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Multi-Period Credit Risk Analysis: A Macro-Scenario Approach

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Multi-Period Credit Risk Analysis

A Macro-Scenario Approach

- **The problem we are solving**

Overcome the challenge of analyzing credit risk dynamically (multi-period) and integrate stress testing (credit risk, PPNR, provisions, mark-to-market) into a unified management framework.

- **Motivation**

Federal Reserve Bank of New York - Staff Report No. 696 – Nov 2014
Supervisory Stress Tests by Beverly Hirtle & Andreas Lehnert.

"The Basel Market Risk Amendment – finalized in 1995 – contained a provision encouraging the use of stress tests to augment the Value at Risk (VaR) measures of computing risk-weighted assets, the denominators in various measures of risk-based capital. VaR models consider the probability distribution of the value of a portfolio of assets. In principle VaR models can be thought of as the result of thousands of individual scenarios, weighted by their probability. In practice however the distributions are not tied to real-world variables other than the observed empirical distributions of the values of various assets."

Multi-Period Credit Risk Analysis

A Macro-Scenario Approach (cont.)

Why is this relevant?

(i) embed stress testing process into the banks' credit management practices (forecasting, provisioning, profitability, risk-based pricing, risk concentration, capital adequacy), (ii) dynamic risk and profitability assessment, (iii) optimal capital management, (iv) risk appetite.

Specifics of what we do

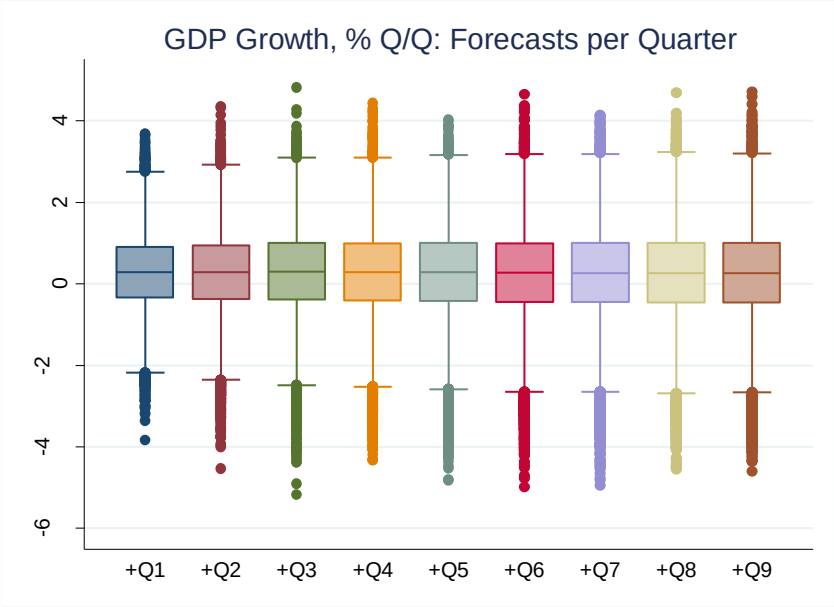
Compute analytical solutions to multi-period credit risk management.

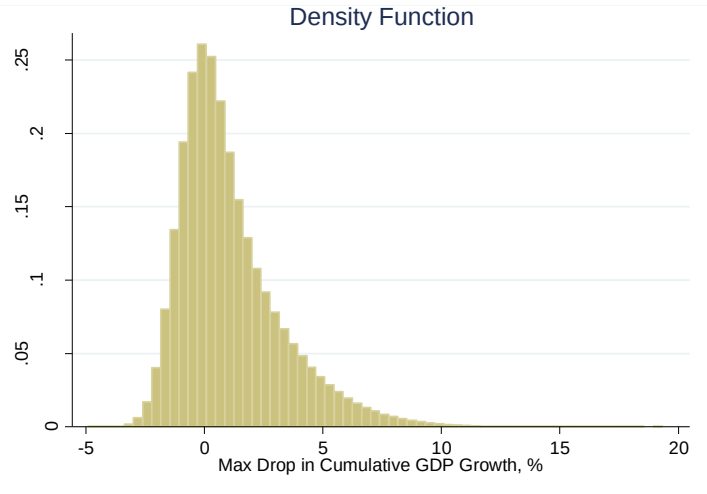
(1) Dynamic simulations of macro scenarios and probabilities for each path.
(2) Multi-period risk parameter simulations (leveraging stress testing models) for conditional credit and mark-to-market parameter realizations.
(3) Analytical calculation of (intra-period and cumulative) expected and unexpected losses, and the corresponding asset contributions.
(4) Scenario-specific analysis: embedding ST into the framework.
(5) Further applications: risk-based pricing, concentration and tail-risk analysis, analytical reverse stress testing, dynamic optimization, integrated mark-to-market and default risk assessment, enhanced Monte Carlo methods.

1

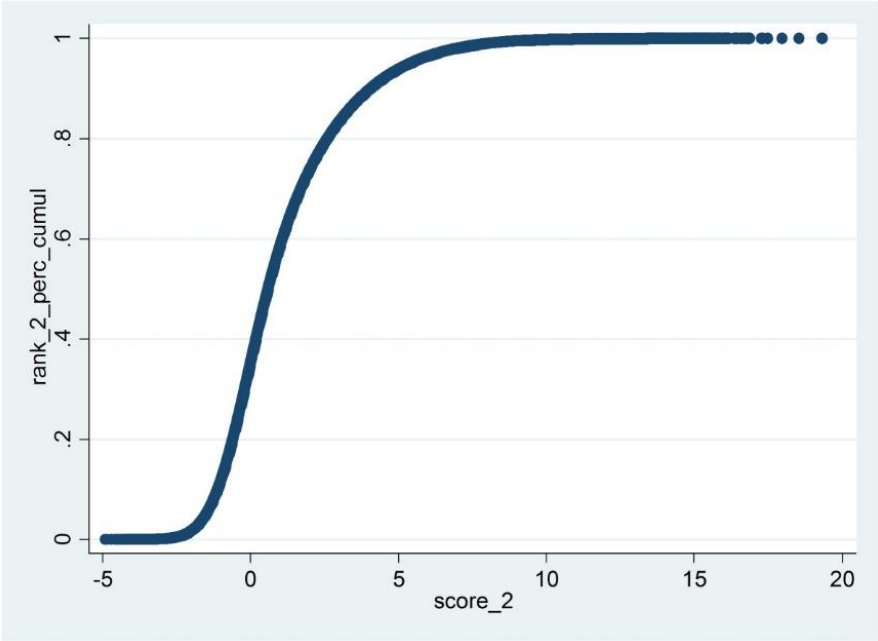
Dynamic Simulations of Macro Scenarios and Probabilities for Each Path

