

2nd Seminar on Banking, Finance & Investment

Venue: Hotel Sea Princess, Mumbai

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Application of Econometric Models in the US Banking Industry

Yash Ratanpal, AIAI

Manager – Acies Consulting LLP



Live Poll



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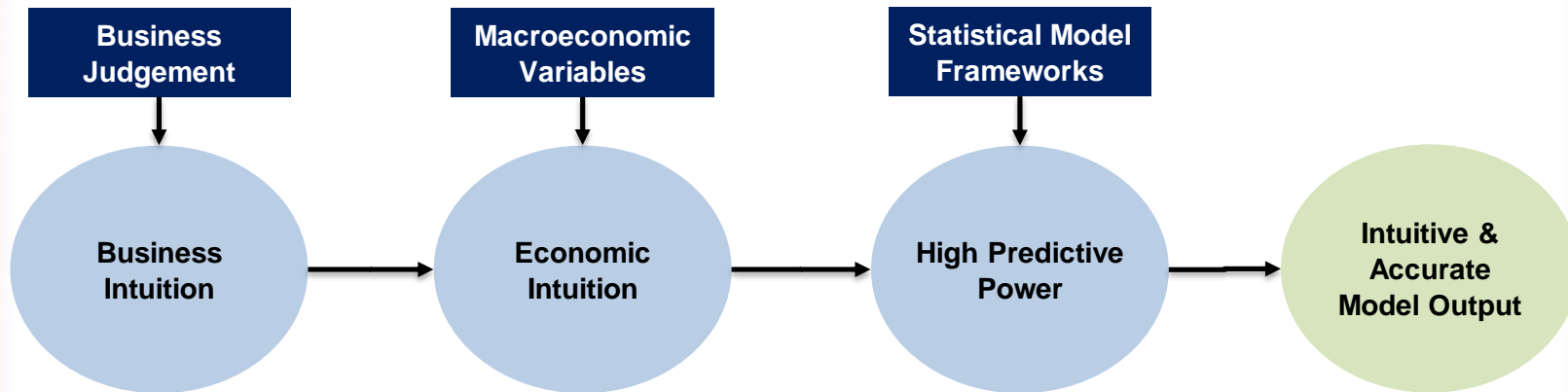


- A Brief on Econometric Models
- Key Drivers for Increased Usage of Econometrics in Banking
- Application Econometric Models used in Banking
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- Role of Actuaries in Banking & Finance
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A Brief on Econometrics

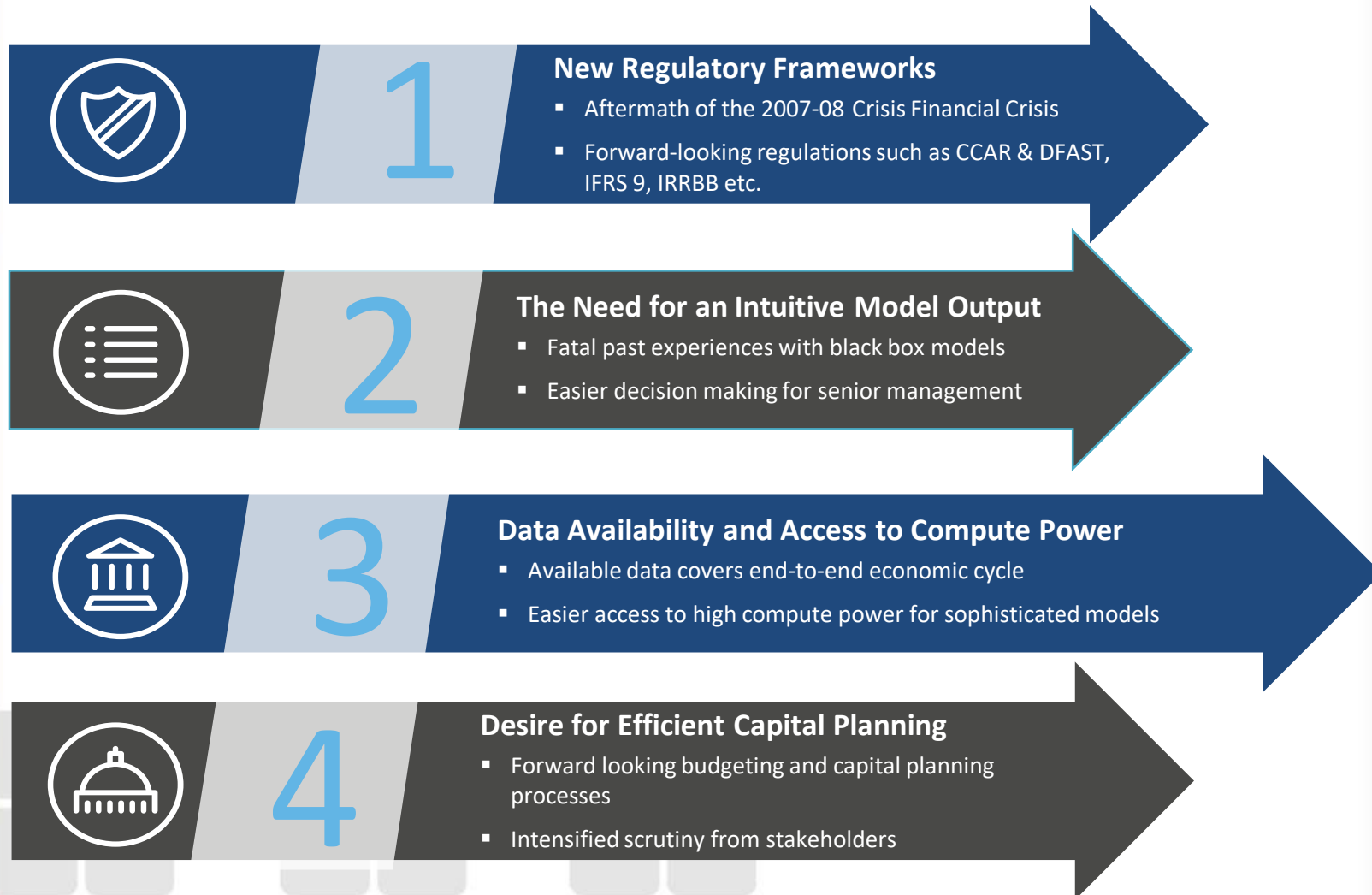
“Econometrics uses economic theory, mathematics, and statistical inference to quantify economic phenomena. The objective of econometrics is to convert qualitative relationships into quantitative statements” – International Monetary Fund (IMF)

What is an Econometric Model ?

