OLIVER WYMAN

Model Validation

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Agenda

1 **Overview of upcoming ASOPs pertaining to validation of life models**

2 **Model validation techniques through case studies**

Upcoming ASOPs
The following exposure drafts include sections on model validation

Modeling[1]

- **Last revised**: November 2014 (second exposure draft)
- **Purpose**: Provide guidance to actuaries selecting, designing, building, modifying, developing, using, reviewing, or evaluating models when performing actuarial services
- **Scope**: The scope of the ASOP is the purpose stated above, applied to all forms of models in all practice areas

Principle-Based Reserves for Life Products[2]

- **Last revised**: June 2014 (second exposure draft)
- **Purpose**: Provide guidance to actuaries when performing actuarial services in connection with developing or opining on principle-based reserves for life insurance in compliance with NAIC Standard Valuation Law and the NAIC Valuation Manual
- **Scope**: The ASOP applies to actuaries performing actuarial services on behalf of life insurance companies in connection with the calculation or review of reserves for individual life insurance policies subject to Chapter VM-20: Requirements for Principle-Based Reserves for Life Product

[1]http://www.actuarialstandardsboard.org/asops/modeling-second-exposure-draft/
[2]http://www.actuarialstandardsboard.org/asops/principle-based-reserves-for-life-products-second-exposure-draft/

What is a model?
Modeling ASOP exposure draft definition of a model

> A representation of relationships among variables, entities, or events using statistical, financial, economic, mathematical, or scientific concepts and equations. Models are used to help explain a system, to study the effects of different components, and to derive estimates and guide decisions. A model consists of:

Specification	A description of a model that identifies the inputs and their interactions with each other to produce output through logic, algorithms, or a set of mathematical formulas
Implementation	An executable form of a model
Model Runs	The output of a model derived from a given set of input

"Model" is not defined in Principle-Based Reserves for Life Products ASOP exposure draft

Mitigation of model risk
Validation language in ASOP exposure drafts

Modeling

- The actuary *should* examine the potential for model risk and undertake reasonable and appropriate steps to mitigate such risk, using validation, governance, and controls, as appropriate to the intended purpose
  - Validation
    - Model integrity
    - Analyzing the output
    - Peer review
  - Appropriate governance and controls

Principle-Based Reserves for Life Products

- The actuary *should* consider validation procedures such as the following:
  - Perform static validation that confirms initial values for reserves, face amount, policy count and other basic statistics materially balance to the insurer's records as of the model date
  - Performing a dynamic validation
  - Alternative model testing
  - Performing an analysis that critically reviews each of the changes made to the model since it was last validated

Both exposure drafts allow for the use of the actuary's professional judgement to determine the full extent of the model validation exercise

Model validation techniques

The following validation tests are used in a majority of model governance and validation programs

1. **Static validation**
2. **Dynamic validation**
3. **Parallel model building**
4. **Extreme value testing**
5. **Alternative “challenger” model**
6. **Regression testing / attribution analysis / sensitivity testing**

Static validation
Overview

- Checks that reconcile policy, contract, and asset metrics from the model to the data extract:
  - Counts
  - Face amounts
  - Account values
  - Cash surrender values
  - Guarantee amounts
  - Initial asset position (book value, market value)
  - Asset runoff
- First level check identifies missed policies or whole blocks of plans
- Second level check identifies data adjustments or approximations made

Static validation
Extract reconciliation

	Contract Count			Contract Account Value		
Plan	Extract	Model	Validation	Extract	Model	Validation
Plan 1	158	157	99%	7,742,000	7,693,000	99%
Plan 2	3,421	3,421	100%	165,063,250	165,063,250	100%
Plan 3	931	931	100%	50,274,000	50,274,000	100%
Plan 4	1,848	-	0%	110,880,000	-	0%
Total	6,358	4,509	71%	333,959,250	223,030,250	67%

	Loan Count			Loan Face Amount		
Geographical Location	Extract	Model	Validation	Extract	Model	Validation
Location 1	115	115	100%	124,118,970	129,161,336	104%
Location 2	34	34	100%	95,151,647	101,139,456	106%
Location 3	10	10	100%	27,163,043	27,163,043	100%
Location 4	13	13	100%	44,000,295	44,000,295	100%
Location 5	22	22	100%	37,795,906	39,765,580	105%
Location 6	5	5	100%	16,268,117	16,268,117	100%
Location 7	18	18	100%	30,678,063	33,435,607	109%
Total	217	217	100%	375,176,041	390,933,434	104%

