

Critical Stress Testing for Time Series Forecasting in Python

FIM 500-001
Group #1

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Introduction

- Stress testing on US equity and debt indices using macroeconomic variables
- Areas of focus
 - Financial Markets
 - Macroeconomics
 - Data Analytics
- Project outcomes
 - Gain more knowledge in the realm of stress testing
 - Utilize python programming

- Selected from the *Yahoo! Finance* database focusing on most popular series
 - S&P 500
 - Wide coverage of sectors within US economy
 - Index methodology
 - Inclusion of large cap companies
 - Acceptance of index among multiple industries
 - Treasury Yield 10 Years (^TNX)
 - Intermediate term maturity
 - Captures short and medium term policy impacts

Data Preprocessing

- Selected 26 macroeconomic indicators from FRED database as independent variables
 - Based on Dodd-Frank Act Stress Test Publications and some other popular indicators
- Data upsampling and downsampling to a uniform month-frequency
 - For two seasonal variables
 - Linear interpolation
 - For nine daily or weekly variables
 - Keep the first data of each month

Macroeconomic Variables Selection

- Focus on monthly variables to perform stress testing for time series
- Chose four macroeconomic variables for each of our dependent variables using the adjusted R-squareds from univariate regressions and the variance inflation factor criteria with a threshold of 10

S&P 500		Treasury Yield 10 Years	
Variable	VIF	Variable	VIF
M2	4.70	Treasury Yield 5 Years	9.98
BBB US Corporate Index Effective Yield	8.46	BBB US Corporate Index Effective Yield	5.35
Federal Funds Effective Rate	3.92	Total Assets	2.75
Crude Oil Prices	5.53	Crude Oil Prices	5.83

- M2 Money Supply
 - Measure of money supply
 - Sensitive to monetary policy decisions
- Crude Oil Prices
 - Reflects global demand
- BBB Corporate Yield
 - Less risky bonds issued by corporations
- Effective Federal Fund Rate
 - Interest rate for lending reserve balances
- 5 Year Treasury Rate
 - Reference used in valuing other securities
- Total Assets (Less Eliminations from Consolidation)
 - Feds can control the amount of assets/liabilities on their balance sheet

Statistical Reasoning for Selected Variables

- The selected variables displayed a high positive or negative correlation with our benchmarks

S&P 500		Treasury Yield 10 Years	
Variable	Pearson Correlation	Variable	Pearson Correlation
M2	0.91	Treasury Yield 5 Years	0.99
BBB US Corporate Index Effective Yield	-0.73	BBB US Corporate Index Effective Yield	0.90
Federal Funds Effective Rate	0.49	Total Assets	-0.85
Crude Oil Prices	0.31	Crude Oil Prices	-0.67

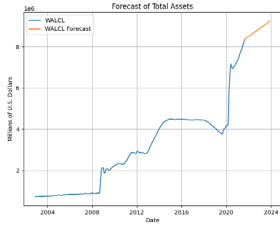
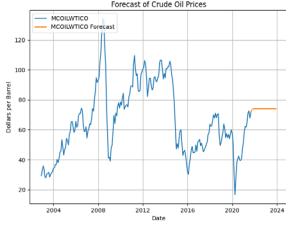
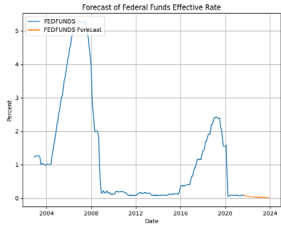
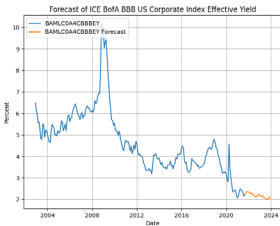
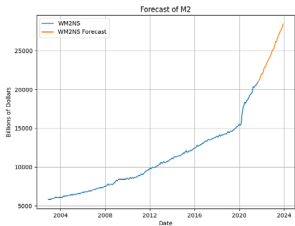
Macro Indicators Forecast