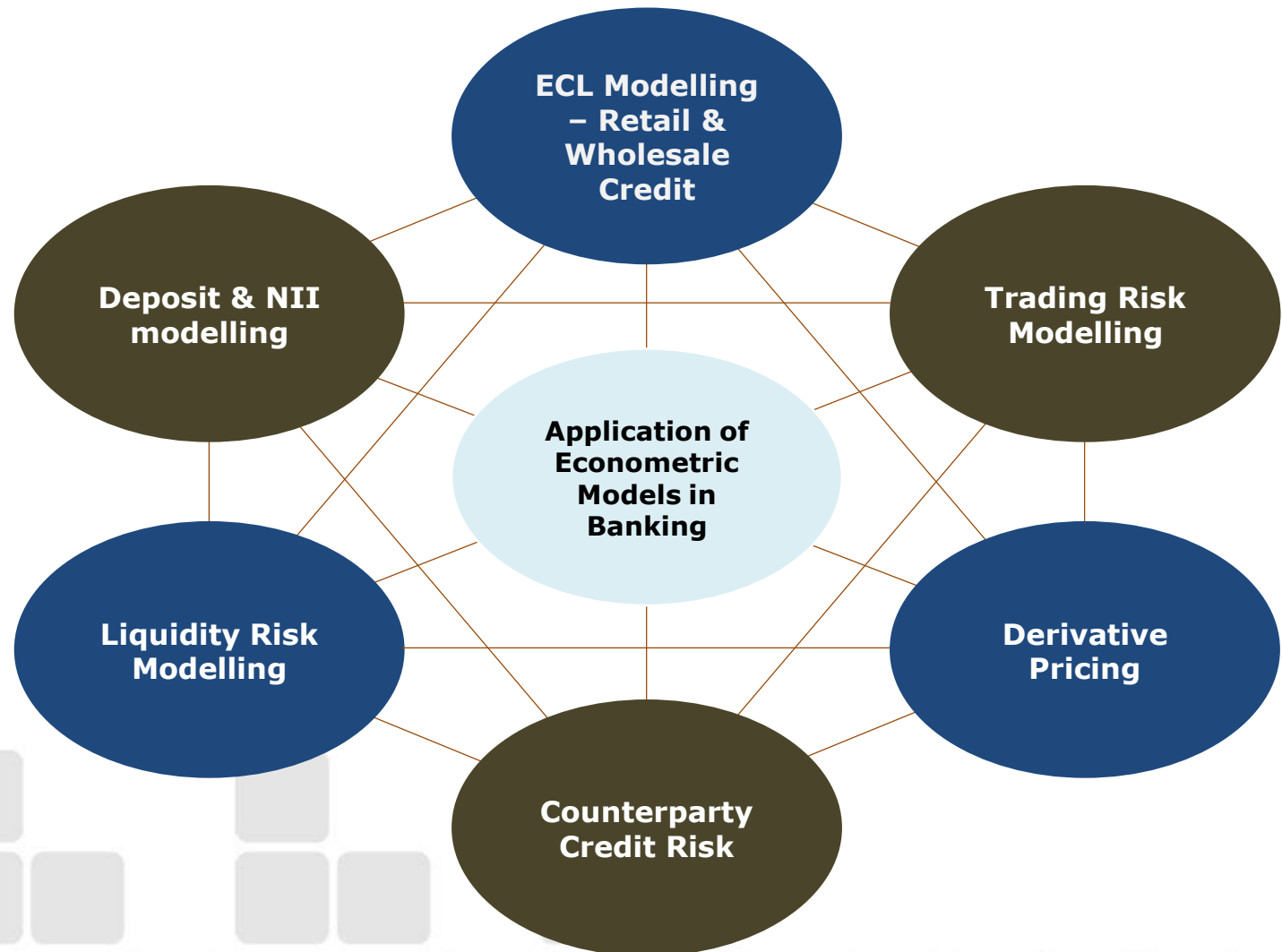


An econometric model combines business judgement, economic intuition and robust statistics to generate an intuitive and accurate model output

Key Drivers for Increased Usage of Econometrics in Banking



Application of Econometric Models in Banking



Introduction to CCAR



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 during supervisory scenarios – Baseline, Adverse and Severely Adverse.

Outlier Banks

- Outlier banks would face ban on capital distribution, severe penalties & operational restrictions.

Illustration of CCAR Results



Institute of Actuaries of India

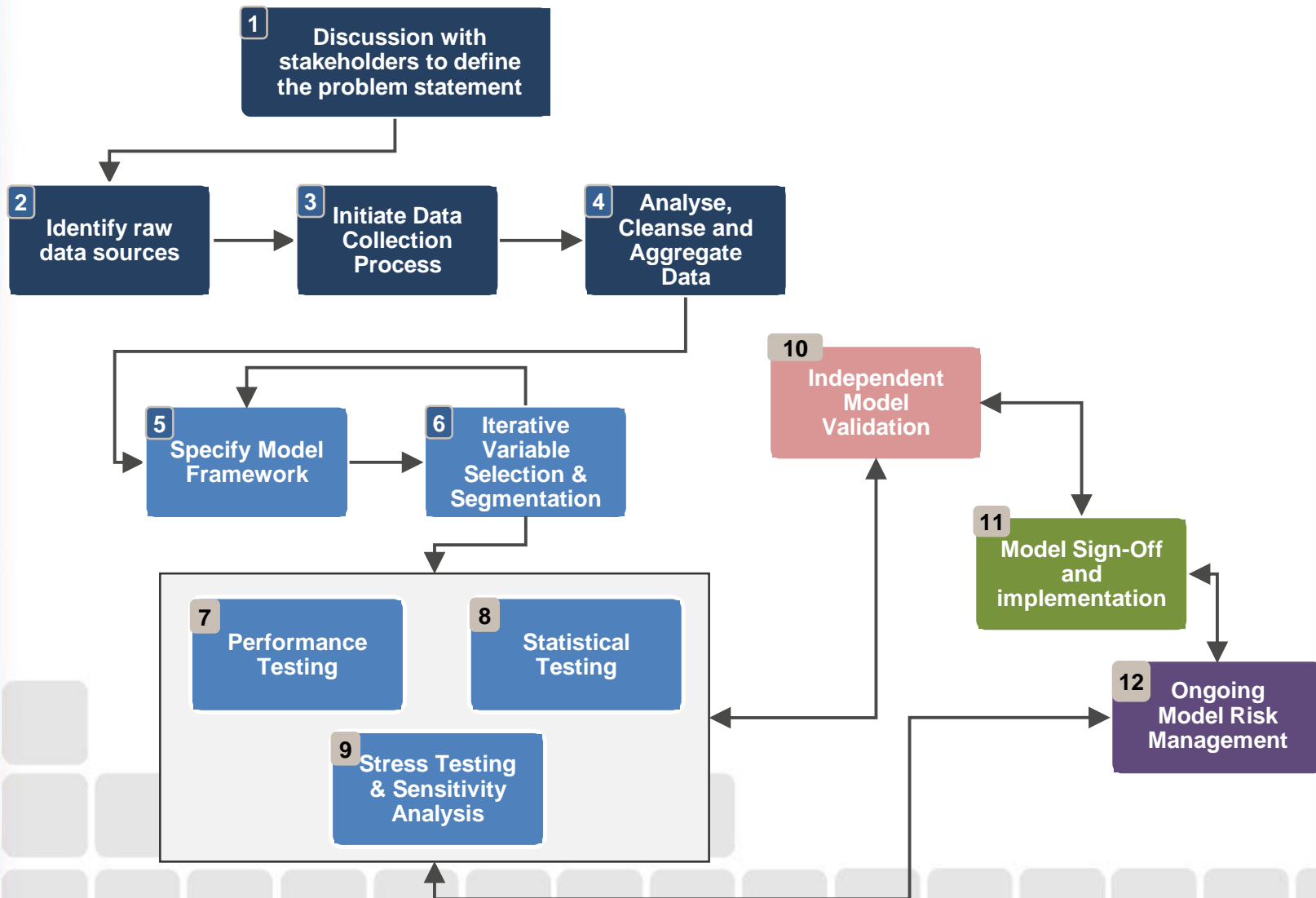
Table 6.A. Projected minimum regulatory capital ratios in the severely adverse scenario, 2018:Q1 to 2020:Q1: Advanced approaches firms
Percent

