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Application of Econometric Models in Banking

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Session #4
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Table of Content

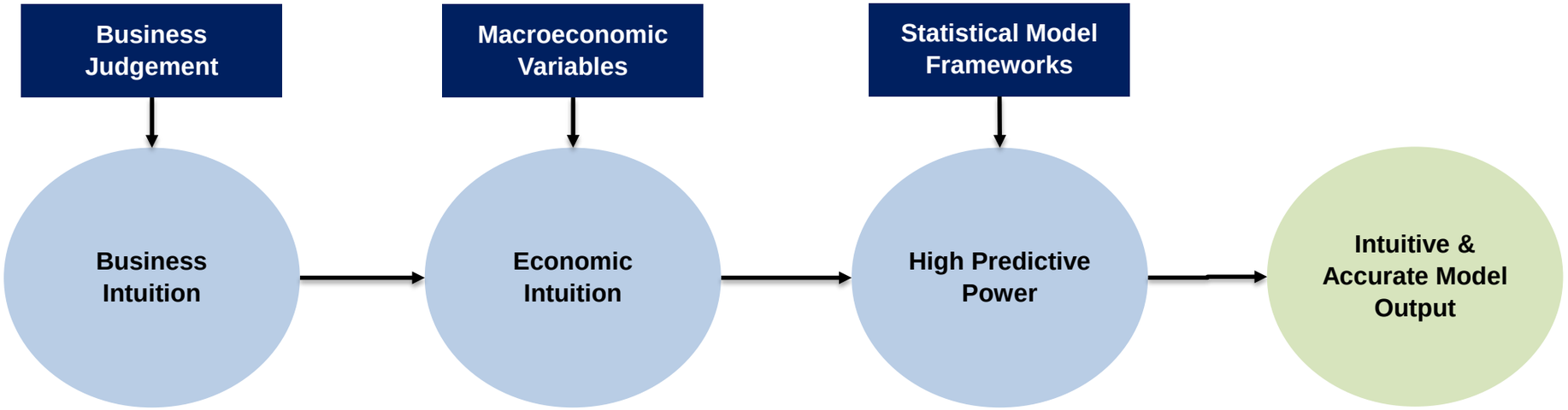
Agenda

Setting the Context

What is Econometrics ?

"*Econometrics uses economic theory, mathematics, and statistical inference to quantify economic phenomena. The objective of econometrics is to convert qualitative relationships into quantitative statements*" – International Monetary Fund (IMF)

What is an Econometric Model ?



An econometric model combines business judgement, economic intuition and robust statistics to generate an intuitive and accurate model output

Setting the Context

Key Drivers behind Increased Usage of Econometric Models

1

New Regulatory Frameworks

- Aftermath of the 2007-08 Crisis Financial Crisis
- Forward-looking regulations such as CCAR & DFAST, IFRS 9, IRRBB etc.

2

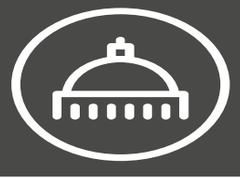
The Need for an Intuitive Model Output

- Fatal past experiences with black box models
- Easier decision making for senior management

3

Data Availability and Access to Compute Power

- Available data covers end-to-end economic cycle
- Easier access to high compute power for sophisticated models



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Desire for Efficient Capital Planning

- Forward looking budgeting and capital planning processes
- Intensified scrutiny from stakeholders

A Case Study: Application of Econometric Models in Banking

Overview of the Case Study

Development of an econometric model to forecast 9Q losses arising out of the Equity portfolio of a US based investment bank, across different scenarios, to comply with the CCAR Regulation.

A Brief on CCAR: Comprehensive Capital Analysis and Review

An annual exercise conducted by the Federal Reserve to assess whether the largest bank holding companies operating in the United States have sufficient capital to continue operations throughout times of economic and financial stress.

Large BHCs	▪ Applicable for large banks with total consolidated assets > 50 billion USD
Econometric Models	▪ Need to develop forward-looking econometric models to forecast revenues, losses and balances
Stress-Testing	▪ Sufficient capital to absorb losses and support operations during supervisory scenarios
Outlier Banks	▪ Outlier banks would face ban on capital distribution, severe penalties & operational restrictions.

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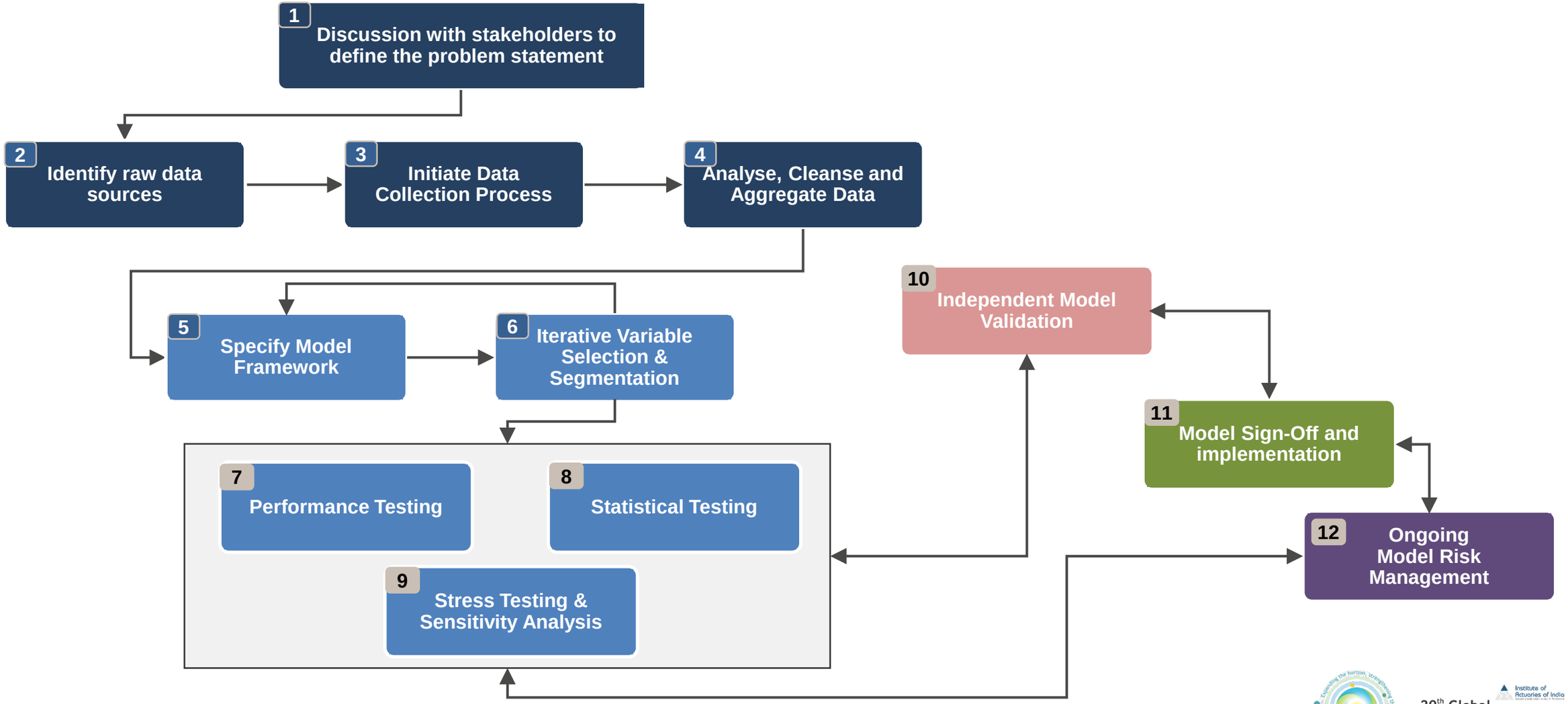
Model Development Lifecycle