	Loan Count			Loan Face Amount		
Loan Type	Extract	Model	Validation	Extract	Model	Validation
Finished	185	185	100%	330,154,916	330,154,916	100%
Construction	32	32	100%	45,021,125	60,778,519	135%
Total	217	217	100%	375,176,041	390,933,434	104%

Dynamic validation
Overview

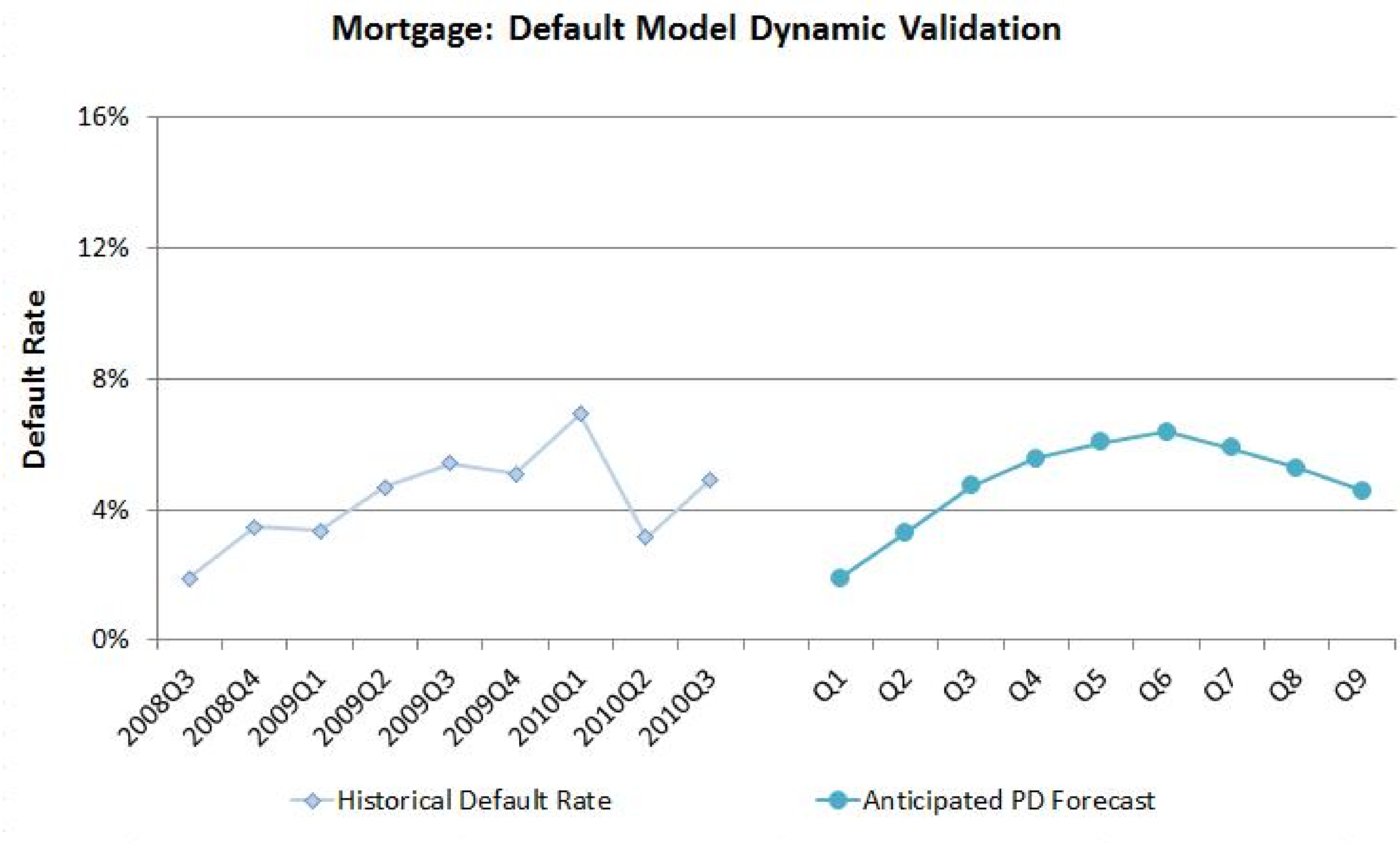
- Compare multiple projection years (usually less than 5 years) of projected results to historical reported values
- Performing dynamic validation of cash flows, balance sheet and income statement will reveal potential issues, but a drill down is often needed to understand the cause (e.g., assumptions)
- Backcasting over the historical period provides additional information if possible
- Getting the information necessary out of model projections is the easier part; often the historical information is not readily available at the right level
- Dynamic validations can be automated as part of the reporting process but more granular validations are usually also performed as part of a formal validation exercise