Firm	Capital actions	Common equity tier 1 capital ratio		Tier 1 capital ratio		Total capital ratio		Tier 1 leverage ratio		Supplementary leverage ratio ¹	
		Actual 2017:Q4	Projected minimum	Actual 2017:Q4	Projected minimum	Actual 2017:Q4	Projected minimum	Actual 2017:Q4	Projected minimum	Actual 2017:Q4	Projected minimum
			Original								
American Express Company	Adjusted	9.0	4.4	10.1	5.7	11.8	7.6	8.6	4.8	n/a	4.1
Bank of America Corporation	Original	9.0	5.0	10.1	6.3	11.8	8.2	8.6	5.3	n/a	4.6
	Adjusted	11.9	5.4	13.4	7.1	15.9	9.5	8.6	4.5	n/a	3.6
The Bank of New York Mellon Corporation	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	11.9	8.3	14.2	10.5	15.1	11.7	6.6	4.9	n/a	4.5
Barclays US LLC	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	13.1	9.6	15.7	12.1	18.8	14.8	8.2	6.5	n/a	5.3
Capital One Financial Corporation	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	10.3	4.6	11.8	6.1	14.4	8.5	9.9	5.1	n/a	4.4
Citigroup Inc.	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	13.0	5.6	14.5	7.2	17.8	10.4	8.8	4.4	n/a	3.4
Credit Suisse Holdings (USA), Inc. ²	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	24.7	17.2	24.7	17.8	24.8	17.8	7.3	6.7	n/a	6.6
DB USA Corporation	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	18.5	12.2	25.9	21.7	25.9	22.0	7.2	5.7	n/a	5.2
The Goldman Sachs Group, Inc.	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	12.1	4.6	14.1	6.4	16.8	9.2	8.4	3.8	n/a	2.6
HSBC North America Holdings Inc.	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	12.1	4.8	14.1	6.6	16.8	9.4	8.4	3.9	n/a	2.7
JPMorgan Chase & Co.	Original	15.5	7.8	18.3	9.5	22.8	13.0	8.9	4.5	n/a	3.5
	Adjusted	12.2	4.9	13.9	6.6	15.9	8.9	8.3	3.9	n/a	3.0
Morgan Stanley	Original	12.2	5.0	13.9	6.9	15.9	9.2	8.3	4.1	n/a	3.2
	Adjusted	16.5	5.0	18.9	7.3	21.7	10.0	8.3	3.2	n/a	2.5
Northern Trust Corporation	Original	16.5	5.5	18.9	7.7	21.7	10.4	8.3	3.4	n/a	2.6
	Adjusted	12.6	9.4	13.8	10.7	15.8	13.0	7.8	5.9	n/a	5.2
The PNC Financial Services Group, Inc.	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	10.4	5.3	11.6	6.5	13.7	9.0	9.9	5.6	n/a	4.6
State Street Corporation	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	11.9	4.0	15.0	7.6	16.0	8.7	7.3	3.5	n/a	3.2
TD Group US Holdings LLC	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	16.0	10.6	16.0	10.6	17.0	11.9	8.8	6.0	n/a	5.3
U.S. Bancorp	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	9.3	6.0	10.8	7.6	12.9	9.8	8.9	6.3	n/a	5.0
Wells Fargo & Company	Original	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adjusted	12.3	6.5	14.1	8.1	17.5	11.4	9.4	5.3	n/a	4.5

