Interest rate spread section / lapse rate by elapsed year >

(bp, %)

Section / year	1	2	3	…	10	11	12
section 1	a_1	a_2	a_3	…	a_{10}	a_{11}	a_{12}
section 2	b_1	b_2	b_3	…	b_{10}	b_{11}	B_{12}
…							
section 6	g_1	g_2	g_3	…	g_{10}	g_{11}	g_{12}
section 7	h_1	h_2	h_3	…	h_{10}	h_{11}	h_{12}
Total	T_1	T_2	T_3	…	T_{10}	T_{11}	T_{12}

- As the period elapses, the spread section, where contracts are concentrated, changes.
  - * Due to the high interest rate-fixed contracts in the past, the proportion of contracts „s spreads that differ by more than '-300bp' after the 13th year comprises more than 50%
- Concerns about distortions in multiplier calculation → Use data from 1st to 12th elapsed years

2. Multiplier Method – Principle

< Interest rate spread section / multiplier conversion by elapsed year >

(bp, %)

section / year	1	2	3	···	10	11	12
section 1	a_1 / T_1	a_2 / T_2	a_3 / T_3	···	a_{10} / T_{10}	a_{11} / T_{11}	a_{12} / T_{12}
section 2	b_1 / T_1	b_2 / T_2	b_3 / T_3	···	b_{10} / T_{10}	b_{11} / T_{11}	b_{12} / T_{12}
···	···	···	···		···	···	···
section 6	g_1 / T_1	g_2 / T_2	g_3 / T_3	···	g_{10} / T_{10}	g_{11} / T_{11}	g_{12} / T_{12}
section 7	h_1 / T_1	h_2 / T_2	h_3 / T_3	···	h_{10} / T_{10}	h_{11} / T_{11}	h_{12} / T_{12}

< Interest rate spread section / number of contracts by elapsed year >

(bp, cases)

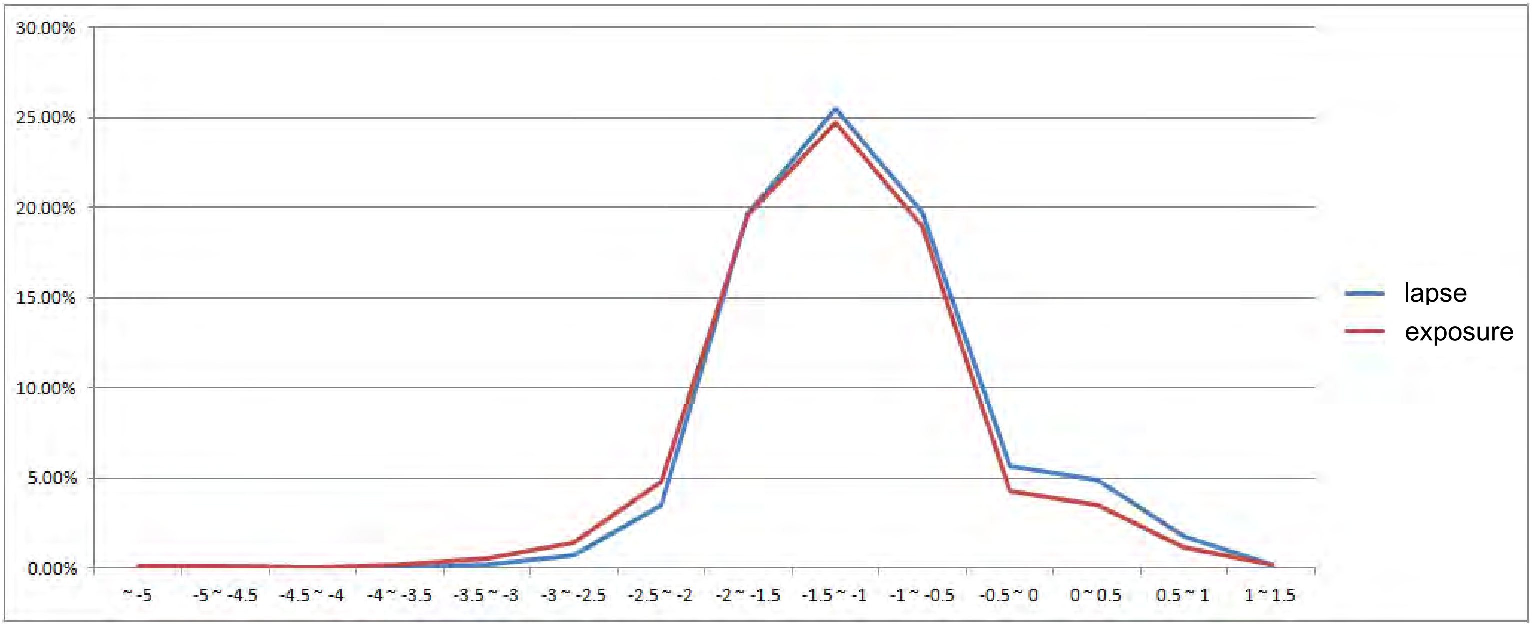
Section / year	1	2	3	···	10	11	12
section 1	A_1	A_2	A_3	···	A_{10}	A_{11}	A_{12}
section 2	B_1	B_2	B_3	···	B_{10}	B_{11}	B_{12}
···	···	···	···		···	···	···
section 6	G_1	G_2	G_3	···	G_{10}	G_{11}	G_{12}
section 7	H_1	H_2	H_3	···	H_{10}	H_{11}	H_{12}

section1 multiplier

$$= \frac{A_1 \times (a_1 / T_1) + A_2 \times (a_2 / T_2) + \cdots + A_{11} \times (a_{11} / T_{11}) + A_{12} \times (a_{12} / T_{12})}{A_1 + A_2 + \cdots A_{11} + A_{12}}$$

2. Multiplier Method – Base Lapse Multiplier (savings product)

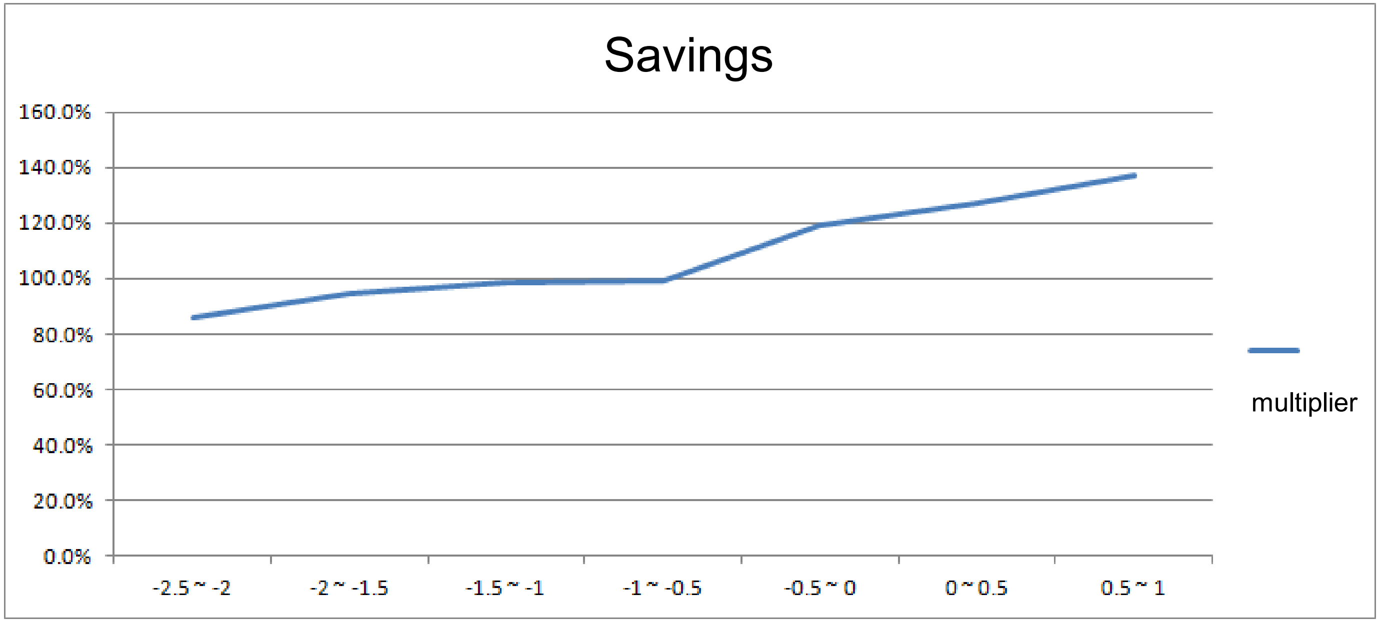
< Ratio of lapsed contracts and in-force contracts by interest rate spread >



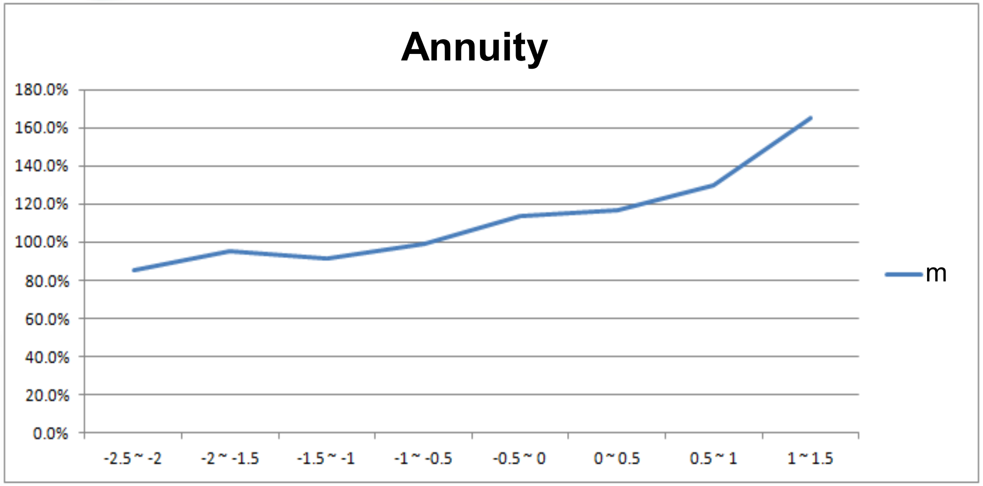
2. Multiplier Method – Base Lapse Multiplier (savings product)