Dynamic validation
CCAR: mortgage probability of default projections

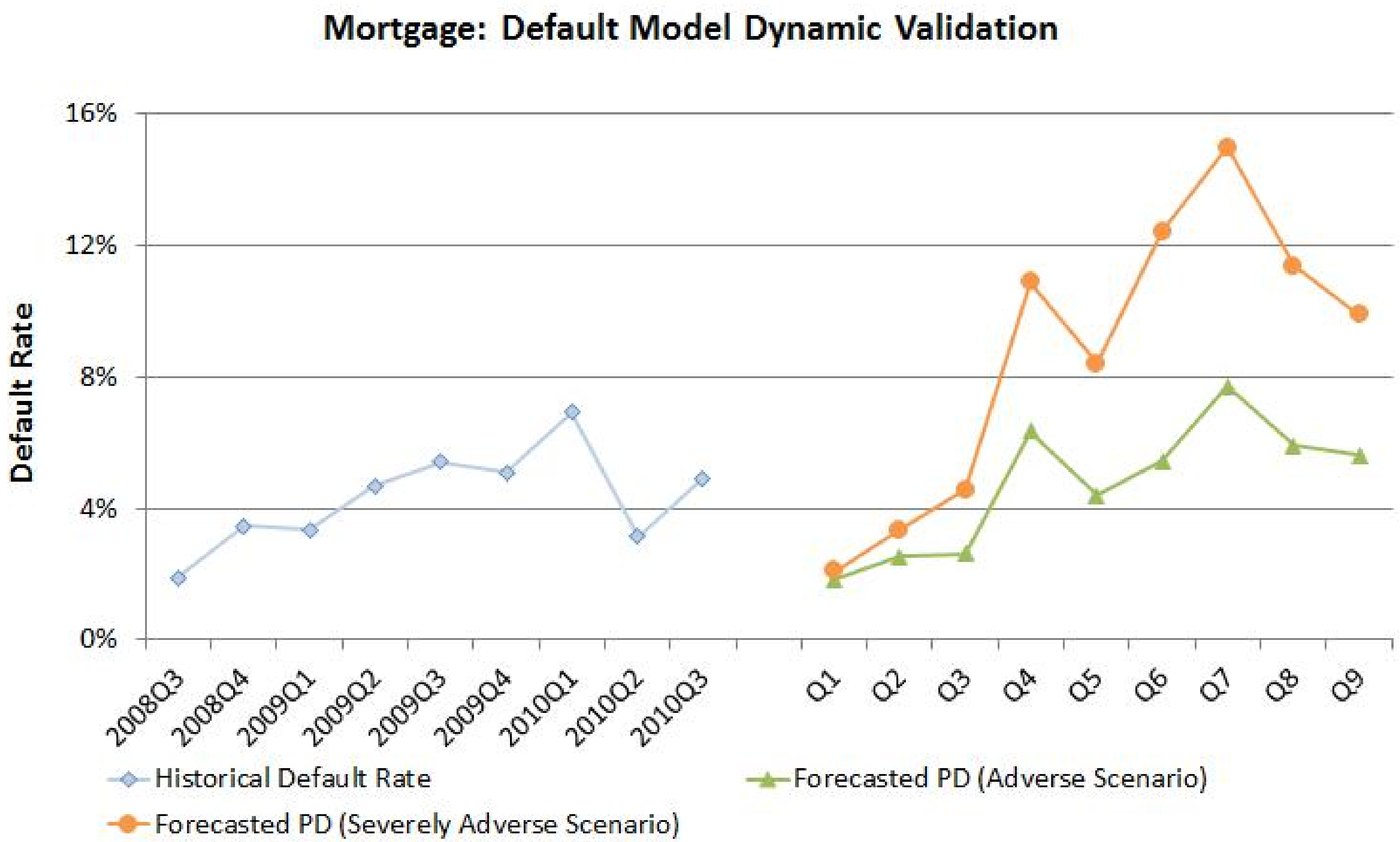
Background

- A bank is projecting expected losses on its mortgage book of business for the purpose of CCAR
- Severely adverse CCAR scenario is similar to 2008-2009 crisis