Forward-Looking Scenario Generation & Severity Ranking



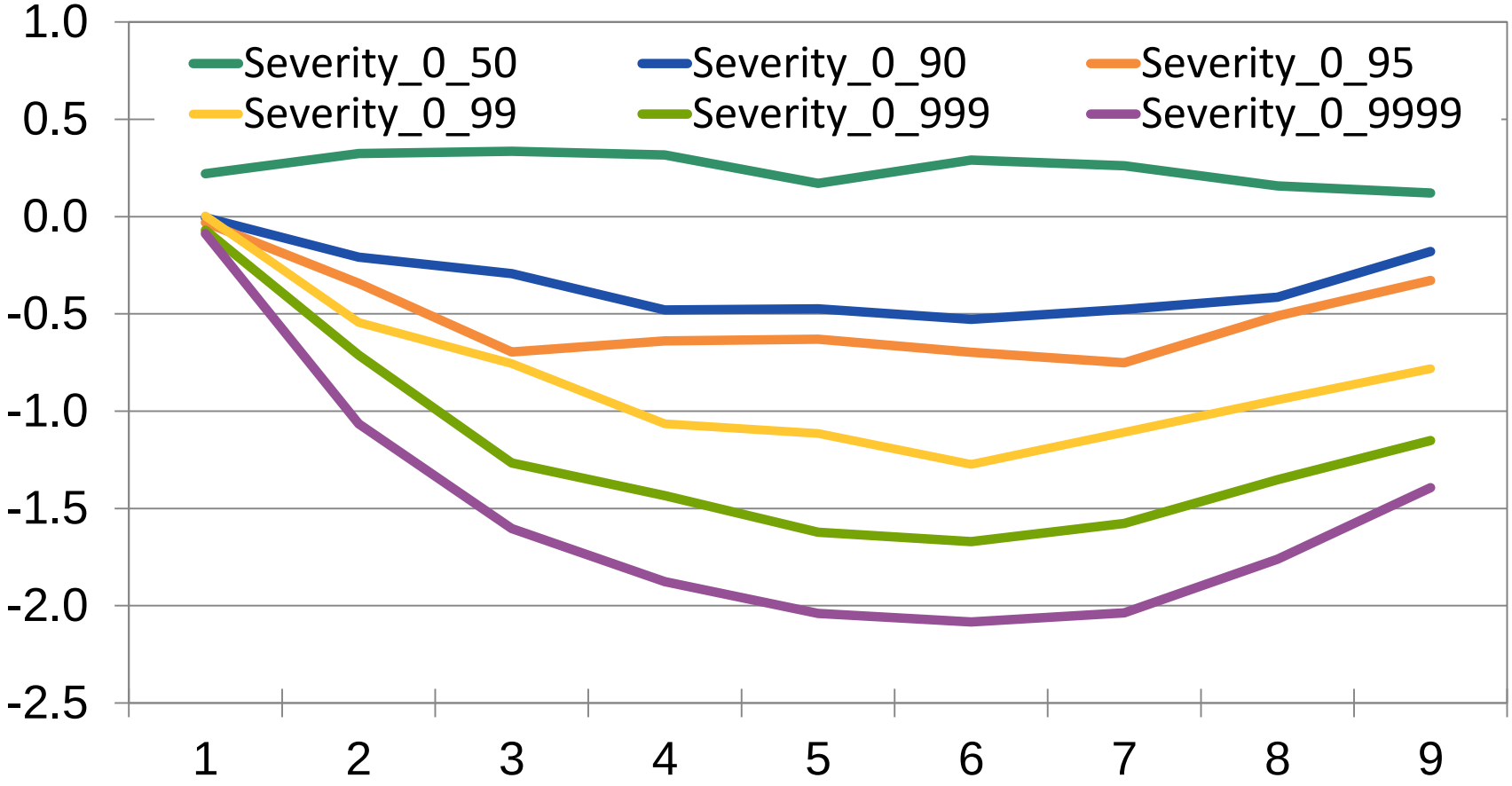


Example of a Marginal Loading into Overall Scenario Rank-Ordering Algorithm



Severity of Alternative Macroeconomic Scenarios

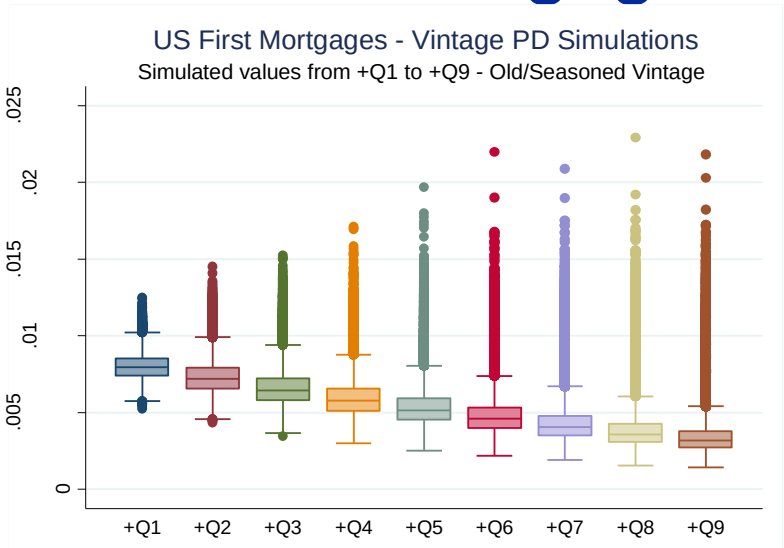
GDP growth, q/q % -- alternative severity points

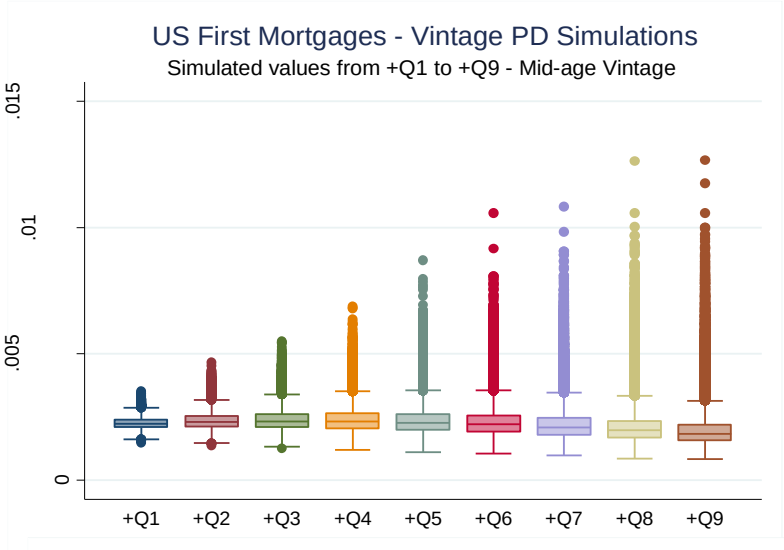


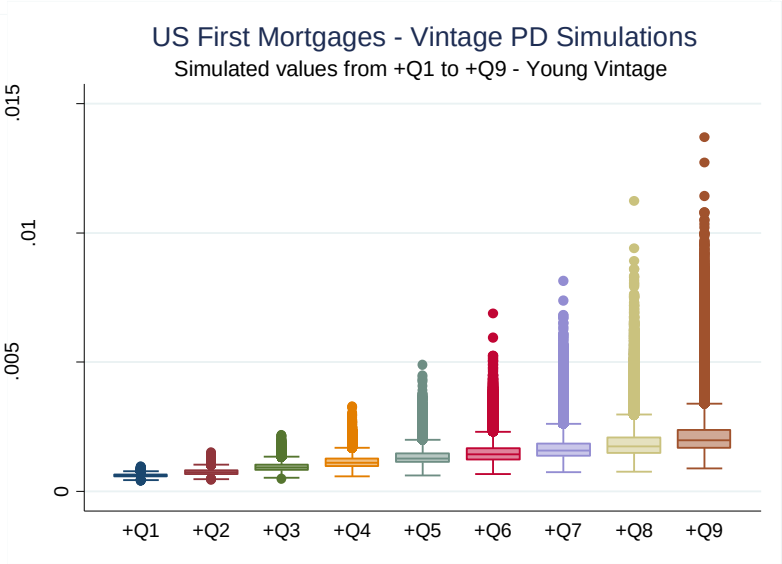
2

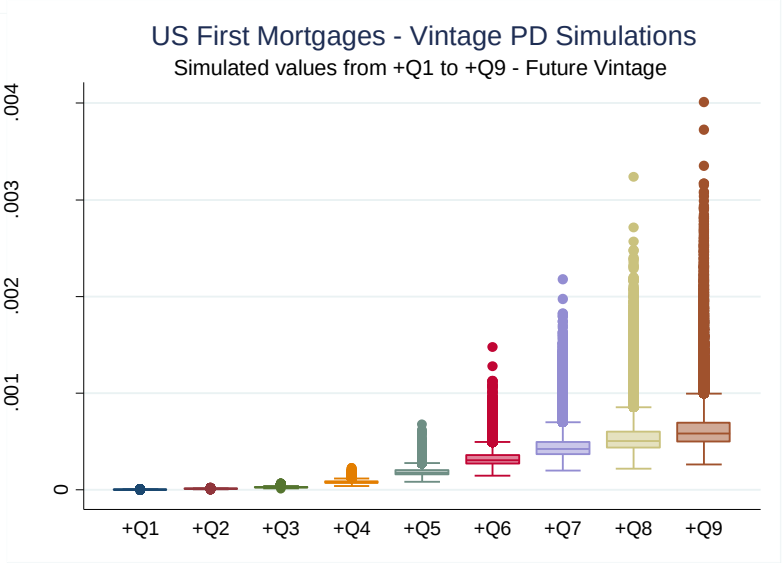
Dynamic Simulations of Credit Risk Parameters (Retail Credit As Leading Example)