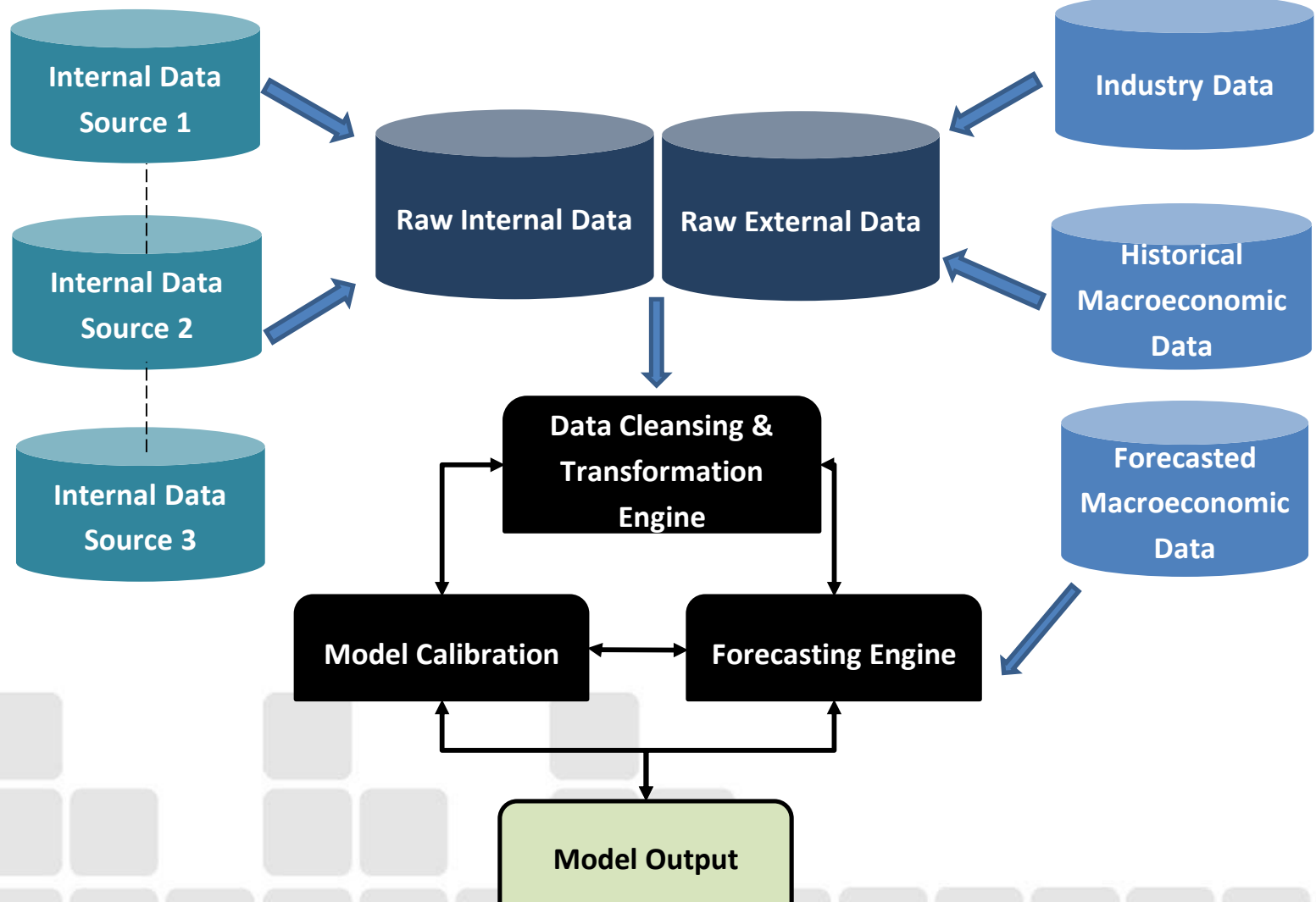
Required minimum capital ratios in CCAR 2018 for advanced approaches firms (percent)

Regulatory ratio	Minimum
Common equity tier 1 capital ratio	4.5
Tier 1 capital ratio	6.0
Total capital ratio	8.0
Tier 1 leverage ratio	4.0
Supplementary leverage ratio	3.0

Model Development Lifecycle

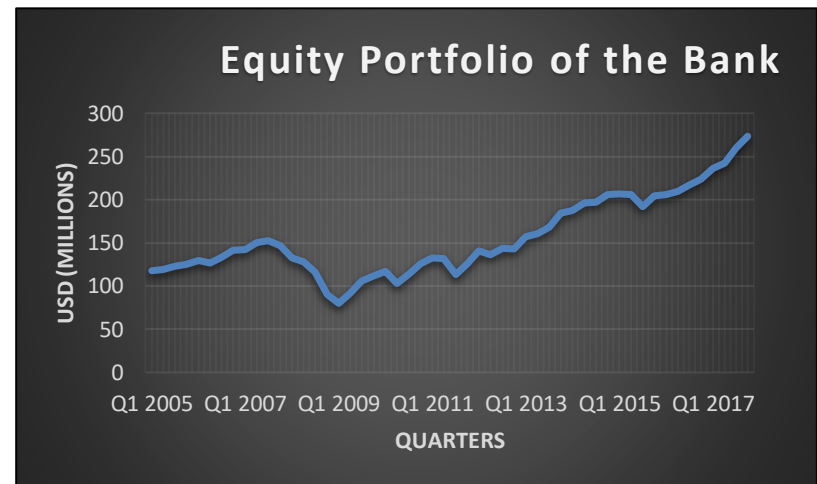


Case Study: Data Sourcing & Cleansing



Case Study: Defining the Dependent Variable

Historical Time-Series of
the Bank's Equity
Portfolio



QoQ Differences in the Equity Portfolio



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

Case Study: Independent 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

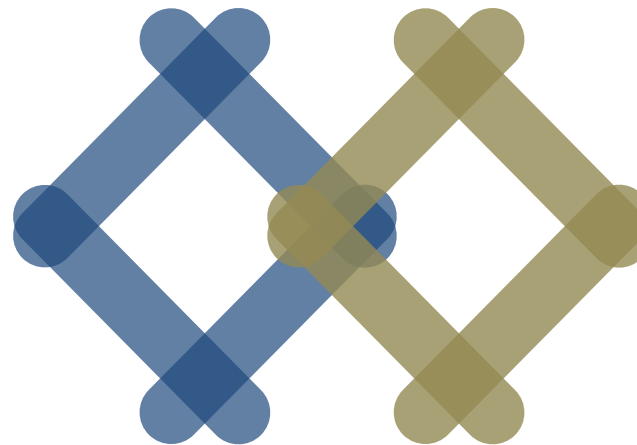
- USD / Euro
- USD / Pound
- Yen / USD

Financial Markets

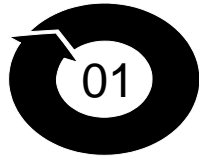
- U.S. 3-month Treasury rate
- U.S. 5-year Treasury yield
- U.S. 10-year Treasury yield
- U.S. BBB corporate yield
- Prime & Mortgage Rates
- Money Supply

Indices

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



Case Study: Independent Variable Selection



**Correlation &
Intuitive Signs**

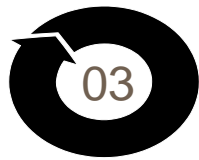
Macro-Economic Variables	Intuitive Economic Relationship	Correlation
BBB Corporate Yield	Inverse	-72.50%
Commercial Real Estate Price Index	Direct	78.26%
Money Supply	Direct	85.82%
Consumer Confidence Index	Direct	80.83%
Business Confidence Index	Direct	63.48%
USD/EURO	Inverse	-61.54%