- Underwriting criteria has become more strict; quality of mortgages has improved since crisis
- Bank is expected lower projected default rates in the severely adverse scenario vs. the 2008-2009 crisis

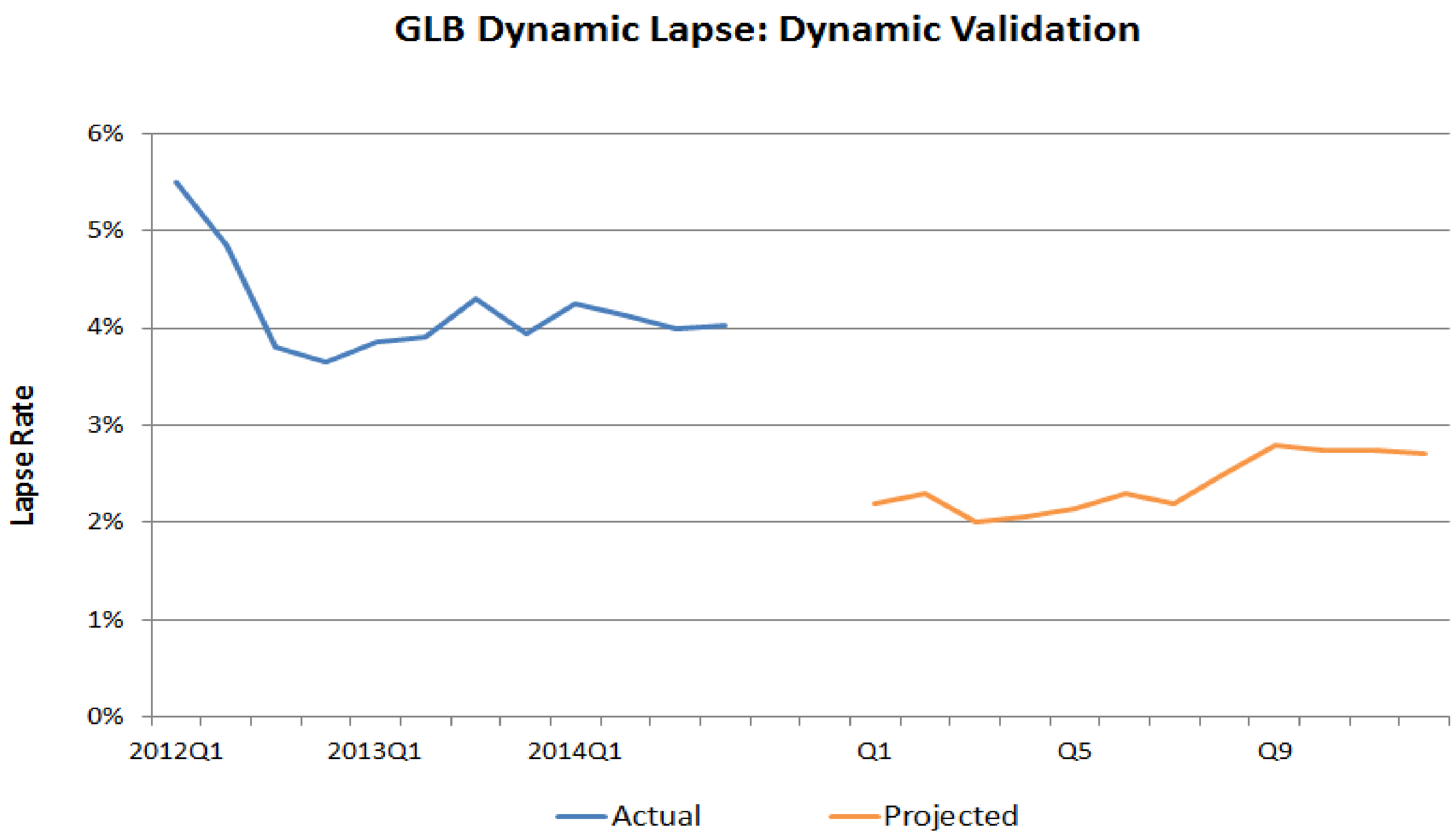
Dynamic validation
CCAR: mortgage probability of default projections



