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

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Dynamic Lapse Modeling
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I Introduction

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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)
  - 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)
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.
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.
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 >**

<table>
<thead>
<tr>
<th>Moneyness (Reserve / Minimum guarantee)</th>
<th>Greater than 100%</th>
<th>Less than 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminology</td>
<td>Out-of-Money</td>
<td>In-the-Money</td>
</tr>
</tbody>
</table>
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:

\[ \lambda = \min[U, \max[L, 1 - M \times \left(\frac{GV}{AV} - D\right)]] * \]


\(<\text{Application of Dynamic Lapse Rate on the Variable Guarantee} >\)
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:

\[
\lambda = \min(U, \max(L, \exp\left(\frac{GV}{AV} - D\right) \times M))
\]

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

<table>
<thead>
<tr>
<th>Authors</th>
<th>Country</th>
<th>Data Provider</th>
<th>Type of Policy</th>
<th>Time Period</th>
<th>Methods</th>
<th>Variables</th>
<th>Main Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renshaw and Haberman (1986)</td>
<td>Scotland</td>
<td>Pool of 7 companies</td>
<td>Endowment &amp; Whole-life</td>
<td>1970-1976</td>
<td>Logistic regression model</td>
<td>Policyholder age and sex</td>
<td>four factors identified as important (age at entry, duration of policy, office, type of policy); additionally, significant interaction between policy type and duration</td>
</tr>
<tr>
<td>Kagroaka (2005)</td>
<td>Japan</td>
<td>1 company</td>
<td>Annuity-type personal accident</td>
<td>1993-2001</td>
<td>Poisson model</td>
<td>Policyholder age and sex</td>
<td>surrender of the insurance contracts is explained by change of unemployment rates and time elapsed from contract date.</td>
</tr>
<tr>
<td>Cerchiara et al. (2009)</td>
<td>Italy</td>
<td>1 company</td>
<td>Saving</td>
<td>1991-2007</td>
<td>Negative binomial model</td>
<td>Seasonality</td>
<td>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</td>
</tr>
<tr>
<td>Milhaud et al. (2010)</td>
<td>Spain</td>
<td>1 company</td>
<td>Endowment</td>
<td>1999-2007</td>
<td>Poisson model</td>
<td>Contract age</td>
<td>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</td>
</tr>
<tr>
<td>Eling and Kiesenbauer (2011)</td>
<td>Germany</td>
<td>1 company</td>
<td>Endowment &amp; Annuity &amp; Term life</td>
<td>2000-2010</td>
<td>Binomial model</td>
<td>Contract age</td>
<td>Product characteristics such as product type or contract age and policyholder characteristics such as age or gender are important lapse drivers</td>
</tr>
</tbody>
</table>
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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

\[ k \text{th month lapse rate} = \frac{k \text{th month number of lapse}}{k \text{th month number of exposure}} \]

\[ (\text{year}) \text{ maintainence rate} = \prod_{k=1}^{12} (1 - k \text{th month lapse rate}) \]

\[ (\text{year}) \text{lapse rate} = 1 - (\text{year}) \text{ maintainence rate} \]
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, %)

<table>
<thead>
<tr>
<th>Section / year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>...</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>section 1</td>
<td>a₁</td>
<td>a₂</td>
<td>a₃</td>
<td>...</td>
<td>a₁₀</td>
<td>a₁₁</td>
<td>a₁₂</td>
</tr>
<tr>
<td>section 2</td>
<td>b₁</td>
<td>b₂</td>
<td>b₃</td>
<td>...</td>
<td>b₁₀</td>
<td>b₁₁</td>
<td>B₁₂</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>section 6</td>
<td>g₁</td>
<td>g₂</td>
<td>g₃</td>
<td>...</td>
<td>g₁₀</td>
<td>g₁₁</td>
<td>g₁₂</td>
</tr>
<tr>
<td>section 7</td>
<td>h₁</td>
<td>h₂</td>
<td>h₃</td>
<td>...</td>
<td>h₁₀</td>
<td>h₁₁</td>
<td>h₁₂</td>
</tr>
<tr>
<td>Total</td>
<td>T₁</td>
<td>T₂</td>
<td>T₃</td>
<td>...</td>
<td>T₁₀</td>
<td>T₁₁</td>
<td>T₁₂</td>
</tr>
</tbody>
</table>