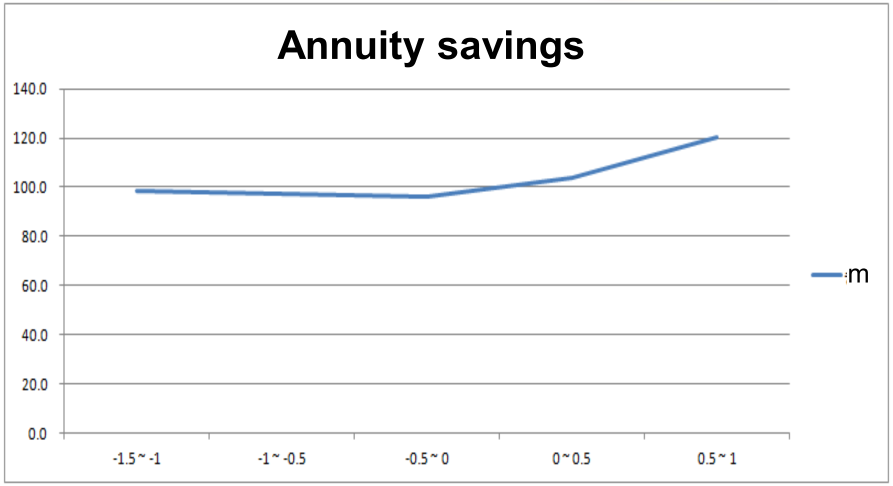
< Multiplier by interest rate spread section for savings product >

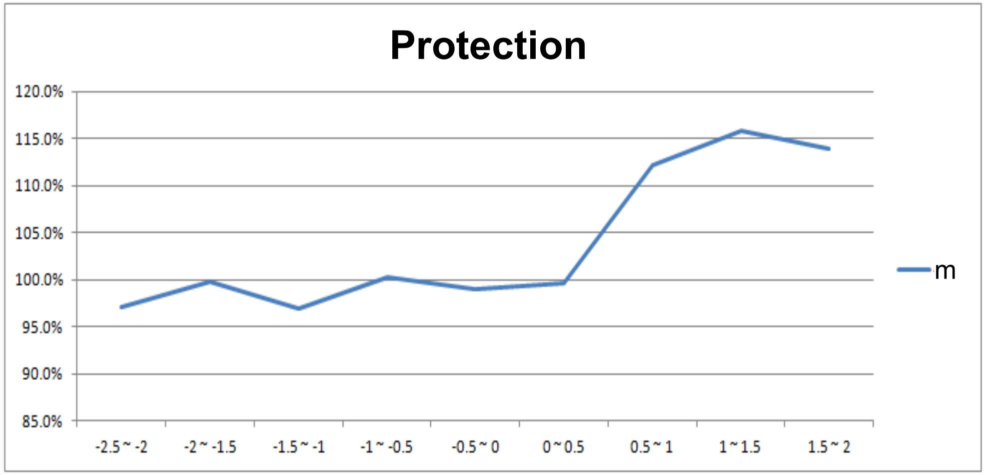
section	-2.5 ~ -2.0	-2.0 ~ -1.5	-1.5 ~ -1.0	-1.0 ~ -0.5	-0.5 ~ 0	0 ~ 0.5	0.5 ~ 1.0
Multiplier(m)	85.6	94.6	98.2	98.9	119.0	127.1	136.1



2. Multiplier Method – Base Lapse Multiplier (others)







2. Multiplier Method – Model Fit (Overview)

The base lapse multiplier calculated from the experience data is fitted to 'Arctangent model'

- (Objective) Apply the lapse multiplier differentially for the spread unit variation regardless of the section width
  - Remove volatilities arising from the base lapse multiplier (Smoothing)
  - Can apply lapse multiplier on section for which the base lapse multiplier has not been calculated
- (Model characteristics) Arctangent function has upper and lower limits
  - It is possible to explain the general phenomenon where the slope of the lapse multiplier increases rapidly and then decreases near the inflection point.
  - Easy to adjust model by changing the coefficient of the model
- (Model form) The base form of Arctangent model is as follows :

Mutiplier = $f(x) = a \times \arctan(m \times (x-k)) + c$,

where k = inflection point, m = sensitivity, a & c= adjustment coefficienct

$F(\infty)$=U(upper limit), $f(-\infty)$=L(lower limit)

2. Multiplier Method – Model Fit (savings)

< Multiplier by spread section→ Convert multiplier by interest rate spread >

Spread section	-2.5 ~ -2.0	-2.0 ~ -1.5	-1.5 ~ -1.0	-1.0 ~ -0.5	-0.5 ~ 0	0 ~ 0.5	0.5 ~ 1.0
base multiplier	85.6	94.6	98.2	98.9	119.0	127.1	136.1

Spread	-2.5	-2.0	-1.5	-1.0	-0.5	0	0.5	1.0
Conversion multiplier	85.6	90.1	96.4	98.6	108.9	123.1	131.6	136.1

< Inflection point and inflection point multiplier setting >

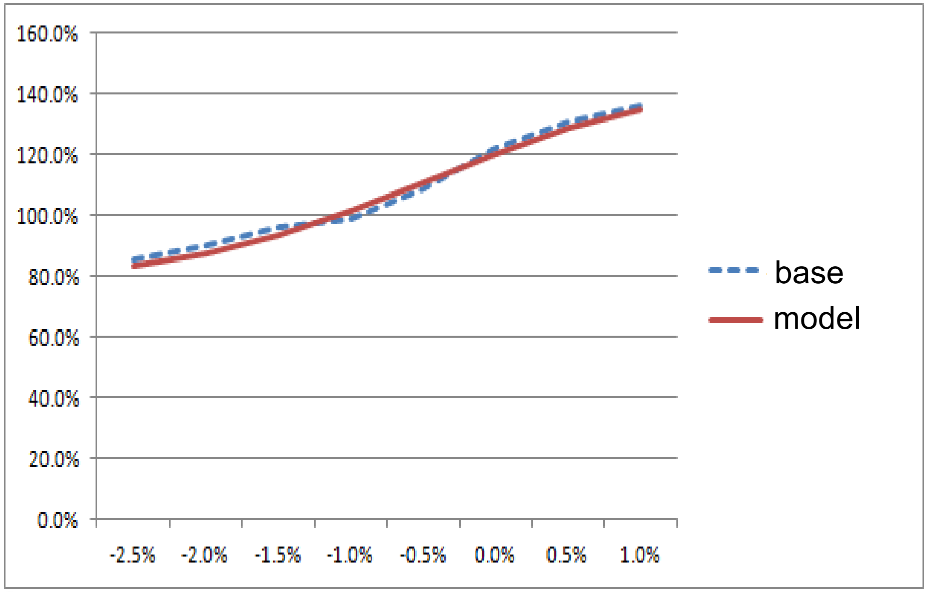
Interest rate spread (bp)	-100	-50	0
Multiplier(%)	98.6	108.9	123.1
Multiplier difference(%p)	10.3		14.2
ratio	0.43 (10.3/24.5)		0.57 (14.2/24.5)
Inflection point(k)	(-100) x 0.43 + (0) x 0.57 = -43(bp)		
f(k) = c	(98.6) x 0.43 + (123.1) x 0.57 = 112.2(%)		

2. Multiplier Method – Model Fit (savings)

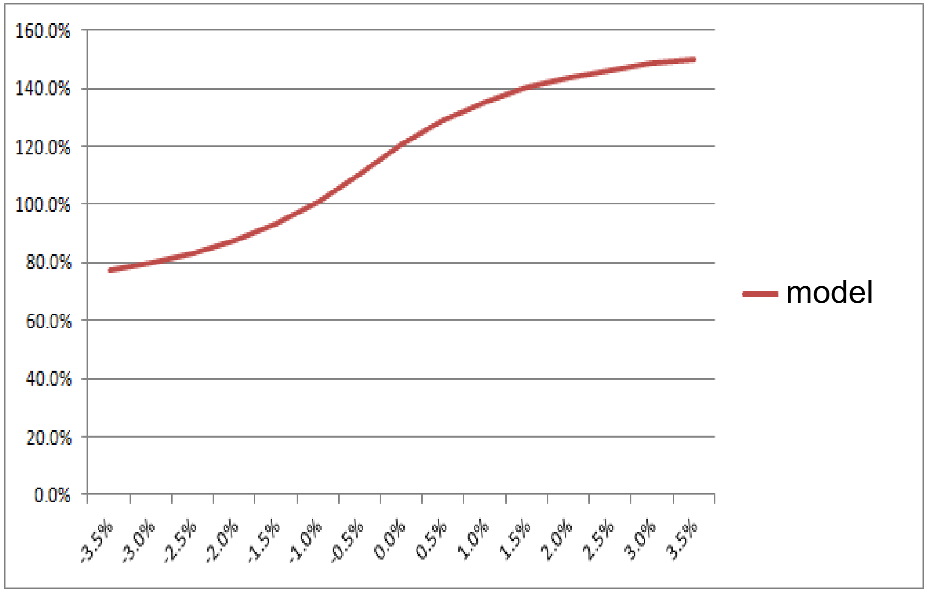
< Arctangent model of savings >

	Upper limit (U)	Lower limit (L)	Inflection point (k)	Inflection multiplier (c)	Adjustment factor (a)	Sensitivity (m)
Coefficient	170%	70%	-43bp	112.2%	31.8%	61.7
Arctan model	f(x) = 0.318 * arctan(61.7 * (x + 0.43) + 1.122					