U.S. First Mortgage Portfolio – Quarterly Vintages

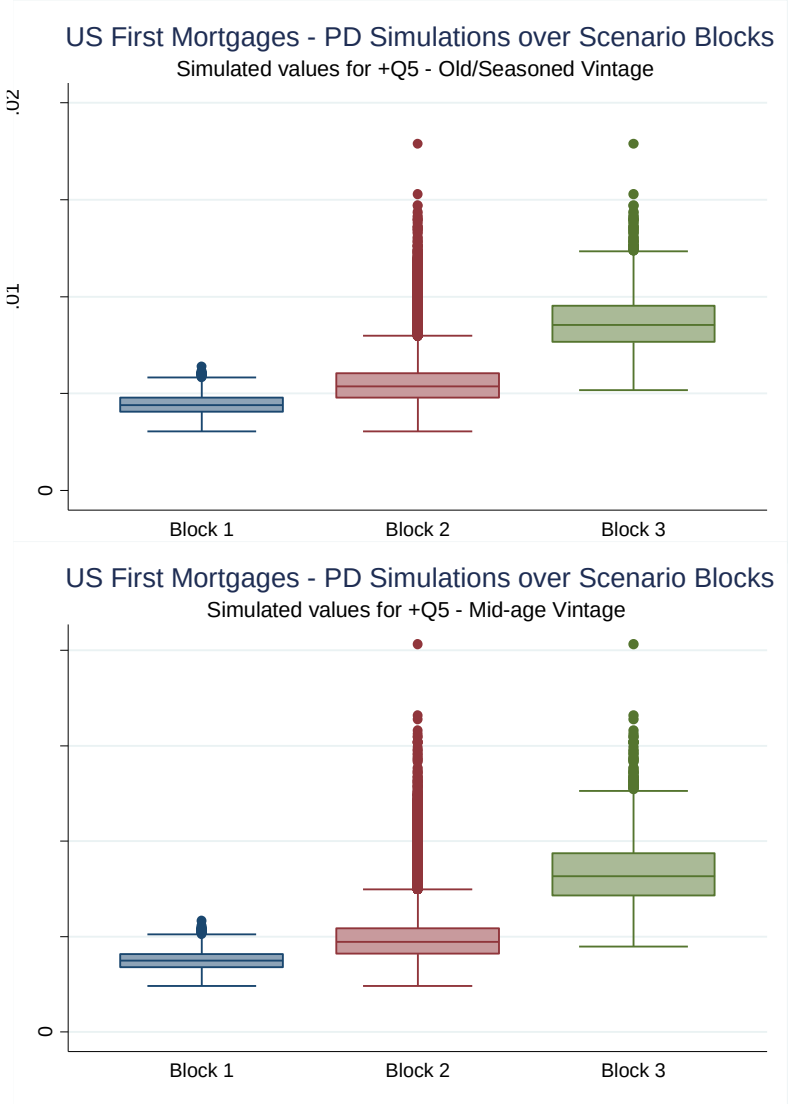


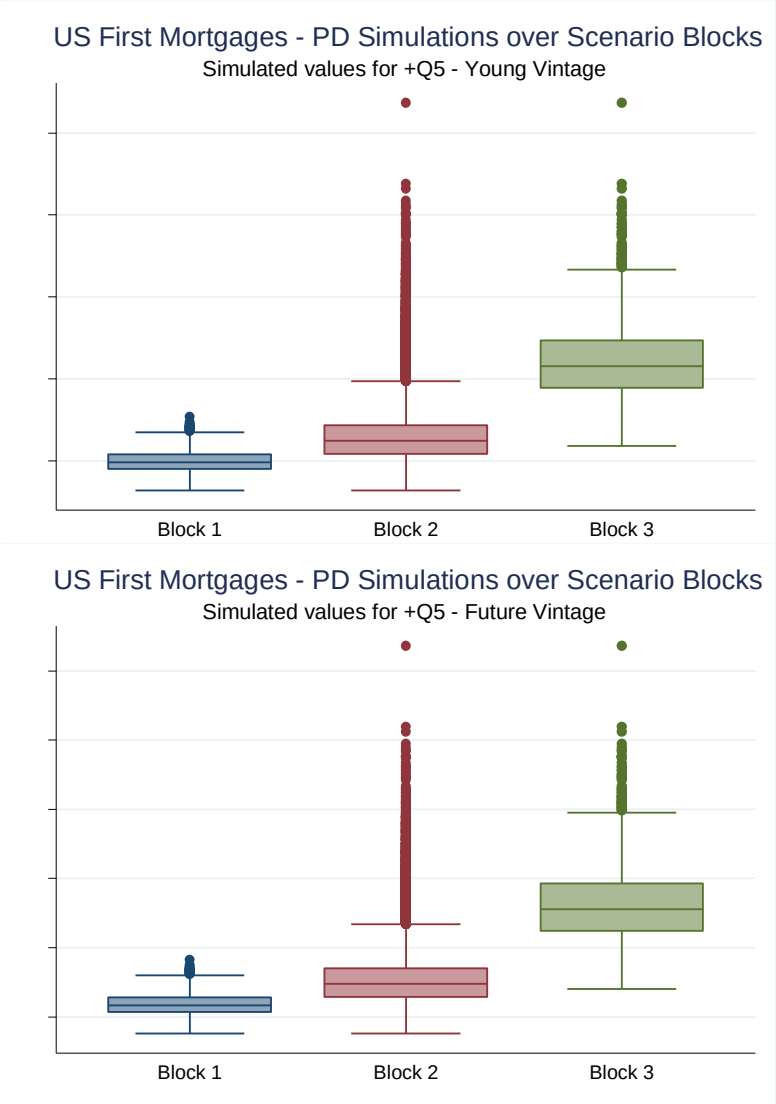






U.S. First Mortgage Portfolio – Quarterly Vintages (cont.)





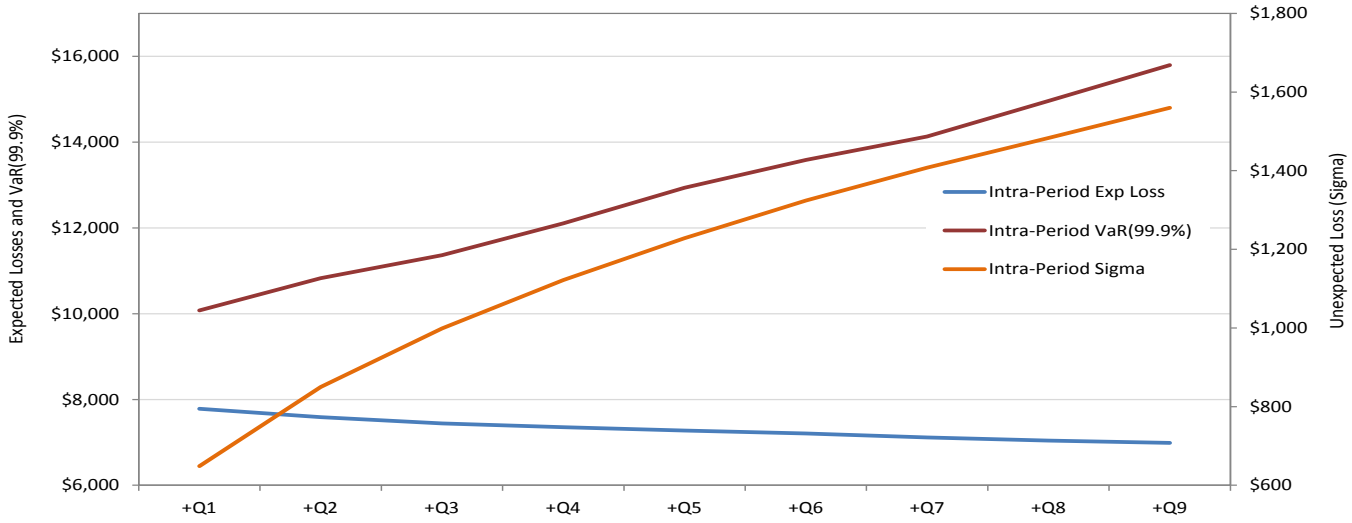
3

Analytical Calculation of (Intra-period and Cumulative) Expected and Unexpected Losses, Asset Contributions.

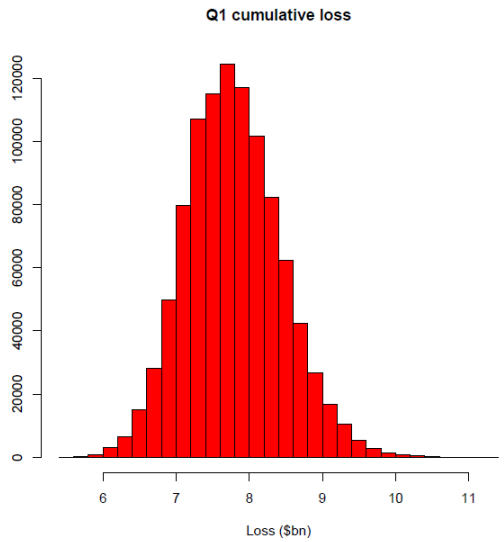
U.S. First Mortgage Portfolio – Loss Metrics

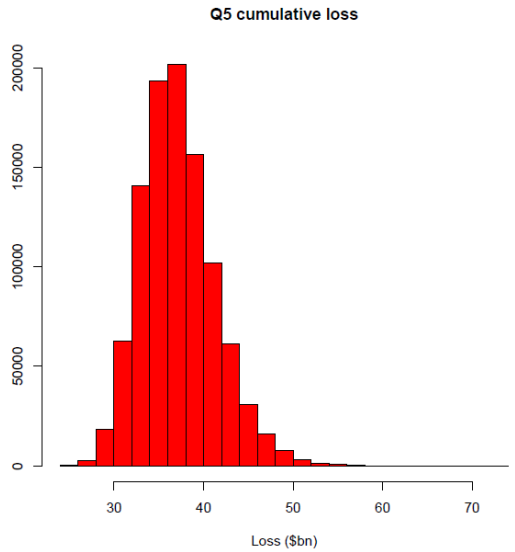
	Intra-Period Exp Loss	Intra-Period Sigma	Intra-Period VaR(99.9%)	Cumulative Exp Loss	Cumulative Sigma	Cumulative VaR(99.9%)
+Q1	$ 7,784.9558	$ 648.5309	$ 10,078.3132	$ 7,784.9558	$ 648.5309	$ 10,078.3132
+Q2	$ 7,587.3311	$ 850.0719	$ 10,828.4443	$ 15,372.2869	$ 1,364.6327	$ 20,248.9755
+Q3	$ 7,442.0702	$ 999.0752	$ 11,365.3219	$ 22,814.3572	$ 2,193.1532	$ 30,983.0449
+Q4	$ 7,354.4725	$ 1,121.8841	$ 12,104.1981	$ 30,168.8297	$ 3,118.9971	$ 42,307.3145
+Q5	$ 7,274.9933	$ 1,228.1673	$ 12,933.1039	$ 37,443.8230	$ 4,124.4656	$ 54,375.8396
+Q6	$ 7,206.7848	$ 1,323.8555	$ 13,583.7713	$ 44,650.6077	$ 5,207.1490	$ 66,748.3775
+Q7	$ 7,113.0817	$ 1,407.5700	$ 14,128.6149	$ 51,763.6895	$ 6,352.9917	$ 79,727.7836
+Q8	$ 7,041.5606	$ 1,483.2394	$ 14,961.4969	$ 58,805.2500	$ 7,553.4249	$ 93,484.9177
+Q9	$ 6,989.0686	$ 1,559.7431	$ 15,795.7796	$ 65,794.3186	$ 8,805.0694	$ 107,915.7781

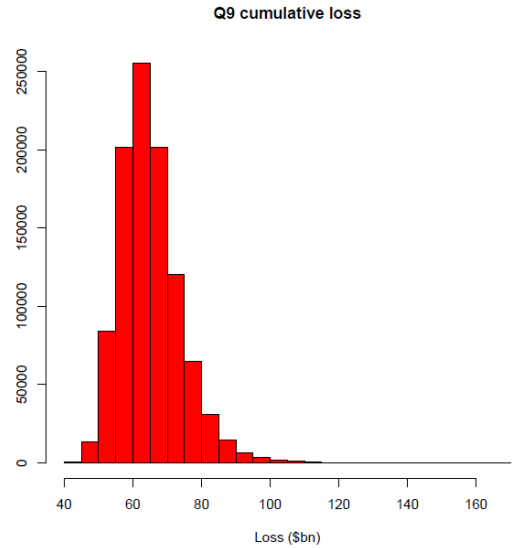
Intra-Period Expected Losses, σ and VaR(99.9%) (Millions of USD)

