



Dynamic Policyholder Behaviour in Life Insurance

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ING

Agenda

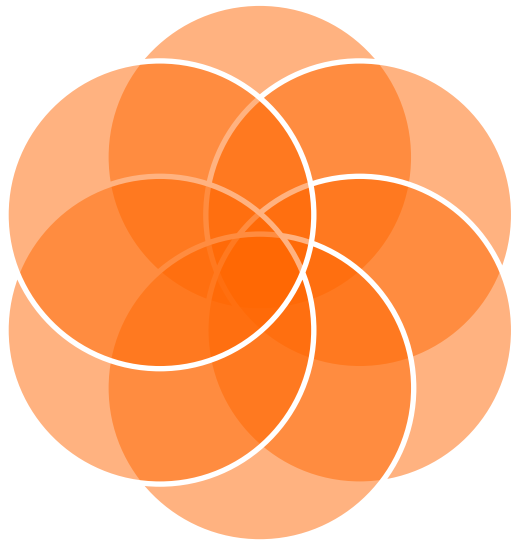
- Introduction
- Background
- Product features and DPHB
- DPHB Models and Their Derivation
- Case Study: Performance of Traditional to Predictive model
- Management of DPHB

Introduction

***What* is dynamic policyholder behaviour?**

***Why* to be engaged in dynamic policyholder behaviour?**

Management



Related product features

Case study

Models and their derivation

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Background

Dynamic policyholder behaviour (DPHB)

- reflection of the fact that policyholder‘s decisions to exercise options available in a life insurance contract may depend on factors related to actual economic and market situation and personal characteristics of the policyholder

- External factors that can influence the policyholder’s behaviour include:
  - Economic conditions (difference between external and guaranteed yields)
  - Customer type (personal reasons, utility function, risk aversion)
  - Distribution channel (big issue, especially in the Czech market)
  - Tax/ regulation
  - …

Background

- Industry view
  - CFO Forum: MCEV Principles and Guidance, MCEV Basis for Conclusion

- Regulatory view
  - Solvency II Directive, QIS5 Technical Standard, Level 2 Implementing Measures

- Company view
  - Critical areas of the management of life insurance companies are impacted by DPHB:
    - ALM
    - Replicating portfolios
    - Product pricing and design

Background

- Insurers need to pay attention to all embedded options.
- One of the identified major risk components in the life insurance companies: Lapses/ surrenders

- Lapses/surrenders influence insurer‘s liquidity and profitability
  - Massive lapse event can threaten the insurer‘s liquidity and force the selling of assets
  - Insurer faces the loss of future profits from lapsed policies
  - Insurer might suffer from losses from early lapsed policies due to upfront investments for acquiring new business
  - Adverse selection
  - High lapses can have a negative effect on the insurer‘s reputation that can result in even more lapses, as well as harm new business

Background

<u>Problems</u>

- Little material available to guide companies, little clarity and consensus on approaches
- SII requirements do not set out how DPHB should be modelled in practice, tend to give only high level principles

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Product features and DPHB

Types of options which can be impacted by DPHB include:

- **Guaranteed lapses/ surrenders**
  - Policyholder can terminate policy at any time
  - Materiality can be high especially for long-term policies
- **Guaranteed annuity options (GAO)**
  - Applies to deferred annuities
  - At the end of the deferred period the policyholder can either take an accumulated lump sum or an annuity
  - Materiality can be high
  - Current take-up rates are low, this does not mean this will always be the case in future
  - More attention should be given to the modelling of GAO (underlying mortality rates as well as guaranteed interest rates should be considered)

Product features and DPHB

- **Option to paid-up**
  - Policyholder can stop paying premium at any time, but this results in lower sum assured
  - Similar but less extreme than lapse risk
  - Can be modelled together with lapses and surrenders
- **Premium holiday**
  - UL policyholder can stop paying premiums for a period
  - Charges continue to be deducted from the account during this period
  - Materiality low
- **Partial surrender**
- **Fund switching**
- **Extension of original policy term on guaranteed terms**
- **Premium increment option**
- **and other…**

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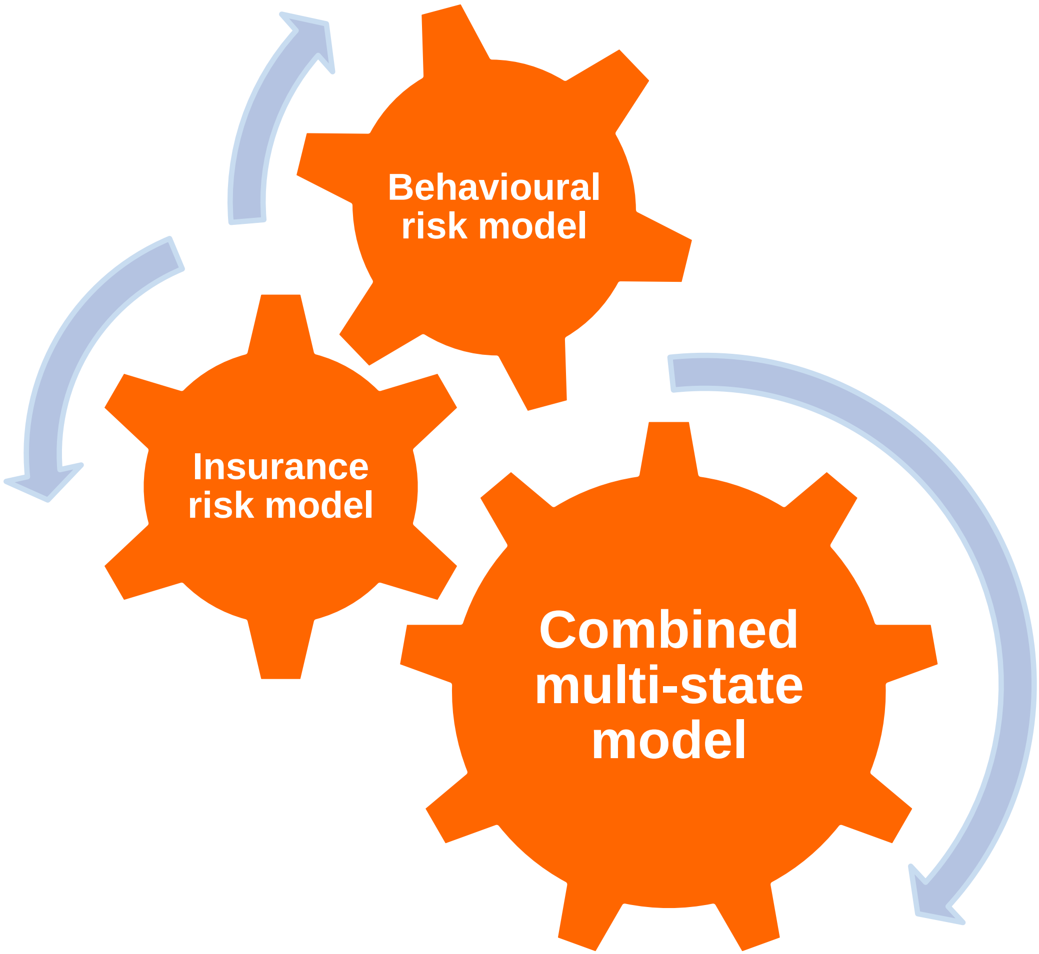
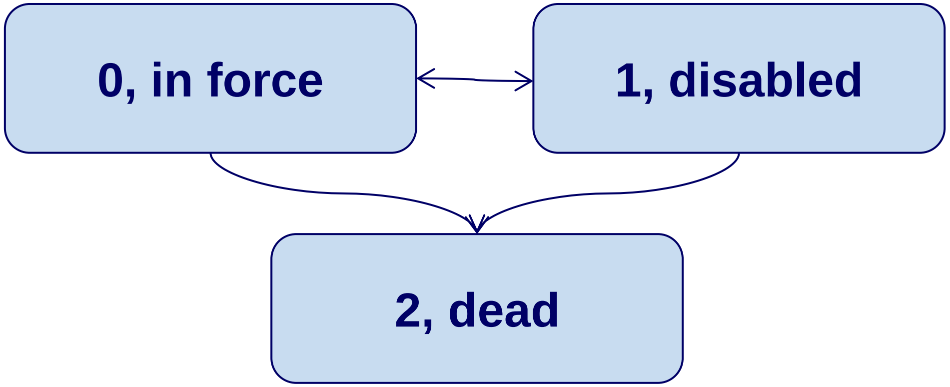
Liability Cash Flows Modelling in Life Insurance



Insurance and Behavioural Risk Models 1/4

Insurance Risk Model (Disability Risk Model)

