Homework

Quantitative Methods, Fall Semester 2018

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Simulation of Financial and Electricity Market Data

MBF-Students with last name beginning with A to L are requested to concern themselves with financial market data; M to Z will base their homework on electricity market data ('Umlaute', e.g. 'Ö', are treated like the related vowel, e.g. 'O').

Financial Market Data (A - L):

Financial time series (weekly data from 14th Aug 2009 to 17th Aug 2018) are provided on StudyNet in the files:

- TimeSeries_I.xls
- TimeSeries_II.xls

Matriculation number:

The last three numbers of your matriculation number define the two times series (assets) you have to work with.

Exemplary matriculation number: 04 762 526
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xyz

1. Number 'x' defines the currency of your time series:

   CHF if x = 0, 3, 6 or 9
   EUR if x = 1, 4, 7
   USD if x = 2, 5 or 8

2. Number 'y' defines your "first asset" out of the file TimeSeries_I.xls:

   Take the **yth index** in the "correct" currency. (Example: USD_I_2)

3. Number 'z' defines your "second asset" out of the other file TimeSeries_II.xls:

   Take the **zth index** in the "correct" currency. (Example: USD_II_6)

Tasks for Financial Market Data (A-L):

1) Descriptive Statistics

a) Generate the time series of continuous returns (r_1, r_2) associated with the "two assets" for the data history 14th Aug 2009 to 17th Aug 2018.

b) Calculate the (expected) weekly returns $(\bar{r}_1, \bar{r}_2)$ and the weekly standard deviations (σ_1, σ_2) for these two time series generated in step 1a) for the respective data history.

c) Calculate and interpret the kurtosis (k_1, k_2) and the skewness (s_1, s_2) for the two time series (generated in step 1a).

d) Compute the variance-covariance matrix (Σ) and their correlation matrix (ρ_{12}) for the two time series generated in step 1a). In addition compute the Spearman rank correlation for the two time series (generated in step 1a) and discuss the results.

e) Apply the transformation f(x) = 100*exp(x) to the two time series you have generated in step 1a). Compute the variance-covariance matrix (Σ) and their correlation matrix (ρ_{12}) for this two transformed time series. In addition compute the Spearman rank correlation for the transformed two time series and compare the results with those you have achieved in step 1d). Discuss your observations.

2) Descriptive Statistics for quartile ranges

a) Determine with respect to the first component the four quartile ranges of the two-dimensional return time series generated in 1a). Evaluate the variances and correlations for each quartile range.

b) Determine with respect to the second component the four quartile ranges of the two-dimensional return time series generated in 1a). Evaluate the variances and correlations for each quartile range.

c) Discuss your observations from the results in 2a) and 2b).

3) Cholesky Decomposition

Use Excel, MatLab or another software to apply the Cholesky decomposition and show the result. Apply the Cholesky decomposition to the covariance matrix (Σ) and call the new matrix D. Remember: $\Sigma = DD'$. (**Remark:** If you decide to use Excel, you need to define a new function. Create a new macro [Visual Basic, Insert, Module] with the code given on StudyNet in the file 'Cholesky.txt'. The command is then '=Cholesky( )'.)

4) Random Numbers

a) Generate 1040 pairs of random numbers $X = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$ that are $N(\xi, \Sigma)$-distributed, where $\xi = \begin{pmatrix} \bar{r}_1 \\ \bar{r}_2 \end{pmatrix}$ are the expected weekly returns evaluated in step 1b). Recall: $X = \xi + DZ$. Plot these random numbers in a scatter diagram and interpret the point cloud.

b) Calculate the moments – expected return $(\bar{r}_{s,1}, \bar{r}_{s,2})$, standard deviation $(\sigma_{s,1}, \sigma_{s,2})$, kurtosis $(k_{s,1}, k_{s,2})$ and skewness $(s_{s,1}, s_{s,2})$ – as well as the variance-covariance matrix (Σ_s) and correlation matrix $(\rho_{s,12})$ of the two simulated time series, each composed of 1040 random numbers. Compare them with the historical moments of steps 1b) and 1c) and discuss.

c) Determine and interpret the weights $W = \begin{pmatrix} w_1 \\ w_2 \end{pmatrix}$ of the minimum variance portfolio. Estimate the expected weekly return of the minimum variance portfolio $(\bar{r}_p)$ as well as its 95%-confidence interval with respect to the expected value **and** the return realization.

5) Simulation

Consider the 1040 pairs of random numbers as 20 paths, each path covering a period of 52 weeks. Evaluate, plot and interpret the profit and loss distribution (P&L-distribution) of your minimum variance portfolio after 52 weeks – you need not to rebalance the portfolio when simulated. (Set the initial asset prices to $p_1 = 100$, $p_2 = 80$ and apply the weights.)