① Standardized Predict Mean Squared Error

$$\widehat{MSE} = \frac{MSE}{\sigma^2}$$

Variable	Holt-Winters Standardized MSE	ARIMA Standardized MSE
M2	0.53	0.60
BBB US Corporate Index Effective Yield	0.24	0.32
Federal Funds Effective Rate	0.10	0.41
Crude Oil Prices	0.46	0.40
5 Year Treasury Rate	0.46	0.53
Total Assets	2.27	2.18

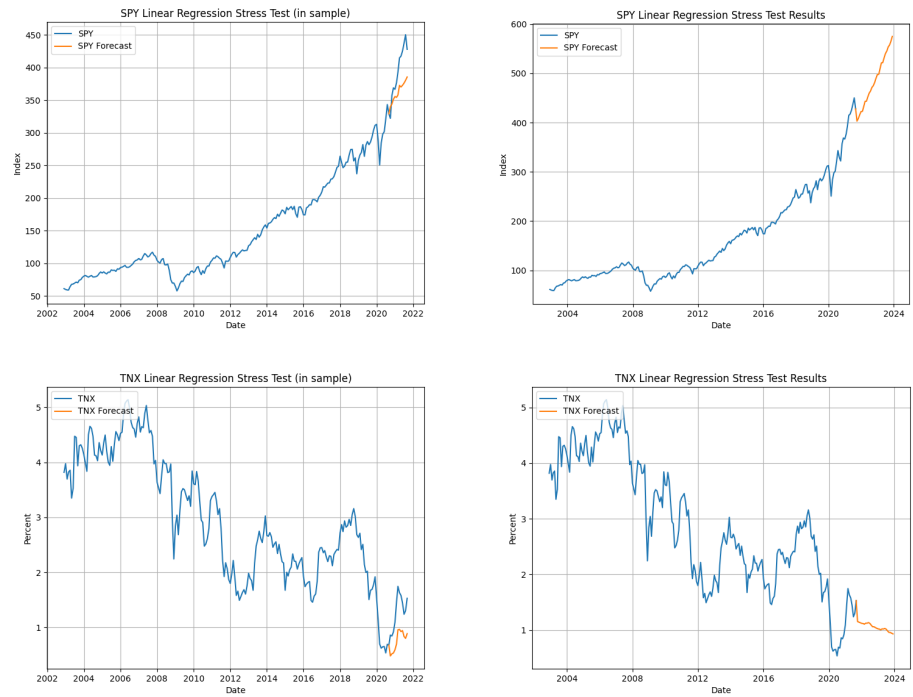
② Out-of-sample Forecast



Critical Stress Testing for Time Series Forecasting in Python

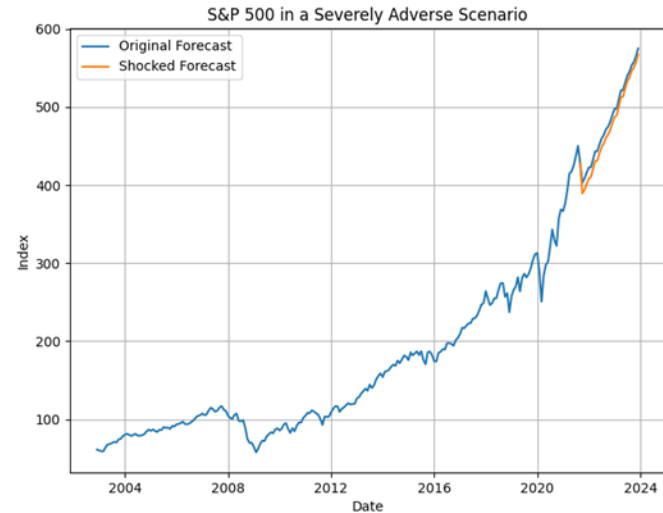