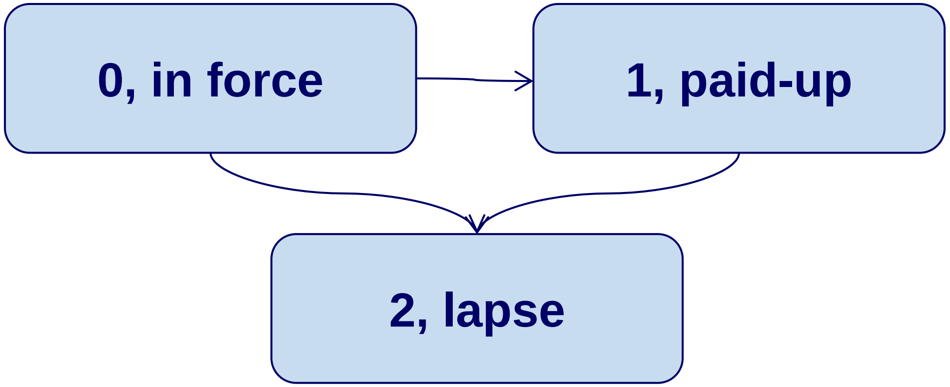
- 3-state model
- Recovery is possible



Insurance and Behavioural Risk Models 2/4

Behavioural Risk Model

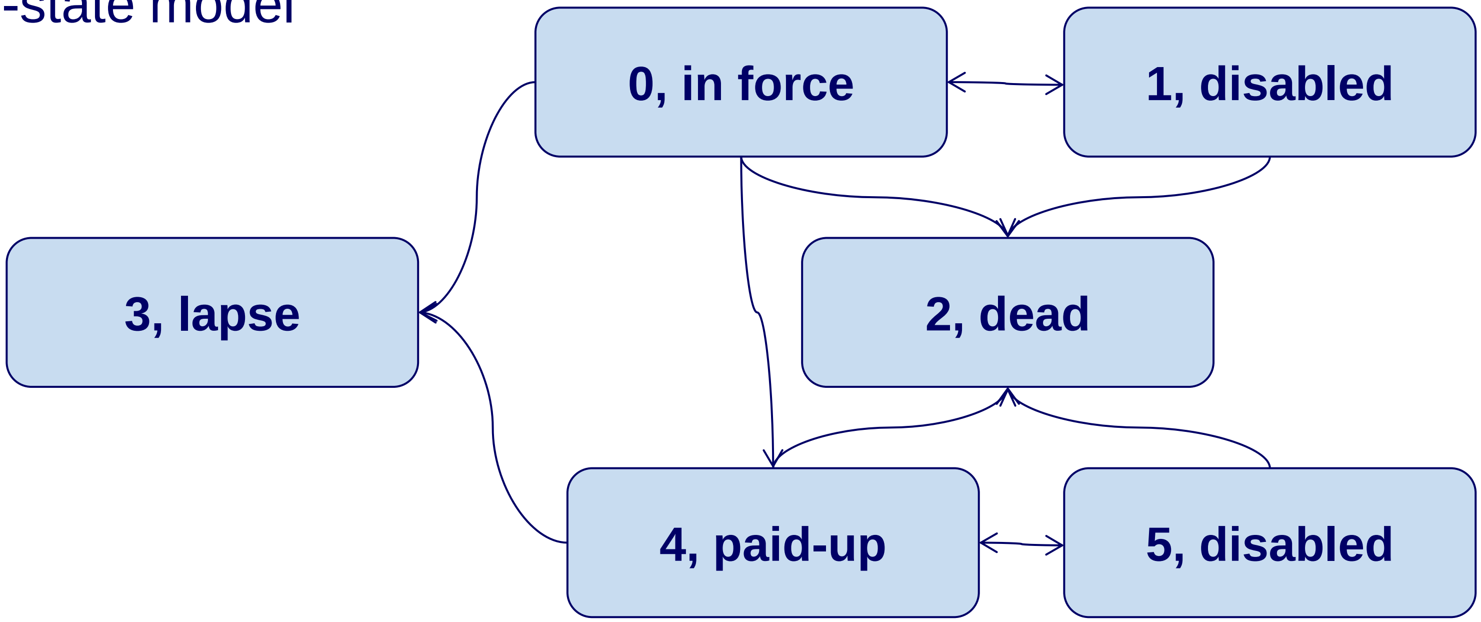
- 3-state model
- 2 policyholder‘s options



Insurance and Behavioural Risk Models 3/4

Combined Model

- 6-state model



Insurance and Behavioural Risk Models 4/4

Transition probabilities in Behavioural Risk model

- Approaches
  1) Lapse and paid-up actions are random → rationality behind surrender and paid-up is disregarded
  2) Lapse and paid-up actions are rational and purely occur when it is beneficial with some objective measure
  3) Combination of approach 1 and 2: lapse and paid-up occur randomly, but the probability is controlled by rational factors

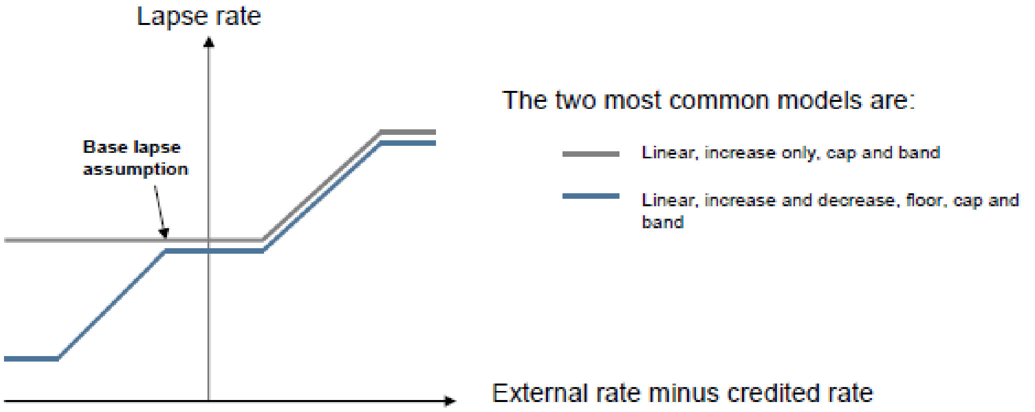
Analysis of Policyholder Behaviour - Approaches

Traditional techniques

- Univariate analysis
- **Base** (irrational) and **Dynamic** (rational) behaviour component
- Dynamic component is typically applied to adjust expected behaviour up or down
- Relationship between dynamic behaviour and key driver is usually based on linear, more complex or „stepped“ function
- Floors/caps
- A band with no DPHB
- **PROS**
  - Easy integration of dynamic behaviour into existing model
- **CONS**
  - Difficult to separate base and dynamic behaviour
  - Limited number of explanatory variables
  - Interactions between variables are typically ignored
  - Does not fully account for correlations between explanatory variables

Traditional techniques – example (surrender/lapse)

- Base surrender/lapse rate varying by policy duration (BE determined based on the output of analysis and expert judgement)
  - $\widehat{s_t^{p,d}} = \frac{S^{p,d}(t)}{E^{p,d}(t)}$
  - $S^{p,d}(t)$ … nb. of surrenders/ lapses for product *p* per period *t* with policy duration *d* in the beginning of period
  - $E^{p,d}(t)$ … nb. of in force contracts for product *p* with policy duration *d* in the beginning of the period *t*
- Shock applied at the end of surrender charge period
- Dynamic component applied



Behavioural economics

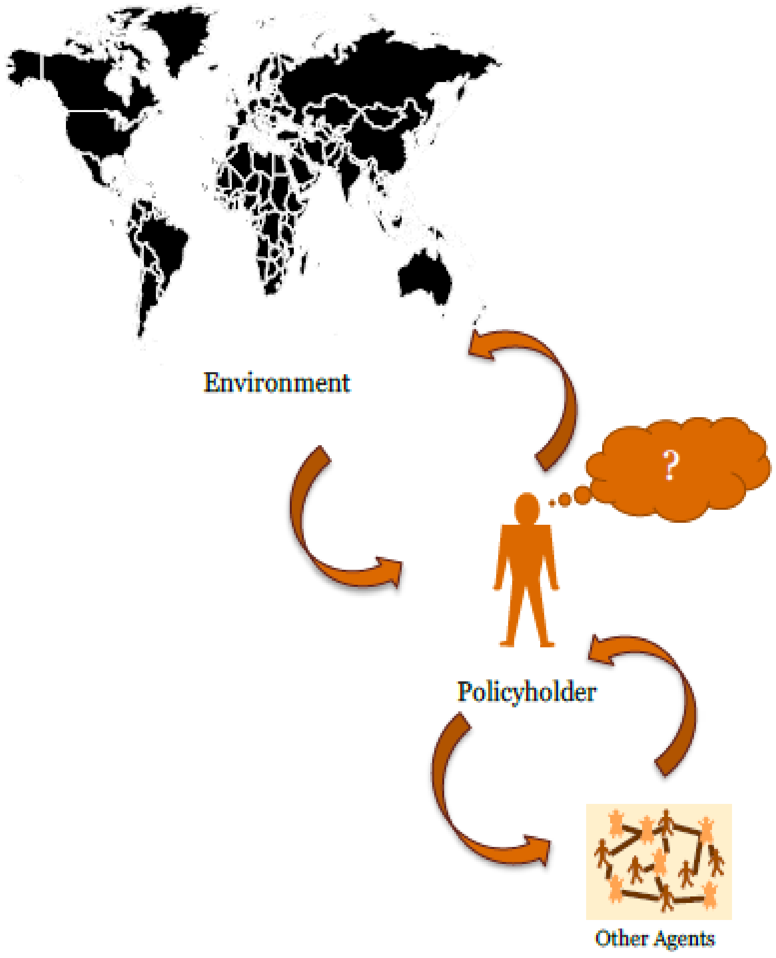
- Study of actual (as opposed to rational) decision making by policyholders, takes into account their social, cognitive and emotional biases.
- Provides insight into changing policyholder behaviour by „nudging“ policyholders to make decisions that are beneficial to them and the system overall.
- Can be applied for example in modelling of lapse rates, projecting when policyholder might exercise options or determining how customers react to changing economic patterns.
- Analyses have uncovered the underlying behavioural principles such as bounded rationality and willpower driving decision making.
- **PROS**
  - Shortcuts and decision rules are described and used to explain policyholder behaviour
- **CONS**
  - Using of decision rules requires move from aggregate level model to an individual policyholder-level model.