- 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 >

<table>
<thead>
<tr>
<th>section / year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>...</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>section 1</td>
<td>$a_1/T_1$</td>
<td>$a_2/T_2$</td>
<td>$a_3/T_3$</td>
<td>...</td>
<td>$a_{10}/T_{10}$</td>
<td>$a_{11}/T_{11}$</td>
<td>$a_{12}/T_{12}$</td>
</tr>
<tr>
<td>section 2</td>
<td>$b_1/T_1$</td>
<td>$b_2/T_2$</td>
<td>$b_3/T_3$</td>
<td>...</td>
<td>$b_{10}/T_{10}$</td>
<td>$b_{11}/T_{11}$</td>
<td>$b_{12}/T_{12}$</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>section 6</td>
<td>$g_1/T_1$</td>
<td>$g_2/T_2$</td>
<td>$g_3/T_3$</td>
<td>...</td>
<td>$g_{10}/T_{10}$</td>
<td>$g_{11}/T_{11}$</td>
<td>$g_{12}/T_{12}$</td>
</tr>
<tr>
<td>section 7</td>
<td>$h_1/T_1$</td>
<td>$h_2/T_2$</td>
<td>$h_3/T_3$</td>
<td>...</td>
<td>$h_{10}/T_{10}$</td>
<td>$h_{11}/T_{11}$</td>
<td>$h_{12}/T_{12}$</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Section / year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>...</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>section 1</td>
<td>$A_1$</td>
<td>$A_2$</td>
<td>$A_3$</td>
<td>...</td>
<td>$A_{10}$</td>
<td>$A_{11}$</td>
<td>$A_{12}$</td>
</tr>
<tr>
<td>section 2</td>
<td>$B_1$</td>
<td>$B_2$</td>
<td>$B_3$</td>
<td>...</td>
<td>$B_{10}$</td>
<td>$B_{11}$</td>
<td>$B_{12}$</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>section 6</td>
<td>$G_1$</td>
<td>$G_2$</td>
<td>$G_3$</td>
<td>...</td>
<td>$G_{10}$</td>
<td>$G_{11}$</td>
<td>$G_{12}$</td>
</tr>
<tr>
<td>section 7</td>
<td>$H_1$</td>
<td>$H_2$</td>
<td>$H_3$</td>
<td>...</td>
<td>$H_{10}$</td>
<td>$H_{11}$</td>
<td>$H_{12}$</td>
</tr>
</tbody>
</table>

section 1 multiplier

\[
\frac{A_1 \times \left( \frac{a_1}{T_1} \right) + A_2 \times \left( \frac{a_2}{T_2} \right) + \cdots + A_{11} \times \left( \frac{a_{11}}{T_{11}} \right) + A_{12} \times \left( \frac{a_{12}}{T_{12}} \right)}{A_1 + A_2 + \cdots + A_{11} + A_{12}}
\]
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 >

<table>
<thead>
<tr>
<th>section</th>
<th>-2.5 ~ -2</th>
<th>-2.0 ~ -1.5</th>
<th>-1.5 ~ -1.0</th>
<th>-1.0 ~ -0.5</th>
<th>-0.5 ~ 0</th>
<th>0 ~ 0.5</th>
<th>0.5 ~ 1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiplier (m)</td>
<td>85.6</td>
<td>94.6</td>
<td>98.2</td>
<td>98.9</td>
<td>119.0</td>
<td>127.1</td>
<td>136.1</td>
</tr>
</tbody>
</table>

![Graph of Savings](Image)
2. Multiplier Method – Base Lapse Multiplier (others)

- **Annuity**
- **Annuity savings**
- **Protection**
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:

\[
\text{Multiplier} = f(x) = a \times \arctan(m \times (x-k)) + c,
\]

where \( k \) = inflection point, \( m \) = sensitivity, \( a \) & \( c \) = adjustment coefficient

\( F(\infty) = U(\text{upper limit}) \), \( f(-\infty) = L(\text{lower limit}) \)
2. Multiplier Method – Model Fit (savings)