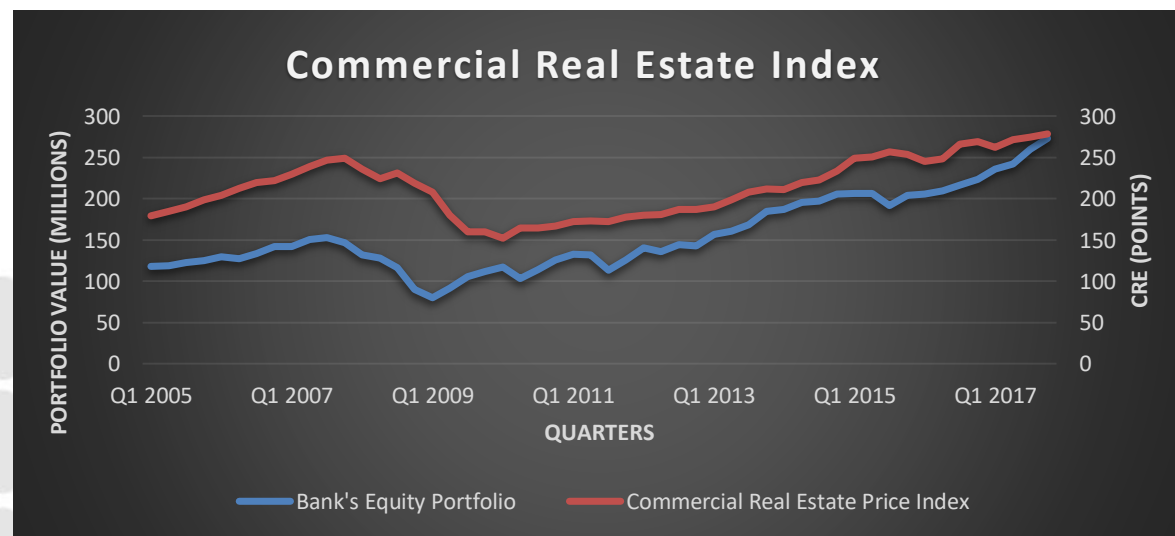
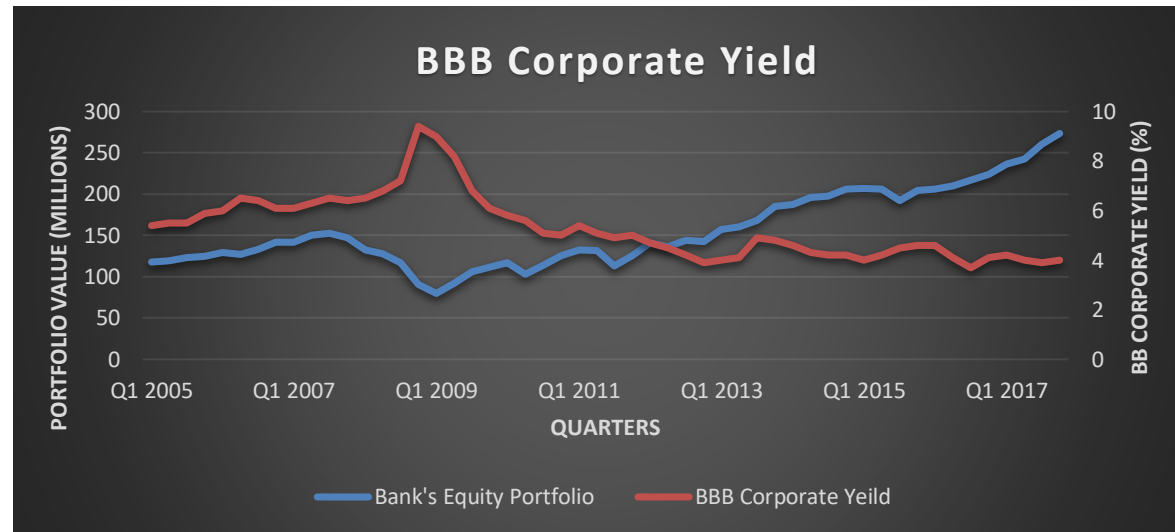
Cross-Correlation

Correlation Matrix						
	<i>BBB Corporate Yield</i>	<i>Commercial Real Estate Price Index</i>	<i>Money Supply</i>	<i>CCI</i>	<i>BCI</i>	<i>USD / EURO</i>
BBB Corporate Yield	1					
Commercial Real Estate Price Index	-0.24	1				
Money Supply	-0.71	0.57	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

