Assignment 1: Portfolio VaR & ES

Quantitative Financial Risk Management

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1 Setup

For this assignment, your group will have to measure and predict Value-at-Risk (VaR) and Expected Shortfall (ES) for a portfolio of assets. These assets should be 'interesting', that is that your portfolio should have exposure to both stock price variation, interest rates, and exchange rate uncertainty.

Hence, your portfolio needs to contain:

1. stocks or market indices (3-5), but not all denominated in the same currency.
2. a loan, against e.g. the LIBOR or EURIBOR + credit spread
3. or, instead of a loan, a cash component, receiving a floating interest rate.
4. around 8-10 years of daily data

2 Tasks

2.1 General tasks

For your data, you wil

1. synchronise the data, such that you have a sample with full information on all portfolio constituents for all days (either by filling in mock data for singular missing observations, ore removing dates for which too much information is missing)
2. choose the portfolio weights, and fix them
3. then evaluate the VaR and ES of the portfolio at the 1-day horizon, using a range of methods
4. backtest your VaR and ES, comparing the number of VaR violations per year to the expected number of violations, and the average ES per year against the actual average shortfall. Investigate the dependence in the violations at least graphically.
5. do 5- and 10-day VaR (see below)

6. perform stress testing (see below)

The methods to consider are

1. Variance-Covariance method based on the multivariate normal distribution
2. Variance-Covariance method based on the multivariate Student-t distribution using 3, 4, 5, or 6 degrees of freedom. Use QQ-plot to judge what DF would seem to fit best
3. Historical simulation
4. GARCH(1, 1) with Constant Conditional Correlation
5. Filtered Historical Simulation with EWMA for each risk factor

For each of the methods, do take into account the length of the sample you choose: Should you use the full sample, or only non-crisis periods, or only crisis period? What effect does it have on the outcomes?

2.2 Multi-day VaR

Use the historical simulation method to compute the 1-, 5- and 10-days VaR, using non-overlapping data. Then extend the historical 1-day VaR with the square-root-of-time rule to the 5- and 10-days predicted VaR, and compare. Does this square-root-of-time rule give a decent outcome for your portfolio?

2.3 Stress testing

What can happen in extreme cases? That is something of utmost interest to your supervisor in your bank. Test this out on the portfolio and your resulting VaR, by considering, individually,

- Equity index values or stock prices changing by +/- 20% and +/- 40% of the current values
- Currencies moving by +/- 10% for major currencies and +/- 20% for other currencies
- Commodity prices changing by +/- 20% and +/- 40% of the current values
- Interest rates shifting by +/- 2% and +/- 3%

3 Expected output

In your group of 4, write a concise report containing your findings, illustrated by graphs (where necessary and/or appropriate) and tables of results. For examples, consult McNeil, Frey, and Embrechts (2015, §9.3.4), especially Tables 9.1, 9.2, and Figures 9.5, 9.6.

Keep thinking, in the report and in your analysis, what a risk analyst would do, what VaR or ES approach would be best. So do end your report with a set of recommendations for further actions.

Hand in the report in PDF format, plus clear code + data that I can consult.

Concerning the code: You will not be able to perform the exercise using only excel, hence you have to choose your own programming environment. The choice of environment/language is up to the group, though Python may be preferred for easier communication within the course.

References

McNeil, A. J., R. Frey, and P. Embrechts (2015). *Quantitative Risk Management: Concepts, Techniques, and Tools*. Revised. Princeton: Princeton University Press. ISBN: 978-0-691-16627-8.