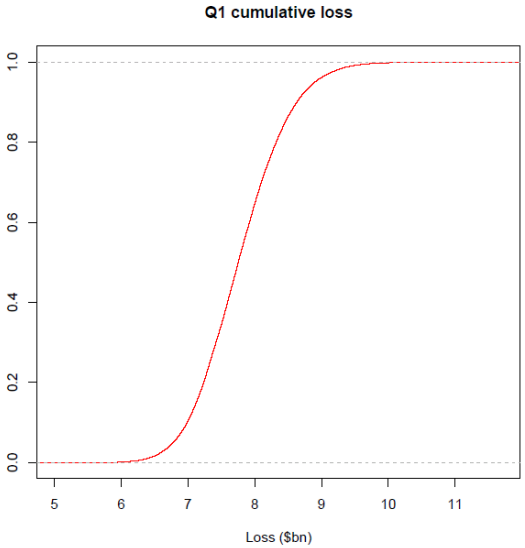


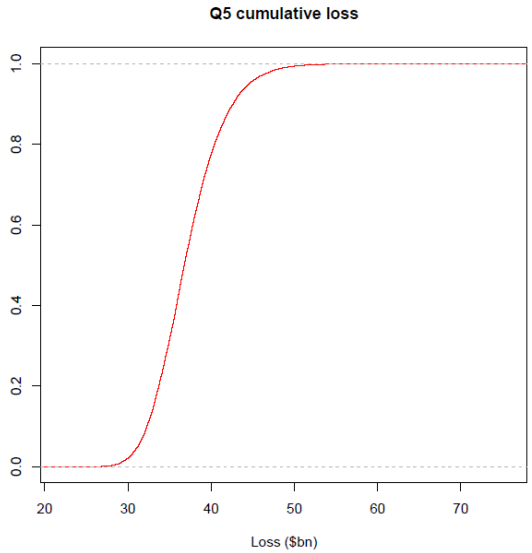
U.S. First Mortgage Portfolio – Loss Metrics (cont.)