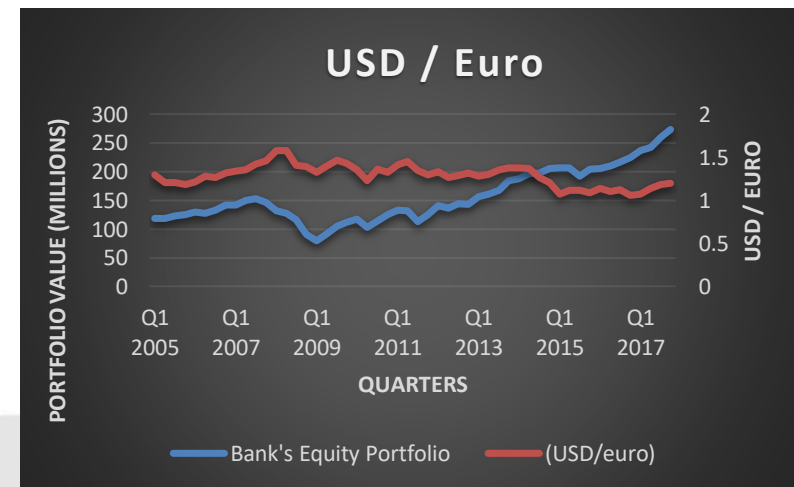
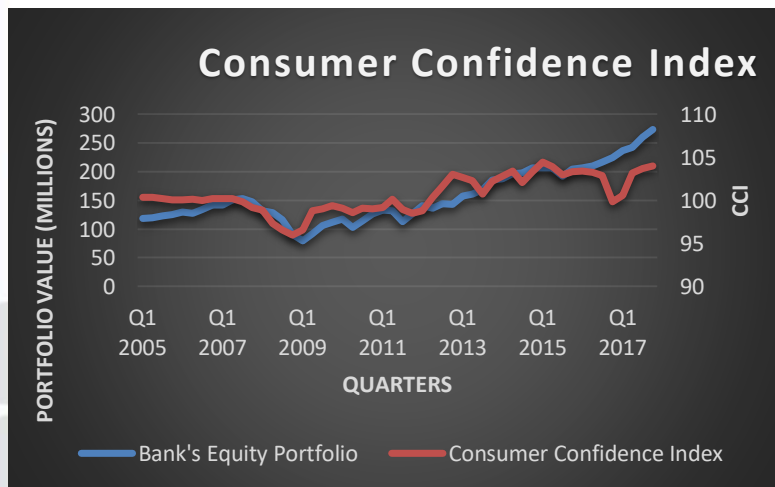
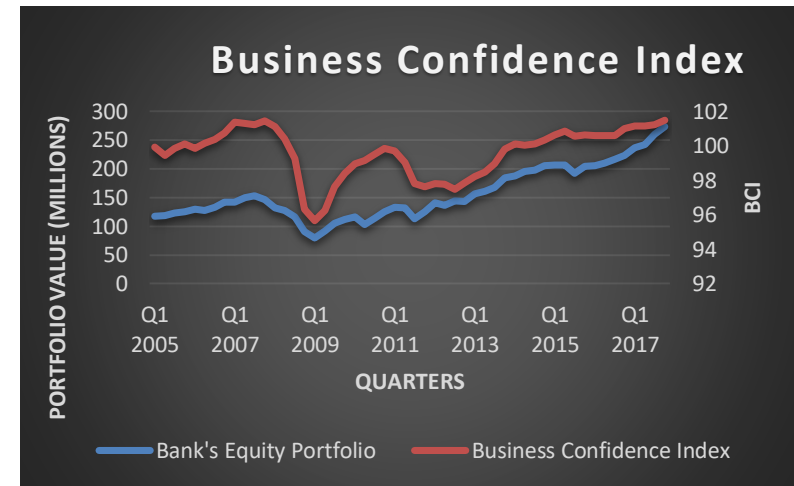
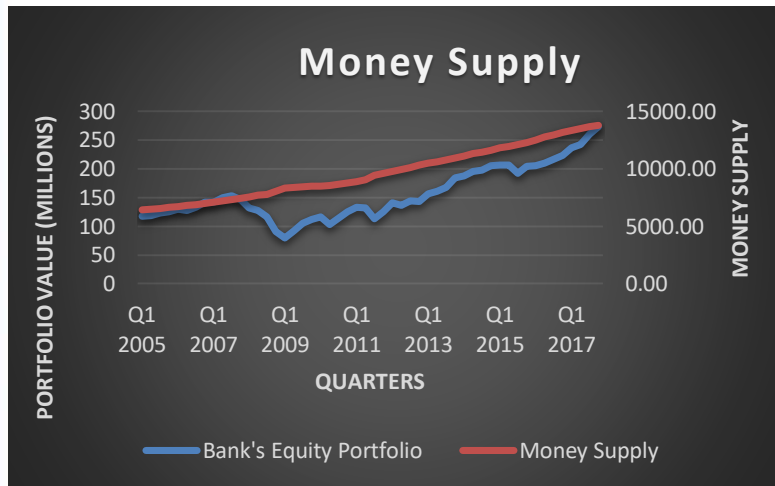
Case Study: Independent Variable Selection



Graphical Analysis



Case Study: Independent Variable Selection



Case Study: Model Calibration



Model Framework

Multiple Linear Regression Model (OLS) with Log Transformation

Model Equation

$$EquityPortfolio_t = \alpha + \beta_1 * \ln(CRE_t) + \beta_2 * \ln(BBBCorpYield_t) + \varepsilon_t$$

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)

Post-Calibration Results

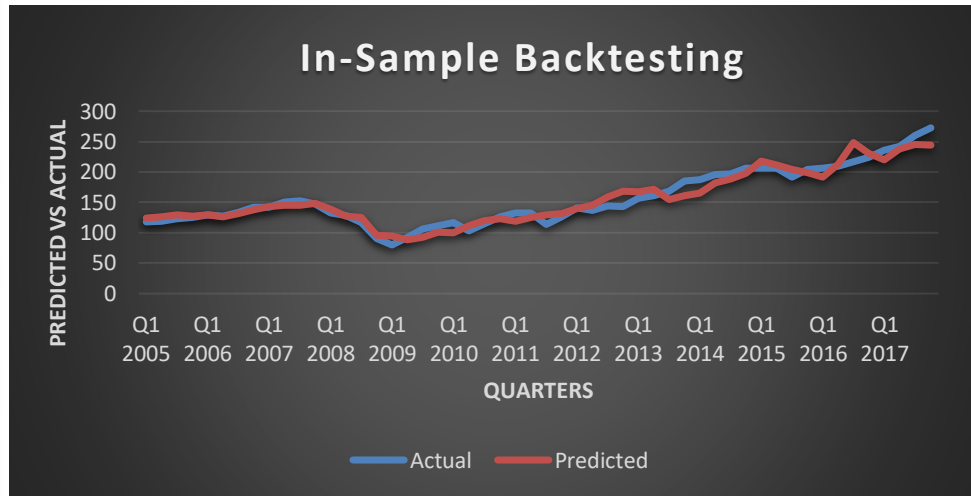
<i>Parameter</i>	<i>Coefficients</i>	<i>Standard Error</i>	<i>T-Stat</i>	<i>P-value</i>
Intercept	3.4451	0.3977	8.6625	< 0.0001
Log Transformed CRE	0.9744	0.0686	14.2132	< 0.0001
Log Transformed BBB Corporate Yield	-0.8172	0.0507	-16.1039	< 0.0001