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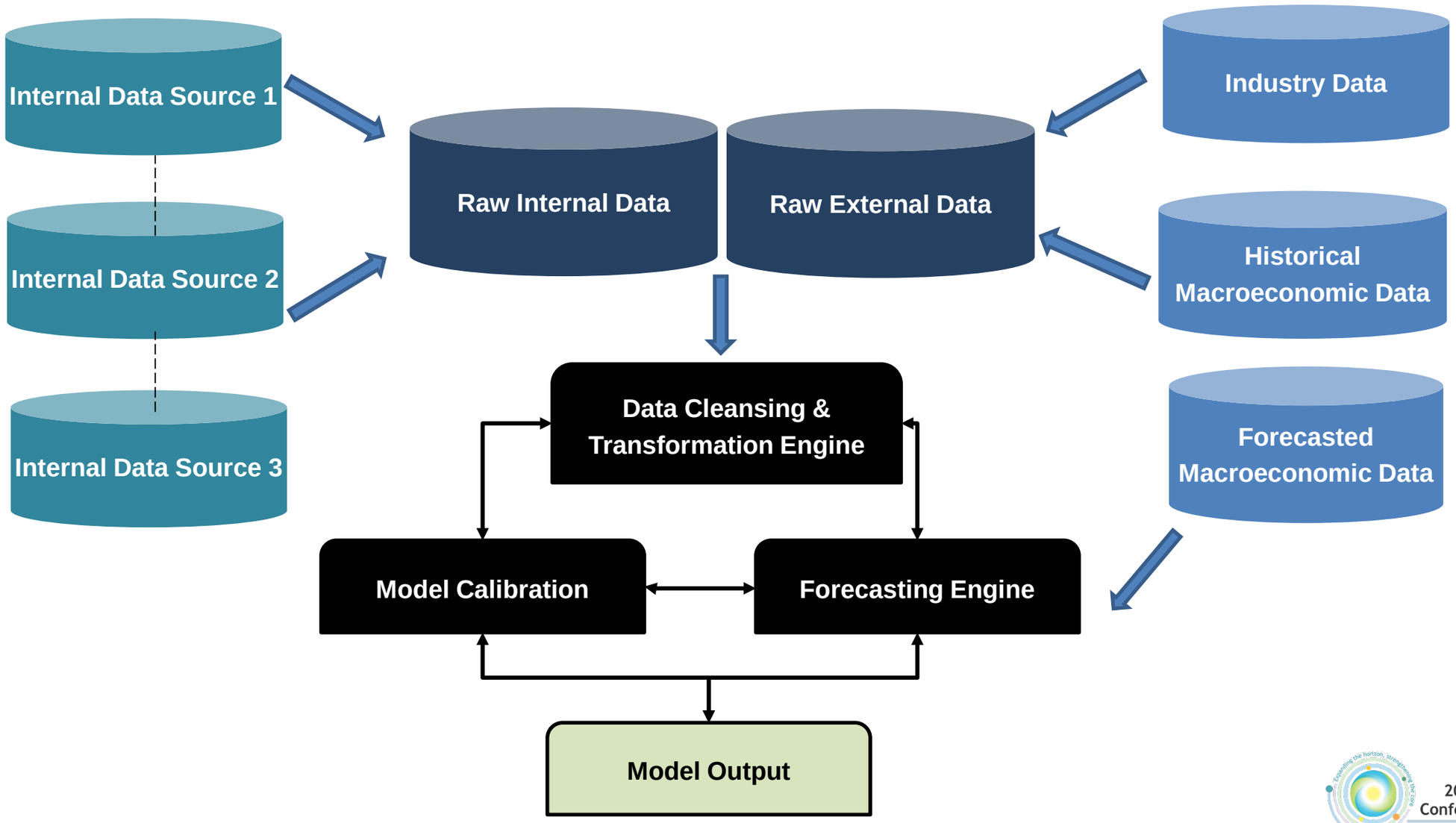
Step 1: Data Collection, Cleansing & Transformation