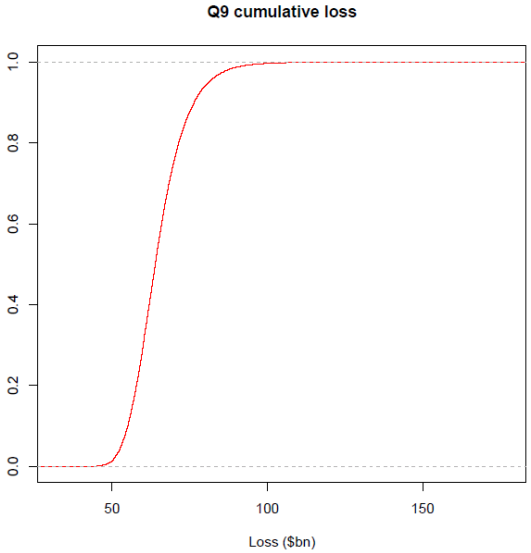




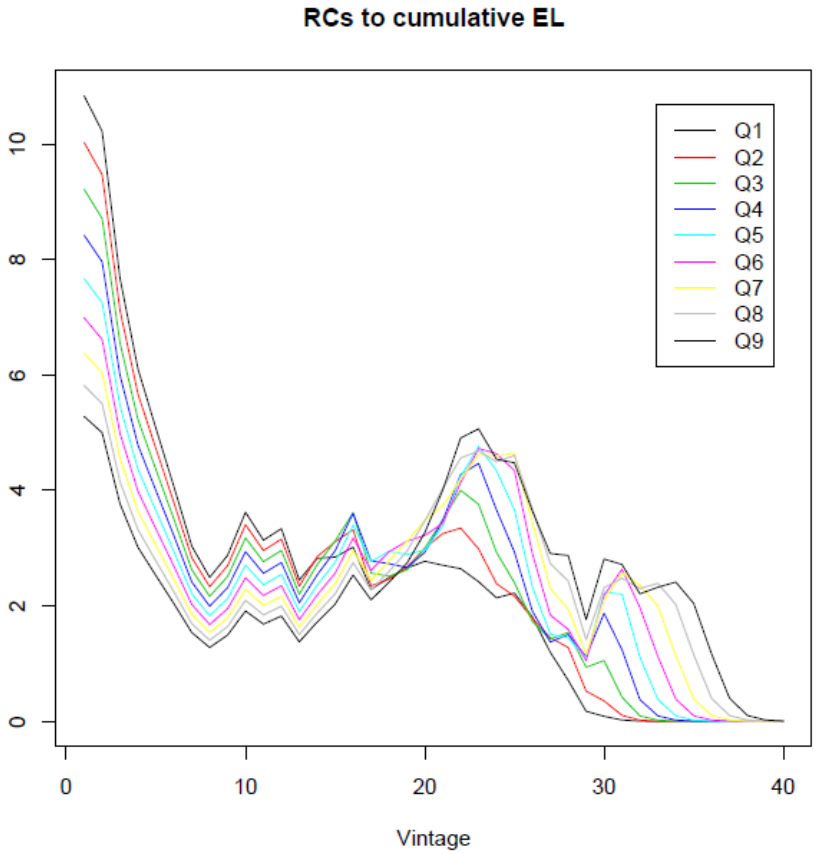


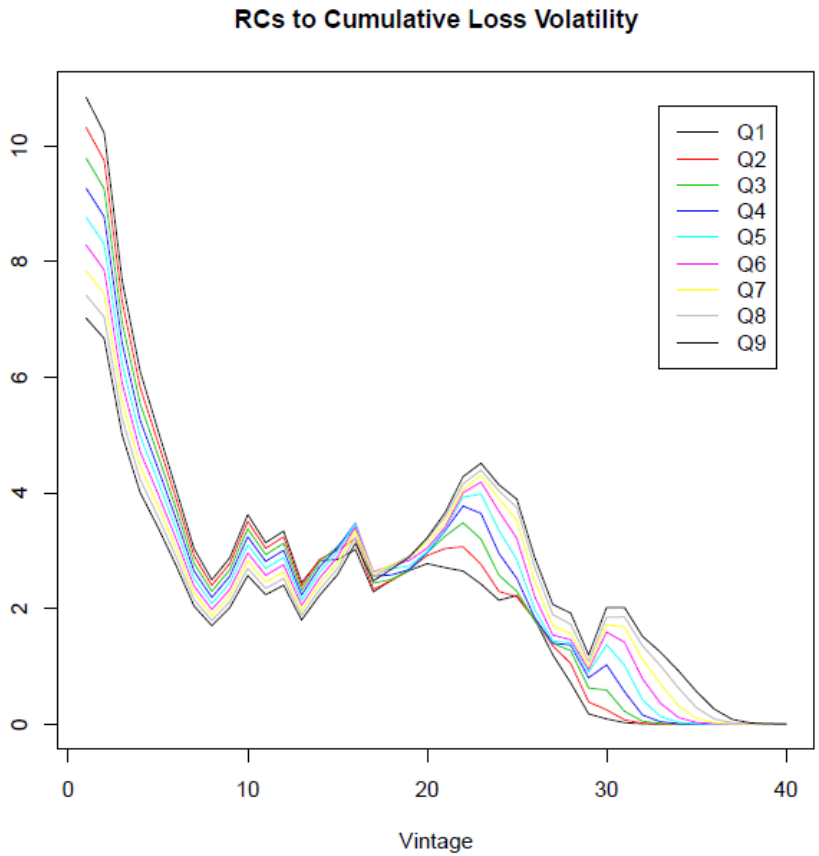




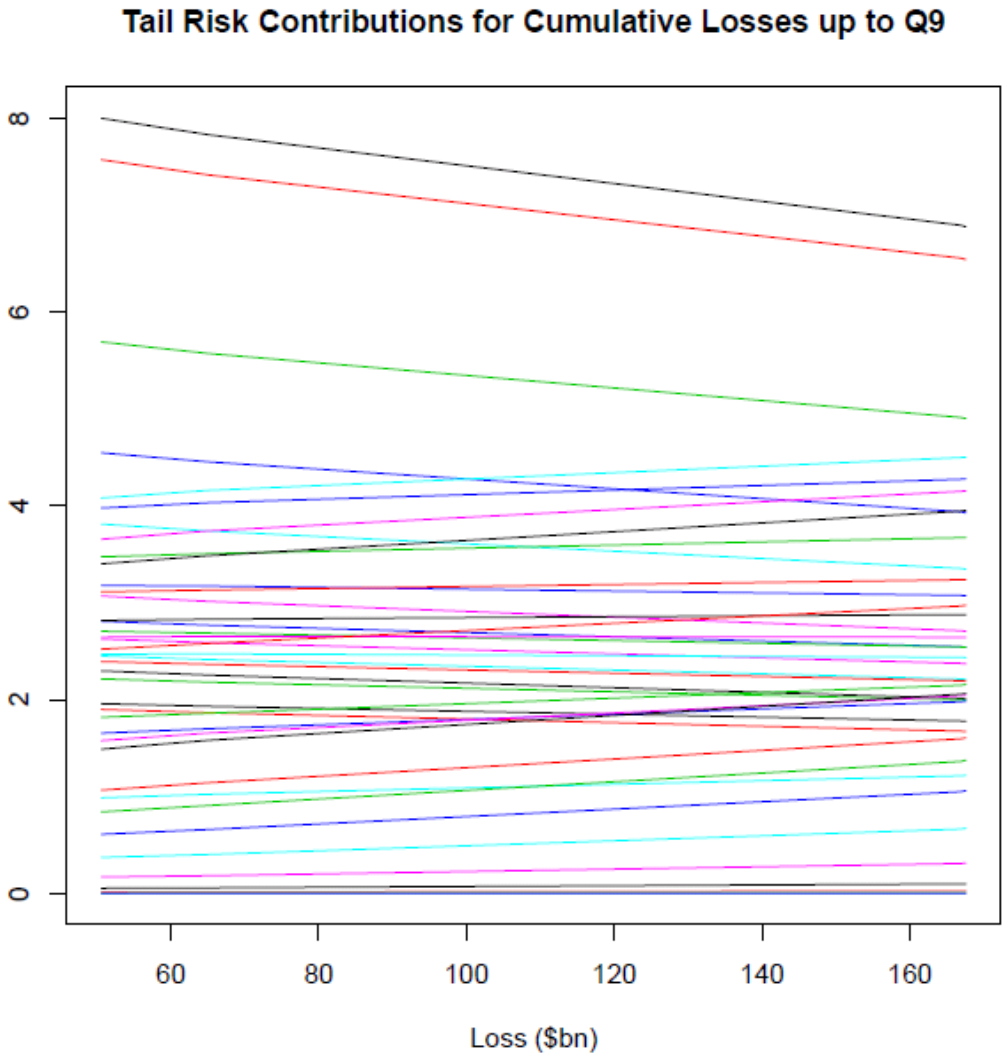


U.S. First Mortgage Portfolio – Loss Metrics (cont.)





U.S. First Mortgages – Tail-Risk Contributions



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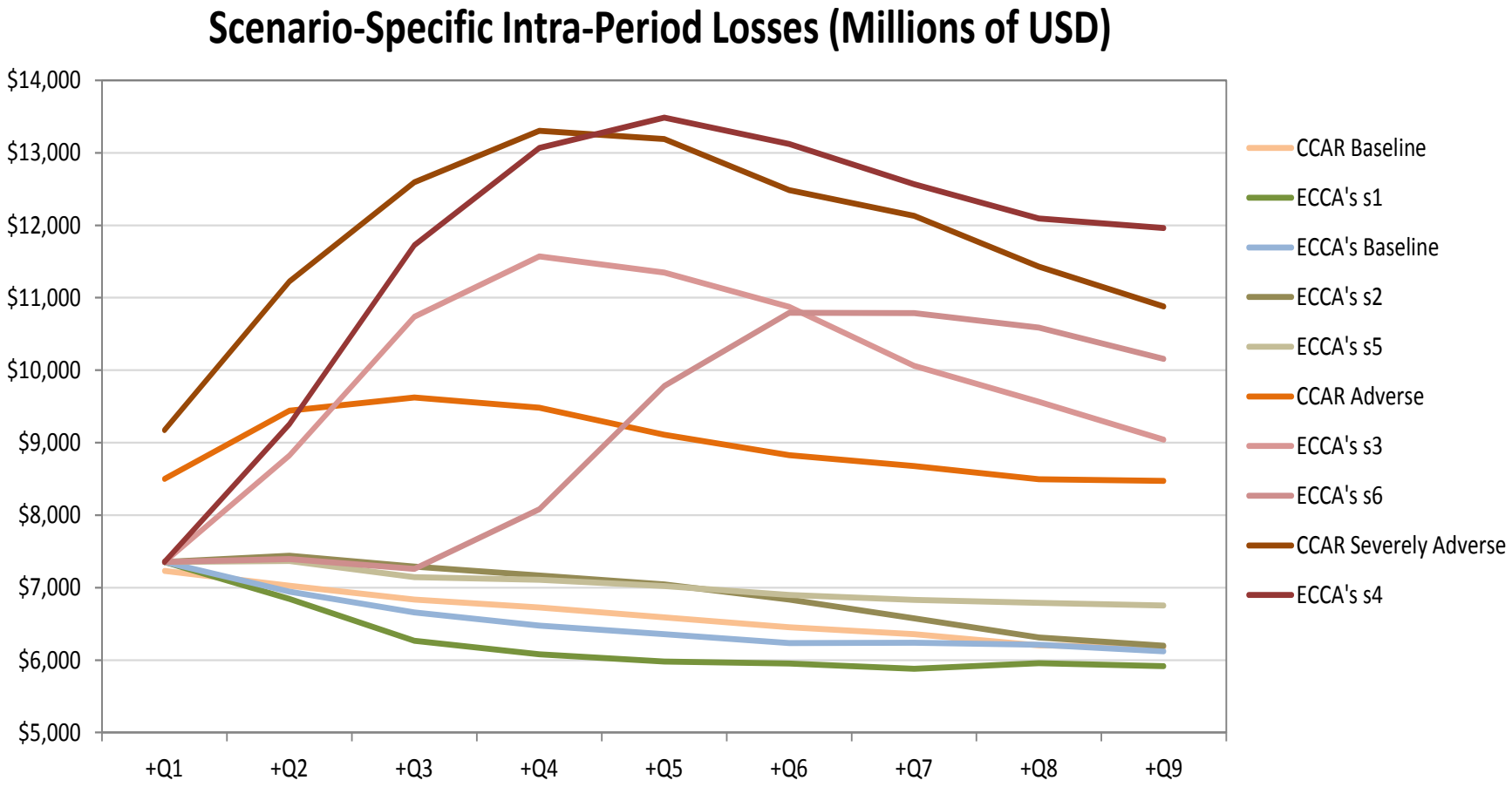
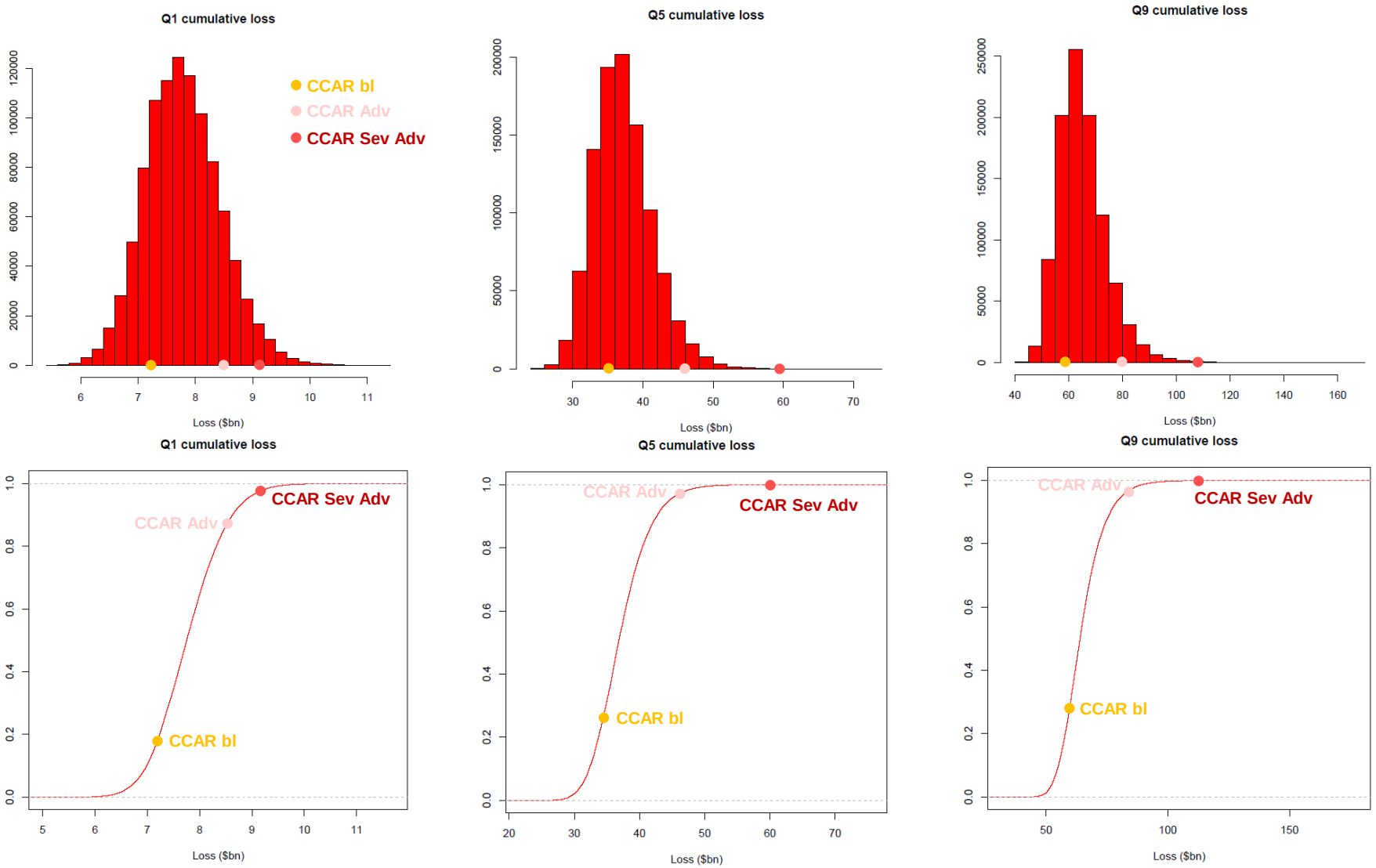
Scenario-Specific Analysis: Embedding ST Into Dynamic Portfolio Analysis