Predictive modelling

- Advanced algorithms and statistical techniques are used to data set to better understand the behaviour of a target variable based on the co-relationships of several explanatory variables
  - CART model (Classification and Regression Trees model)
  - GLM (Generalized Linear Model)
- **PROS**
  - Captures a greater number of risk factors that drive the behaviour
  - Accounts for correlations between variables
  - Captures interactions between variables where impact on one variable is impacted by another
  - Uses less data than traditional techniques to achieve convergence
- **CONS**
  - Relies on historical experience to predictive future experience=>it is not very reliable predicting future behaviour when there is a fundamental change in the environment

Behavioural simulation (1/2)

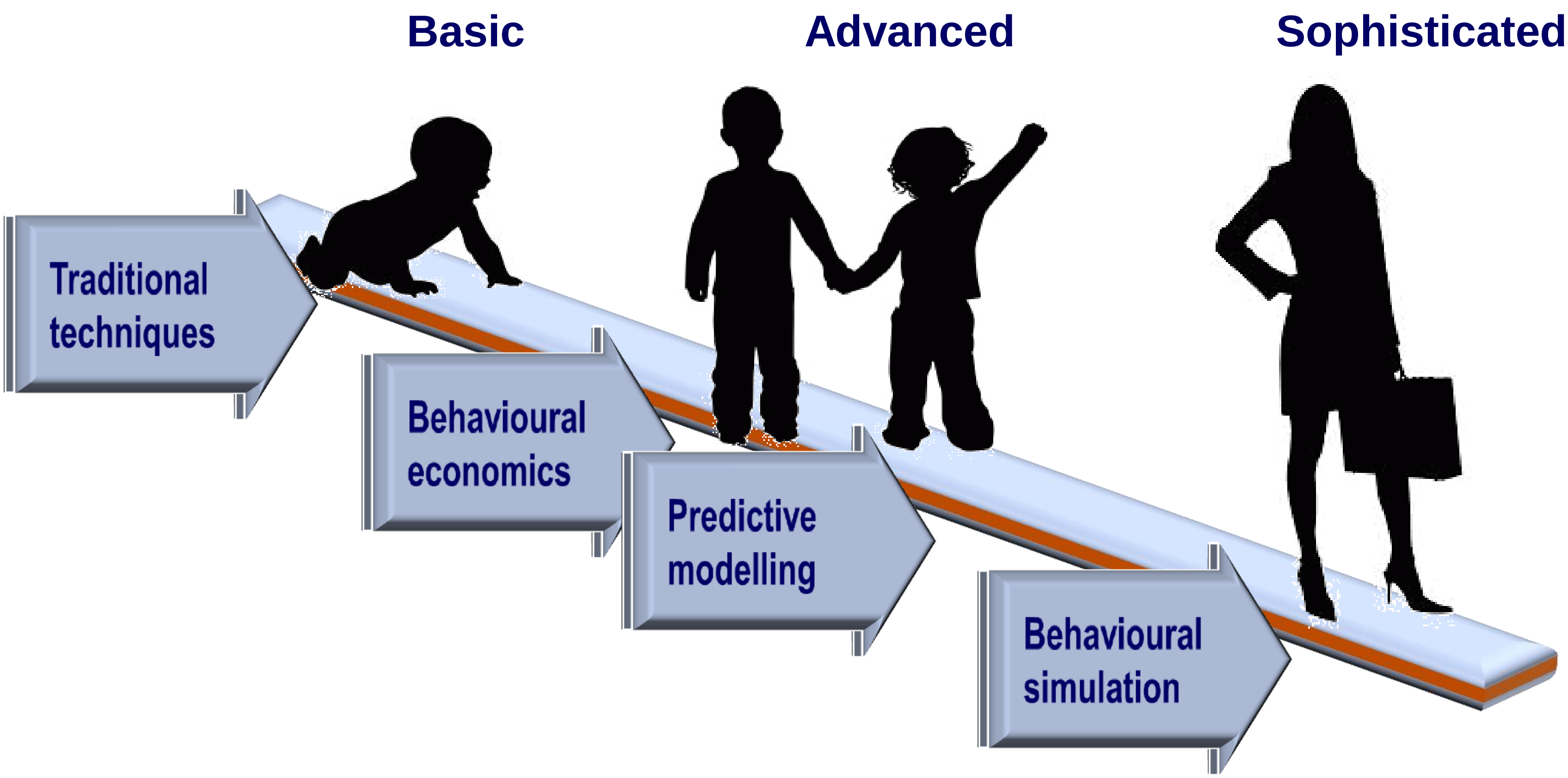
- More sophisticated solution
- Unique approach that combines individual decisions and artificial intelligence (AI) software modelling to model policyholder behaviour.
- These models simulate the simultaneous operations and interactions of multiple individuals to recreate a system and predict the complex phenomena => behaviour at macro level is based on micro-level interactions.



Behavioural simulation (2/2)

- Agent
  - Attributes (age, gender, marital status, occupation, risk profile)
  - Behaviours (employment choices, spending habits, savings habits, investment choices, retirement goals)
- Environment
  - Where the policyholder is in his life cycle (dependent, single and rich, growing family, pre-retiree, retiree, new generation)
  - The current stat of economy (regimes: good economy, normal economy, recession)

Analysis of Policyholder Behaviour: Development



Major drawback of all approaches

- It is not advisable to base assumptions entirely on the past experience as only some of possible economic scenarios have been observed. It would be dangerous to assume that because reaction to a modest change in interest rates has not been significant, this can be extrapolated for a large change in interest rates.

Rationality

- No statistically reliable evidence of the rationality in past experience does not necessarily mean that policyholder will never act rationally in the future.
- More extreme scenarios could drive higher levels of policyholder rationality.
- The level of public awareness of the value of embedded options increases over time. In practice, rationality may also be driven by distributor recommendations.

DPHB Models and Their Derivation

Methods used for derivation DPHB assumptions

- Qualitative or statistical analysis of historical experience
- Market study, industry survey, industry trends
- Expert/ actuarial judgement (consideration of policyholder's rationality)
- Cross-functional discussion
- Discussion with regulator

Combination of methods may be the most appropriate method

Lapses and DPBH

<u>Terminology</u>

- Inconsistency in literature
- Original definition:
  - Lapse (termination of insurance contract before maturity without pay-out to policyholder)
  - Surrender (termination of insurance contract before maturity with surrender value paid out to policyholder)
- Standard definition
  - Lapse is used to refer to both surrender and lapse
- Broader definition
  - Includes also paid-up option

Lapses and DPBH: Explanatory variables in literature

Environmental characteristics (macroeconomic indicators and company data)	Interest rate => Interest rate hypotheses	Lapse rates are negatively related to internal rates of return (surplus participation) and positively related to external rates of return (market interest rate, stock return)
	Unemployment rate => Emergency fund hypotheses	Personal financial distress forces policyholders to lapse their contracts
		Focus on unemployment rate as indicator of adverse economic condition
	Moneyness hypotheses	The probability that a policy is surrendered increases with its moneyness.
	Broader set of economic explanatory variables and company characteristics: GDP growth, bond performance, stock performance, seasonal effects, company size and legal form	
Single contracts data	Product and policyholder characteristics	

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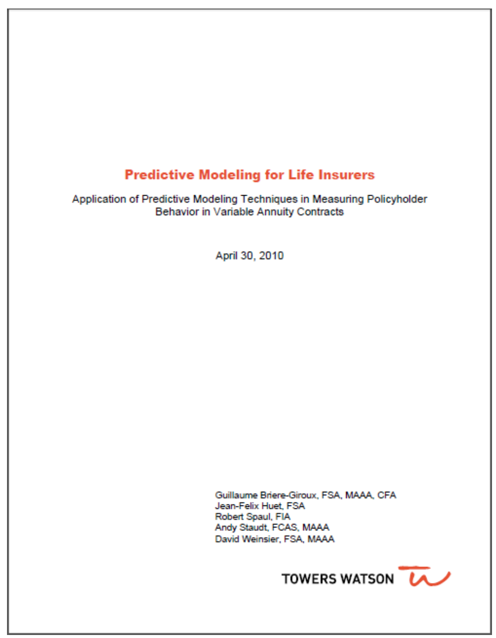
Source

- Case Study: Application of Predictive Modelling Techniques in Measuring Policyholder Behaviour in Variable Annuity Contracts
- Paper prepared by Towers Watson, approved for publication and released by SOA in August 2010

  http://www.soa.org/files/pdf/research-pred-mod-life-huet.pdf
- Proposal of application of predictive modelling



