FINM 35000 Problem Set 3: Equity Valuation Stress Testing

Instructor: Joanna Harris, TA: Lisheng Su
Due November 10, 2023, 6PM

Please submit one copy per group of your responses. The submission should include a PDF or Word document with the written results, tables and figures and a separate code file (in a programming language of your choosing). Please use a different font color for responses typed by each group member.[1] Please make sure to write the names of all group members at the top of the writeup (the font color of the names should match each group member's responses). We would like to ask that you make sure your code would run on a third person's computer and submit your input files with your homework.

Stress testing an equity portfolio (100 points)

Project market value changes of an equity portfolio from time0 to time1 based on the changes in the macroeconomic variables (MEVs) from the severely adverse economic domestic scenario of the Federal Reserve's Comprehensive Capital Analysis and Review (CCAR) 2021. Time0 is 12/31/2020 and time1 is 12/31/2021.[2] To make the projections, you may need to map the changes of MEVs from time0 to time1 to the change in values of the stocks from time0 to time1. In addition to the scenario given above,

- Investment instruments: a portfolio of 20 stocks, 10 million shares in each stock.
- Additional scenarios and historical data of the MEVs in the Fed scenarios. The Federal Reserve also provide scenario description narratives.
- Equity and Fama-French factor historical data (total returns), '*returns*' tab in wrds_data.xlsx

1. Build three projection models then compare the approaches and project the changes in the portfolio's value: CAPM, Fama-French, and a "general multi-factor" model. You are required to provide support for your modeling choices where applicable (segmentation[3], variable selection, choice(s) of historical data window, etc.). Your report should provide a clear picture of the modeling development process and modeling choices:
    i. Outline your steps in developing each model.
    ii. Describe your data processing procedures for missing data, data quality and if any, variable transformation. Provide justification if it's necessary to use data

[1] For questions where the output is a figure, you can write a note with the name of the group member that created the figure.
[2] We are pretending that any information after 12/31/2020 is unknown to us when forecasting the stock prices on 12/31/2021. However, you are allowed to use the market data after 12/31/2020 to perform out-of-time (or out-of-sample) back-testing.
[3] You have 20 stocks in your portfolio. Each stock can be modeled individually. Alternatively, you do not have to run regressions on the individual stocks. You can group your stocks into sub-portfolios that share similar risks and then run fewer regressions. However, you must substantiate why you put which stocks into what sub-portfolio.

outside of the data files from the assignment and the data files underlying the links in this document.

iii. Demonstrate your variable selection process in each model supported by economic reasoning based on your understanding in the MEVs.

iv. State the data window for each of your regression model. Perform your regressions using two data sets as if you were doing this homework twice-data from all times and data from only the "stressed times",[4] or else? How do different data choices affect your regression coefficients and forecasts?

v. Define and support the granularity of your modeling. You can model and make projections at the individual stock level, or at the segment level (e.g., industry groups, or by stock style (growth versus value), etc.), or at the portfolio level.

vi. If model at the segment or portfolio level, you may need to construct a synthetic time series for the segment or portfolio returns. The total return data of each stock goes back to as far as 1963. However, the market weight data of each stock does not go back that far (see '*prices'* tab in wrds_data.xlsx). Use judgment or arbitrarily assign weights when constructing the synthetic portfolio total return time series.

vii. Provide rationale for your selection(s) of the equity market variable, the MEVs, and the time window of historical data used in the regressions. For example, the data file, wrds_data.xlsx ('*returns*' tab), contains historical equity and market data for CAPM and Fama-French. The Fed historical data also contains equity market data. (Hint: You may need to choose an equity market index from different sources)

viii. Perform stationarity test(s) on the MEVs and transform the data if necessary and, in your own words, discuss stationarity testing is necessary in your modeling process.

ix. In the stress test, you will need to build a two-step regression for the 3-factor Fama-French model. In the first step, regress Fama-French factors as functions of the MEVs in the Fed scenario. In the second step, combine your regressions into the Fama-French model and project the time1 portfolio value in the scenario.

[4] Think stressed times as the time periods of severe bear markets or extreme equity market losses. Therefore, your stressed times dataset can contain from data windows, e.g., data from around 1987 and around 2008. Apparently there are other stressed times. You will need to look through the data history to determine which ones they are.

x. The general multi-factor model (GMF): Model the equity portfolio's scenario values directly as a function of the MEVs provided in the Fed scenario and project the time1 portfolio value in the scenario.

xi. Conduct performance testing for each model. You may need to use these tests to guide yourself to go through an iterative process to improve model performance:
    - Goodness of fit.
    - Residual analysis.
    - At least one more test to support the robustness of your models.

xii. Finally the forecast portion in your report should contain a summary of projection outcomes (%return and $value change) from the three modeling approaches (i.e., CAPM, Fama French, and GMF).

2. Model risk assessment and controls
    i. Outcome analysis to substantiate the reasonableness of the projection outcomes
        - Back-test your portfolio value projections and discuss the reliability of each modeling approach based on the projections.
        - Discuss the benchmarking results by comparing the reasonableness of each model's projections. Which model performs the best? Why?
    ii. Discuss the potential model risks as the sources of uncertainties in the forecasting process
        - Model complexity and interpretability
        - Discuss how model search might cause uncertainties in the forecasts
        - Which model is more prone to the Law of Small Numbers? Why?
3. Repeat necessary steps in 1 and 2 for the supervisory baseline domestic scenario. Compare the forecasting results from the two scenarios.

Bonus portion (Optional for extra credit. Must be completed individually. 15 points)

There are two choices of earning the bonus points. Successfully completing one will get you 15 points. Successes on both will not earn 30 bonus points but may provide you advantages in the job market.

a. Incorporate the out-of-time (or out-of-sample) testing in your model development process. Obtain your own data after 12/31/2022 and submit your data files.

b. Read SR letter 11-7, name the three major pillars in model risk management, and in your own words discuss the significance of each pillar in your forecasting process.

Potentially beneficial references:

- Ken French publishes on his website SMB and HML returns with risk free rate. You may need to read the construction method. The website also contains additional information.
- Recommended text for multi-factor modeling: ISLR, G.James, D. Witten, T.Hastie, R.Tibshirani, Springer 2013