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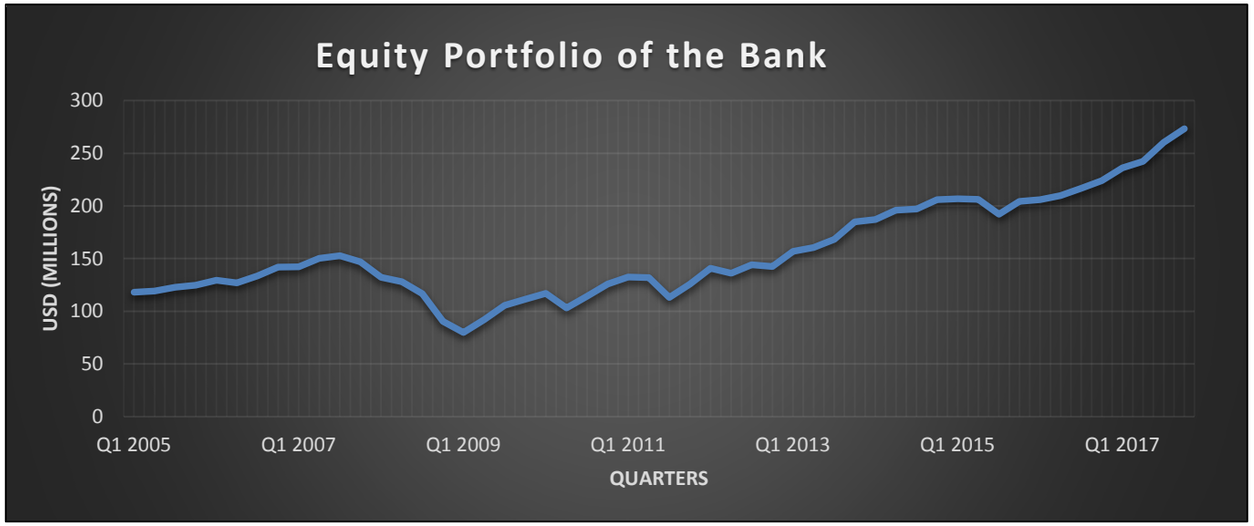
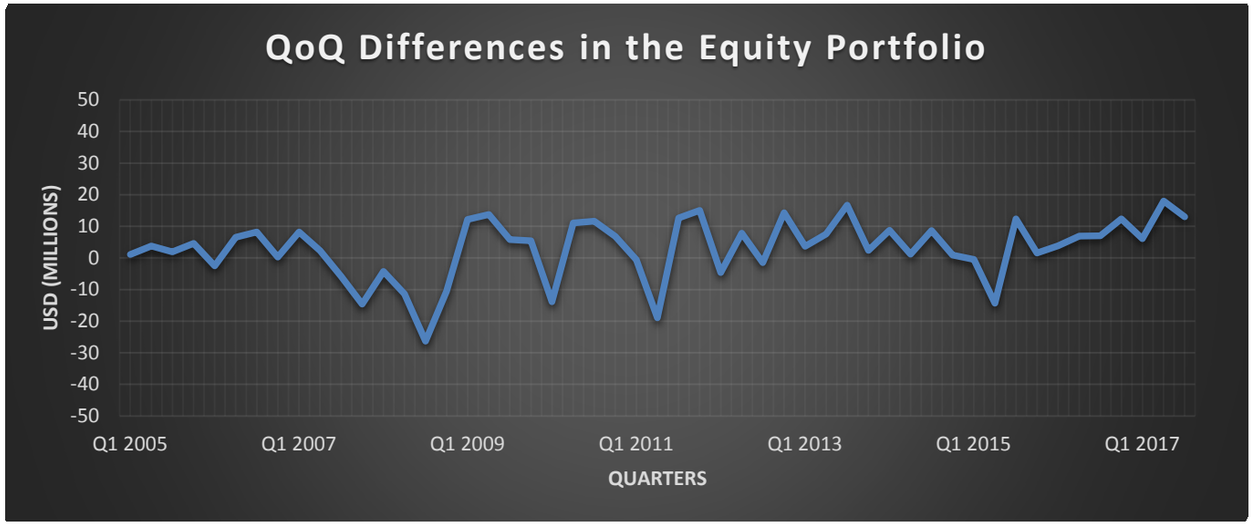
Step 2: Defining the Dependent Variable

Historical Time-Series of the Bank's Equity Portfolio



QoQ Differences computed using the historical time-series of Bank's Equity Portfolio



Step 3: Variable Selection

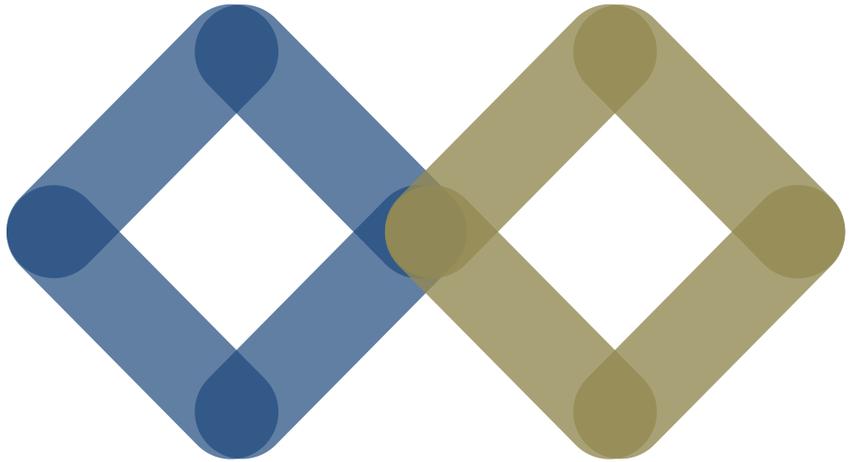
Initial set of macro-economic variables provided by the US regulator to initiate the model development process

Productivity & Income

- U.S. Real GDP growth
- U.S. nominal GDP growth
- U.S. real disposable income growth
- U.S. nominal disposable income growth

Unemployment & Inflation

- U.S. unemployment rate
- U.S. CPI inflation:
- U.S. nominal disposable income growth
- Euro Inflation
- Developing Asia Inflation
- Japan Inflation
- UK Inflation



Exchange Rates

- USD / Euro
- USD / Pound
- Yen / USD

Financial Markets

- U.S. 3-month Treasury rate
- U.S. 5-year Treasury yield
- U.S. 10-year Treasury yield
- U.S. BBB corporate yield
- Prime & Mortgage Rates
- Money Supply

Indices

- S&P 500 and Dow Jones
- House Price Index
- Commercial Real Estate Index
- Market Volatility Index (VIX)
- Consumer & Business Confidence

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Step 3: Variable Selection – Quantitative Analysis

