Team 2

Stress Test Modeling under Capital Plan Rule

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Outline

- Overview of CCAR
- Project - Portfolio Description
- Methodology
- Discussion of Results & Conclusions in different scenarios
- Constraints & Limitations
Overview of Comprehensive Capital Assessment Rule (CCAR)

- CCAR is the Federal Reserve framework for evaluating the risks of Banking and Financial Holding Entities. It provides guidelines for Stress Testing Under the risk exposures of Banking and Financial Entities under Three Scenarios:
  - Baseline: Sustained, Moderated Economic Activity
  - Adverse: Global Weakening in Economic Activity
  - Severe: Substantial Weaken in Global Economic Activity, with a large reduction in asset price

Project - Portfolio Description

- Fixed Income Assets
  - US Treasury 5 year $1,000,000

- Equity Shares
  - Helix Energy Solutions #20000
  - AMC Entertainment Holdings #11000
  - General Electric #16500
  - Apple #10000

- Options
  - AAPL170120P00100000 #100
  - GOOG170120C00730000 #500
  - BA170120C00140000 #60
Methodology - Data Employed

- Quarterly Historical Stock Price (From Yahoo Finance)
  - Apple (From 1980)
  - AMC Entertainment (From 2013)
  - General Electric (From 1962)
  - Helix Energy Solution (From 2011) e.t.c

- Daily Historical Treasury Price (From U.S Department of the Treasury)
  - US Treasury for 3 month, 6 month, 1 year, 1.5 years, 2 years

- Historical volatility of different stocks (From Quandl)
Methodology

- Determine the contribution of historical shock variables on the driving factors of the asset prices and interest rate.
- Model selection for all portfolio assets
  - determine which the shock variables provides strong prediction fit and contributes to dependent variables. Reasonable qualitative and quantitative justifications needed.
  - quantitative factors: t-statics, F-statics, p-values, AIC/BIC as appropriate, R-sq etc.
Methodology

- Forecasting and Prediction of future values - 2016 to 2017 based on selected models for each asset using the scenarios described by:
  - Severely Adverse Market Shocks (Excel)
  - Adverse Market Shocks (Excel)
  - Macro Scenario Tables (Excel)
  - Supervisory Historical Data (Excel)

  as prescribed by the FEDs.

- GARCH Analysis for volatility regression
- Interest rate simulated by Vasicek model
- Calculation of VAR at 99% confidence for the stock price and interest rates under baseline, severe and adverse-severe scenarios to determine if the business has adequate capital and shocks to withstand demands of capital.
- Finally calculate total value our portfolio
Regression, Model Fitting & Selection for Google

Before:
GOOG stock price=-998.2+0.04476*Dow Jones Total Stock Market Index+38.62*Unemployment Rate -14.09*10-yr treasury yield +2.356*House Price Index+2.583*Market Volatility Index-1.128*Real GDP growth
Reasons: drop 10-yr treasury yield since low t statistic
drop real GDP growth since it should be positive related.

After:
GOOG stock price=-972.4+0.04745*Dow Jones Total Stock Market Index+37.28*Unemployment Rate+1.692*House Price Index+2.713*Market Volatility Index.
Vasicek model to simulate interest rate for Google

- Formula: \( r_{i+1} = r_i + \alpha(t, r_i)dt + \beta(t, r_i) \cdot \text{randn} \cdot \sqrt{dt} \)
- Explanation
  - \( \text{randn} \) ~ normal distribution (0,1)
  - The initial \( r_i \) is the forecast \( r \) by regression model for 3 month treasury rate.
  - \( \alpha(t, r_i) \) and \( \beta(t, r_i) \) can be determined based on historical 3 month treasury rate
GARCH Model to forecast volatility for Google

- Formula: \( \sigma_t^2 = a + \sum b_i R_{t-i}^2 + \sum c_j \sigma_{t-j}^2 \)
- Explanation
  - Choose model among GARCH(1,1), GARCH(1,2), GARCH(2,1), GARCH(2,2) based on AIC
Monte Carlo to simulate stock price for Google

- **Formula:** \[ S_{i+1} = S_i \exp((r - \sigma^2/2) \cdot dt + \sigma \cdot \sqrt{dt} \cdot \text{randn}) \]
- **Explanation**
  - randn~normal distribution (0,1)
  - the initial \( S_i \) is the forecast \( S \) by regression model for Google
- **VaR:** take 99% quantile lowest in the stock simulation
Google Stock Prices VAR under 3 Scenarios

<table>
<thead>
<tr>
<th></th>
<th>2016 Q1</th>
<th>2016 Q2</th>
<th>2016 Q3</th>
<th>2016 Q4</th>
<th>2017 Q1</th>
<th>2017 Q2</th>
<th>2017 Q3</th>
<th>2017 Q4</th>
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<tr>
<td>Baseline</td>
<td>397.69</td>
<td>416.01</td>
<td>423.86</td>
<td>397.37</td>
<td>452.84</td>
<td>459.85</td>
<td>468.09</td>
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<td>Adverse</td>
<td>249.25</td>
<td>243.46</td>
<td>230.11</td>
<td>198.25</td>
<td>217.52</td>
<td>214.76</td>
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<tr>
<td>Sever</td>
<td>106.84</td>
<td>107.29</td>
<td>119.38</td>
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<td>173.56</td>
<td>189.01</td>
<td>223.19</td>
<td>236.48</td>
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</table>

![GOOG Chart](chart.png)
Discussion of Results & Conclusions

- Link to results: [https://docs.google.com/spreadsheets/d/1ULlj96qNu3OJK-RkIpHhvGS4WKVLka0u7Lw8j07Nukk/edit#gid=811678971](https://docs.google.com/spreadsheets/d/1ULlj96qNu3OJK-RkIpHhvGS4WKVLka0u7Lw8j07Nukk/edit#gid=811678971)
- Discussion
  - The trend of total value of portfolio goes down by economy goes down.
  - Almost every stock price goes down.
    - exception: AMC, since numbers of historical HV90 are limited.
  - Value of fixed income goes down and up
    - regression forecast of 0.5, 1, 1.5, 2-yr treasury yield under severely adverse scenarios are relatively lower
      - since the forecast data of 0.25, 5, 10 yr treasury yield from Federal Reserve are relatively lower under severely adverse scenario.
  - Related data of the portfolio provides good reference for banks to operate in weak or severely weak economic condition.
    - eg. how much capital to add in the portfolio, how to hedge the portfolio, how to manage their risk in different economic conditions.
Constrains

- Regression model
  - regression then selection v.s. selection then regression
  - selection may not be perfect.
  - limited numbers of historical data makes fitting and forecasting vary
- Evaluation of portfolio
  - consideration the covariance between each asset
Questions