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

<table>
<thead>
<tr>
<th>Spread section</th>
<th>-2.5 ~ -2.0</th>
<th>-2.0 ~ -1.5</th>
<th>-1.5 ~ -1.0</th>
<th>-1.0 ~ -0.5</th>
<th>-0.5 ~ 0</th>
<th>0 ~ 0.5</th>
<th>0.5 ~ 1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>base multiplier</td>
<td>85.6</td>
<td>94.6</td>
<td>98.2</td>
<td>98.9</td>
<td>119.0</td>
<td>127.1</td>
<td>136.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spread</th>
<th>-2.5</th>
<th>-2.0</th>
<th>-1.5</th>
<th>-1.0</th>
<th>-0.5</th>
<th>0</th>
<th>0.5</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion multiplier</td>
<td>85.6</td>
<td>90.1</td>
<td>96.4</td>
<td>98.6</td>
<td>108.9</td>
<td>123.1</td>
<td>131.6</td>
<td>136.1</td>
</tr>
</tbody>
</table>

< Inflection point and inflection point multiplier setting >

<table>
<thead>
<tr>
<th>Interest rate spread (bp)</th>
<th>-100</th>
<th>-50</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiplier(%)</td>
<td>98.6</td>
<td>108.9</td>
<td>123.1</td>
</tr>
<tr>
<td>Multiplier difference(%)p</td>
<td>10.3</td>
<td></td>
<td>14.2</td>
</tr>
<tr>
<td>ratio</td>
<td>0.43 (10.3/24.5)</td>
<td></td>
<td>0.57 (14.2/24.5)</td>
</tr>
<tr>
<td>Inflection point(k)</td>
<td>(-100) x 0.43 + (0) x 0.57 = -43(bp)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f(k) = c</td>
<td>(98.6) x 0.43 + (123.1) x 0.57 = 112.2(%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Multiplier Method – Model Fit (savings)

< Arctangent model of savings >

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

< Comparison of Savings Product Multiplier >

< Extension of Savings Product Multiplier >
2. Multiplier Method – Model Fit (others)

< Annuity Multiplier Comparison >

< Annuity savings Multiplier Comparison >

< Annuity model fit multiplier extension >

< Annuity savings model fit multiplier extension >
2. Multiplier Method – Model Fit (others)

< Protection Multiplier Comparison >

- Graph showing comparison between base and model multipliers across different percentages.

< Protection model fit multiplier extension >

- Graph showing model multipliers across different percentages.

SOCIETY OF ACTUARIES
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** = \(2r - 2\ln L = n \times \log\{\text{SSE}(r)/n\} + 2r\)
- **SC** = \(\log(n) \times r - 2\ln L = n \times \log\{\text{SSE}(r)/n\} + r \times \log(n)\)

\((r : \text{Number of explanatory variable}, \ n : \text{Number of observations}, \ \text{SSE} : \text{Sum of squared error}, \ \text{L} : \text{Maximum value of the likelihood function})\)
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 >

<table>
<thead>
<tr>
<th>Exclusion variable</th>
<th>Model fitting statistics (unit : 1000)</th>
<th>Increase (difference with all, unit : 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AIC</td>
<td>SC</td>
</tr>
<tr>
<td>-</td>
<td>29,062</td>
<td>29,062</td>
</tr>
<tr>
<td>Elapsed period</td>
<td>29,230</td>
<td>29,230</td>
</tr>
<tr>
<td>5-year government bond</td>
<td>29,063</td>
<td>29,063</td>
</tr>
<tr>
<td>spread</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD interest rate spread</td>
<td>29,076</td>
<td>29,076</td>
</tr>
<tr>
<td>Unemployment rate</td>
<td>29,062</td>
<td>29,062</td>
</tr>
<tr>
<td>Inflation</td>
<td>29,074</td>
<td>29,074</td>
</tr>
<tr>
<td>Economic behavior index</td>
<td>29,062</td>
<td>29,062</td>
</tr>
</tbody>
</table>

* 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 >

Month

Year

< Single Pension real vs estimated lapse rate >

Month

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

< Non-single protection real vs estimated lapse rate >

Month

Year

< Single protection real vs estimated lapse rate >

Month

Year
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] >

![Graph showing actual and estimated lapse rates over months and years.](image-url)
3. Logistic – Dummy Variable (others (1))