Predictive Modeling for Life Insurers

Application of Predictive Modeling Techniques in Measuring Policyholder Behavior in Variable Annuity Contracts

April 30, 2010

Guillaume Briere-Giroux, FSA, MAAA, CFA
Jean-Felix Huet, FSA
Robert Spaul, FIA
Andy Staudt, FCAS, MAAA
David Weinsier, FSA, MAAA

TOWERS WATSON

Methodology and underlying data

- Large sample of hypothetical but representative data (developed based on actual industry experience, with certain adjustments)
- More than 10 issue years included in the data
- Two models were calibrated to the data
  - Traditional model following typical industry approach reflecting typical variables to analyse VA lapses
  - Predictive model using a Generalized Linear Model (GLM) and the variables detected to be most significant
- Data set was randomly split into two groups
  - 70 % of the data used to set the model parameters
  - 30 % of the data used to test the model effectiveness

Variables Used in the Traditional and the Predictive Model

Traditional Model	Predictive Model
• Policy duration • Surrender charge length and strength • End of the surrender charge period • Commission structure • Presence and nature of living benefit • ITM of living benefits	• Policy duration • Surrender charge length and strength • Proximity to end of surrender charge • Commission structure • Presence and nature of living benefits • ITM of living benefits • **AND** • Premium (i.e. policy size) • Fund value • Portfolio mix (aggressive, balanced, conservative, cash) • Attained age

Case Study: Traditional approach

- Univariate analyses
- Underlying data are categorized, aggregated and analysed
- Single lapse rate, which is function of both base and dynamic behaviour is determined
  - Attempts made to separate these impacts decreases the credibility of the resulting groups => impact can not be precisely validated
- Limited number of explanatory variables are considered
- Interactions between variables are ignored
- Correlations between explanatory variables are not fully accounted

Case Study: Developing the Predictive Model

Initial analysis

- Helps the user to understand the underlying data

Generalized linear modelling

- Brief introduction to the theory of GLMs

Choice of GLM form

- Decisions required for choosing the structure of the model

Choice of explanatory variables

- Decisions required for choosing which variables to include in model and which to exclude

Interpreting parameter estimate graphs

- How to interpret the graphs that describe variable effects within a model

Interactions

- A method for including of an interaction within model

GLM - Initial analysis

- Check and clean data
- Decide on the business in scope for the analysis (product coverage, time length, frequency of study or „time step" used for the analysis)
- Make sure that the various in-force statistics are appropriately captured etc.
- Univariate analysis
  - Highlights potential significant variables
  - Allows us to see if the grouping of numeric variables is sensible

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GLM – brief description

- Provides rich class of models
  - Not restricted to linear relationships
  - Not restricted to normality assumption

$$l_i = \mathrm{E}[L]_i + \varepsilon_i = \mu_i + \varepsilon_i = g^{-1}(\eta_i) + \varepsilon_i = g^{-1}\left(\xi_i + \sum_{j=1}^{p} x_{ij}\beta_j\right) + \varepsilon_i,\ i = 1, \dots, n$$

l_i ... observations, realisations of random variable L, $L \sim$ Exponential family

g ... link function

$\eta_i = \xi_i + \sum_{j=1}^{p} x_{ij}\beta_j$ ... linear predictor

ξ_i ... offset

β_j ... unknown parameters

ε_i ... residual error

- How to find parameters and offset: values are chosen to maximize the log-likelihood for the observed lapses and can be found using iterative numerical techniques

GLM – presentation of results

- Presentation of the results in easy-to-understand format
  - In some cases it is possible to turn the results into a set of multiplicative relativities and a base level

- Example of a multiplicative approach to determining lapse rates

Policy Lapse Rate

=

Base Level
10%

×

Duration	Multiplier
3	0.3
5	0.5
8	2.5
10	1
…	…

×

ITM	Multiplier
-30%	1.2
-10%	1.2
0%	1.0
20%	0.8
40%	0.5
…	…

GLM

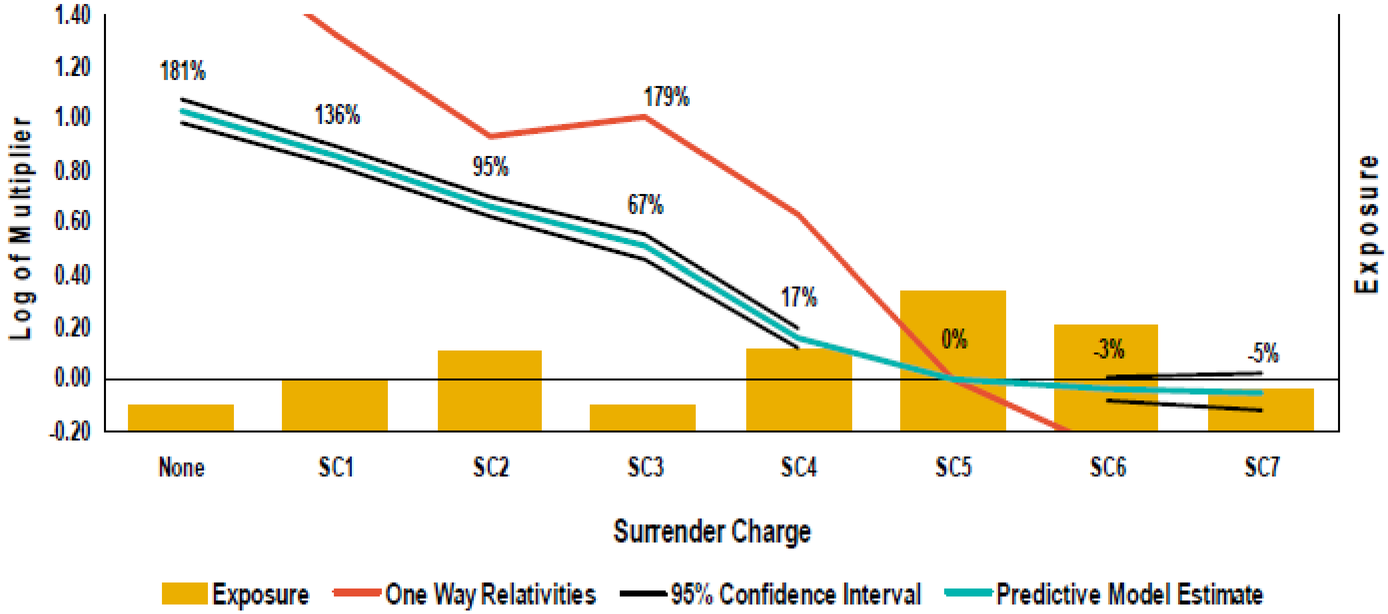
- Choice of GLM form
  - We are trying to predict the probability of lapse
  - Link function: logit
  - $\mathrm{logit}(x) = \log\left(\frac{x}{1-x}\right)$
  - Distribution of random error: binomial

- Choice of explanatory variables
  - Parameter estimate graphs
    - See next slide
  - P-value tests
    - The significance of each variable can be determined through tests of significance by comparing a model with and without the variable in question

GLM - Interpreting parameter estimate graphs

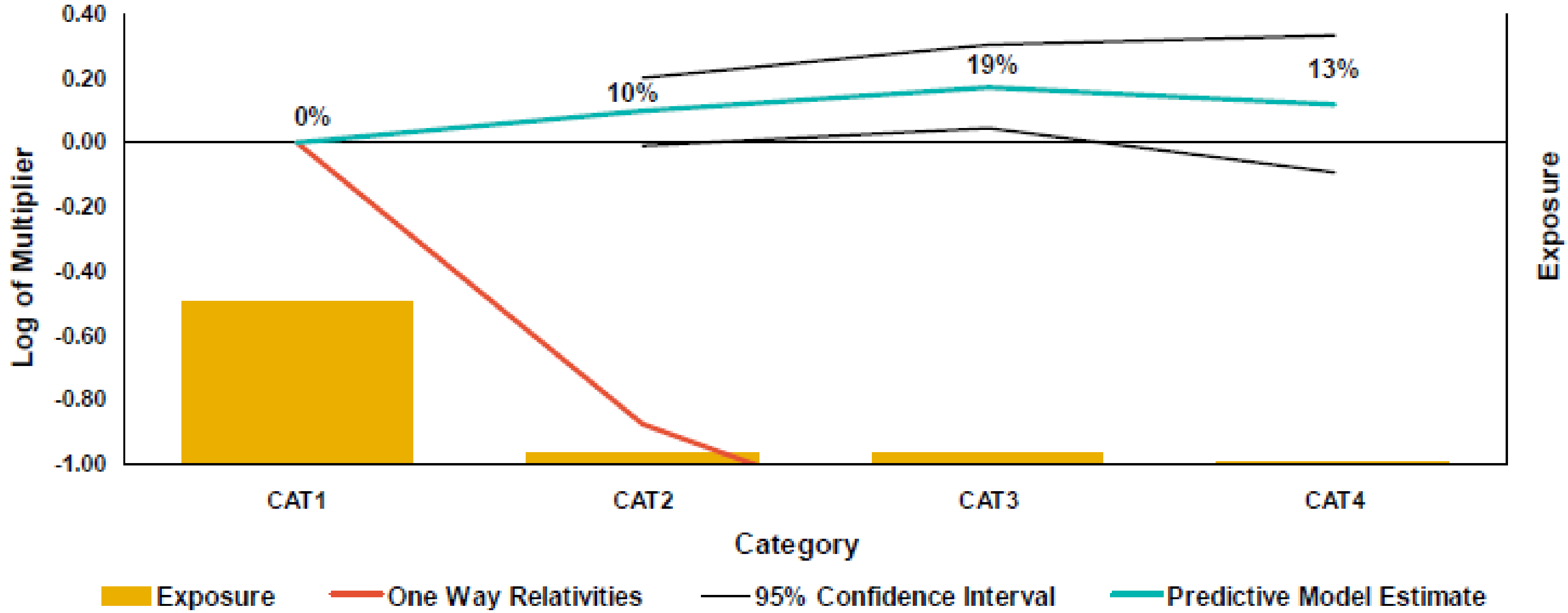
- Graphical output is often the most helpful to assess fitted parameters