Filter universal variable set using correlation analysis, economic intuition and cross-correlation matrix

01

Correlation & Intuition Analysis

Macro-Economic Variables	Intuitive Economic Relationship	Correlation
BBB Corporate Yield	Inverse	-72.50%
Commercial Real Estate Price Index	Direct	78.26%
Money Supply	Direct	85.82%
Consumer Confidence Index	Direct	80.83%
Business Confidence Index	Direct	63.48%
USD/EURO	Inverse	-61.54%

02

Cross-Correlation Analysis

Correlation Matrix						
	BBB Corporate Yield	***Commercial Real Estate Price Index***	***Money Supply***	***Consumer Confidence Index***	***Business Confidence Index***	***(USD/euro)***
BBB Corporate Yeild	1					
Commercial Real Estate Price Index	-0.24	1				
Money Supply	-0.71	0.54	1			
Consumer Confidence Index	-0.79	0.48	0.70	1		
Business Confidence Index	-0.38	0.67	0.22	0.46	1	
(USD/euro)	0.55	-0.47	-0.58	-0.59	-0.31	1

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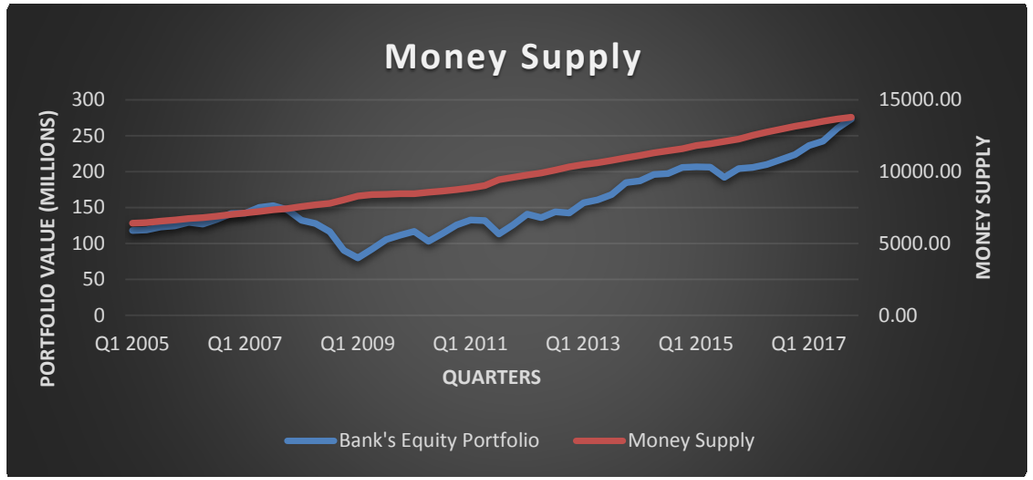
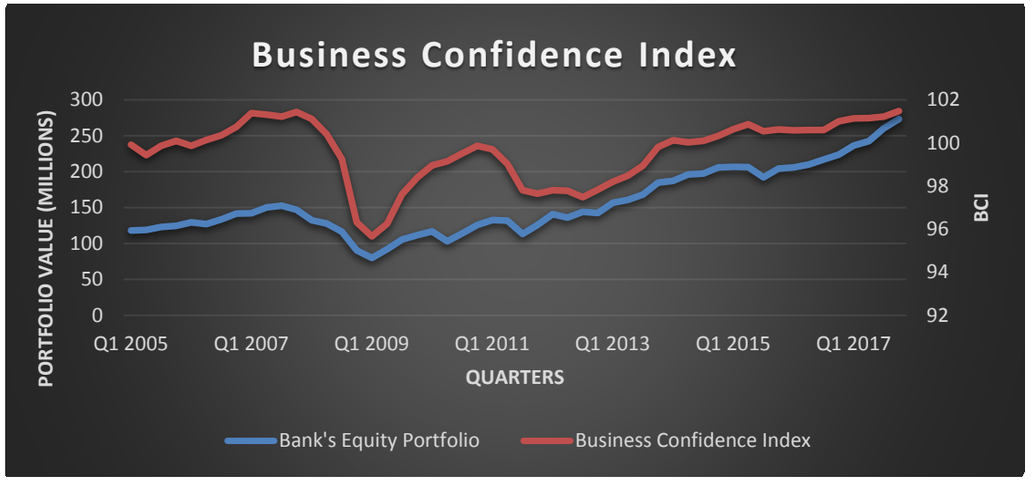
Step 3: Variable Selection – Quantitative Analysis

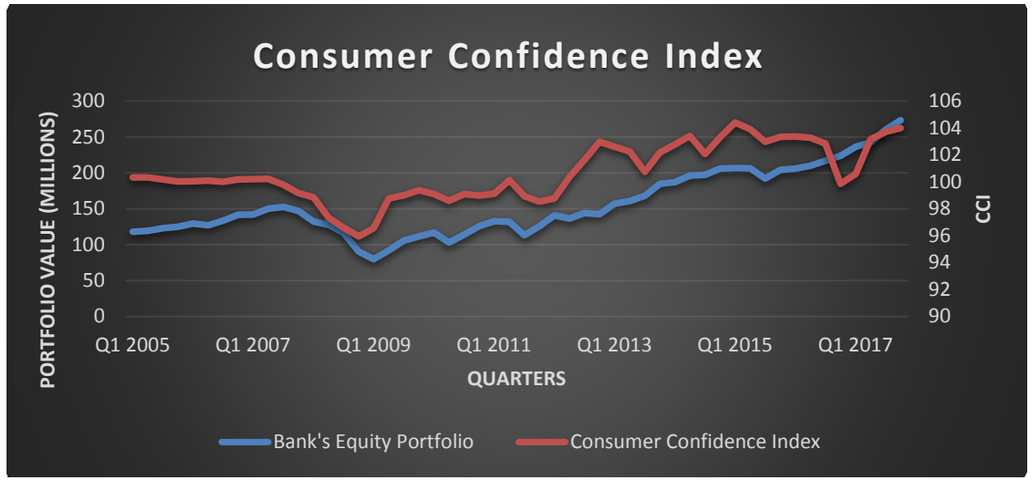
Usage of Graphical Analysis and Qualitative Judgement for selection of macro-economic indicators