< Comparison of Savings Product Multiplier >

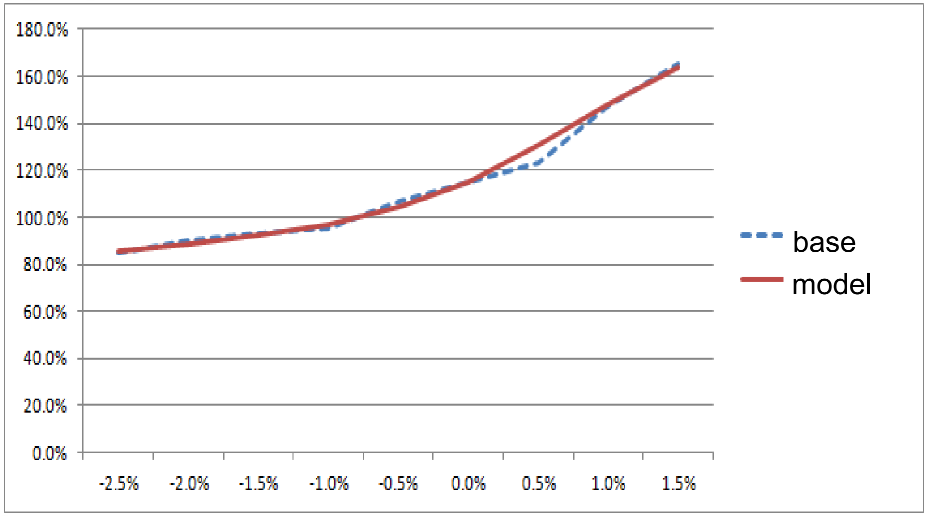


< Extension of Savings Product Multipler >

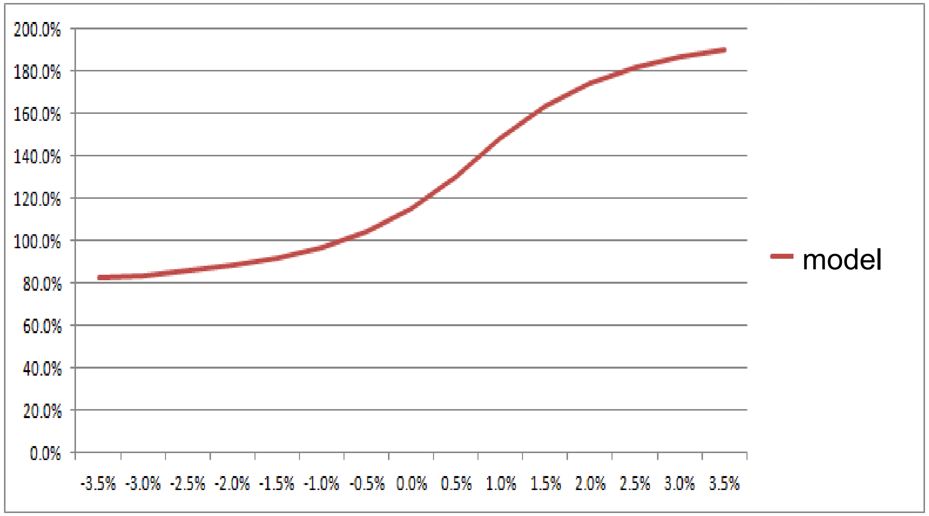


2. Multiplier Method – Model Fit (others)

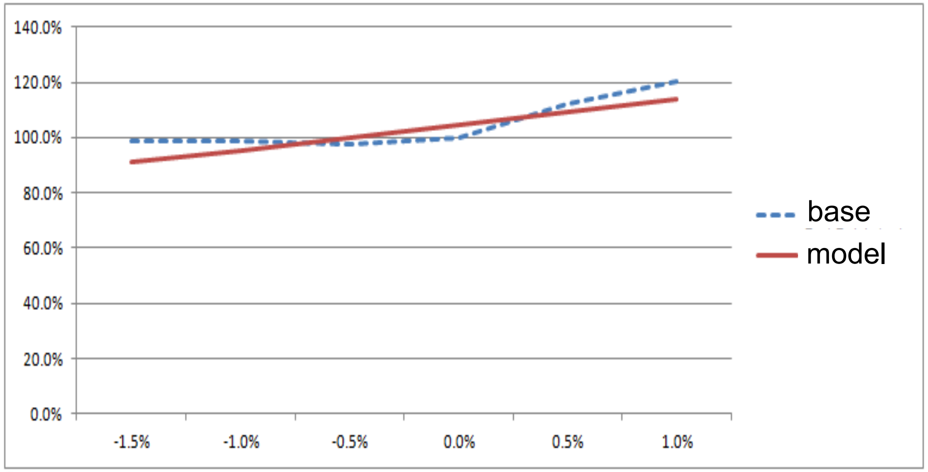
< Annuity Multiplier Comparison >



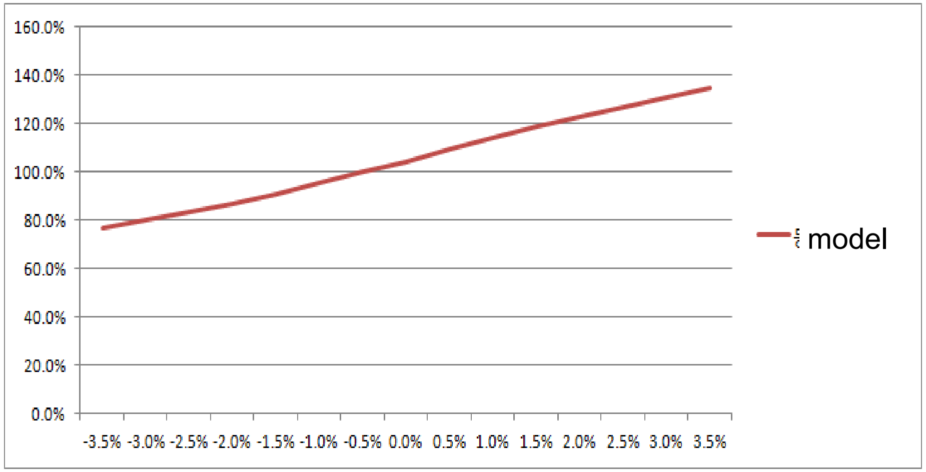
< Annuity model fit multiplier extension >



< Annuity savings Multiplier Comparison >

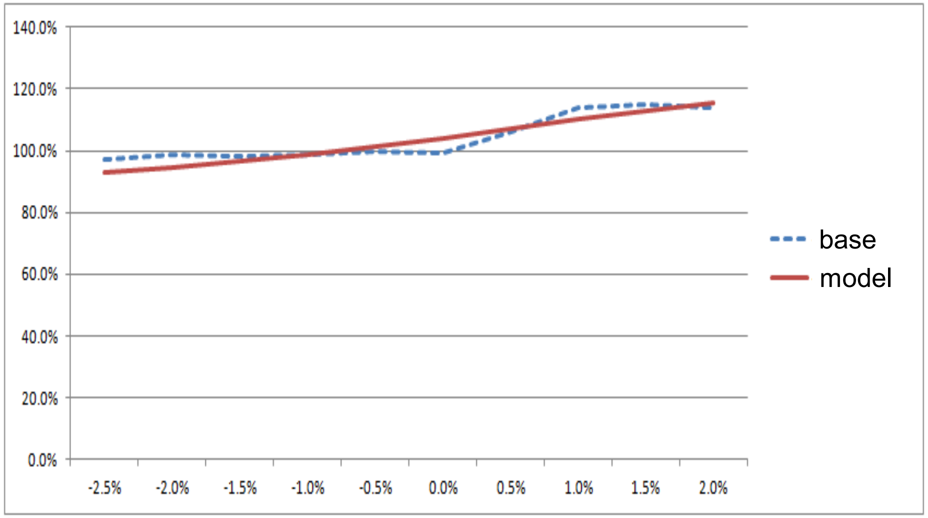


< Annuity savings model fit multiplier extension >

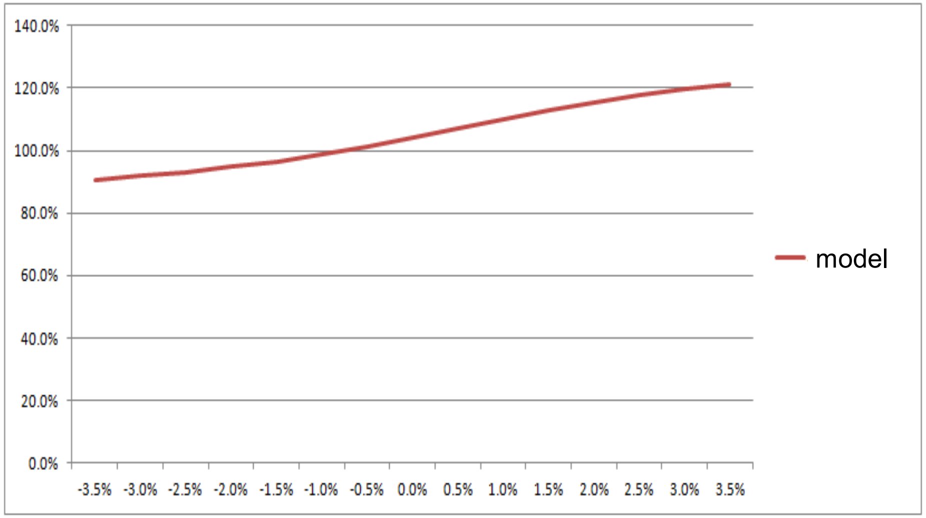


2. Multiplier Method – Model Fit (others)

< Protection Multiplier Comparison >



< Protection model fit multiplier extension >



3. Logistic – Principle

Like the multiplier method, data are grouped by 4 product types, and additional classification of 'elapsed period (on a monthly basis)' and 'payment method„ is proceeded

- (Dynamic variables) Possible to include all market and economic variables that may affect the rate of lapse rate
  - 5-year government bond yield, CD interest rate (91 days) *; Interest rate assumption
    * Observation of policyholder behavior on short-term interest rates
  - Unemployment rate; Emergency fund assumption
  - Inflation rate
  - GDP growth rate, economic behavior index previous month ratio, etc.
- Use the ' AIC ', ' SC ', and ' - 2 LogL „ measures to gauge the impact of the explanatory variables on the model

Definition of Measure
· **AIC = 2r – 2lnL = n x log{SSE(r)/n] + 2r**
· **SC = log(n) x r – 2lnL = n x log{SSE(r)/n] + r x log(n)**
(r : Number of explanatory variable, n : Number of observations, SSE : Sum of squared error, L : Maximum value of the likelihood function)

3. Logistic – Base Variable Selection

- In the case of non-single savings, the explanatory power of the variable is in the sequence of elapsed period > CD interest rate spread > inflation > ...
  - Considering the impact on the model, we adopt „elapsed period', 'inflation', and 'CD interest rate spread' as basic variables