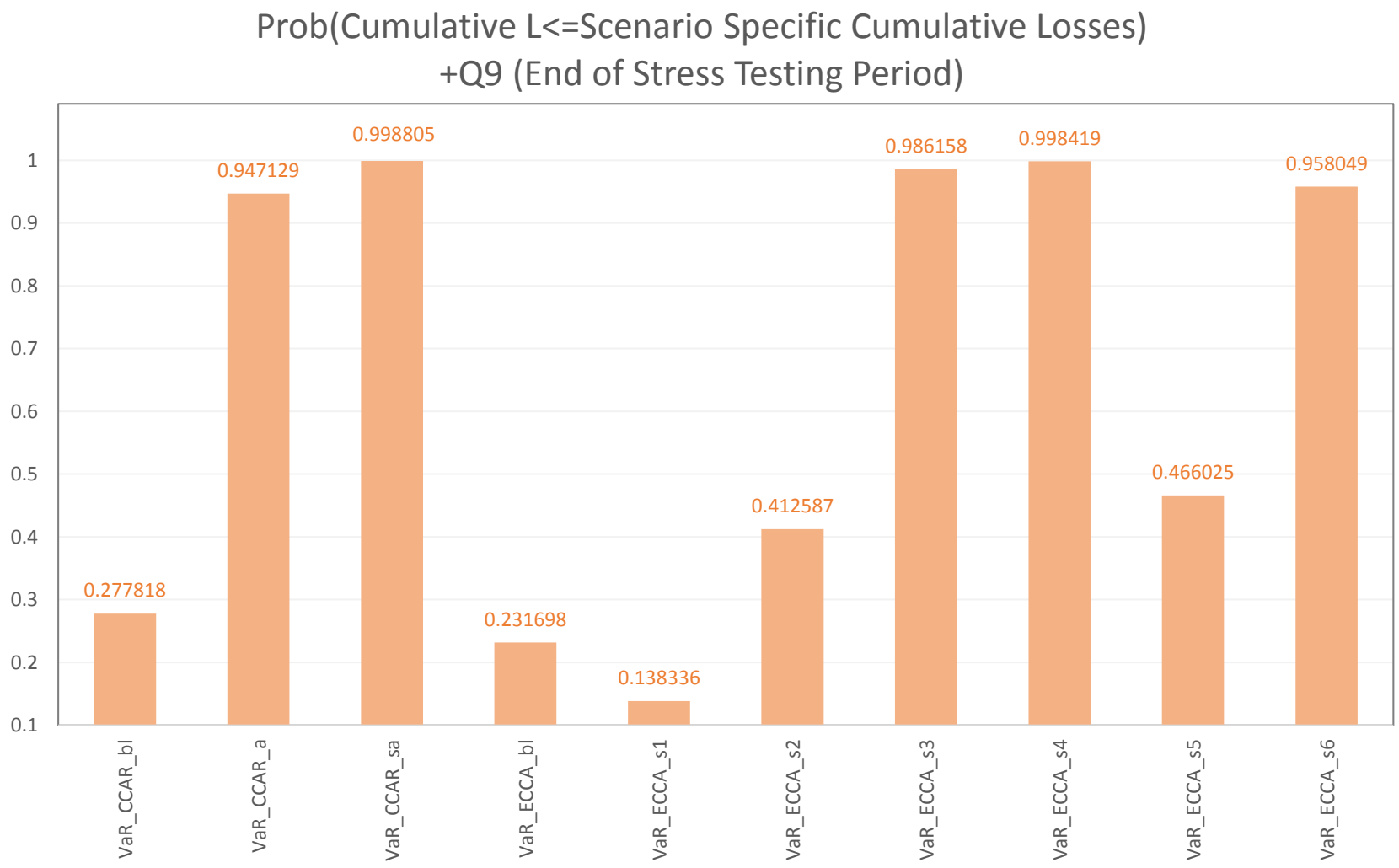
U.S. First Mortgages – Intra-Period Scenario Losses



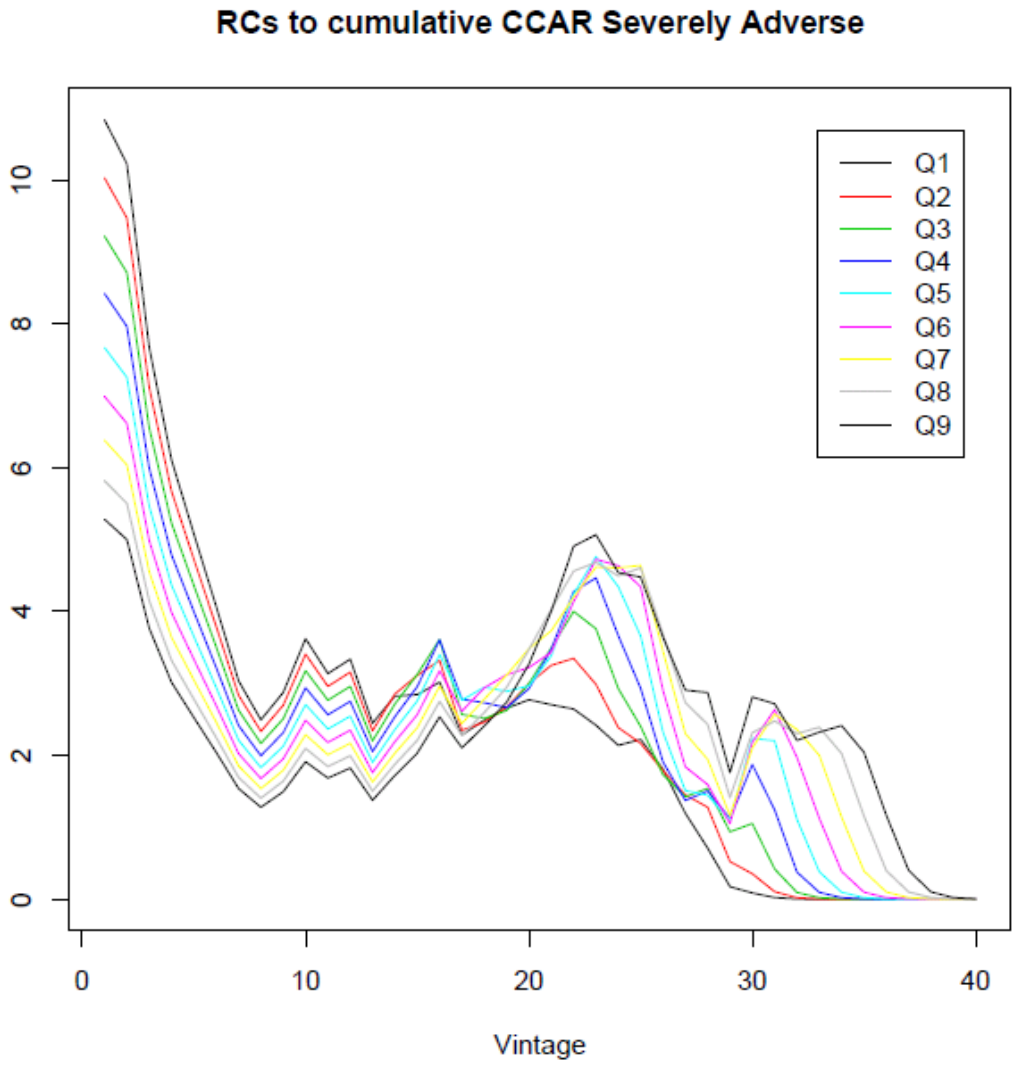
U.S. First Mortgages – Cumulative Scenario



U.S. First Mortgages – Cumulative Scenario Losses (cont.)



U.S. First Mortgages – Cumulative Scenario Losses (cont.)



5

Practical Applications: RAROC, Optimization, Optimal Importance Sampling, and Reverse Stress Testing

Risk Adjusted Pricing (RAROC)

Analytical calculation of the portfolio volatility up to the new deal's maturity allows us to instantaneously price.

The Sharpe ratio of the new portfolio with the new deal (or deals) should be larger than without:

$$\frac{\mu^* - r}{\sigma(L^*)} > \frac{\mu - r}{\sigma(L)} \quad \Rightarrow \quad \text{BUY}$$

Portfolio Optimisation

What is the portfolio composition n_i that minimises the portfolio loss volatility given a level of expected loss (and hence return) $EL = L$?

