Optimization Methods in Finance

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Objective and Rules

This course is evaluated on the basis of an assignment. This assignment aims at developing and training your data optimization skills needed as an applied financial economist.

The assignment consists of (i) using various optimizers to find the maximum of an objective function, (ii) analyzing textual data, (ii) estimating a GARCH model and performing a small-scale return/risk analysis of a security, and (iv) optimizing portfolio weights according to a minimum variance criterion and (v) analyzing the return impact of portfolio choices in a backtest.

The assignment can be done individually or in groups of maximum four students.

The analysis has to be done with R/Rstudio. The code to be used is similar to the one in class.

The report needs to be presented in a professional and visually attractive way (concise, clear, complete). The R scripts that allow to replicate the analysis should be attached to the report. Please make sure that the plots have clearly defined labels.

The report needs to be handed in by email to: kris.boudt@ugent.be, at the latest by November 30, 2022

PART I: Optimizing a function using the grid search, quasi-Newton and Differential Evolution optimization methods

In the course, we have seen various approaches to find the maximum of an objective function.

Explain in your own words the optimization using (i) grid search, (ii) quasi-Newton optimization and (iii) differential evolution. Use all three methods for finding the maximum for the function fn below. What is the solution you obtain?

```
fn <- function(x){
  return( -x^4 + 3*x^3 + 9*x^2 + 23*x + 12 )
}
vx = seq(0,6,0.01)
plot(vx,fn(vx),type="l")
```

PART II: Characterizing the return/risk profile of a single security

Congratulations, you have received a mandate to study the history, fundamentals and price behavior for the company Chevron with ticker CVX.

Initial analysis:

1. Present in five lines the business model of that company.

2. Study the history of the firm over the period January 1 2004 – August 31, 2022 and identify the major events that could have affected the price and return volatility over that period.

3. Download the adjusted close price series from Yahoo!Finance for this period. Plot the price series and discuss the evolution of the price series over time, connecting the large price movements to important macroeconomic and/or firm-specific events.

4. Select two subperiods of 6 months which have been critical for the company. Explain why you selected those periods. Plot the prices for that subperiod. Compare the distribution of returns of those two subperiods with the distribution of the returns over the complete period.

5. Compute the daily log-returns and discuss the dynamics in the (annualized) rolling mean, and standard deviation statistics using a 3-month window and the function chart.RollingPerformance. Discuss the persistence in the series and also discuss the triggers for the major movements in the obtained annualized mean and standard deviation statistics.

6. Use rugarch to estimate the GARCH(1,1) model with normal innovations and constant mean.

6.1 Write down the estimated mean-variance model.

6.2 Compute the daily volatility forecasts using the estimated GARCH model. Plot those forecasts and discuss the periods of low and high volatility. Are they as expected? Is it driven by mostly aggregate macroeconomic uncertainty or do you also find periods of firm-specific uncertainty?

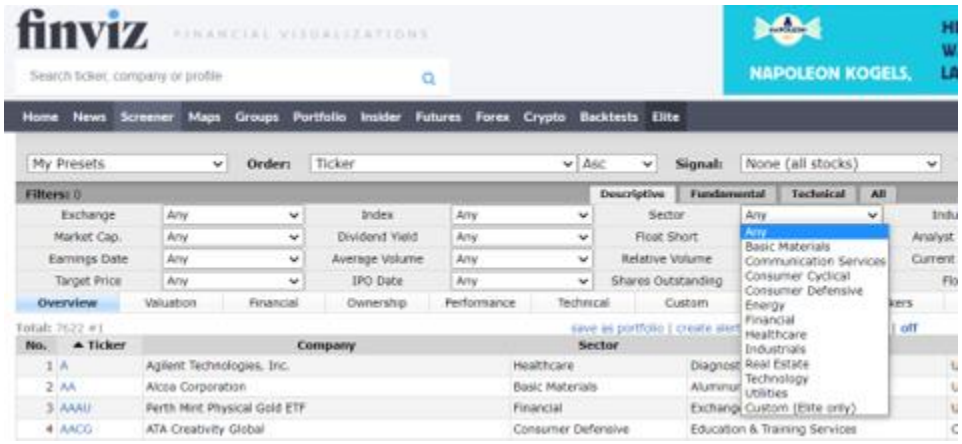
6.3. How much is the predicted 5% daily value-at-risk for the last day of your data? Suppose volatility doubles, how much will be the new level of value-at-risk? Suppose the investor has a portfolio of 1,000,000$, how much is the value-at-risk expressed in US Dollars?

7. For which type of investor would you recommend investing in this company? Explain your choice and motivate this by referring to the estimation results obtained already (in particular the level of annualized volatility) and use the information on the firm fundamentals available at Yahoo!Finance and/or http://finviz.com/screener.ashx (among others: volume, price/earnings, the stock's beta, analyst recommendations, etc.)

Portfolio analysis:

8. Congratulations, you have received a mandate to implement an original portfolio strategy invested in US stocks and ETFs under the following:

- The portfolio needs to contain 5 stocks and 5 ETFs (each of them needs to be publicly listed since at least January 2004)
- The stocks need to include the company you analyzed above as well as four other stocks that belong to the same sector. Check this on finviz:



Download the monthly (adjusted) price series of those stocks and ETFs for the period 2003-12-31 till 2022-08-31, together with the price series of the S&P 500.

10. For each of the stocks, compute the mean and volatility of the monthly (simple) returns for the overall period. Plot those numbers in a scatter diagram. Then add the efficient frontier with weights constrained to be between 0 and 1, as well as the efficient frontier with weights constrained to be between 0 and 15%. Interpret the effect of the weight constraints.

11. Focus on the long only, fully invested minimum variance and maximum Sharpe ratio portfolio weights under the conditions of full investment, long-only and maximum 15 per cent. Are the weights as expected? Why (not)? Are the portfolio constraints binding? Do you find the portfolios well-diversified?

12. Perform an out-of-sample backtest evaluation using the monthly returns on the minimum variance and maximum Sharpe ratio investment strategy over the period 2011-01-01 till 2022-08-31 (assuming monthly rebalancing to reset the weights to the optimized weights, no transaction cost and no re-estimation of the weights). Compare it with the performance of the S&P 500 and an equal-weight strategy (based on full sample return statistics and rolling absolute and relative performance charts). Interpret each of the tables and plots that you report.

13. What is the portfolio investment advice that you give to the investor who has given you the mandate? Is your active selection (compared to the S&P 500) to be recommended? In your answer, please use also economic arguments referring to the current market regime (volatility, economic growth, low interest rates,…) and explain for which investment horizon your recommendation is valid.