- Relative effect of surrender charge within GLM



GLM - Interpreting parameter estimate graphs

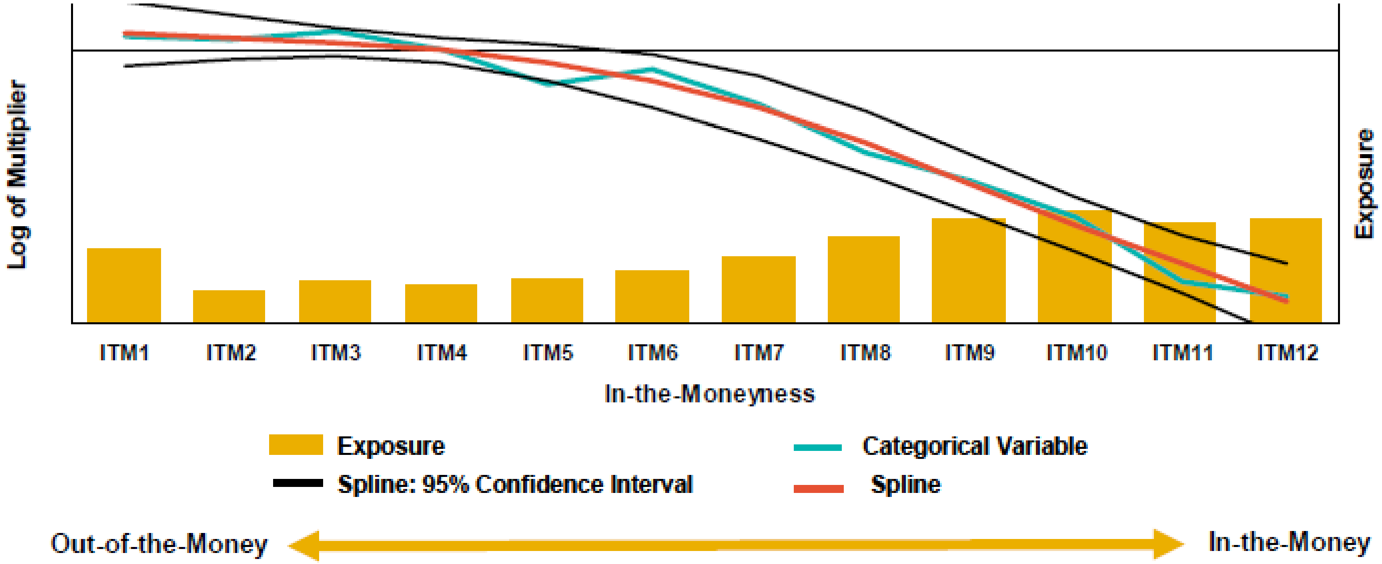
- Example of a factor with insignificant levels



- In this case there is only one parameter estimate more than two standard errors from zero, and we could consider removing this variable or collapsing some of the levels to improve the significance

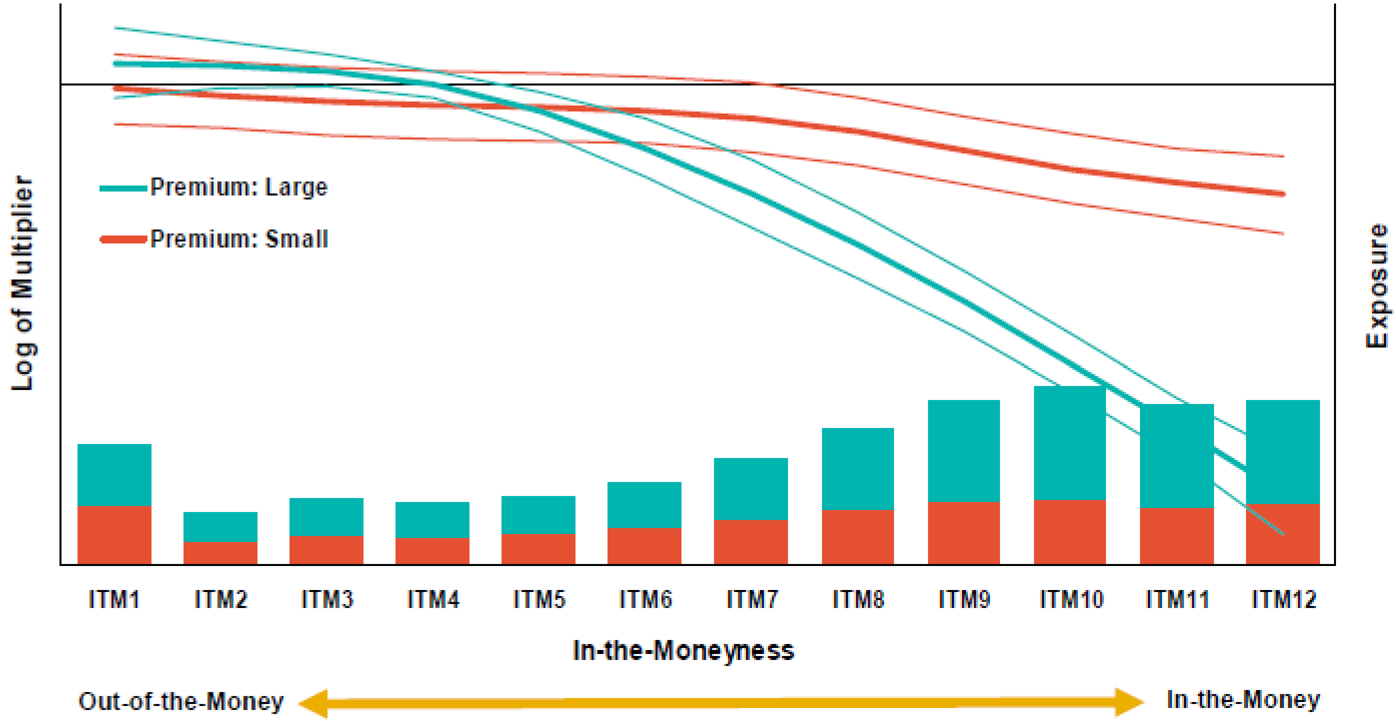
GLM – Model with no interactions

- The effect of some variables may be dependent on the values of other variables.
- Modelling ITM with no interaction



GLM – Model with interaction

- Modelling ITM with an interaction with premium size



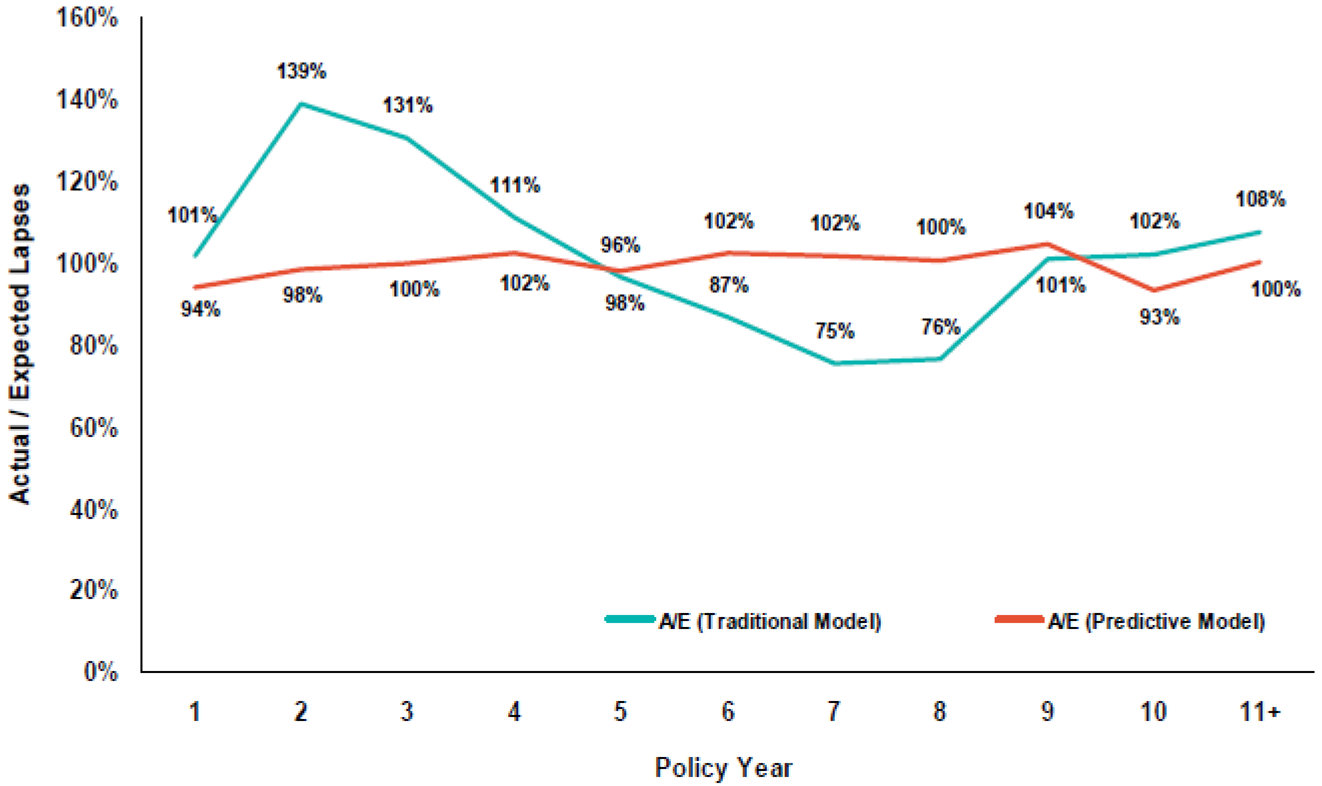
- It is clear that the effect of ITM is very different depending on the size of the premium in this data.