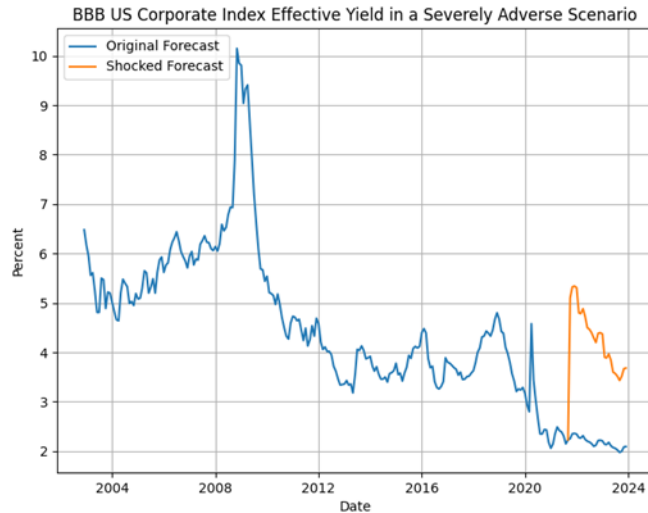
Linear Regression Models for Stress Testing

- These figures show the stress testing results with original and forecasted independent variables



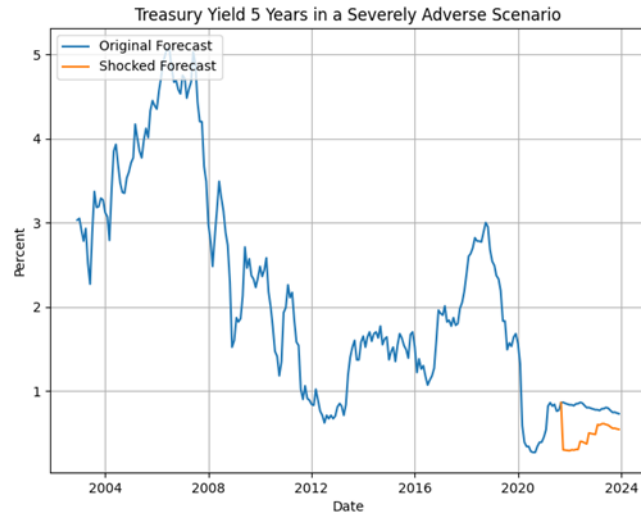
Linear Regression Models for Stress Testing

- Introduce a shock assumed in a severely adverse scenario
 - (based on Dodd-Frank Act Stress Test Publications)

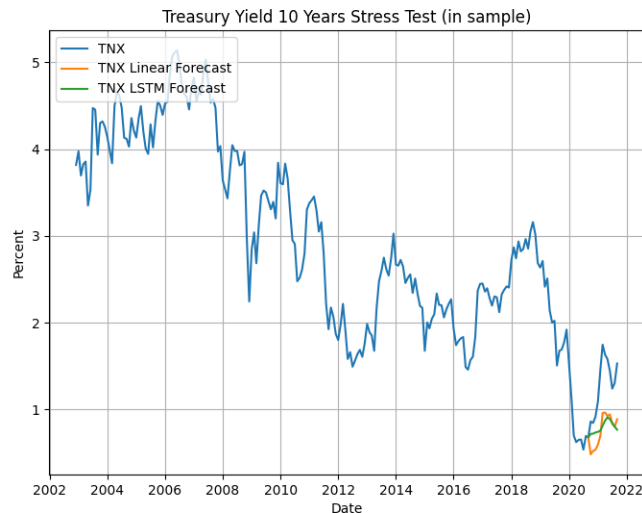
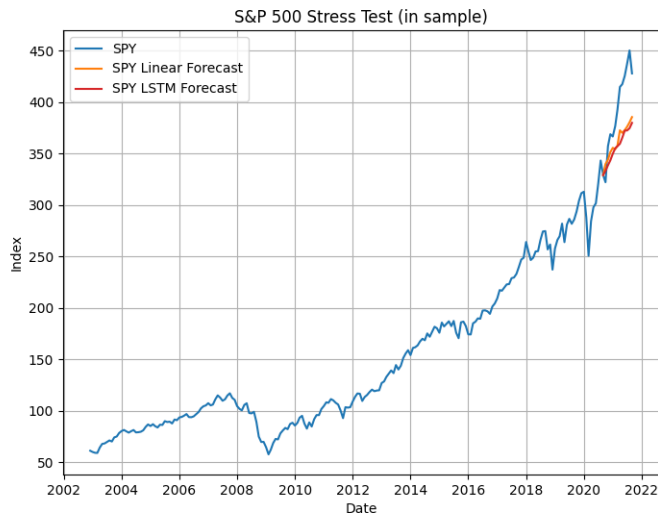


