Financial Risk Management

Spring 2021

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Individual Assignment 1

Due on April 13 (Tuesday) 2021 before 11:59 p.m.

Please upload to iLMS

[Part I: Python for finance]

[Note: You need to submit your Python code]

1) Collect data on the S&P 500 Index from Yahoo Finance, and five individual stocks: (1) Apple Inc., (2) Microsoft Inc., (3) Starbucks Inc., (4) McDonald's Corporation, and (5) Tesla Inc. The data to be collected is "daily" data from 2011/03/22 to 2021/03/22. You are required to write problems by using Python to (1) Compute statistics: Mean, Standard Deviation, Minimum, Maximum, Skewness, Kurtosis and (2) Plot probability density distribution. In addition, you are required to provide the discussion by comparing these figures.

2) Suppose you invest in a portfolio that consists of five individual stocks: (1) Apple Inc., (2) Microsoft Inc., (3) Starbucks Inc., (4) McDonald's Corporation, and (5) Tesla Inc. Calculate **VaR (1-day, 95%)** of a portfolio equally invested in these four stocks. Portfolio market value is USD 100 million.

- Compute VaR on this portfolio based on four methods
  (1) Full covariance model
  (2) Diagonal model (with one factor and the one factor is the stock market index)
  (3) Beta model (with one factor and the one factor is the stock market index)
  (4) Undiversified model (i.e., the summation of individual VaR on each assets)
  You are required to collect data on the S&P 500 Index for the stock market index and the data on these four stocks from Yahoo Finance. The data to be collected is "daily" data from 2011/03/23 to 2021/03/23, and these data are to estimates parameters you need to compute VaR on the four models.

(3) Historical Simulation Method

Use the **Historical Simulation method** to compute **VaR (1-day, 95%)** for (1) Apple Inc., (2) Microsoft Inc., (3) Starbucks Inc., (4) McDonald's Corporation, and (5) Tesla Inc. The data to be collected is "daily" data from 2011/03/22 to 2021/03/22. Please use the 2-year window to compute VaR. That is, the first VaR is identified on March 25, 2013, where it uses the data subsample from March 22, 2011 to March 22, 2013, and the second VaR is identified on March 26, 2013, using subsample from March 23, 2011 to March 25, 2013, and so on.

(i) You should calculate the indicator "hit" sequence for historical simulation models. The hit sequence takes on the value 1 if the return is below the VaR and 0 otherwise.

(ii) Discuss whether using the Historical Simulation method to compute VaR for the is suitable or not.

[Note: Collect data in Yahoo Finance. And please refer to the example I provided in the class (excel file, named, HS_backtest_S&P500).]

(4) Monte Carlo Simulation Method

Please replace the Historical Simulation Method with the Monte Carlos Simulation Method and answer all the above questions.

Also, you need to discuss which method (the HS or the MC) is the most suitable one in terms of the daily VaR for Amazon.

[Note: Please refer to the example I provided in the class (excel file, named, MC_VaR_S&P500_WCC).]

[Pat II: Solve the questions

Note: You CANNOT use software. You NEED to "type" or you can write down on the papers and scan them.]

Question (1)

Consider a portfolio equally invested in two assets: TESCO and MORRISON. Portfolio market value is 100 million. The annualized volatility for TESCO stock returns is 40%, and the annualized volatility for MORRISON stock returns is 30%. The correlation between TESCO and MORRISON stock returns is 0.8. Use this information to answer question (1.1) and question (1.2).

1.1) Calculate the VaR on each asset and the VaR on the portfolio based on the full covariance approach assuming normally distributed returns with a 95% confidence level for a 10-day holding period and 250 business days in a year**.**

1.2) Compute VaR of the portfolio based on the **beta** model with one common factor assuming normally distributed returns with a 95% confidence level for a 10-day holding period and 250 business days in a year**.** The only factor affecting stock returns is the market, and the daily volatility of the market (σ_m) is 0.03. The market exposure (β) for TESCO is 0.5, and for MORRISON is 0.2.

1.3) VaR on a portfolio can be measured by four approaches: (1) VaR (full covariance), measured by the full covariance model; VaR (Diagonal model with one common factor) (3) VaR (beta model with one common factor); (4) VaR (undiversified measured by adding up all individual VaRs. You are required to rank the VaRs computed based these four approaches and provide a theoretical discussion on the rank you provide.

Question (2)

2.1) A report mentions that the VaR (Value at Risk) for a portfolio is $2.5 million over one month and at the 99% confidence level. Based on the definition of VaR, what does this report indicate?

2.2) Consider a zero coupon bond with 5 years maturity with face value $100. The internal rate of return (IRR, y) is 2% and the daily volatility of the IRR is 0.0008 (8 basis points). Compute the dollar VaR based on the duration model over 1-day and under 99% confidence level.

Question (3)

Explain under what circumstances is NOT valid the "square root" rule for computing n-day (e.g. 10 days) VaR using 1 day VaR (see Danielsson and Zigrand (2006). and Diebold et al. "Converting 1-day volatility to h-day volatility: scaling by root-h is worse than you think". Wharton Financial Institutions Center. Working Paper 97-34))

References

[1] Danielsson, J., & Zigrand, J. P. (2006). On time-scaling of risk and the square-root-of-time rule. *Journal of Banking & Finance, 30*(10), 2701-2713.

[2] Diebold, F. X., Hickman, A., Inoue, A., & Schuermann, T. (1997). Converting 1-day volatility to h-day volatility: scaling by is worse than you think. *Penn Institute for Economic Research Working Papers*, 97-030.

Question (4)

A bank sells one call option on stock X and one put option on stock Z. X market value is $50, strike price is $51, volatility is 28% (annual) and time to maturity 9 months. Z market value is $20, strike price is $19, volatility is 25% (annual) and time to maturity is 1 year. No dividends are paid. One-year risk free rate is 6%. Correlation between assets Z and X returns is 0.4. Calculate portfolio's VaR (99%, 10 days):

4.1) Using only the delta-normal method to compute VaR

[Hint: The delta for call and put options are $\Delta(call) = N(d_1)$ and $\Delta(put) = N(d_1) - 1$, where $N(\cdot)$ is normal cumulative density function, and $d_1 = \left[\ln(S_t/K) + \left(r + (1/2)\sigma^2\right)(T-t)\right] \Big/ \left(\sigma\sqrt{(T-t)}\right)$. **]**

4.2) Compute the VaR required in the question (4.1) by using Monte Carlo simulation method. **[Bonus question!]**