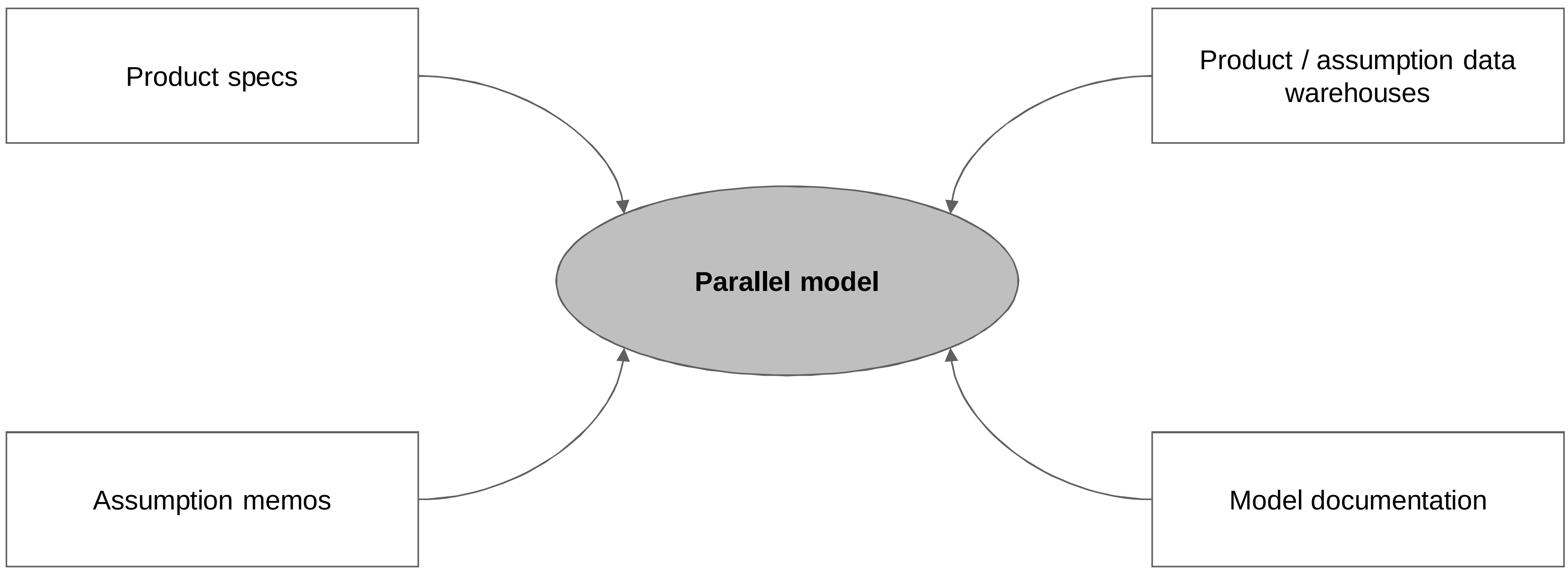
Dynamic validation
CCAR: mortgage probability of default projections