< Comparison of model fitting statistics for non-single savings >

	Model fitting statistics (unit : 1000)			Increase (difference with all , unit : 1)		
Exclusion variable	**AIC**	**SC**	**-2LogL**	**AIC**	**SC**	**-2LogL**
-	29,062	29,062	29,062	-	-	-
Elapsed period	29,230	29,230	29,230	167,923	167,907	167,925
5-year government bond spread	29,063	29,063	29,063	1,344	1,328	1,346
CD interest rate spread	29,076	29,076	29,076	13,887	13,870	13,889
Unemployment rate	29,062	29,062	29,062	19	3	21
Inflation	29,074	29,074	29,074	12,118	12,102	12,120
Economic behavior index	29,062	29,062	29,062	110	94	112

* Economic growth rate variable is excluded because it is not significant. (p-value > 0.05)

- The model using the basic variables is as follows :

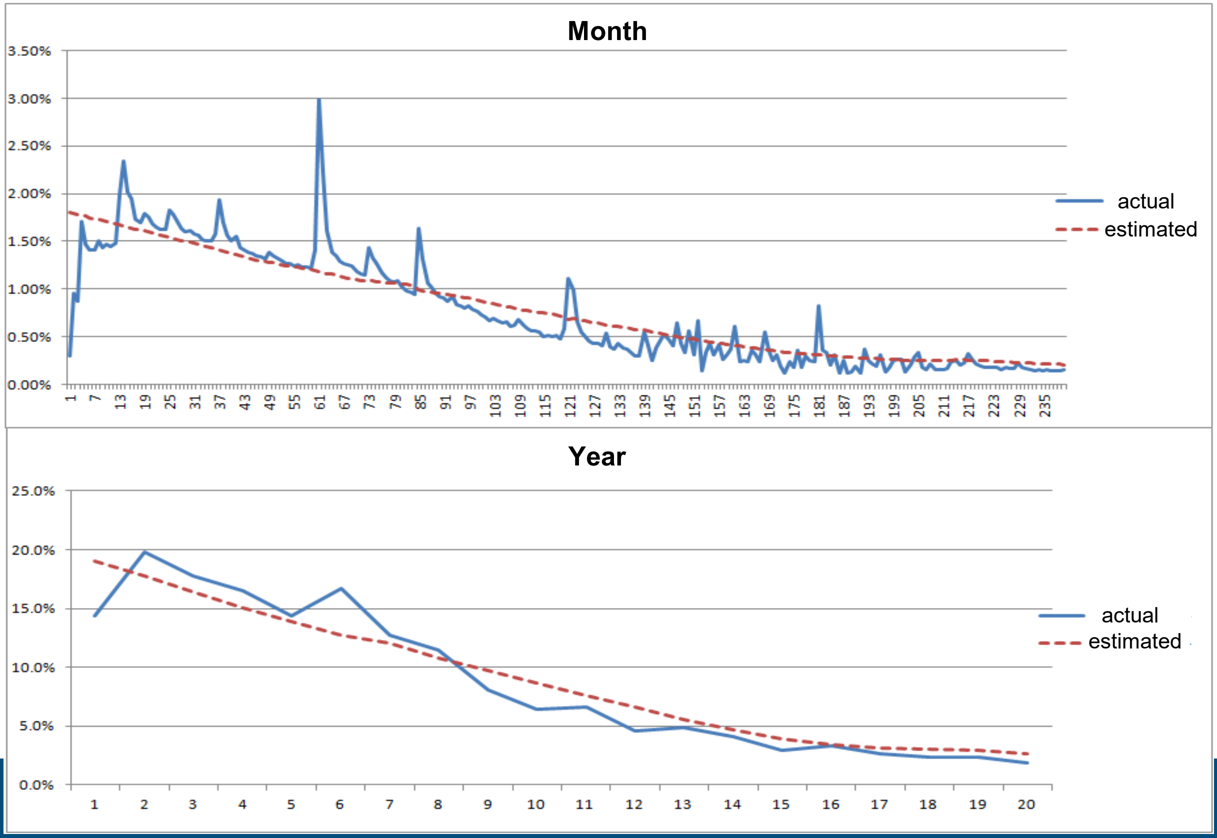
$$\log\left(\frac{q_s}{1-q_s}\right) = -3.8414 - 0.00689 \times V_1 + 0.1908 \times V_2 + 0.0564 \times V_3$$

q_s: lapse rate, V_1: elapsed period(month), V_2: interest rate spread of CD, V_3: inflation

3. Logistic – Base Variable (non-single savings)

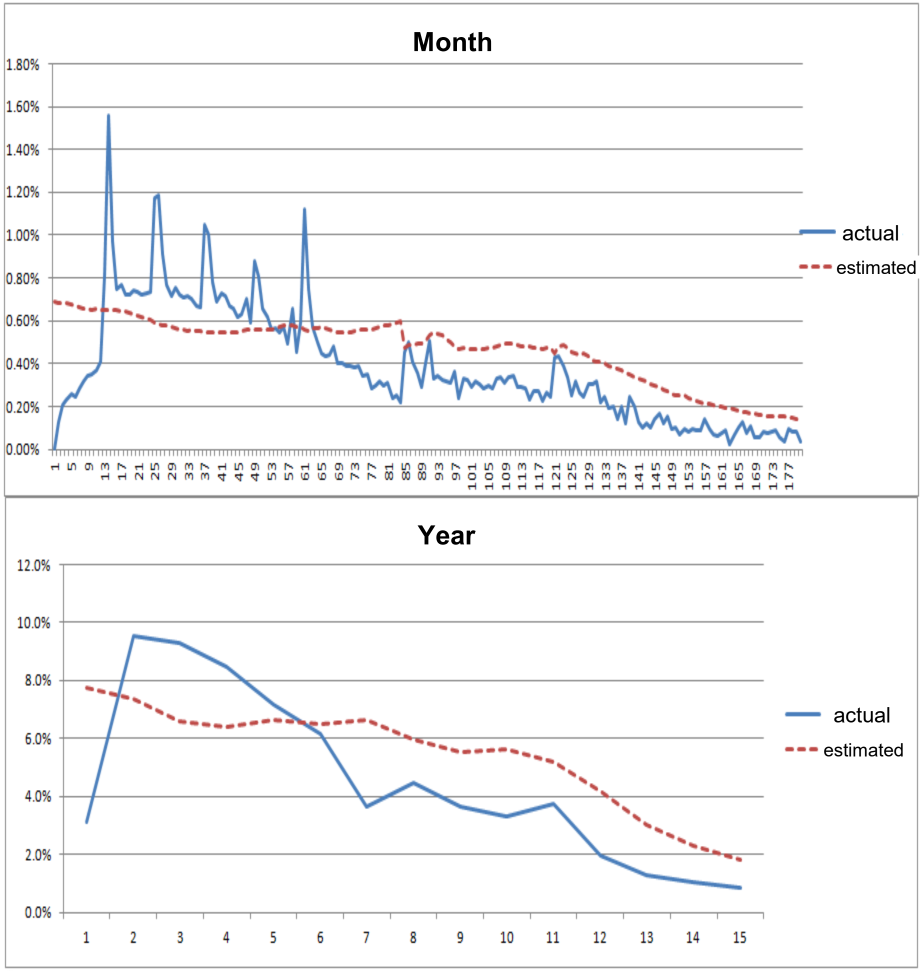
- As a result of estimation using the calculated parameters, it is relatively well suited to the actual lapse rate trend
  - However, the temporary surge of the lapse rate due to the characteristics of savings products should be treated separately
  - Volatility of 1st to 2nd year lapse rate should also be treated separately