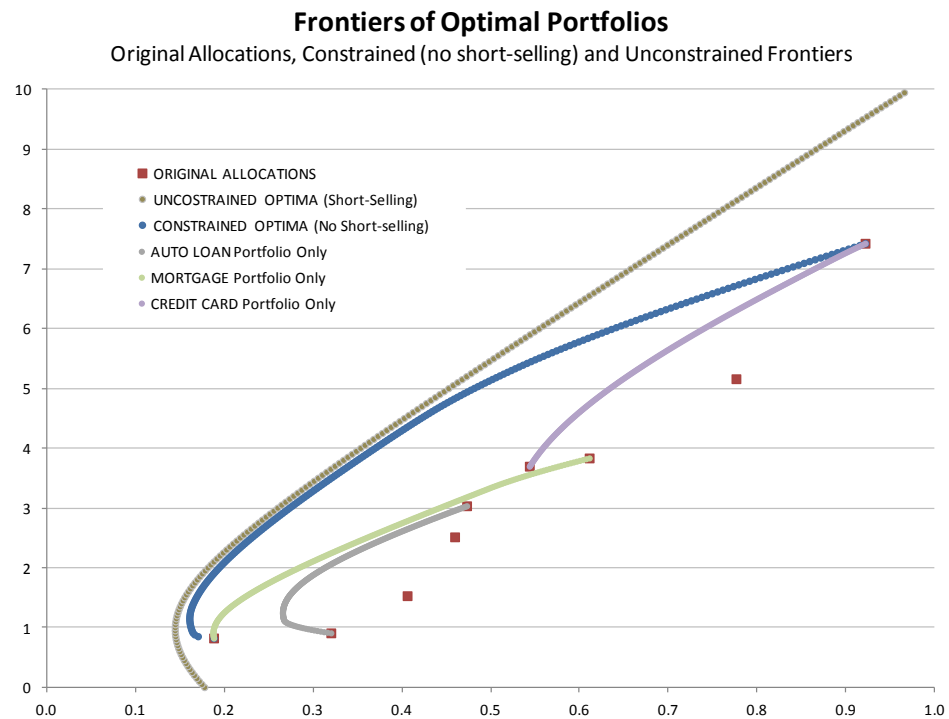
Using the Lagrange multipliers:

$$\Lambda(n_i, \lambda) = \sigma(L;\ n_i) + \lambda(EL(n_i) - L)$$

Thus:

$$n_i C_i + \lambda EL_i^* = 0$$

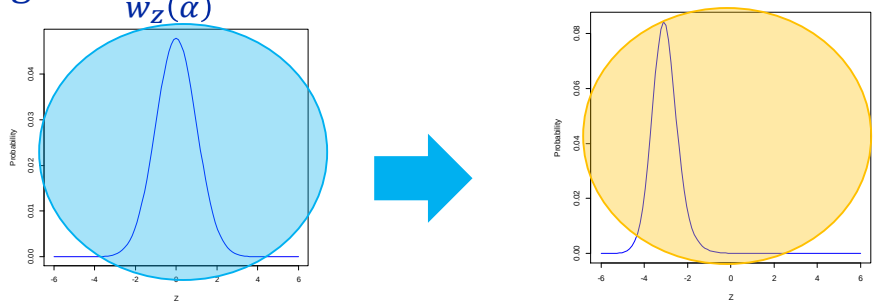
$$\sum_{i=1}^{N} n_i EL_i^* - L = 0$$

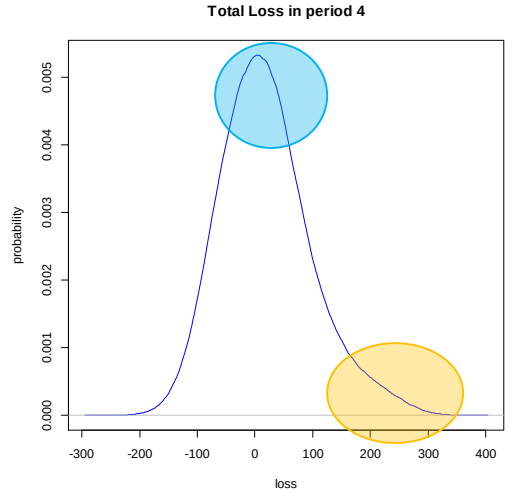


- Extend the current framework to study DYNAMIC OPTIMISATION (infinite horizon) ***Recursive Dynamic Programming*** (Bellman Equations) and the study of the optimal solutions to the underlying stochastic difference equations

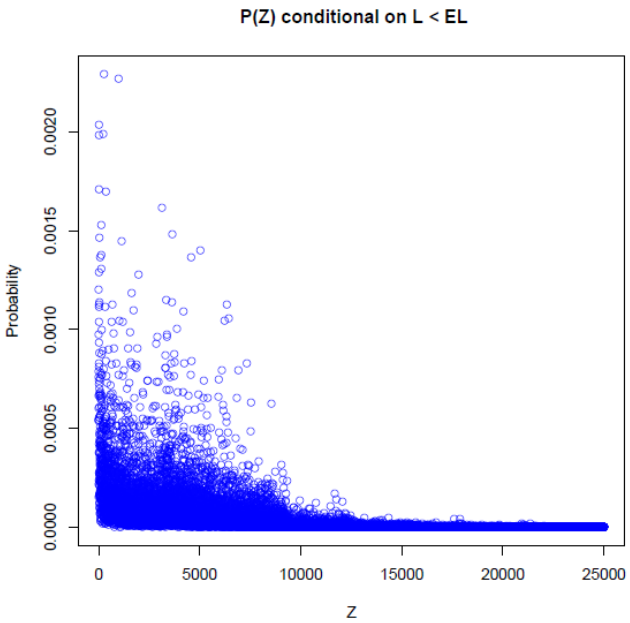
Optimal Importance Sampling

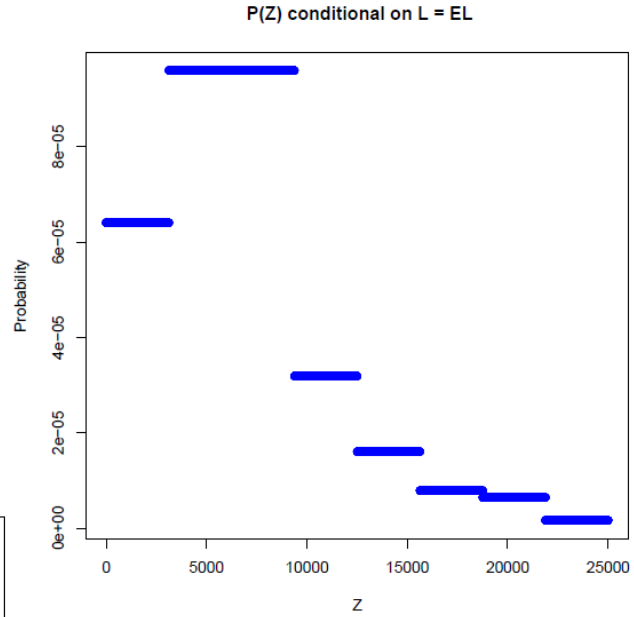
Instead of drawing random numbers with unconditional probability from conditional distribution w_z draw from conditional $w_z(\alpha)$. After the simulation reweigh the loss distribution using $\text{weight} = \frac{w_z}{w_z(\alpha)}$