Case Study: Statistical Testing



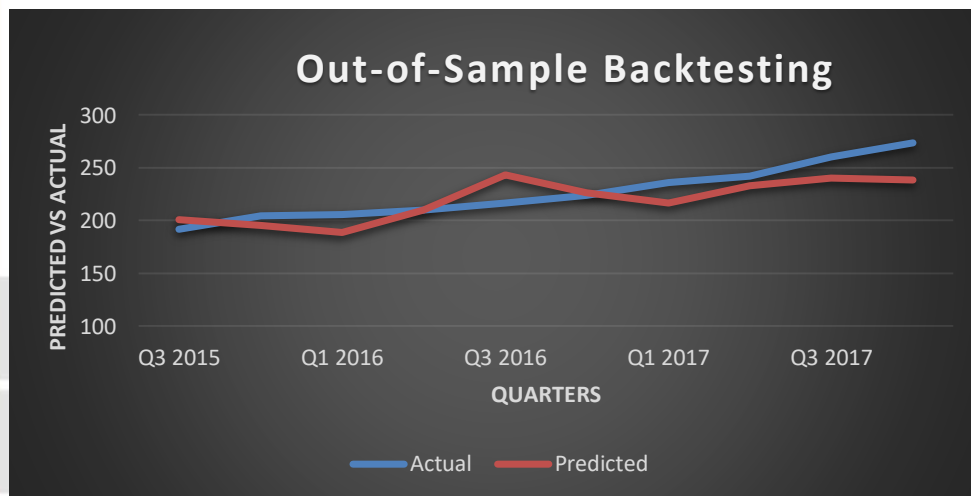
Criteria	Qualitative Tests	Quantitative Tests	P-Value	Interpretation (95% LOC)
Stationarity	ACF & PACF Plots and Graphical Analysis	Phillips Peron Test	0.04028	The dependent variable is stationary
		ADF Test	0.025	The dependent variable is stationary
Linearity	Scatter-Plots (Residuals vs Fitted Values)	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

Case Study: Performance Testing



In-Sample Error Metrics

RMSE (Millions)	4.8
MAPE (%)	3.70%

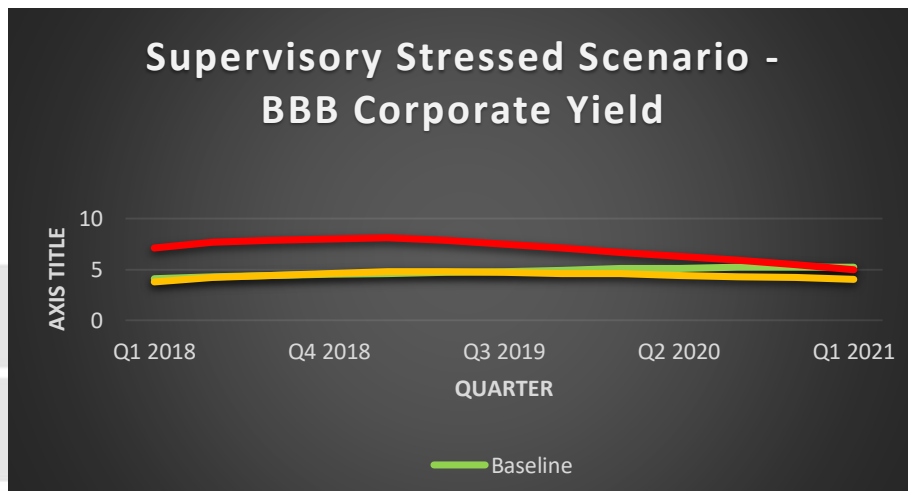
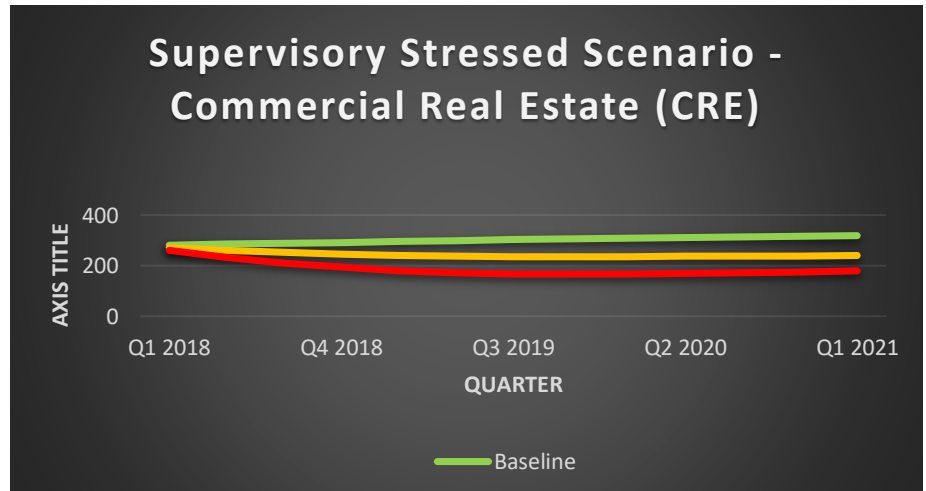


Out-of-Sample Error Metrics

RMSE (Millions)	9.75
MAPE (%)	6.32%

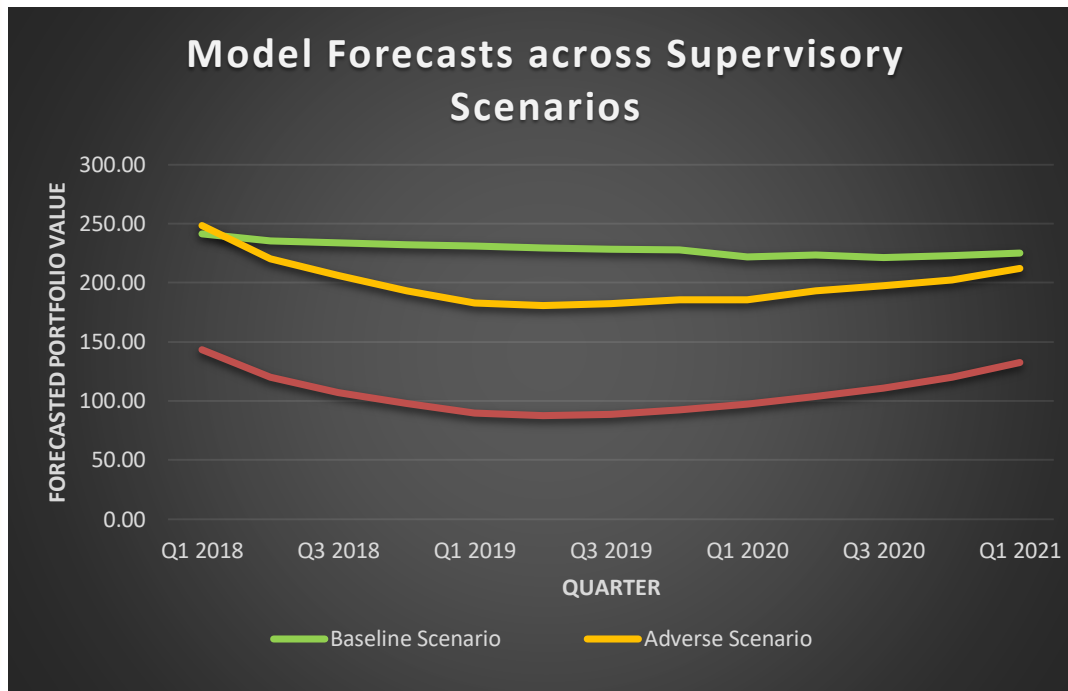
Case Study: IV Forecasts

CRE tends to be significantly lower under severely adverse scenarios

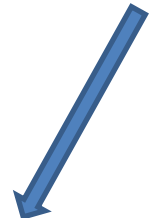


BBB corporate yields tend to be significantly higher under severely adverse scenarios