< Non-single savings: real vs estimated lapse rate >

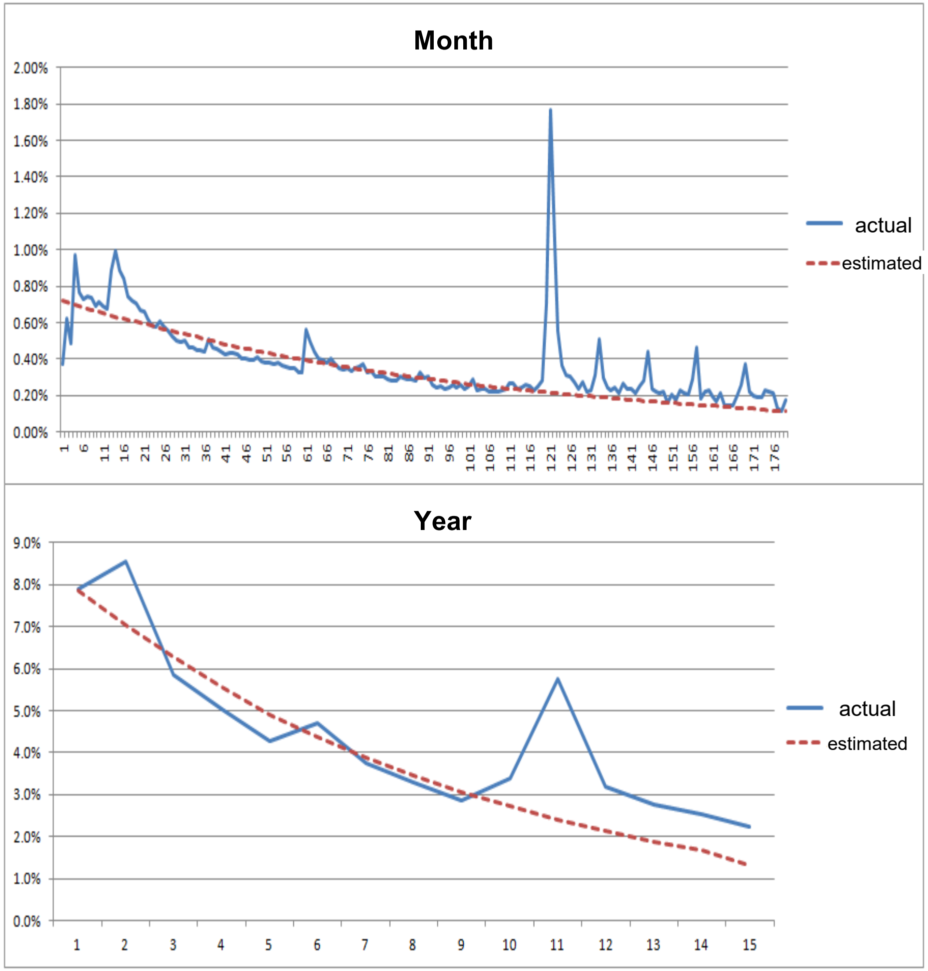


3. Logistic – Base Variable (others (1))

< Single savings real vs estimated lapse rate >

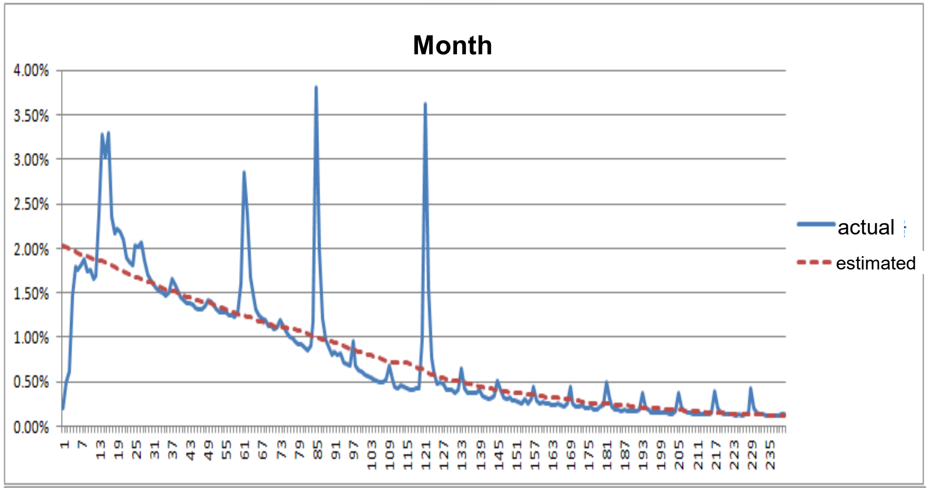


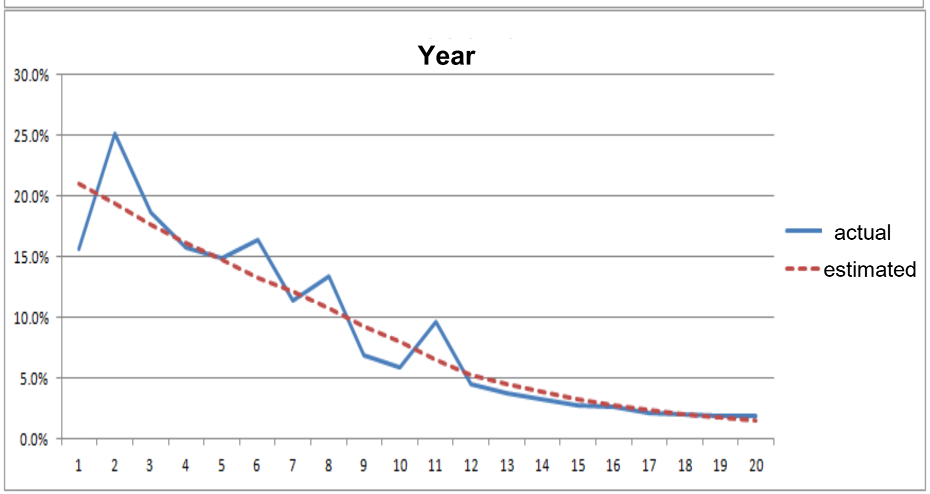
< Non-single annuity savings real vs estimated lapse rate >



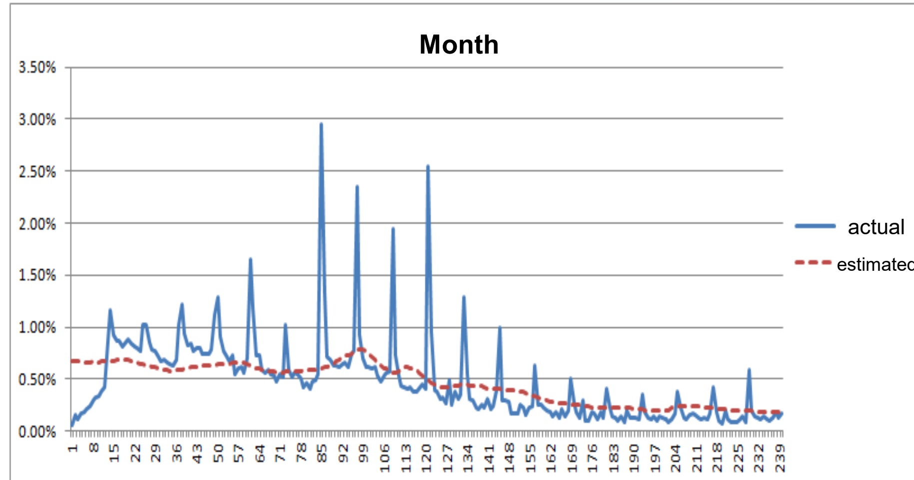
3. Logistic – Base Variable (others (2))

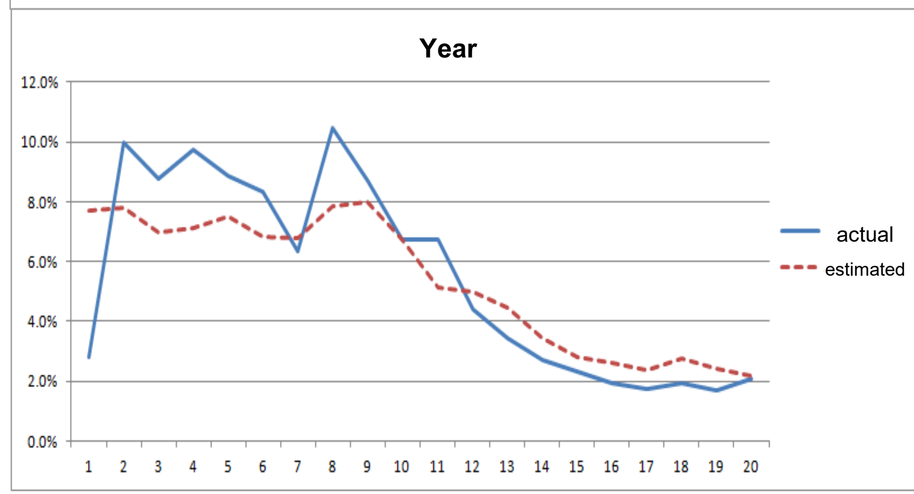
< Non-single Pension real vs estimated lapse rate >





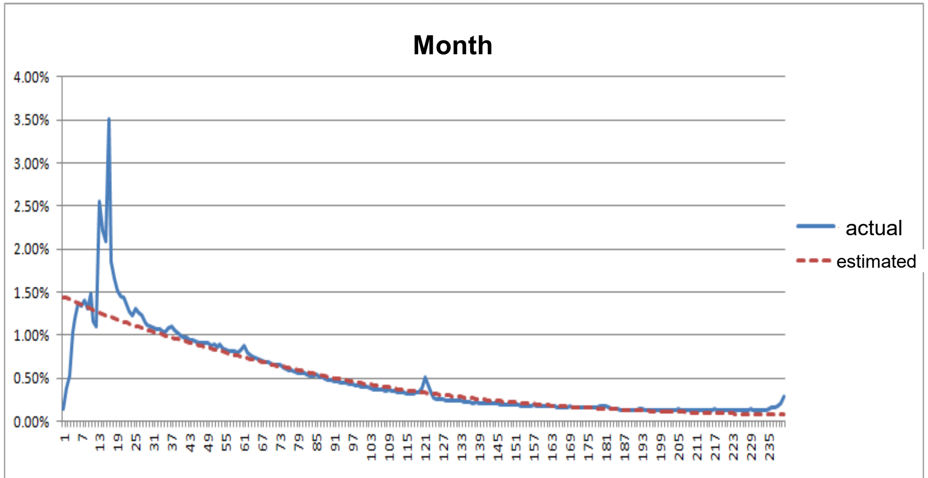
< Single Pension real vs estimated lapse rate >