Results

- First group of data used to fit the model
- Second group of data then used to project expected lapse rates
- Actual to expected analysis was performed

Results

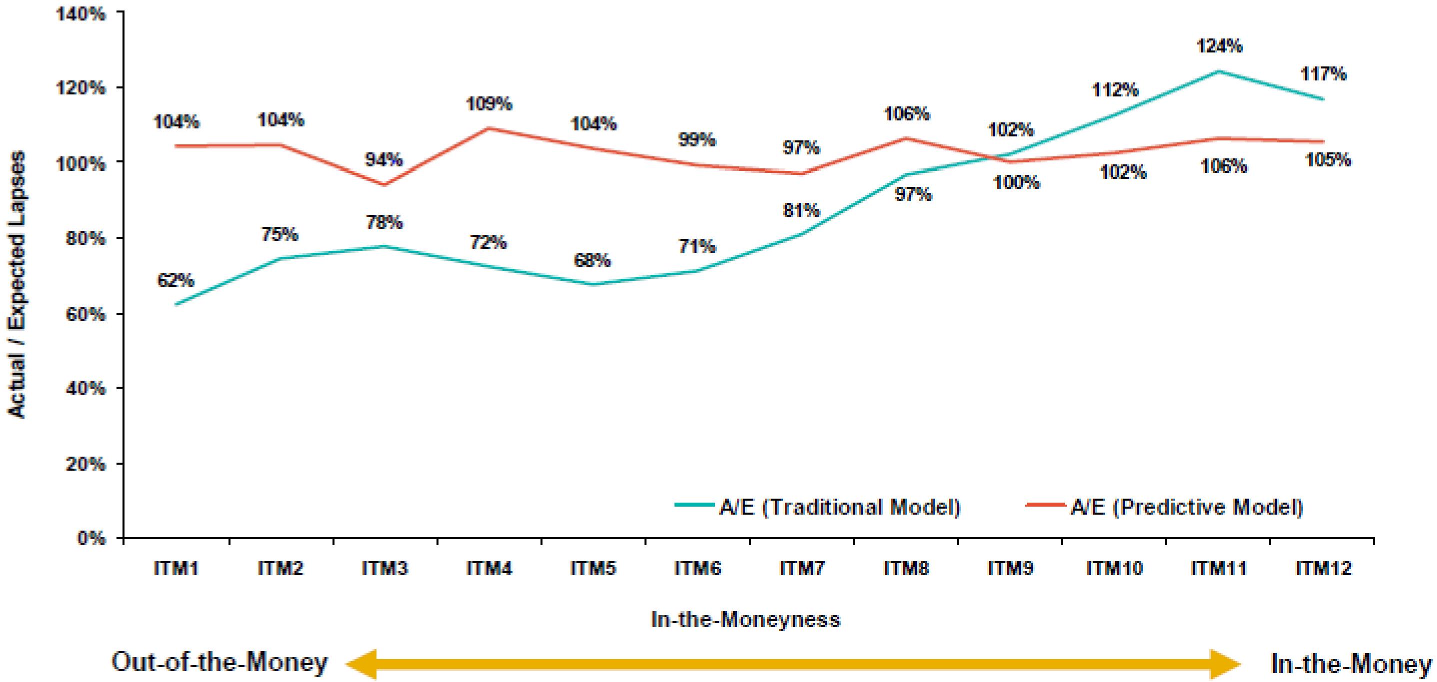
- Actual-to-expected results by policy duration



- The predictive model shows appreciably better fit than the traditional model.

Results

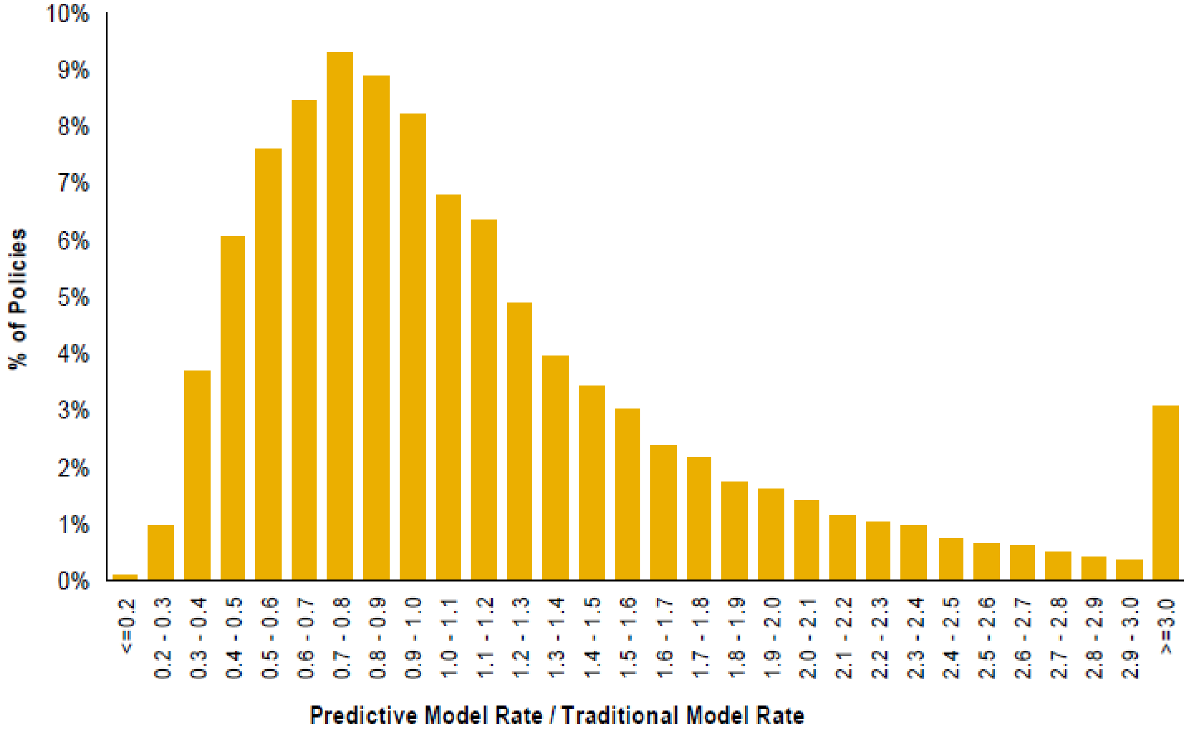
- Actual-to-expected results by ITM



- The predictive model shows appreciably better fit than the traditional model.

Results

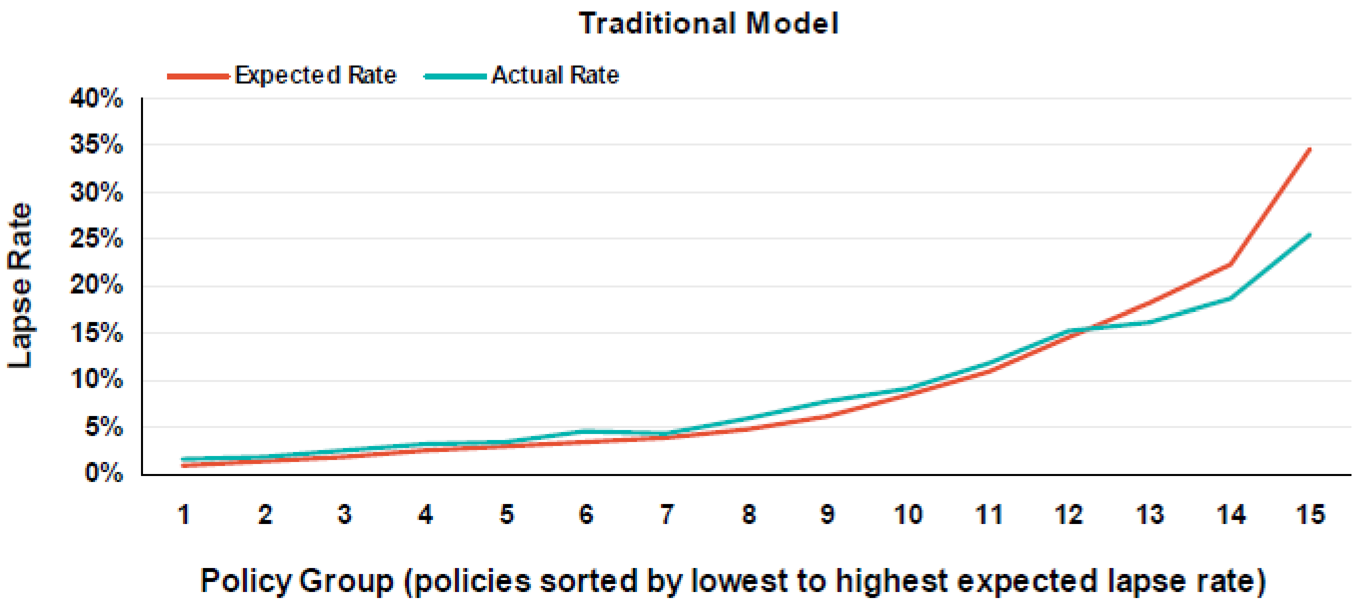
- Comparison of expected lapse rates: predictive vs. traditional