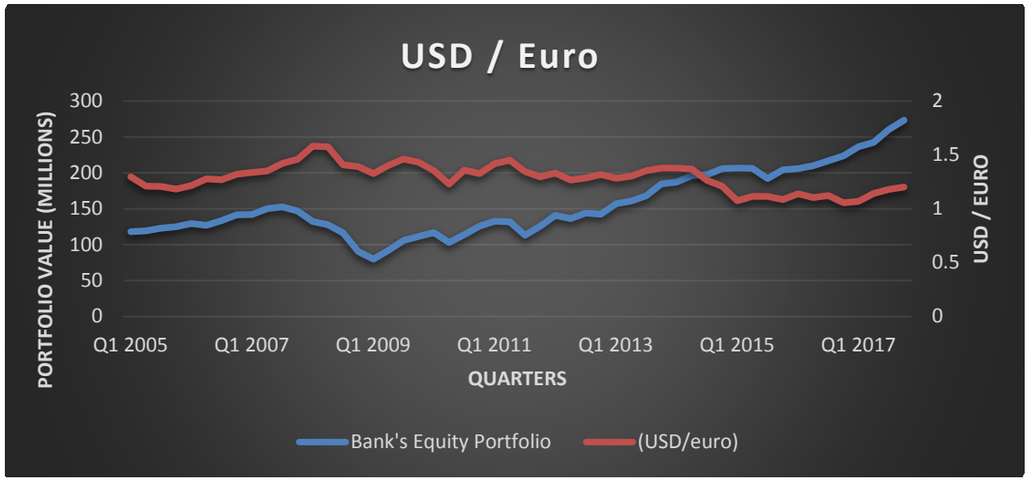
03

Graphical Analysis









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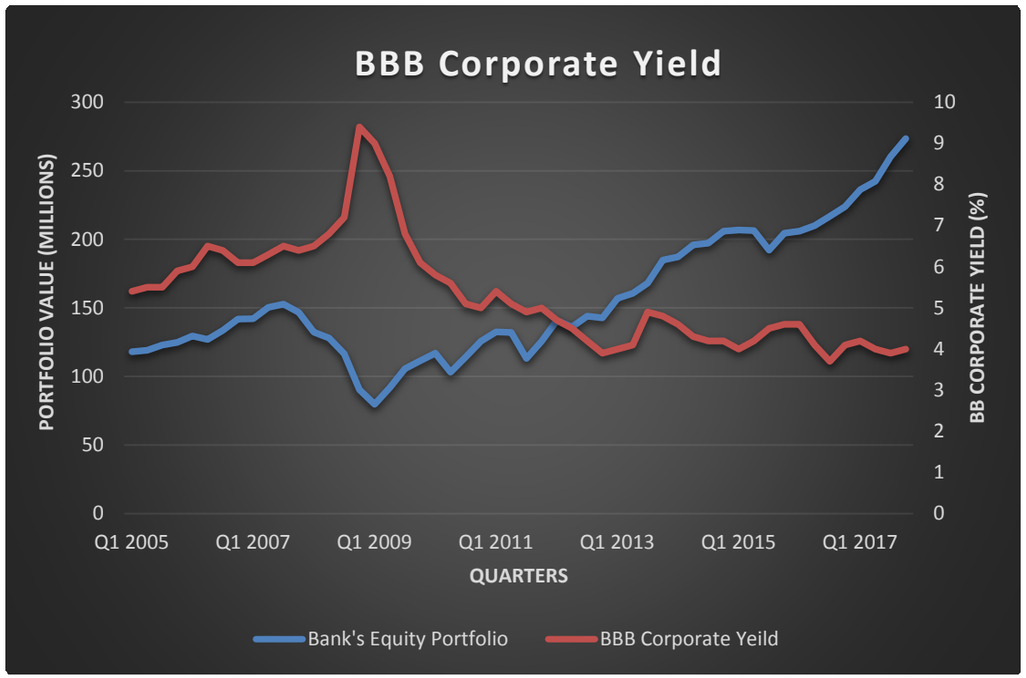

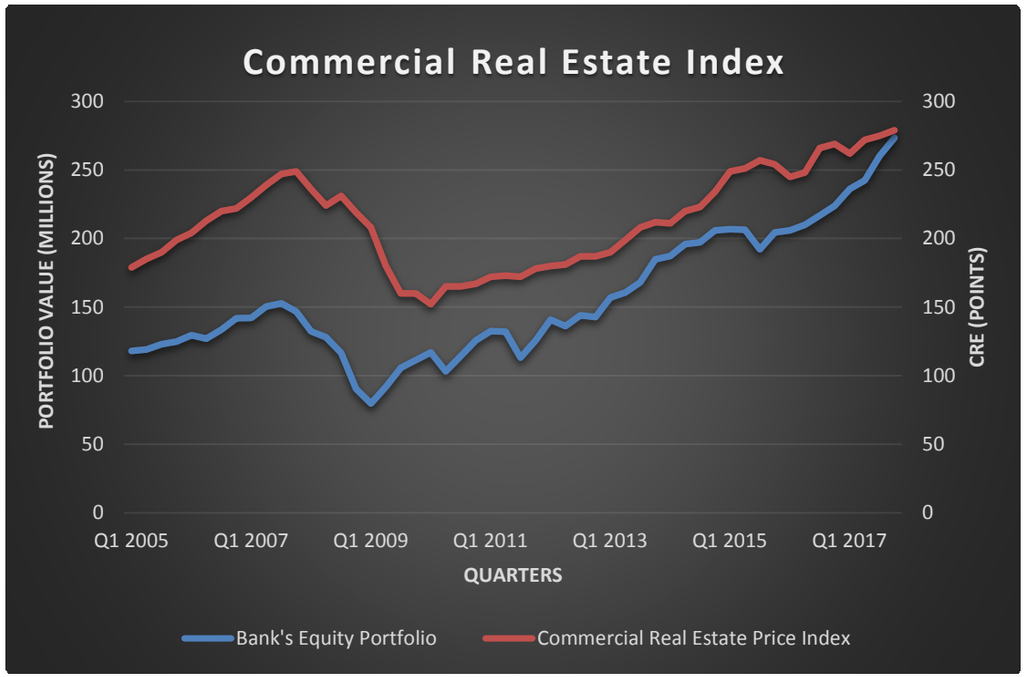

Step 4: Model Calibration

Model Framework

Multiple Linear Regression Model (OLS) with Log Transformation

Model Equation

$$\text{EquityPortfolio}_t = \alpha + \beta_1 * \ln(\text{CRE}_t) + \beta_2 * \ln(\text{BBBCorpYield}_t) + \varepsilon_t$$

where:

α is the Intercept

β_1 is the regression coefficient of Commercial Real Estate Index

β_2 is the regression coefficient of BBB Corporate Yield

ε_i are residual errors (Actual – Predicted)

Calibration Results

Parameter	Coefficients	Standard Error	T-Stat	P-value
Intercept	3.4451	0.3977	8.6625	< 0.0001
Log Transformed CRE	0.9744	0.0686	14.2132	< 0.0001
Log Transformed BBB Corporate Yield	-0.8172	0.0507	-16.1039	< 0.0001

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Step 5: Statistical Testing

Criteria	Qualitative Tests	Quantitative Tests	P-Value	Interpretation (95% LOC)
Stationarity	ACF & PACF Plots and Graphical Analysis	Phillips Peron Test	0.04028	The dependent variable is stationary
		ADF Test	0.025	The dependent variable is stationary
Linearity	Scatter-Plots (Residuals vs Fitted Values)	Ramsay-Reset Test	0.7960	The linear regression model is "linear in parameters."
Multicollinearity	IV Graphical Plots & Sensitivity of Model Parameters	Variable Inflation Factor	5.591	There is no multi-collinearity between independent variables
Normality	Quantile-Quantile Plot (QQ Plot) and Histograms	Jarque -Bera	0.815	Residuals are normally distributed
		Shapiro Wilk	0.453	Residuals are normally distributed
		Kolmogrov-Smirnov	<0.001	Residuals are non-normally distributed
Heteroskedasticity	Residuals vs Fitted and Standardized Residuals Plots	Breusch Pagan	0.351	Residuals are homoscedastic
Serial-Correlation	ACF, PACF and Residual Time-Series Plots	Durbin-Watson T	<0.001	Residuals are autocorrelated
		Breusch-Godfrey	0.0027	Residuals are autocorrelated

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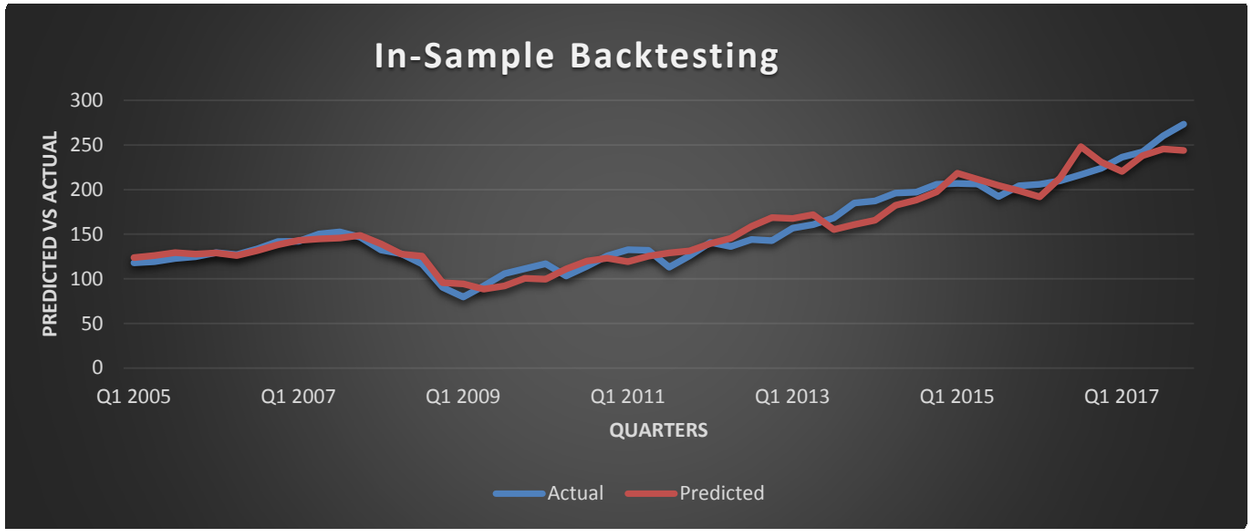
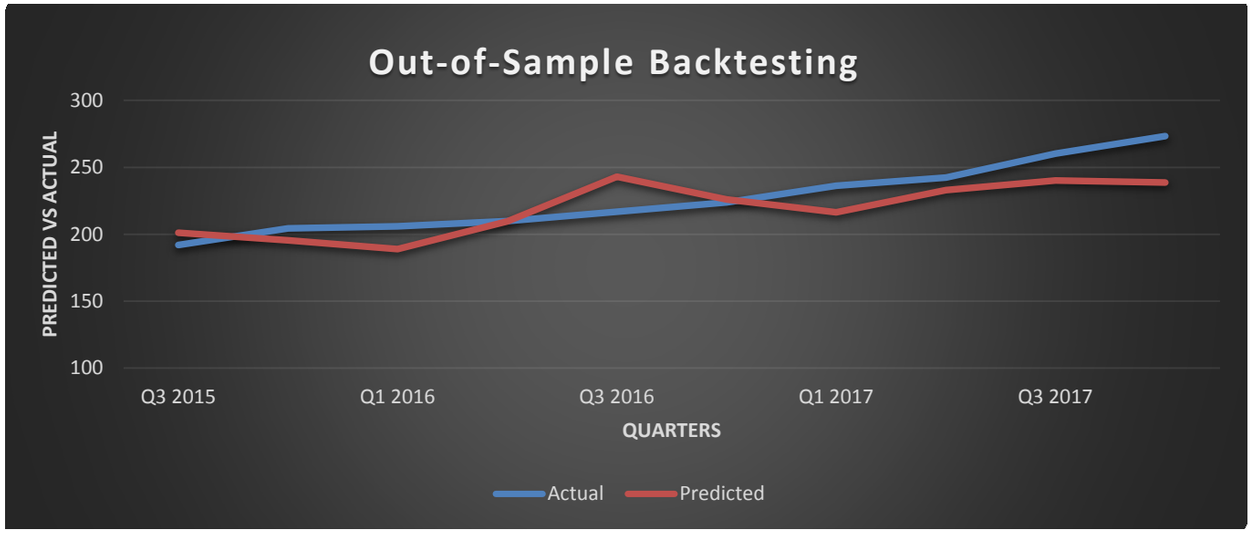
Step 5: Statistical Testing