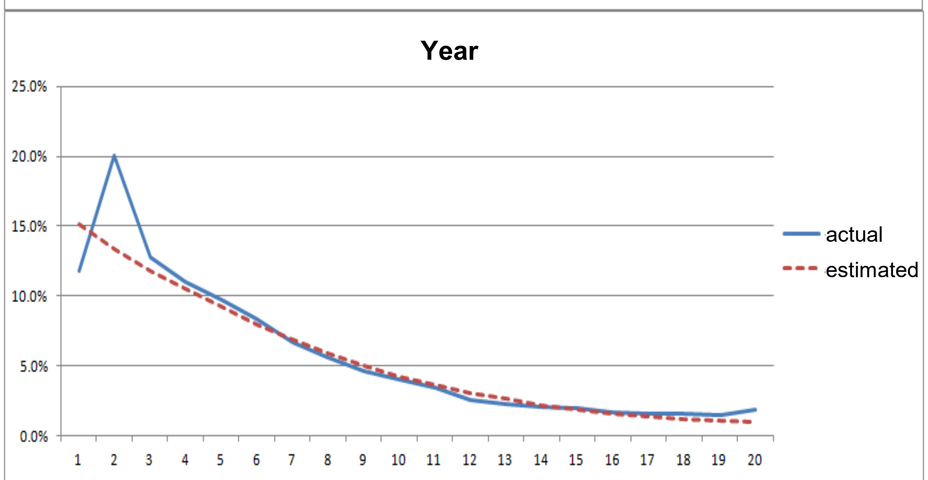




3. Logistic – Base Variable (others (3))

< Non-single protection real vs estimated lapse rate >





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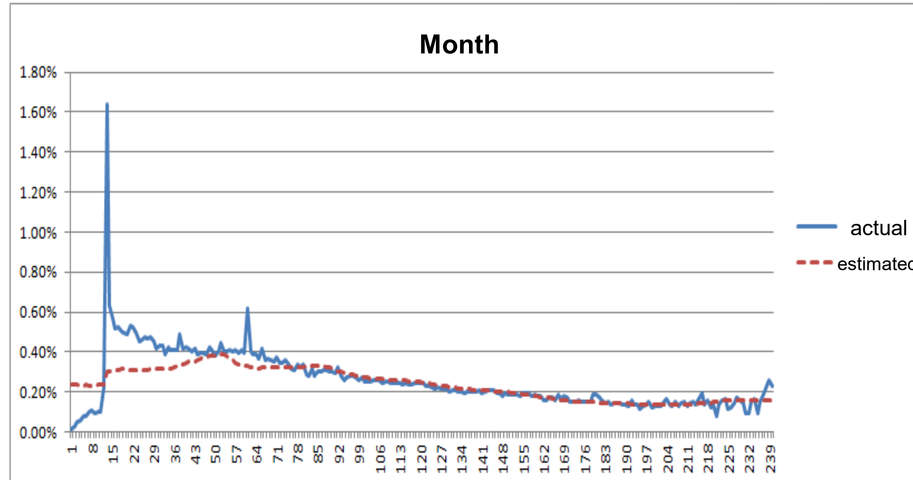
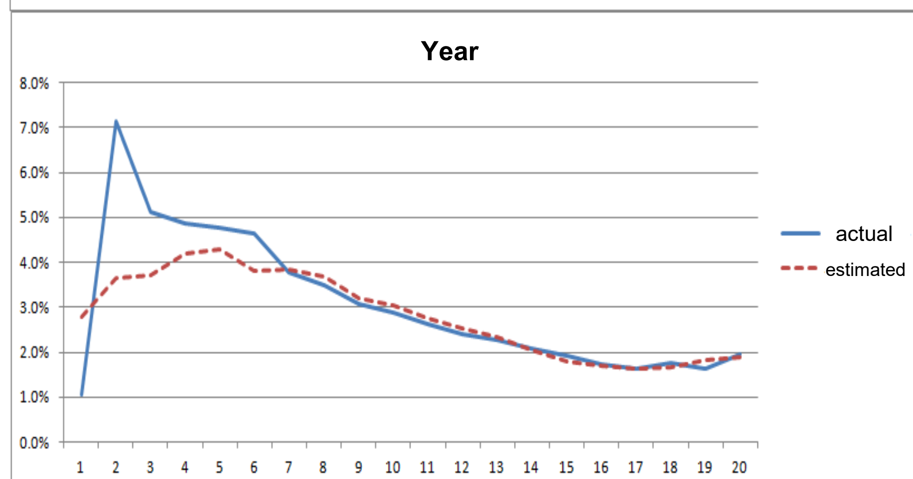
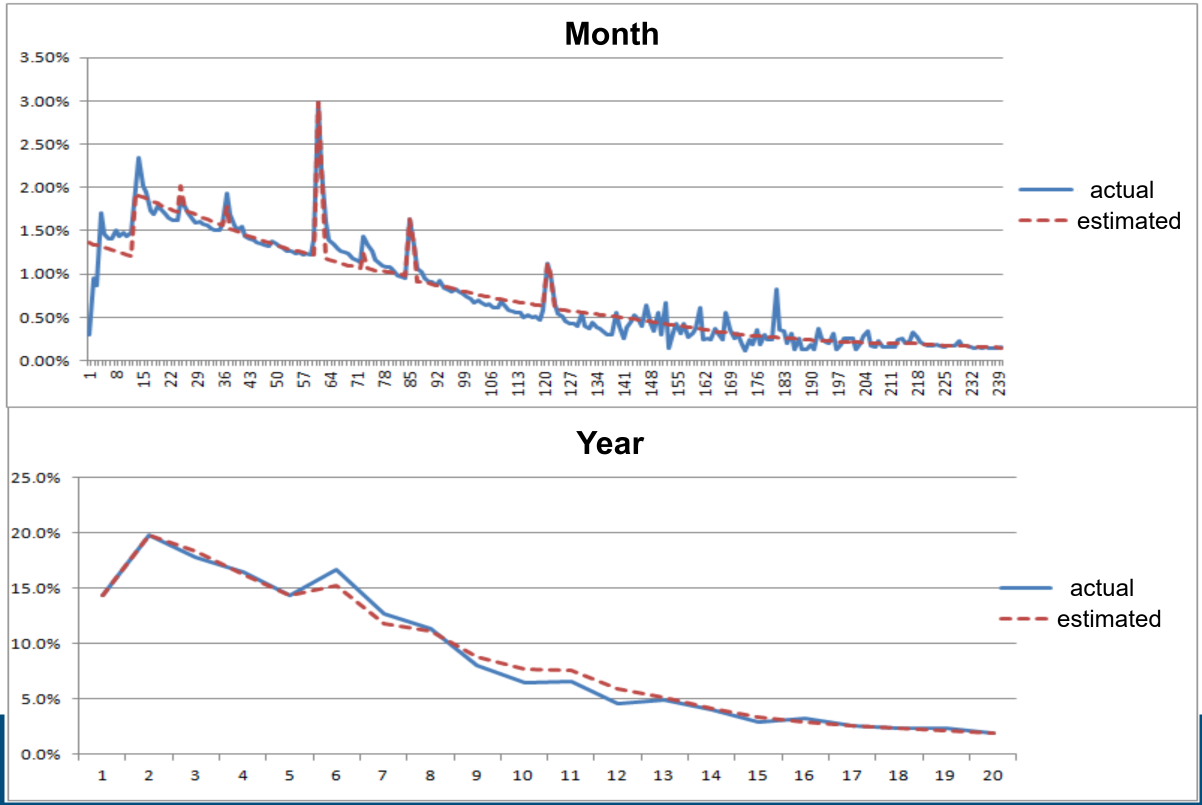




3. Logistic – Dummy Variable (non-single savings)

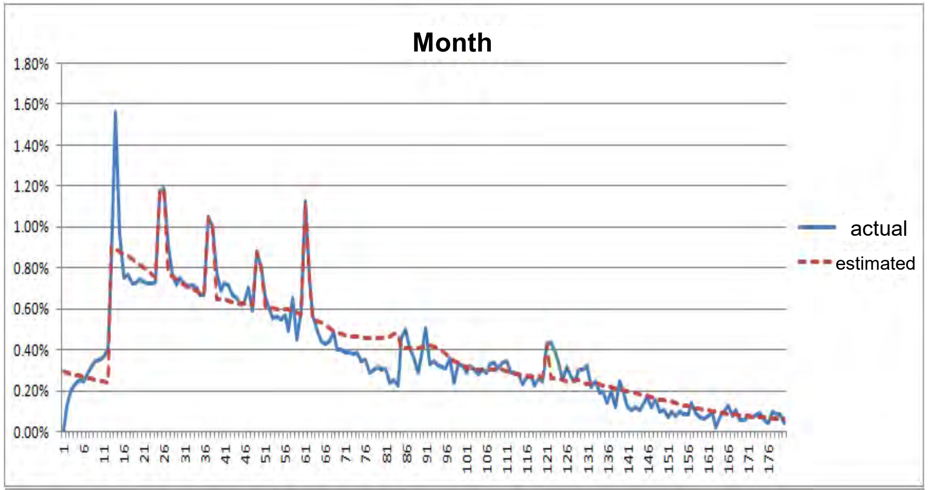
- Treat parts that are not adequately reflected by basic variables as dummy variables
  - Include dummy variables immediately after each year to reflect the temporary surge for the 5th, 7th, and 10th years
  - Include payment completion effect dummy variables immediately after 2nd, 3rd and 6th years / Include the dummy variables corresponding to each of the first and second years

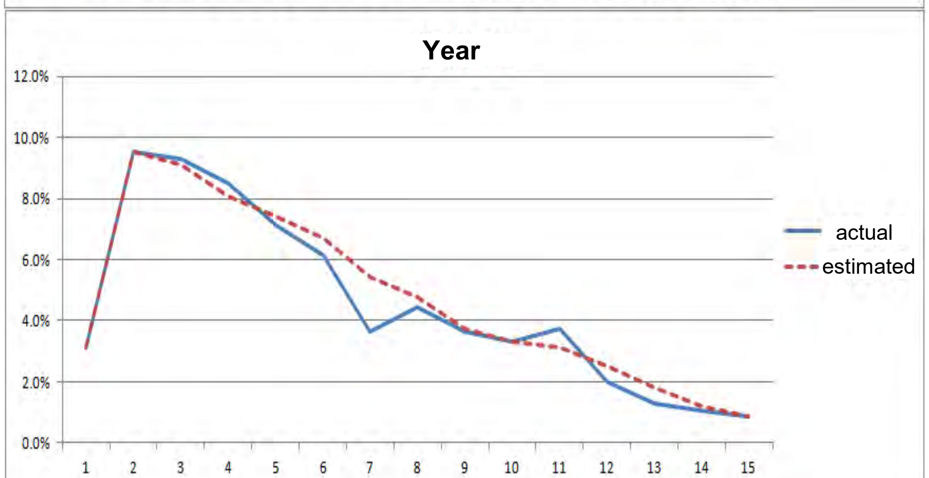
< Non-single savings real vs estimated lapse rate [2] >



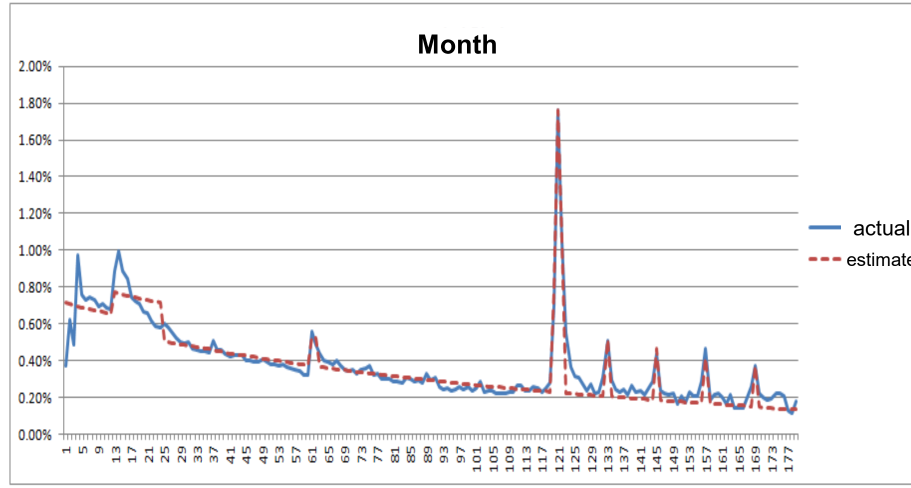
3. Logistic – Dummy Variable (others (1))