- For significant proportion of the policies the two models produce radically different expected lapse rates.

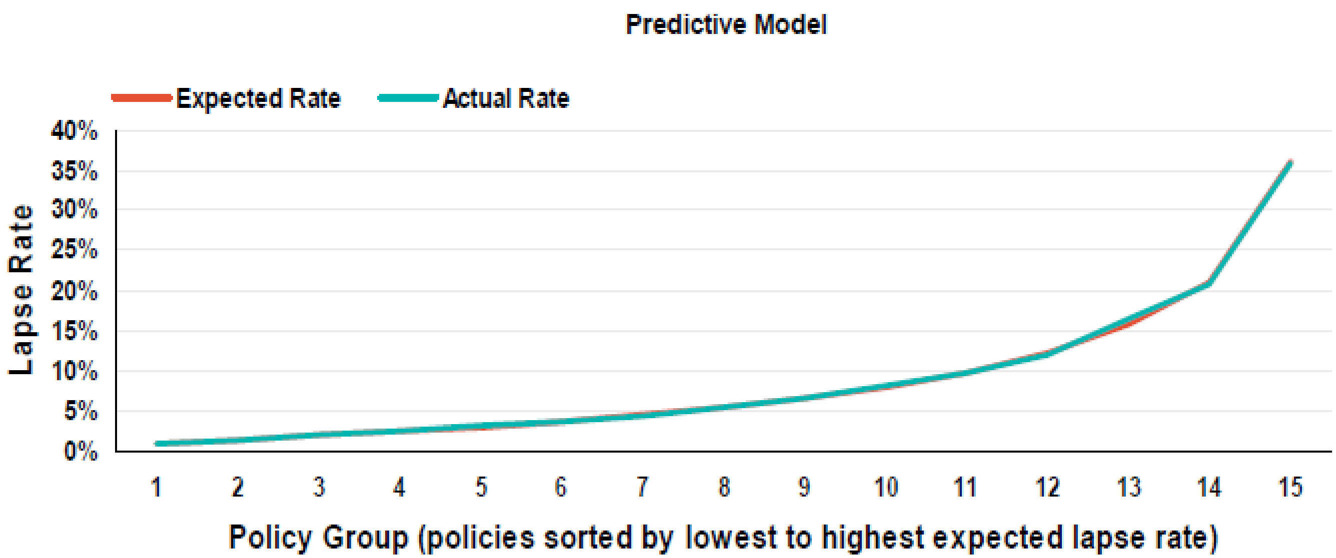
Results

- Lift chart for the traditional model actual vs. expected lapse rates



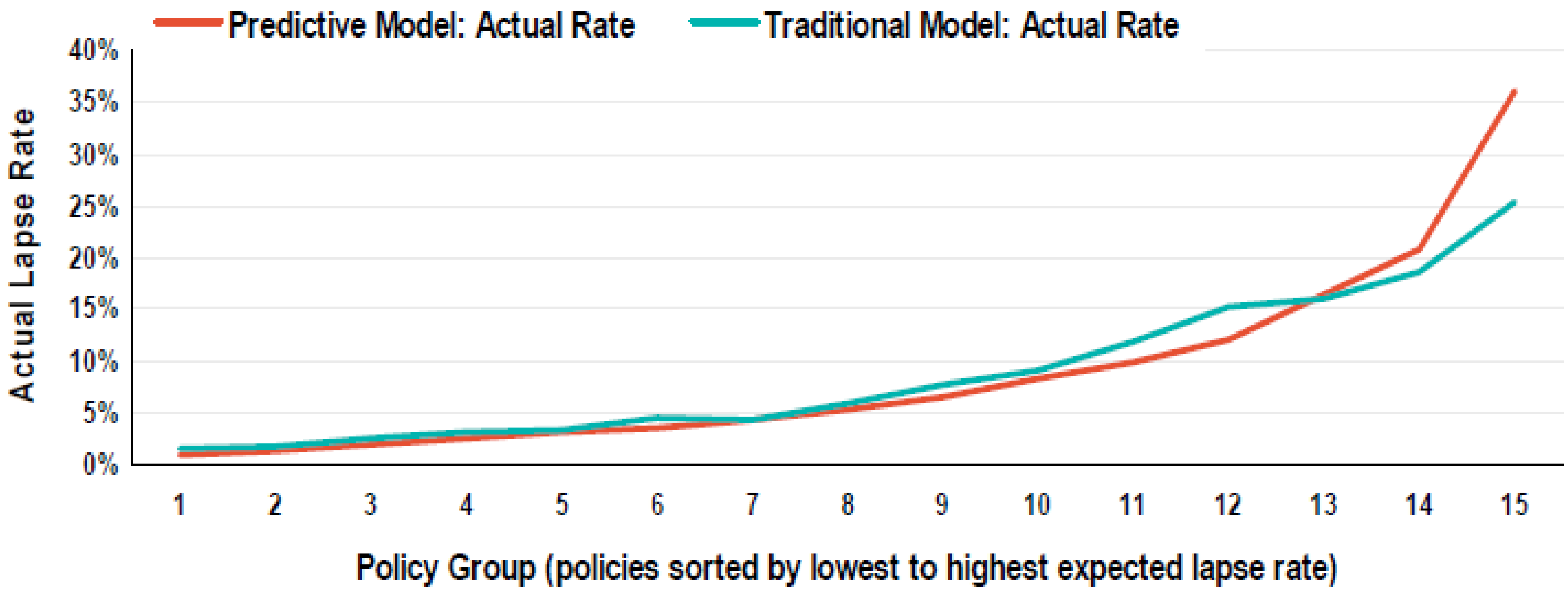
Results

- Lift chart for the predictive model actual vs. expected lapse rates



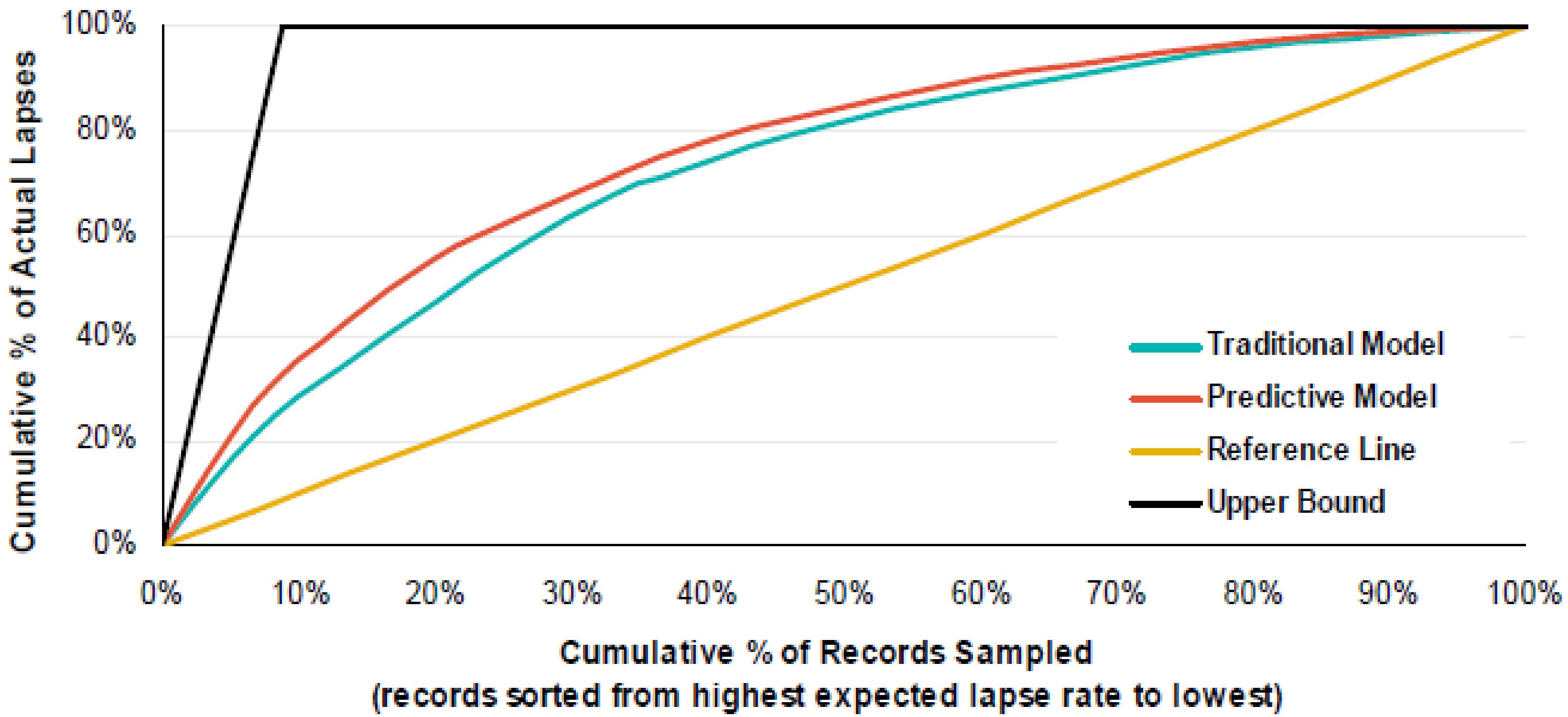
Results

- Comparison of traditional and predictive models using a lift chart

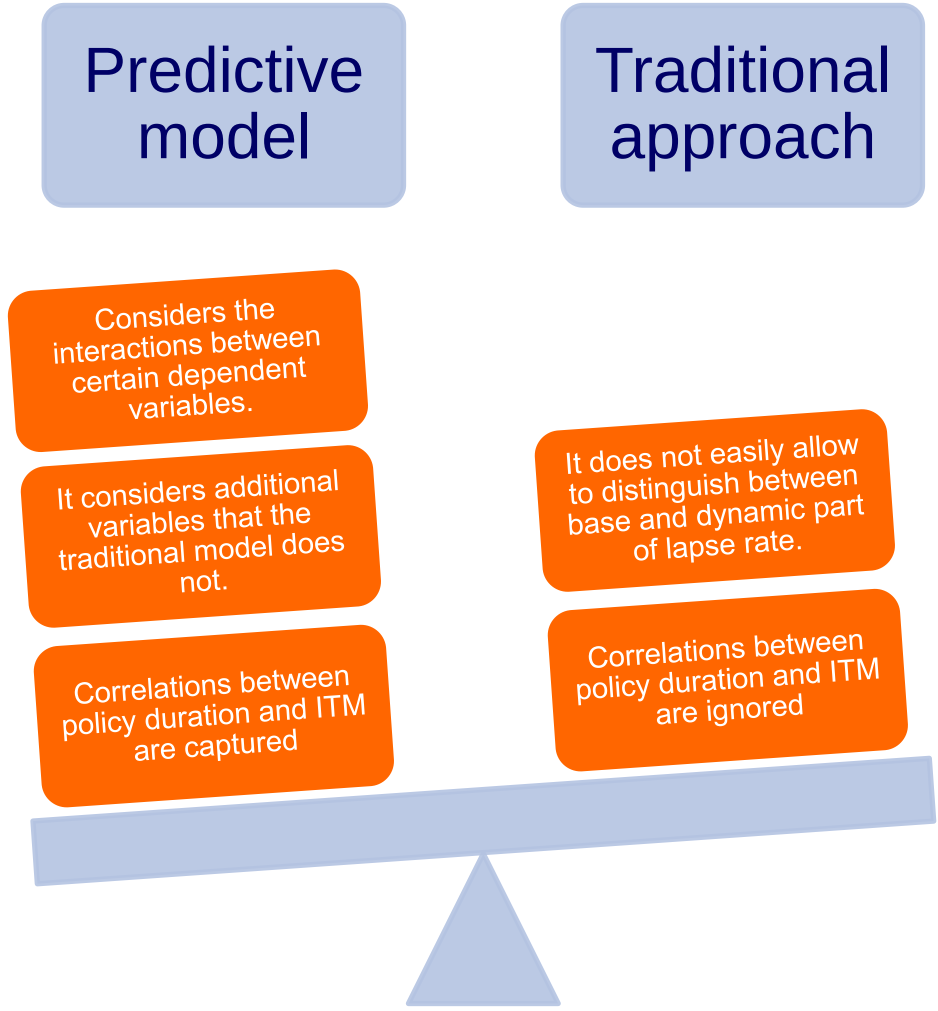


Results

- Comparison of traditional and predictive models using a gain chart



Results


Predictive model
Traditional approach
Considers the interactions between certain dependent variables.
It considers additional variables that the traditional model does not.
Correlations between policy duration and ITM are captured
It does not easily allow to distinguish between base and dynamic part of lapse rate.
Correlations between policy duration and ITM are ignored

Results

Conclusion

- The predictive model had an appreciably better fit under a typical actual-to-expected analysis
- Additional tests which can assess the models at more granular level performed:
    - Lift charts and gain charts: predictive model produces a more granular fit than a traditional model and better differentiates between policies with low and high risk of lapsing

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Management of DPHB

- ✓ Regular monitoring is important
- ✓ DPHB is a key risk with a lot of uncertainty and companies should consider ways of mitigating it
- ✓ Third party solutions are generally not available (hedge, reinsurance)
- ✓ New products should be designed to be robust to different DPHB experience

Management of DPHB

- <u>Intelligent product design</u>
  - Surrender penalties
  - Deferral of bonuses
    - Terminal bonus
    - Loyalty bonus
  - Reduce guaranteed interest rate
  - Innovative profit sharing arrangement
  - Customer retention
  - Customer targeting

- <u>Focus on distribution channels</u>
  - Commission structure
  - Claw-back structure
  - Service quality differences between distribution channels

Questions and answers

Thank you for your attention

Contacts

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Disclaimer

The opinions and conclusions mentioned in this presentation are my personal views and not necessarily those of ING Group.

Summary of references

- Behavioral Simulations, Using agent-based modeling to understand policyholder behaviors, L. Lombardi, M. Paich, A. Rao, October 2012, Society of Actuaries, available online at http://www.soa.org/Files/Research/Projects/research_2012_behav_sim.pdf