Dynamic validation
GLB dynamic lapse



Parallel model building
Overview



Parallel model building
Missing dynamic lapse component

Case

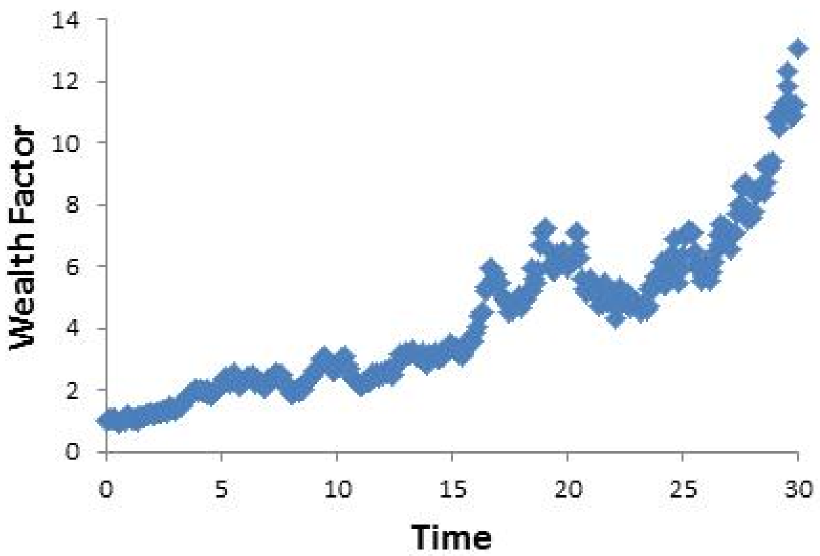
- A VA GLWB writer implemented a new dynamic lapse function using the actuarial present value of future benefits (withdrawal and death benefits) as a variable
- In coding the valuation model, the present value of future death benefits was mistakenly excluded from the formula
- The disconnect between the calibration of the assumption and valuation implementation drove lapses to be overstated relative to the carrier's intent

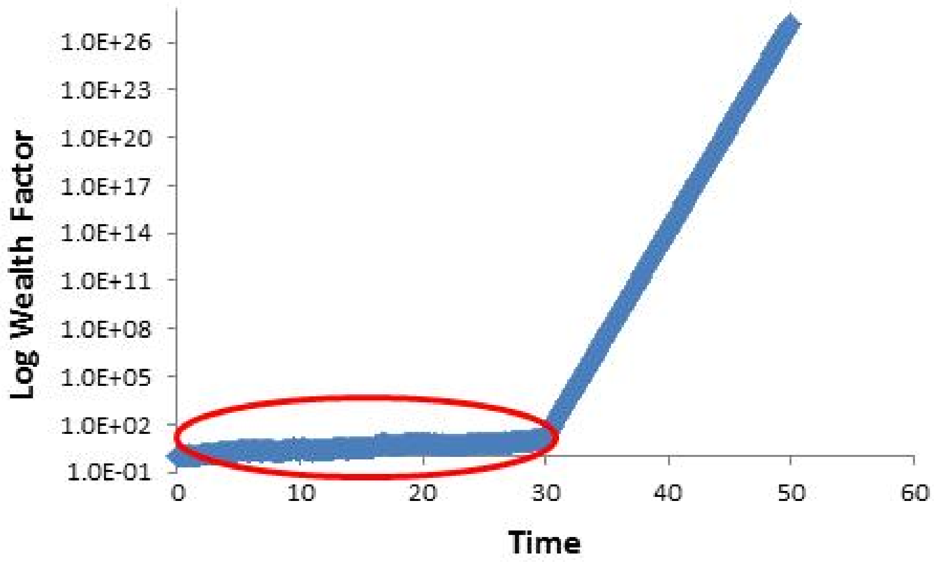
Parallel model build outcome

- Simultaneously, the insurer updated its parallel model in Microsoft Excel
- The parallel model development utilized the assumption change memo provided by the experience studies group
- Reconciliation between models aided in identifying the coding mistake

Extreme value testing
Terminal claim calculation

- The account value of a variable annuity is projected for 30 years under a stochastic scenario
- The projection is extended for an additional 20 years using the final monthly return from the stochastic scenario (e.g., 25% monthly return)
- The extended projection causes an overflow error due to the large account value growth