Case Study: Forecasting & Stress-Testing



Model generates economically intuitive stress forecasts

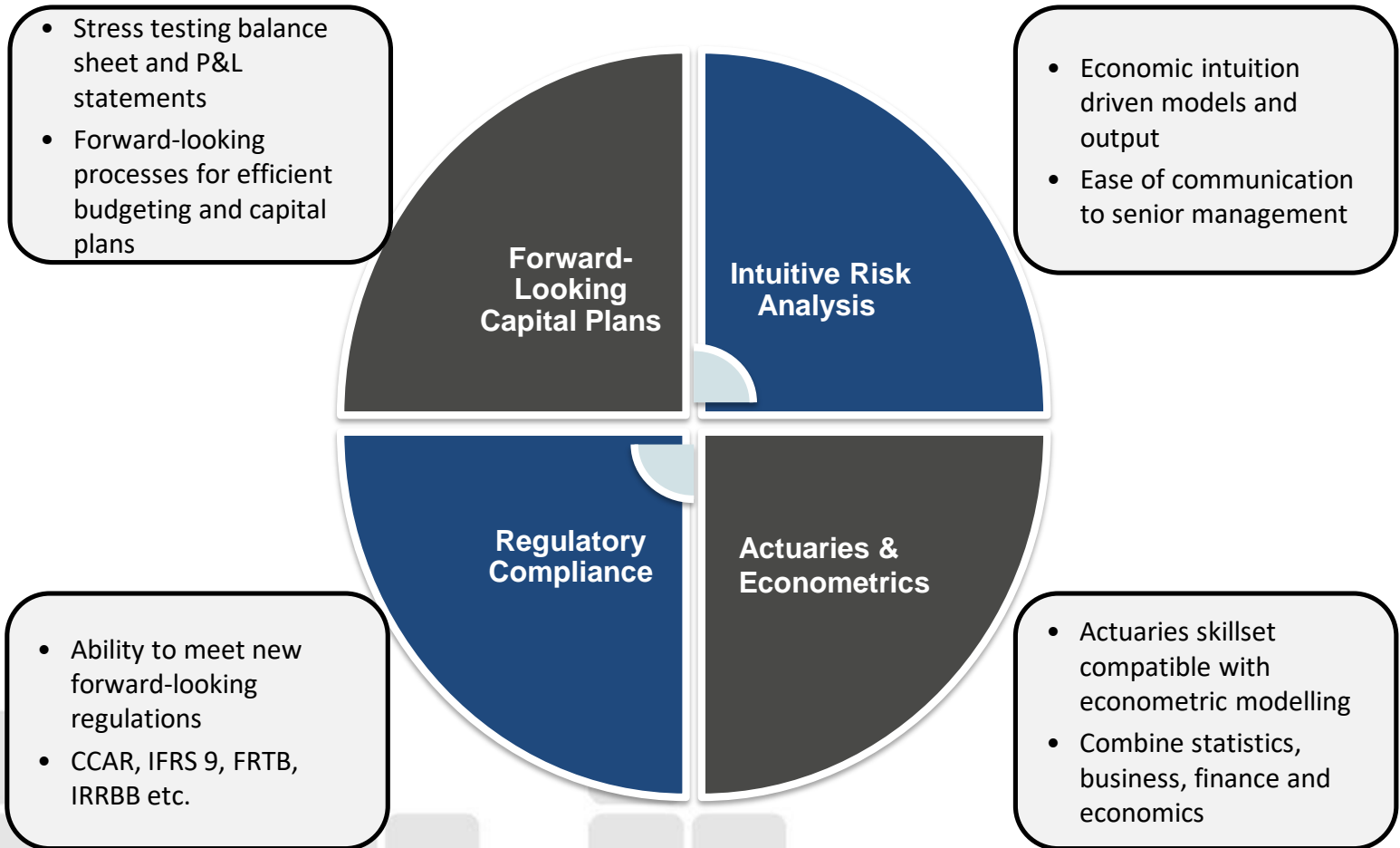


Expected 13Q Loss Under Each Scenario (Millions)			
Initial Portfolio Value (Q4 2017)	Baseline Scenario	Adverse Scenario	Severely Adverse Scenario
273.35	5.18	8.78	17.63

Role of Actuaries in Banking & Finance



Key-Takeways



Reference Material



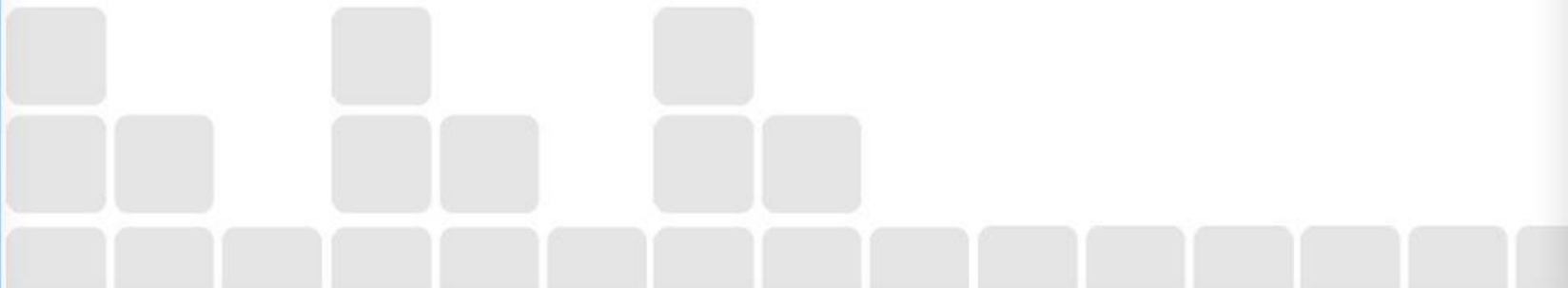
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Q/A



Questions ?

Comments



Thank You

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