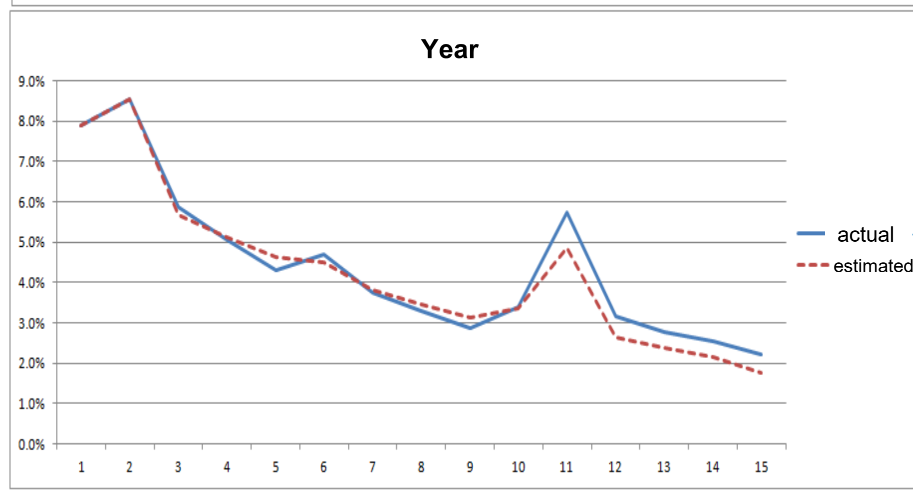
< Single savings real vs estimated lapse rate[1]>





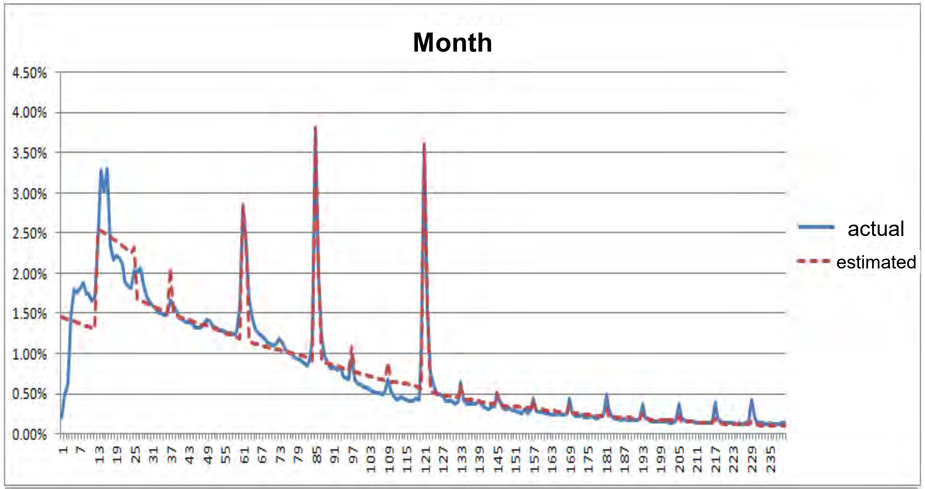
< Non-single annuity savings real vs estimated lapse rate[1]>

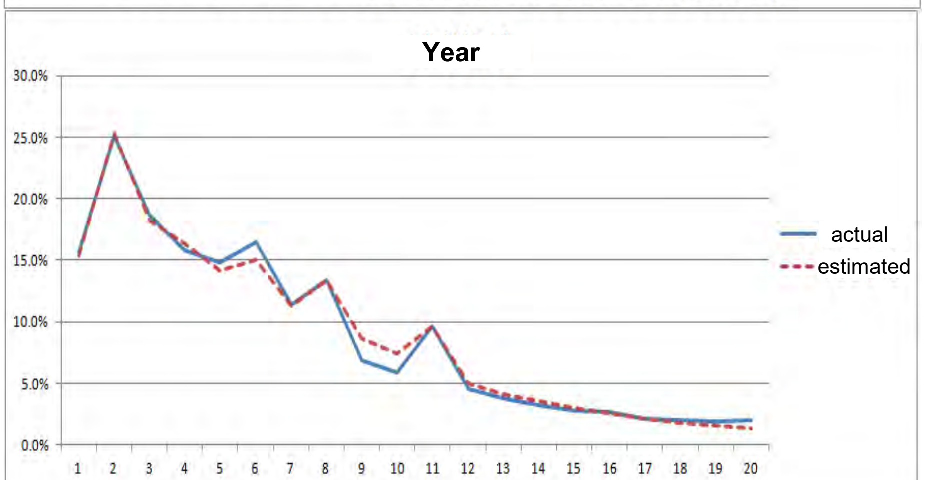




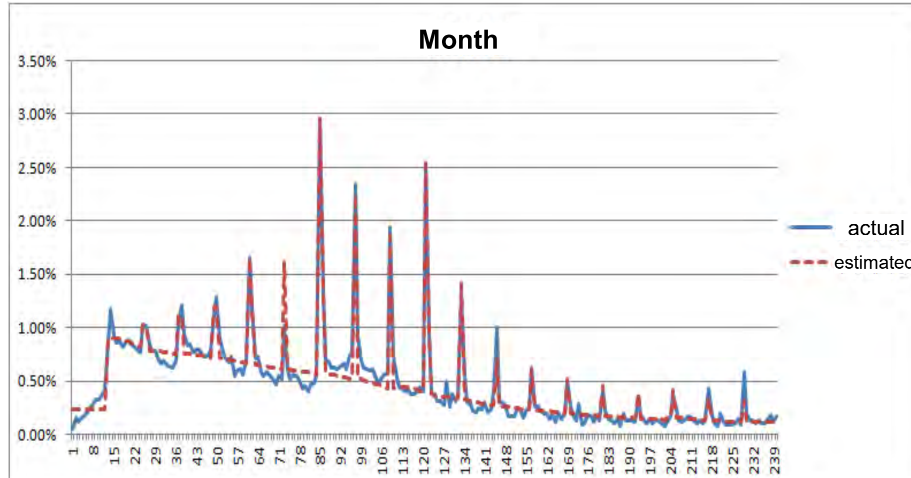
3. Logistic – Dummy Variable (others (2))

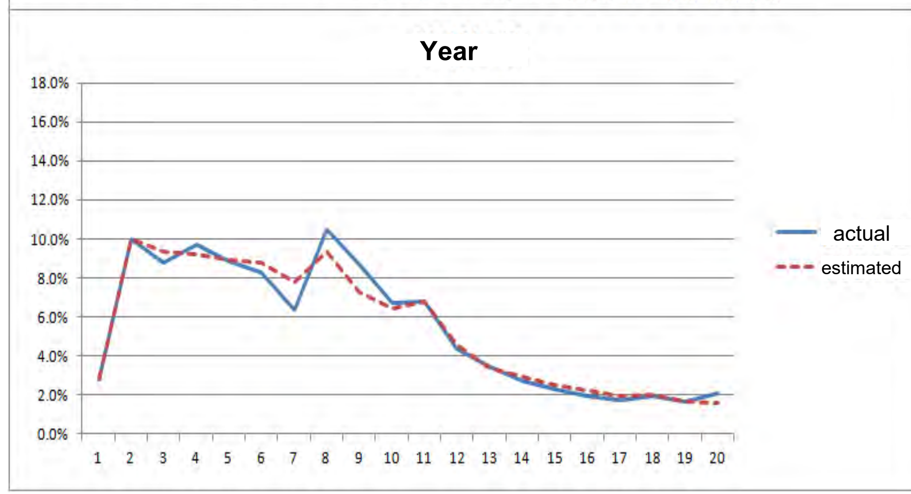
< Non-single pension real vs estimated lapse rate[1]>





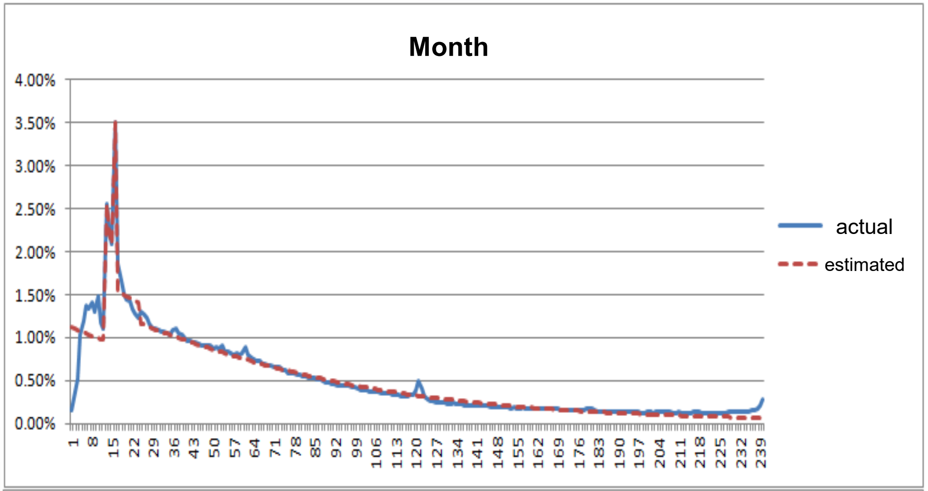
< Single pension real vs estimated lapse rate[1] >