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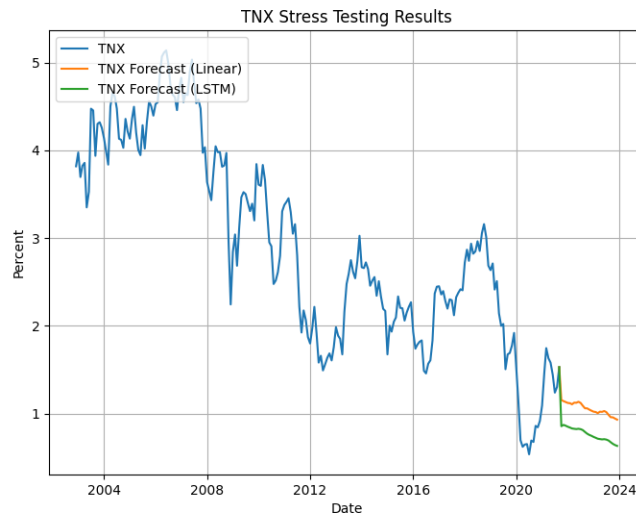
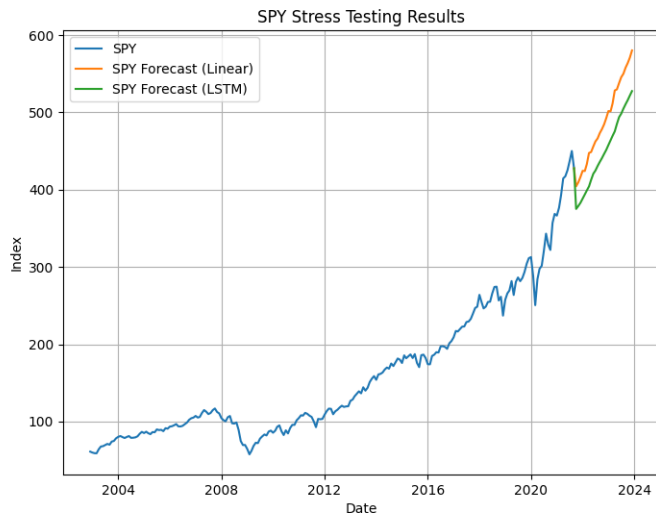


- Compare the results of real-world data, linear regression models and LSTM models