Extreme value testing
GLWB dynamic lapse calculation

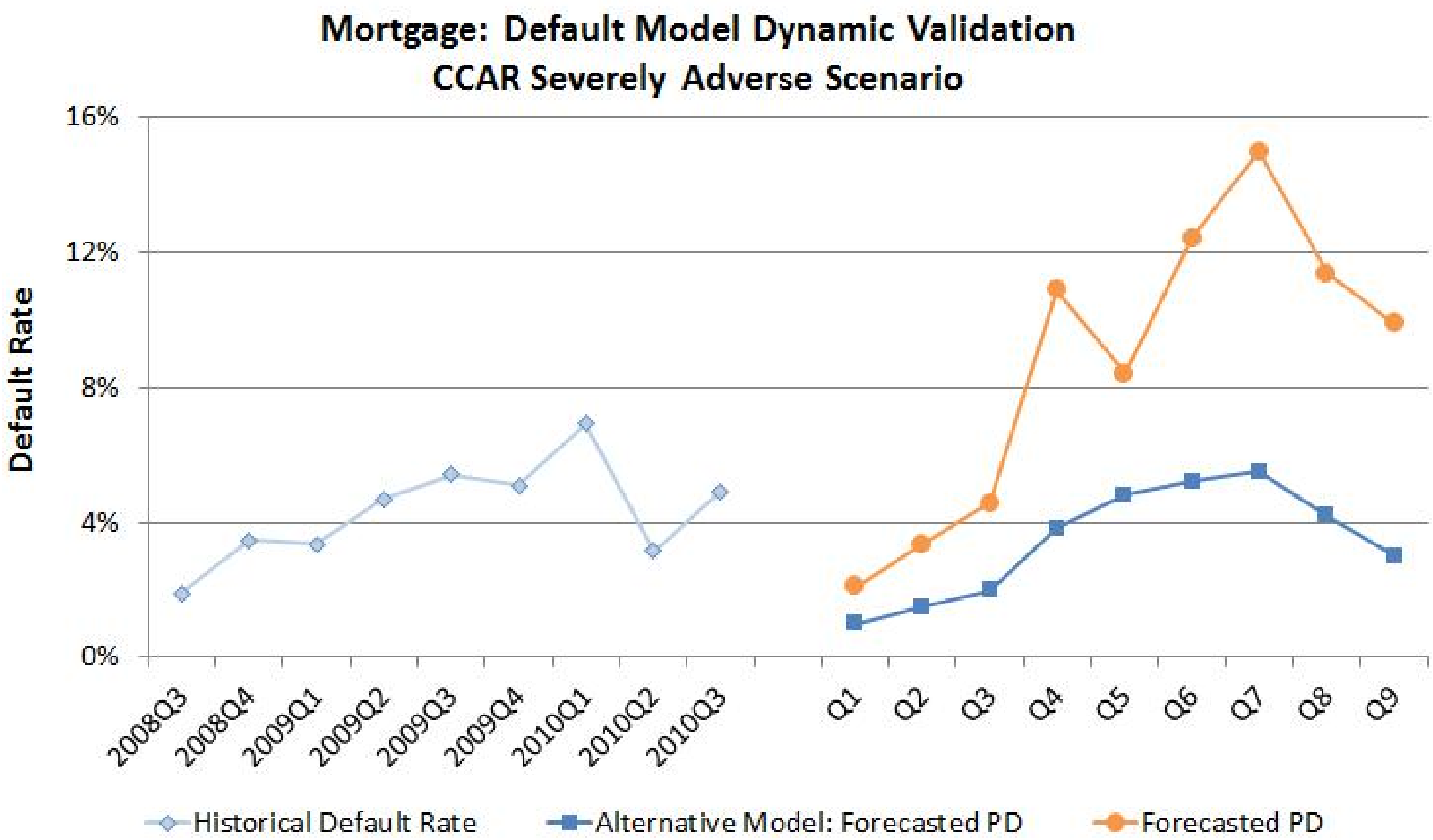
- The dynamic lapse function for a variable annuity with a GLWB rider is modeled with the form below:

$$\frac{1}{1+\exp[-(B0+B1 * X)]}$$ where,

X = Income available under the GLWB rider / alternative income available upon surrender

- After a contract holder elects lifetime withdrawals, as the account value depletes, the variable "X" will grow; if the account value gets sufficiently close to 0 then "X" may become too large for the coded precision and a overflow error will occur