6) Summary

Summarize all your findings and interpretations on two A4-pages. Submit a pdf-document with only these two pages (no further excel sheets or pages) via Studynet by **18th November 2018**, at the latest**.** Choose the filename of the pdf-document in the style "HW_QM17_matriculation-number_ Name.pdf". Make sure that your name as well as your matriculation number is also written in the headlines of both pages of the document.

Note: The submission is closed automatically after the deadline.

Electricity Market Data (M - Z):

The electricity time series (daily data from 1st Jan 2011 to 31st July 2018) are provided on StudyNet in the file:

- TimeSeries_III.xls

Matriculation number:

The last three numbers of your matriculation number define the two times series you have to work with.

Exemplary matriculation number: 04 762 526
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xyz

1. Number 'x' defines the exchange your time series originates from:

   EPEX (Germany) if x = 0 - 4
   EXAA (Austria) if x = 5 - 9

2. Number 'y' defines your "first asset" out of the file TimeSeries_III.xls:

   Depending on 'y' you choose the time series of electricity to be delivered in **hour i**. This index is determined by '13-y'. (Example: if y = 2; i = 13 - 2 = 11; you choose the time series of hour 11)

3. Number 'z' defines your "second asset" out of the file TimeSeries_III.xls:

   Depending on 'z' you choose the time series of electricity to be delivered in **hour j**. This index is determined by '23-z'. (Example: if z = 6; j = 23 - 6 = 17; you choose the time series of hour 17)

Tasks for Electricity Market Data (M-Z):

1) Descriptive Statistics

a) Generate the time series of continuous returns (r_1, r_2) associated with the "two assets" for the data history 1st Jan 2011 to 31st July 2018.

b) Calculate the expected daily returns $(\bar{r}_1, \bar{r}_2)$ and the daily standard deviations (σ_1, σ_2) for these two time series generated in step 1a) for the data history.

c) Calculate and interpret the kurtosis (k_1, k_2) and the skewness (s_1, s_2) for the two time series (generated in step 1a).

d) Compute the variance-covariance matrix (Σ) and their correlation matrix (ρ_{12}) for the two time series generated in step 1a). In addition compute the Spearman rank correlation for the two time series (generated in step 1a) and discuss the results.

e) Apply the transformation f(x) = 100*exp(x) to the two time series you have generated in step 1a). Compute the variance-covariance matrix (Σ) and their correlation matrix (ρ_{12}) for this two transformed time series. In addition compute the Spearman rank correlation for the transformed two time series and compare the results with those you have achieved in step 1d). Discuss your observations.

2) Descriptive Statistics for quartile ranges

a) Determine with respect to the first component the four quartile ranges of the two-dimensional return time series generated in 1a). Evaluate the variances and correlations for each quartile range.

b) Determine with respect to the second component the four quartile ranges of the two-dimensional return time series generated in 1a). Evaluate the variances and correlations for each quartile range.

c) Discuss your observations from the results in 2a) and 2b).

3) Cholesky Decomposition

Use Excel, MatLab or another software to apply the Cholesky decomposition and show the result. Apply the Cholesky decomposition to the covariance matrix (Σ) and call the new matrix D. Remember: $\Sigma = DD'$. (**Remark:** If you decide to use Excel, you need to define a new function. Create a new macro [Visual Basic, Insert, Module] with the code given on StudyNet in the file 'Cholesky.txt'. The command is then '=Cholesky( )'.)

4) Random Numbers

a) Generate 1200 pairs of random numbers $X = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$ that are $N(\xi, \Sigma)$-distributed, where $\xi = \begin{pmatrix} \bar{r}_1 \\ \bar{r}_2 \end{pmatrix}$ are the expected daily returns evaluated in step 1b). Recall: $X = \xi + DZ$. Plot the random numbers in a scatter diagram and interpret the point cloud.

b) Calculate the moments – expected return $(\bar{r}_{s,1}, \bar{r}_{s,2})$, standard deviation $(\sigma_{s,1}, \sigma_{s,2})$, kurtosis $(k_{s,1}, k_{s,2})$ and skewness $(s_{s,1}, s_{s,2})$ – as well as the variance-covariance matrix (Σ_s) and correlation matrix $(\rho_{s,12})$ of the two simulated time series, each composed of 1200 random numbers. Compare them with the historical moments of steps 1b) and 1c) and discuss.

c) Determine and interpret the weights $W = \begin{pmatrix} w_1 \\ w_2 \end{pmatrix}$ of the minimum variance portfolio. Estimate the expected daily return of the minimum variance portfolio $(\bar{r}_p)$ as well as its 95%-confidence interval with respect to the expected value **and** the return realization.

5) Simulation

Consider the 1200 pairs of random numbers as 20 paths, each path covering a period of 60 days. Evaluate, plot and interpret the profit and loss distribution (P&L-distribution) of your minimum variance portfolio after 60 days – you need not to rebalance the portfolio when simulated. (Set the initial asset prices to $p_1 = 100$, $p_2 = 80$ and apply the weights.)

6) Summary

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