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

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

Month

Year

Month

Year

actual

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

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

Month

Year

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

Month

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

<table>
<thead>
<tr>
<th>Month</th>
<th>Actual</th>
<th>Estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Actual</td>
<td>Estimated</td>
</tr>
</tbody>
</table>

- 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.

\[
RMSE = \sqrt{\frac{1}{n} \times \sum_{i=1}^{n} (y_i - \hat{y}_i)^2}
\]

- 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] >

<table>
<thead>
<tr>
<th>Product type</th>
<th>Payment method</th>
<th>2006 ~ 2013 Experience data</th>
<th>2014 Estimated lapse rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Elapsed month</td>
<td>Elapsed year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RMSE (estimated)</td>
<td>RMSE (base)</td>
</tr>
<tr>
<td>Savings</td>
<td>Non-single</td>
<td>0.3279</td>
<td>0.2989</td>
</tr>
<tr>
<td></td>
<td>Single</td>
<td>0.2574</td>
<td>0.3670</td>
</tr>
<tr>
<td>Annuity</td>
<td>Non-single</td>
<td>0.3054</td>
<td>0.3164</td>
</tr>
<tr>
<td></td>
<td>Single</td>
<td>0.7447</td>
<td>0.8158</td>
</tr>
<tr>
<td>Annuity</td>
<td>Non-single</td>
<td>0.1252</td>
<td>0.1148</td>
</tr>
<tr>
<td>Savings</td>
<td>Non-single</td>
<td>0.1411</td>
<td>0.1253</td>
</tr>
<tr>
<td></td>
<td>Single</td>
<td>0.1426</td>
<td>0.1969</td>
</tr>
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</table>
### 3. Logistic – Comparison of Predictability (2)

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

<table>
<thead>
<tr>
<th>Product type</th>
<th>Payment method</th>
<th>'06 ~ '13 Experience data</th>
<th>'15 Estimated lapse rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Elapsed month</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>RMSE (estimated)</td>
<td>RMSE (base)</td>
</tr>
<tr>
<td>Savings</td>
<td>Non-single</td>
<td>0.3594</td>
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<td>Annuity</td>
<td>Non-single</td>
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<td>0.3711</td>
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<tr>
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<td>single</td>
<td>0.7037</td>
<td>0.7870</td>
</tr>
<tr>
<td>Savings pension</td>
<td>Non-single</td>
<td>0.1238</td>
<td>0.1344</td>
</tr>
<tr>
<td>Protection</td>
<td>Non-single</td>
<td>0.1319</td>
<td>0.1093</td>
</tr>
<tr>
<td></td>
<td>single</td>
<td>0.1828</td>
<td>0.2291</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elapsed year</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>RMSE (estimated)</td>
<td>RMSE (base)</td>
</tr>
<tr>
<td>Savings</td>
<td>Non-single</td>
<td>3.1150</td>
<td>3.1567</td>
</tr>
<tr>
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<tr>
<td>Annuity</td>
<td>Non-single</td>
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<tr>
<td>Savings pension</td>
<td>Non-single</td>
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<tr>
<td>Protection</td>
<td>Non-single</td>
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<td></td>
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<td>1.0368</td>
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</tbody>
</table>
### 3. Logistic – Comparison of Predictability (3)

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

<table>
<thead>
<tr>
<th>Product type</th>
<th>Payment method</th>
<th>Elapsed month</th>
<th>Elapsed year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RMSE (estimated)</td>
<td>RMSE (base)</td>
<td>RMSE difference</td>
</tr>
<tr>
<td>Savings</td>
<td>Non-single</td>
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<td>Non-single</td>
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</tr>
<tr>
<td>Savings</td>
<td>Non-single</td>
<td>0.2073</td>
<td>0.1054</td>
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<tr>
<td>pension</td>
<td>Non-single</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>single</td>
<td>0.1242</td>
<td>0.0912</td>
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<td>Protection</td>
<td>Non-single</td>
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<td>0.0912</td>
</tr>
<tr>
<td></td>
<td>single</td>
<td>0.1825</td>
<td>0.2166</td>
</tr>
</tbody>
</table>
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

I. Introduction
II. Outline of Dynamic Lapse
III. Dynamic Lapse Modeling
IV. Conclusion
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!