Alternative "challenger" model
CCAR: mortgage probability of default



Regression testing / attribution analysis / sensitivity testing

Regression testing

- Model validation practice of testing new model version against previous version to ensure unintended outcomes were not introduced from code changes
- First level comparison of model cells provides high level regression test
- Second level comparison should include a robust test bed to capture all model point permutations

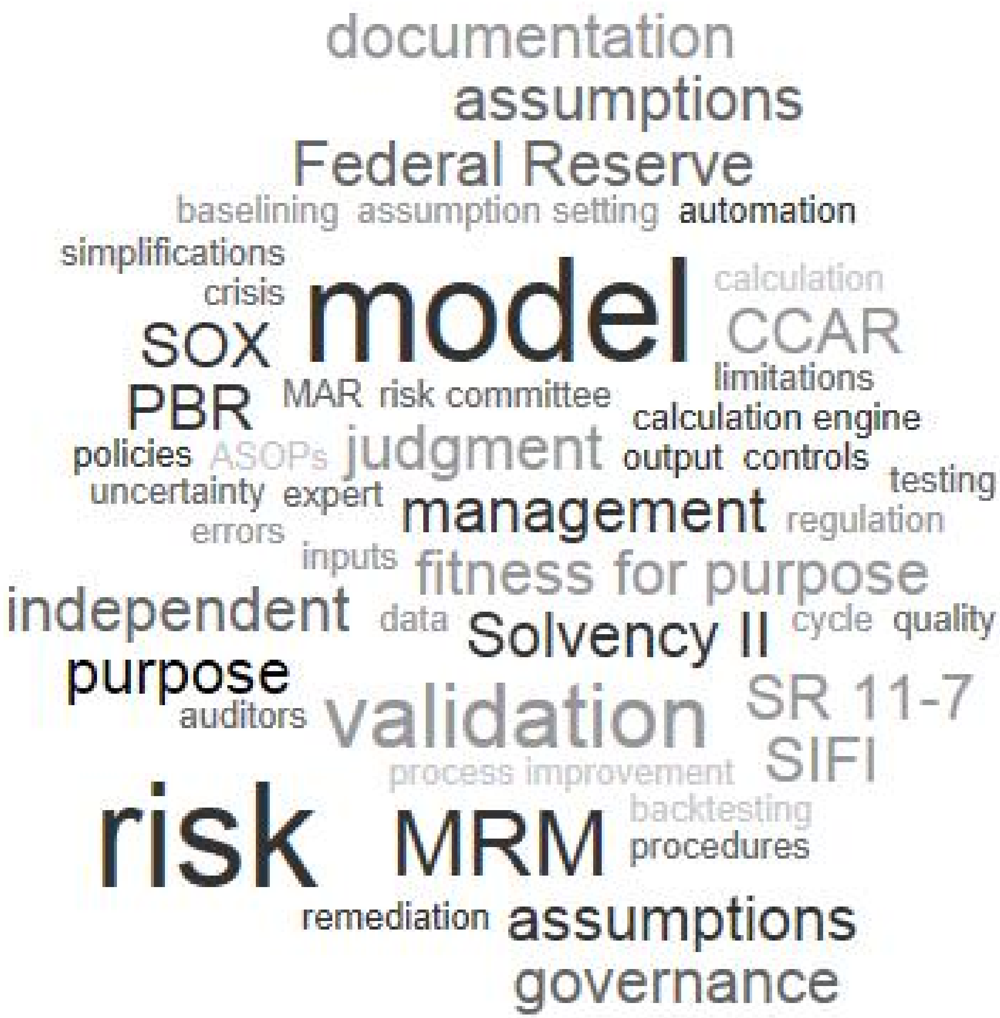
Attribution analysis

- Attribute changes between models (e.g., version updates), or between model runs (e.g., valuation dates)
- Generally, complex models have multiple components to attribute; analysis should be able to quantify impact of individual components and interaction of components

Sensitivity testing

- Evaluation of the sensitivity of model results to changes in the model inputs (e.g., assumptions, parameters, data)
- May be used as a benchmark for attribution analysis

Conclusion



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Federal Reserve
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assumption setting
automation
simplifications
crisis
model
calculation
SOX
CCAR
PBR
MAR
risk committee
limitations
calculation engine
policies
ASOPs
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controls
testing
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expert
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data
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