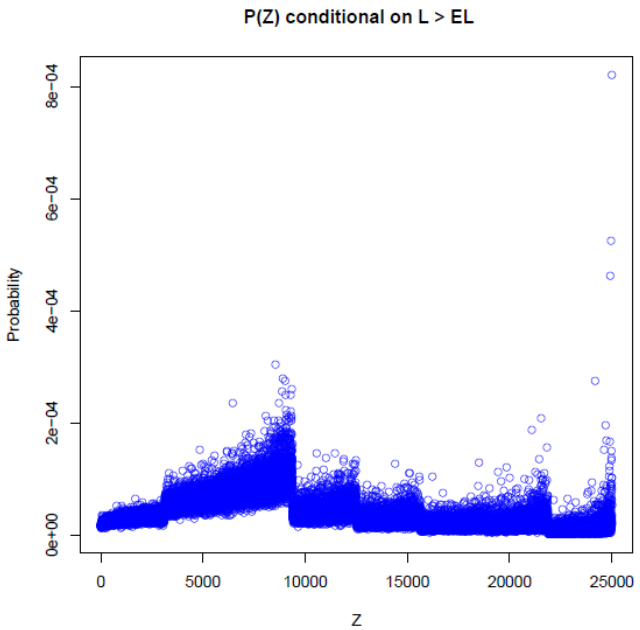




Analytical Reverse Stress Testing





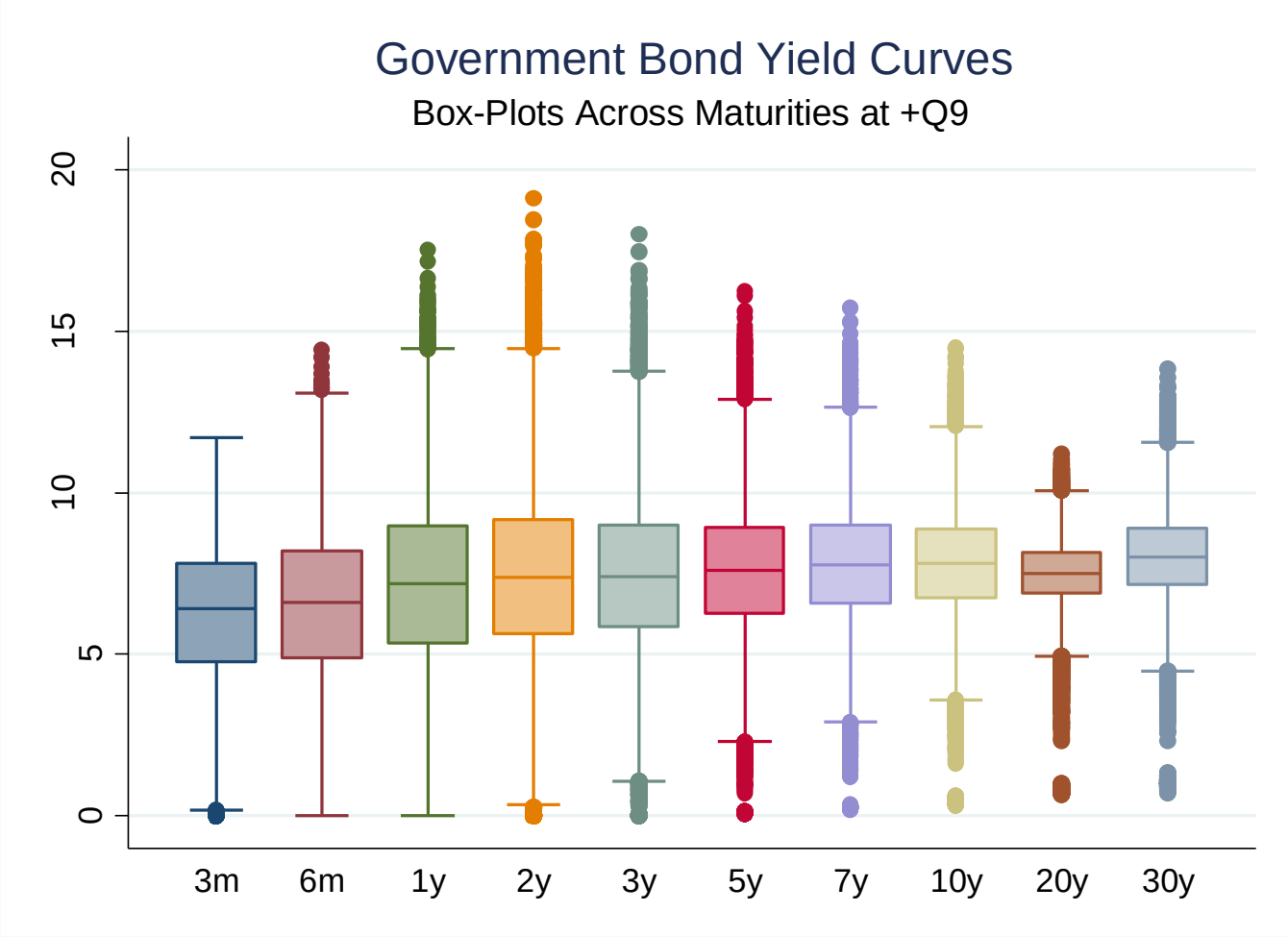


6

Mark-to-Market Risk Examples Interest Rates (Gov Bond Yields) and Corporate Credit Spreads

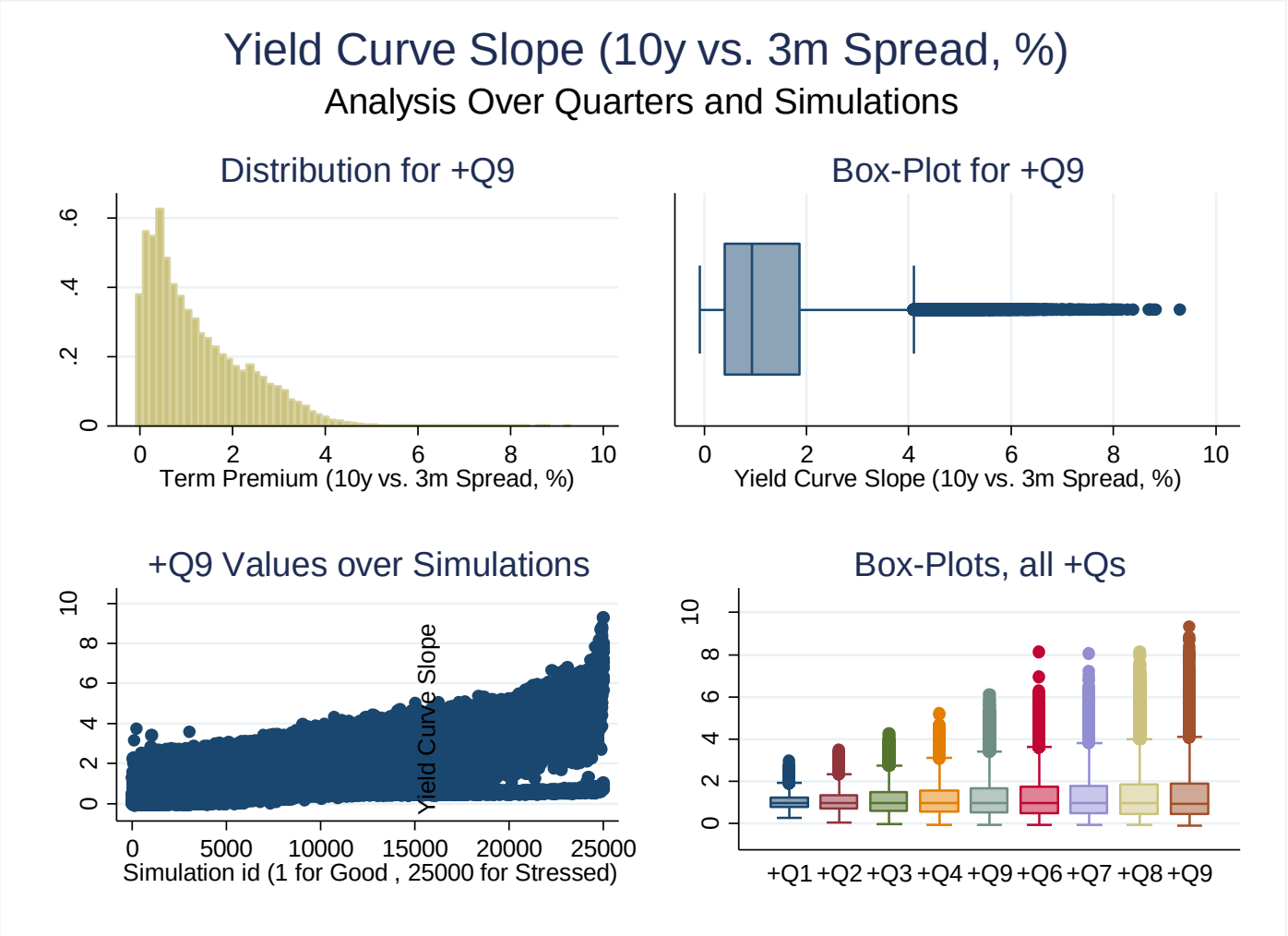
Interest Rate Modeling

Impact on government bond yields



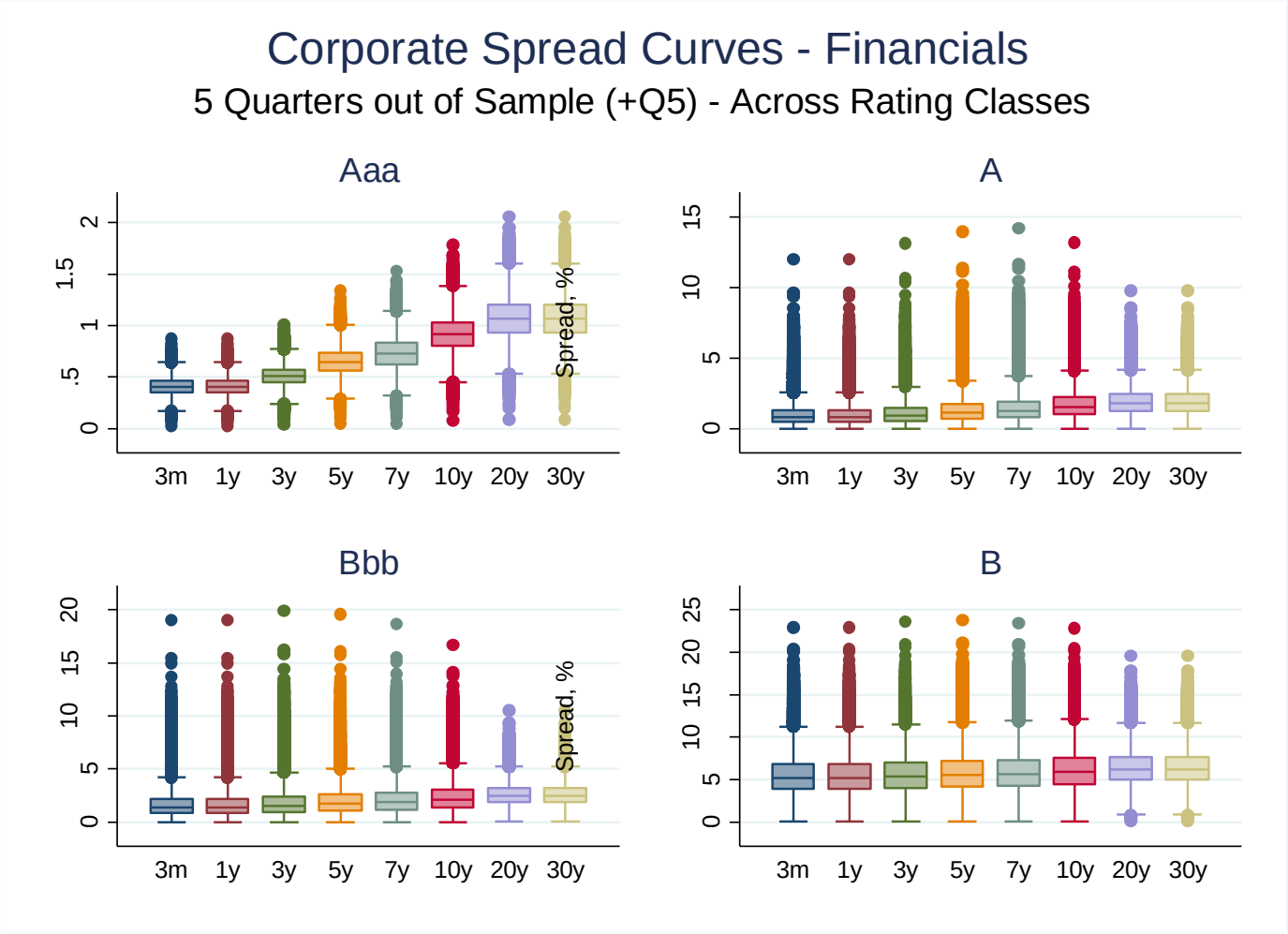
Interest Rate Modeling (cont.)

Impact on government bond yields (cont.)



Credit Spread Modeling

Impact on credit spreads for financials - over maturities and rating classes



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