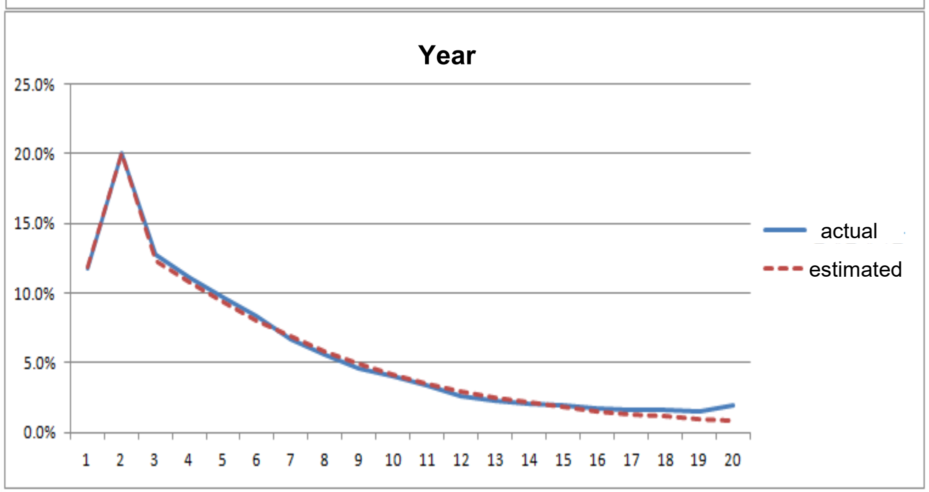




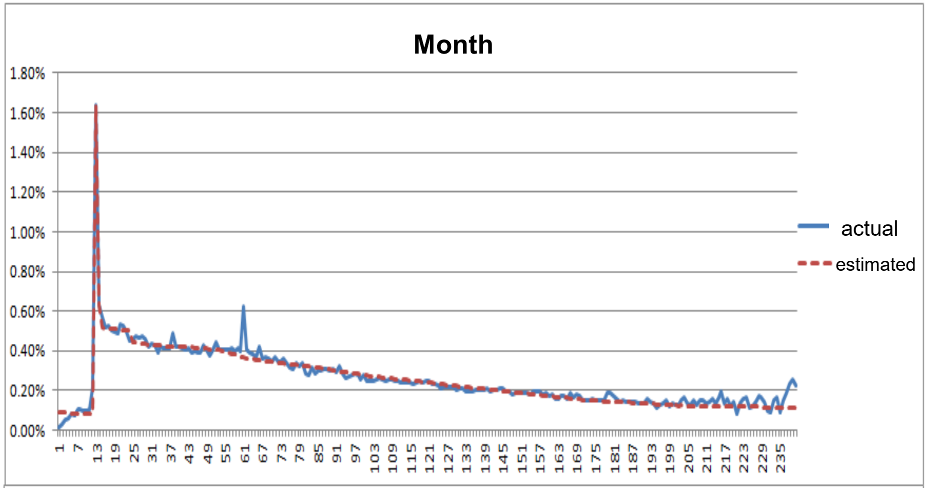
3. Logistic – Dummy Variable (others (3))

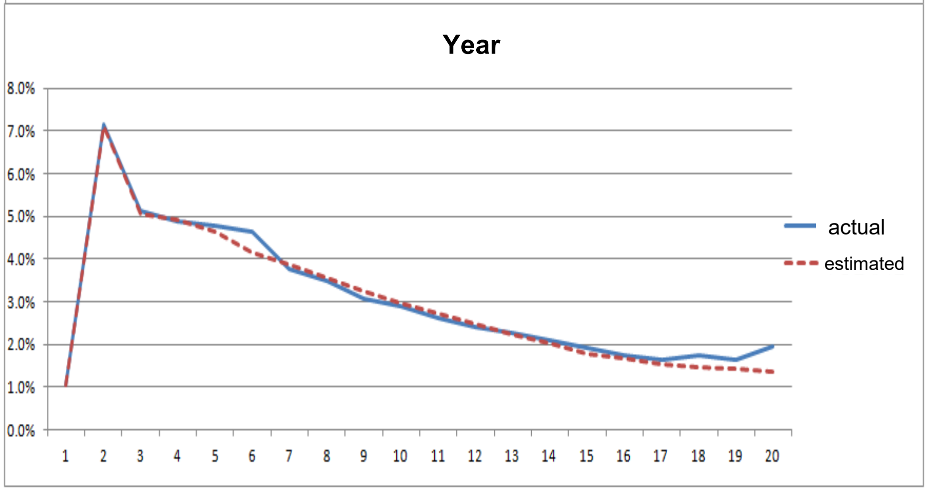
< Non-single protection real vs estimated lapse rate[1] >





< Single protection real vs estimated lapse rate[1] >





3. Logistic – Comparison of Predictability

Base lapse rate VS (logistic) estimated lapse rate

- The base lapse rate and the lapse rate estimated using the logistic model are compared with the actual lapse rate, respectively
  - Confirm the predictability of the logistic model and review the possibility of calculating a more elaborate lapse rate.

- Calculation of base lapse rate based on „06-13" and „07-14 ' experience data respectively
  - Measure the error level of „14 and "15 lapse rate by division unit three times in total.

$$* RMSE = \sqrt{\frac{1}{n} \times \sum_{i=1}^{n} (y_i - \hat{y}_i)^2} \ (\ y_i : \text{ actual } , \hat{y}_i : \text{ estimated })$$

- After comparisons, it showed that the predictability of estimated lapse rate using logistic model is generally better than that of base lapse rate
  - The base lapse rate by elapsed month appears to be at a low error level only in six out of 42 cases
  - The predictability of the estimated lapse rate by elapsed year (or by the elapsed month excluding the data of first and second years) using the logistic model is better in all cases except two cases

3. Logistic – Comparison of Predictability (1)

< Base VS Estimated Lapse Rate : Comparison of the error level with the actual lapse rate[1] >

		'06 ~ '13 Experience data					
Product type	Payment method	'14 Estimated lapse rate					
		Elapsed month			Elapsed year		
		RMSE (estimated)	RMSE (base)	RMSE difference	RMSE (estimated)	RMSE (base)	RMSE difference
Savings	Non-single	0.3279	0.2989	0.0290	2.7506	2.5286	0.2220
	Single	0.2574	0.3670	-0.1096	2.5296	3.6976	-1.1680
Annuity	Non-single	0.3054	0.3164	-0.0110	1.8935	2.3852	-0.4917
	Single	0.7447	0.8158	-0.0711	4.0837	5.3316	-1.2479
Annuity Savings	Non-single	0.1252	0.1148	0.0104	0.4876	0.8138	-0.3262
Protection	Non-single	0.1411	0.1253	0.0158	0.8513	0.9972	-0.1459
	Single	0.1426	0.1969	-0.0543	1.2581	1.8468	-0.5887

3. Logistic – Comparison of Predictability (2)

< Base VS Estimated Lapse Rate : Comparison of the error level with the actual lapse rate[2] >

		'06 ~ '13 Experience data					
Product type	Payment method	'15 Estimated lapse rate					
		Elapsed month			Elapsed year		
		RMSE (estimated)	RMSE (base)	RMSE difference	RMSE (estimated)	RMSE (base)	RMSE difference
Savings	Non-single	0.3594	0.3716	-0.0122	3.1150	3.1567	-0.0417
	single	0.2204	0.3933	-0.1729	1.9619	3.9193	-1.9574
Annuity	Non-single	0.2890	0.3711	-0.0821	1.7408	2.8220	-1.0812
	single	0.7037	0.7870	-0.0833	4.1008	5.4606	-1.3598
Savings pension	Non-single	0.1238	0.1344	-0.0106	0.6550	1.1851	-0.5301
Protection	Non-single	0.1319	0.1093	0.0226	0.5269	0.9300	-0.4031
	single	0.1828	0.2291	-0.0463	1.0368	1.7827	-0.7459

3. Logistic – Comparison of Predictability (3)

< Base VS Estimated Lapse Rate : Comparison of the error level with the actual lapse rate[] >

		'07 ~ '14 Experience data					
Product type	Payment method	'15 Estimated lapse rate					
		Elapsed month			Elapsed year		
		RMSE (estimated)	RMSE (base)	RMSE difference	RMSE (estimated)	RMSE (base)	RMSE difference
Savings	Non-single	0.2195	0.3104	-0.0909	1.4635	2.5423	-1.0788
	single	0.1616	0.2857	-0.1241	1.1386	2.6978	-1.5592
Annuity	Non-single	0.3154	0.3626	-0.0472	1.8792	2.6252	-0.7460
	single	0.6723	0.7042	-0.0319	3.6978	4.5345	-0.8367
Savings pension	Non-single	0.2073	0.1054	0.1019	1.4434	0.9218	0.5216
Protection	Non-single	0.1242	0.0912	0.0330	0.4182	0.7858	-0.3676
	single	0.1825	0.2166	-0.0341	0.9422	1.5750	-0.6328

4. Conclusions and Limitations – Multiplier Method

- Aside from the interest rate spread, there are still various dynamic variables affecting the lapse rate
  - A more sophisticated dynamic lapse rate can be calculated only after considering the influence of other variables on the lapse rate as well as its correlations with the interest rate spread
- Volatility of the range of interest rate spread, the representative of total lapse rate
  - Multiplier for each section is calculated by the lapse rate for each section over the total lapse rate
    → The total lapse rate covers all sections of representative interest rates spread where contracts are concentrated
  - Calculation of the multiplier is done assuming that there will be no significant changes in the range of the representative interest rate spread in the future.
  - Hence, if there is a significant change in the range of interest rate spread over time, multiplier distortion might occurs
    → Review on calculating multiplier for a particular spread range (e.g. - 50 to 50 bp)
- Actuarial judgement
  - Classification of the elapsed year, interest spread section width, type of fitting models, multiplier calculation units, etc.
  - Set up internal guidelines and applying them consistently every year

4. Conclusions and Limitations – Logistic Model

- External market reference rate and its corresponding estimation of crediting rate
  - Can be generated through interest rate forecasting models or scenarios
  - Calculate the interest rate spread for interest rate model(or for each scenario), and fit to the model *

    * The same procedure is applicable for the dynamic lapse multiplier method

- Other economic variables besides the interest rate spreads also have dynamic characteristics
  - It is not reasonable to estimate only the future interest rates
  - US PBR and other overseas regulations emphasize that all dynamic variables(other than the interest rate) should be considered in calculations

- Consequently, it is directly related to the problem of simultaneously estimating dynamic variables or creating scenarios
  - The ability to reasonably estimate these variables is a prerequisite for better modelling of dynamic lapse rate.

Table of Contents

Closing Remarks

- Need continuing research on policyholder behavior assumptions
  - Since the assumption model is generated from the statistics, industry‟s interest in the management of the statistics is critical

- Expansion of industrial statistics and analysis of policyholder behavior assumption
  - Expansion of Industrial Statistics : Provide industry statistics on additional payments and partial withdrawal assumption by product types, elapsed period, channel, and interest rate.
  - Analysis of policyholder behavior assumption : Study calculation methodologies for other policyholder behavior assumptions in demand

Thank You!

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