In-Sample Error Metrics	
RMSE (Millions)	4.8
MAPE (%)	3.70%



Out-of-Sample Error Metrics	
RMSE (Millions)	9.75
MAPE (%)	6.32%

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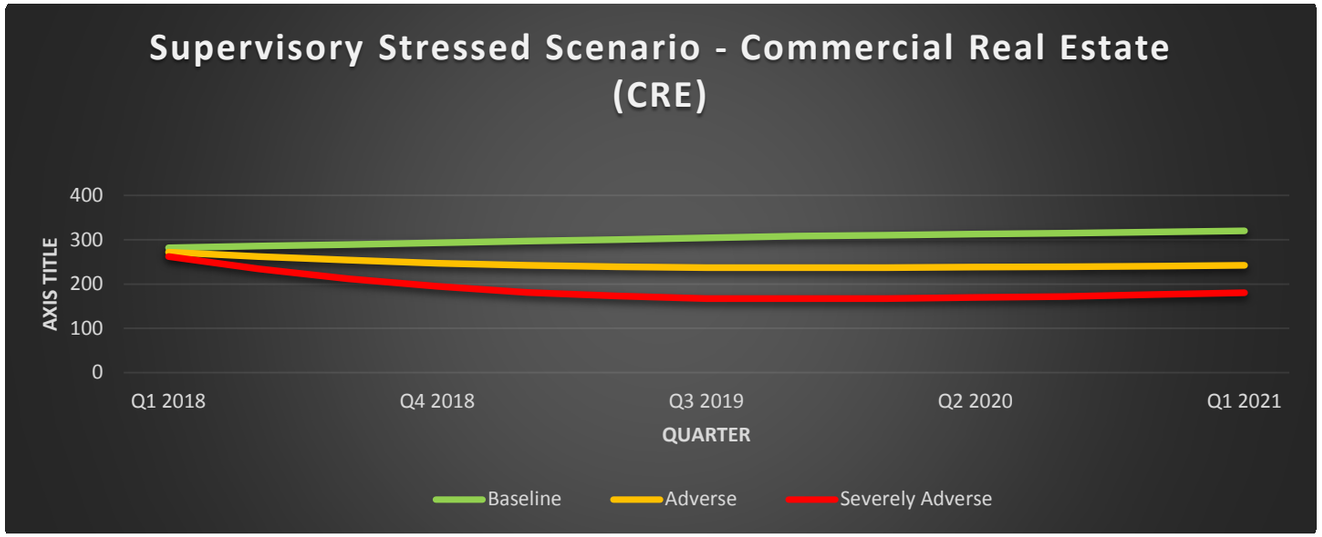
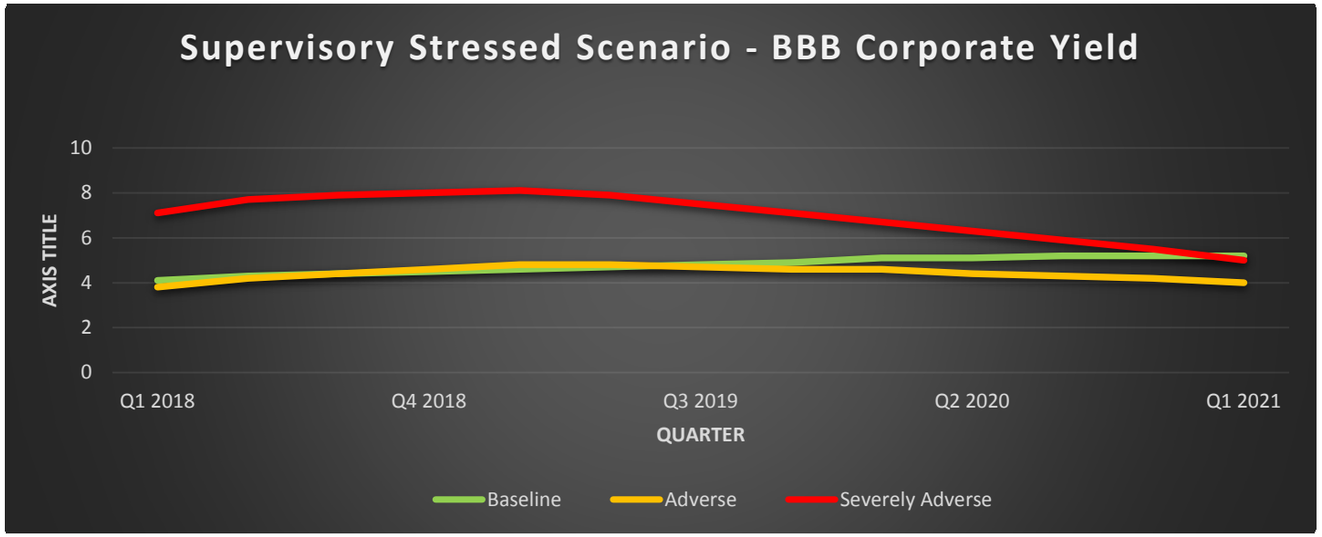
Step 7: Generating / Consume Forecasts for IV

CRE tends to be significantly lower under severely adverse scenarios





BBB corporate yields tend to be significantly higher under severely adverse scenarios