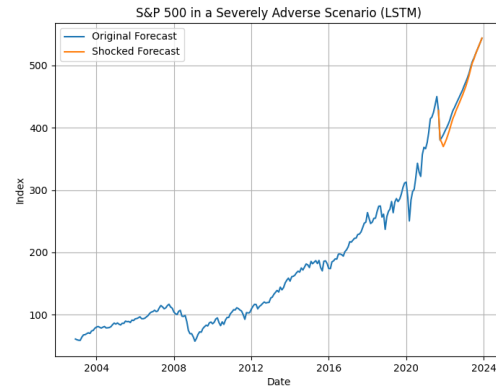
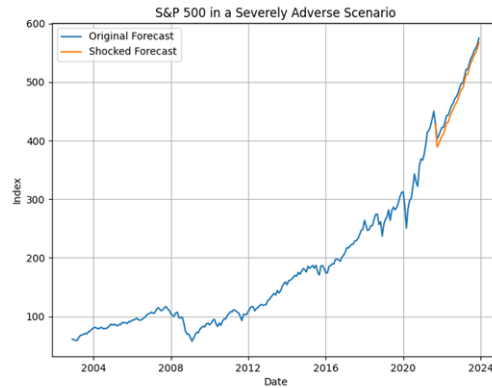
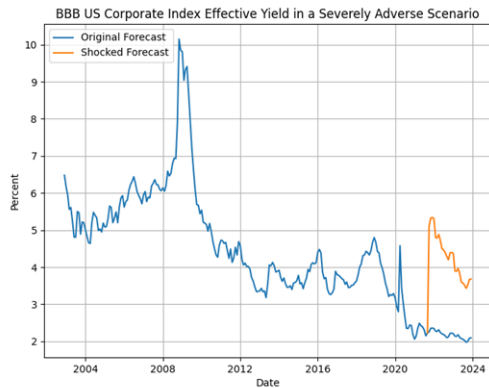
LSTM Models for Stress Testing

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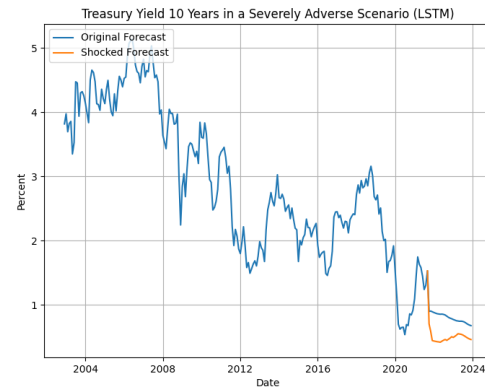
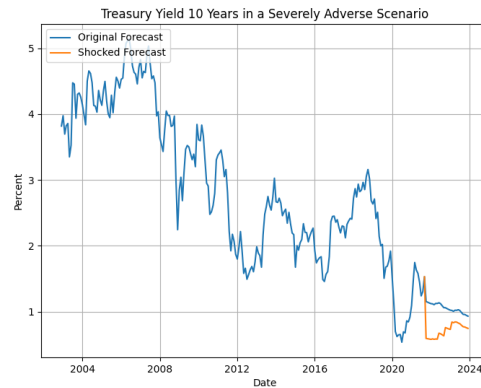
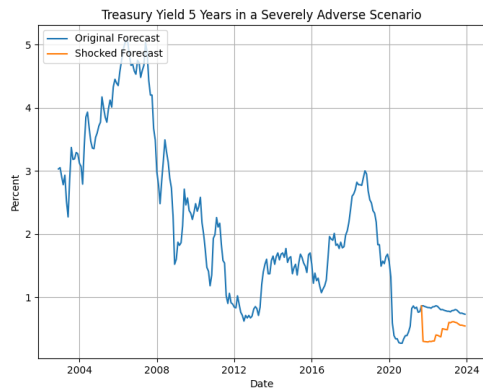
LSTM Models for Stress Testing

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Summary

- Raw data are usually more interpretable than interpolated samples
- As composite macroeconomic responses, the S&P 500 and 10-year treasury yields are affected by many of the same economic variables, of which the impact also act on each other
- The biggest challenges often come from the liquidity risk and interest rate risk arose with macroeconomic shocks instead of a long-lasting downturn
- Although both models had similar conclusions, the LSTM neural network was much more difficult and complex to model on the limited data available

- Apply the PCA method
 - Solve the multicollinearity between macro indicators
 - Maintain the maximum information
 - Compare the results as a experimental group
- Explore the application of other machine learning models and tune the parameters

Thank You For All

We are now open for any questions

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