- Dynamic Policyholder Behavior Assumptions, S. Walpole, August 2011, Society of Actuaries, available online at http://www.soa.org/Files/Pd/2011-hk-ifrs-walpole-42.pdf
- Dynamic Policyholder Behaviour & Management Actions Survey Report, Milliman: D. Clark, J. Kent, E. Morgan, October 2013, available online at http://us.milliman.com/uploadedFiles/insight/2013/milliman%20DPB-MA-survey.pdf
- Generalized Linear Models in Life Insurance: Decrements and risk factor analysis under Solvency II, R. R. Cerchiara, M. Edwards, A. Gambini, University of Calabria – Italy, available online at http://www.italian-actuaries.org/afir/cd1/Papers/AFIR2008_Paper_Cerchiara_Edwards_Gambini.pdf
- Impact of Policyholder Behavior, G. Briere-Giroux, A. A. Dicke, M. E. Dubois, September 2011, Society of Actuaries, available online at http://www.soa.org/Workarea/DownloadAsset.aspx?id=28546
- ING internal documents
- Life Insurance Cash Flows with Policyholder Behaviour, K. Buchardt, T.Møller, November 2013, University of Copenhagen, available online at http://www.math.ku.dk/~buchardt/files/buchardt_phb.pdf
- Markov Chain Modeling of Policy Holder Behavior in Life Insurance and Pension, L. F. B. Henriksen, J. W. Nielsen, M. Steffensen, C. Svensson, September 2013, University of Copenhagen, available online at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2289926
- On the Propensity to Surrender a Variable Annuity Contract: An Empirical Analysis of Dynamic Policyholder Behavior, Ch. Knoller, G. Kraut, P. Schoenmaekers, July 2013, *Munich Risk and Insurace Center*, available online at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1976203
- Predictive Modeling for Life Insurers, Application of Predictive Modeling Techniques in Measuring Policyholder Behavior in Variable Annuity Contracts, G. Bruiere-Giroux, J.F. Huet, R. Spaul, A. Staudt, D. Weinsier, April 2010, Society of Actuaries, available online at http://www.soa.org/files/pdf/research-pred-mod-life-huet.pdf

Summary of references

- Research on Lapse in Life Insurance – What Has Been Done and What Needs to Be Done?, M. Eling, M. Kochanski, December 2012, *The Journal of Risk Finance*, 14(4), 2013.
- Surrender Triggers in Life Insurance: Classification and Risk Predictions: X. Milhaud, S. Loisel, V. Maume-Deschamps, available online at http://isfa.univ-lyon1.fr/vmaume/sites/default/files/documents/lapse.pdf
- What Policy Feature Determine Life Insurance Lapse? An Analysis on the German Market, M. Eling, D. Kiesenbauer, November 2011, *Journal of Risk and Insurance*, 2013.
- Zobecněný lineární model: od základů k aplikaci v analýze chování pojistného kmene a škodných událostí, M. Šimurda, available online at http://www.actuaria.cz/upload/GLM_SMM_MFF_web.pdf