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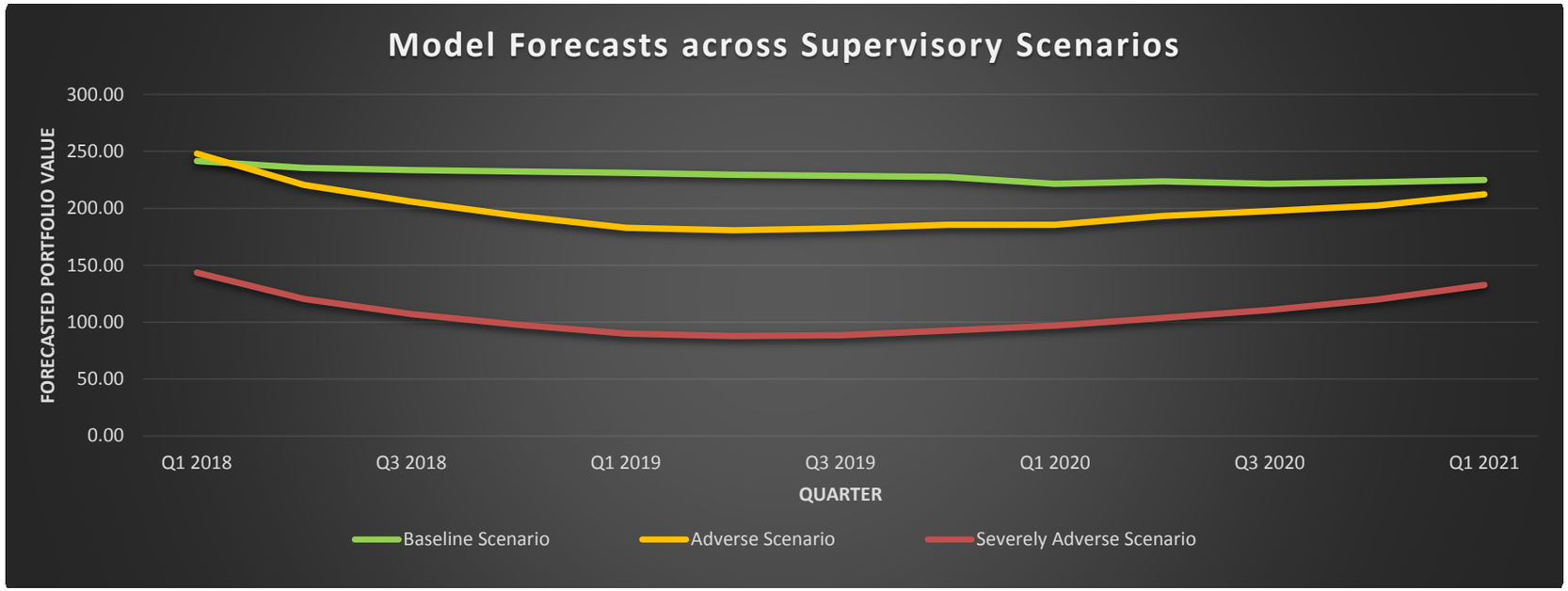
Step 8: Forecasting & Stress-Testing

Model generates economically intuitive stress forecasts

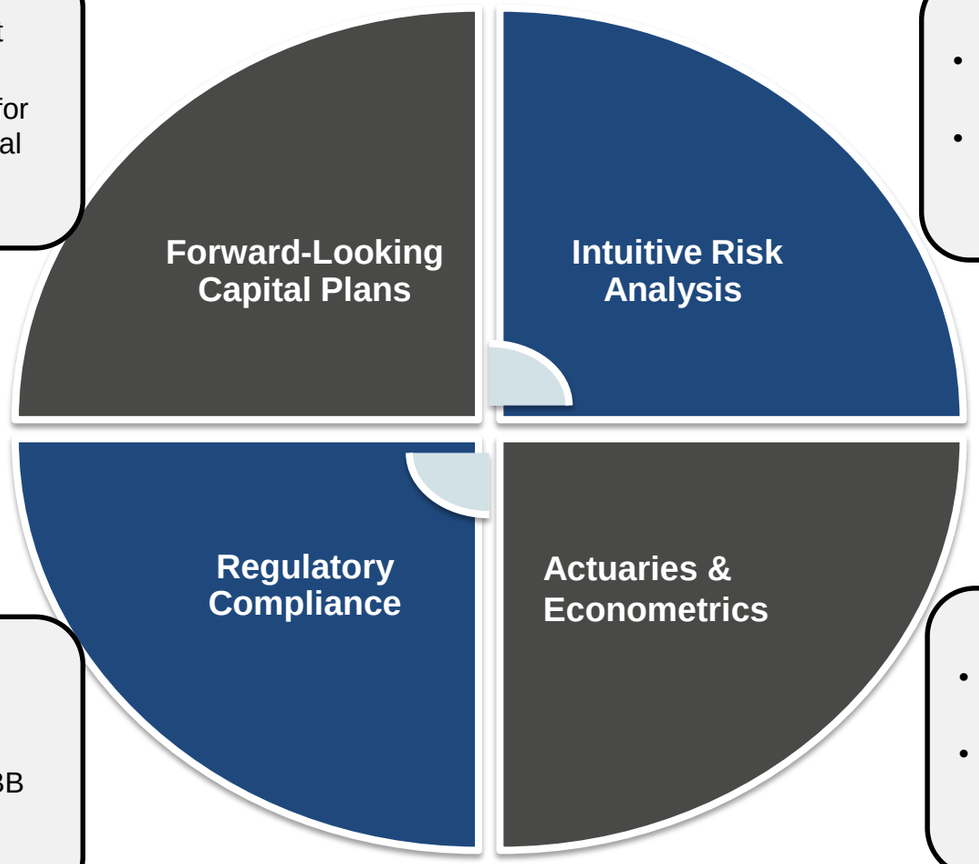


Expected 13Q Loss Under Each Scenario (Millions)			
Initial Portfolio Value (Q4 2017)	**Baseline Scenario**	**Adverse Scenario**	**Severely Adverse Scenario**
273.35	5.18	8.78	17.63

Conclusion

Key-Takeaways

- Stress testing balance sheet and P&L statements
- Forward-looking processes for efficient budgeting and capital plans



- Economic intuition driven models and output
- Ease of communication to senior management

- Ability to meet new forward-looking regulations
- CCAR, IFRS 9, FRTB, IRRBB etc.

- Actuaries skillset compatible with econometric modelling
- Combine statistics, business, finance and economics

Q & A

Questions ?

Comments

Reference Material

- https://www.federalreserve.gov/supervisionreg/ccar.htm
- https://www.bis.org/publ/cgfs60.htm
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