MF821 Individual Project: Pairs Trading

Project Description

In this project, we aim to implement the pairs trading strategy using two groups of intra-day exchange rate time series. These time series are price data for two closely related products: e.g. pairs of highly correlated stocks, spot fx rates and future fx rates, brent and WTI crude prices, etc. Since they reflect information of the very similar fundamental, they are closely related. You will select a relevant pairs, will construct a pairs trading strategy and test its performance out of sample in QuantConnect.com

For other important details including, due dates and grading schemes, please see Blackboard assignment modules.

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Project Details

Data:

You have access to market data for equities (stocks), ETF, FX and futures. Please see QuantConnect.com for details on data access.

Outline of the project:

The following is an outline of what you need to do. Some of the description is intentionally vague. You are encouraged to go beyond of the following outline. Exercising creativity is highly encouraged.

Note: all coding should be done in one python notebook, as always.

1. Data preparation, selection of pairs and illustration Prepare data as follows: a) Use a quantitative and systematic method to screen the universe of securities for pairs trade candidate. You may use heuristic rules, or rigorous statistical filters--it is up to you. b) You can choose data frequency from minute bar to daily. Please avoide higher (than minute bar) or lower (than daily) frequency for this project. c) Make sure you have good bid/ask prices and decent bid/ask spread for all time period. You will use mid-price(=1/2*(bid+ask)) for calibrating/training your model. For backtest and implementation, you will execute at market prices only (that is at Bid or Ask for Sell or Buy orders that cross reach your limit price, respectively).

First Submission:

2. Preliminary heuristic trading rule a) We will be studying a rigorous method for forming co-integration factor and optimizing entry and exit rule in the 2nd half of the semester. b) During the early parts of this semester, you should test some simple spreads and entry and exit rules. They can be heuristic, i.e., you define something based on your intuition but ahead of time; or known technical trading rules, e.g., moving averages, bollinger band, etc. The only requirement is they have to be coded in python and executed automatically. That is you cannot use your eye to detect a pattern nor trade with your discretion. c) Run backtest of your simple pairs trading strategy, and report performance: mean returns, volatility, Sharpe ratio, VAR, max draw down etc. Backtest should be run with out-of-sample parameters (if any), and for a period of no less than one-year for a intraday to daily trading frequency, and no longer than 5 years. Please note, performance of this strategy is not graded, therefore, be honest and introspective in conducting and reporting on backtests. d) write a report (see below) and submit with Python code you that can be run on QuantConnect.com.

Final Submission:

3. VAR model (2nd half of the course) a) Build a VAR model with lag 1 using the mid-prices of pairs selected per the first step. You may use the same pairs as the heuristic trading or use new pairs. I encourage you to use the same pairs so that you can compare results of the heuritic and rigorous trading rules. Fit your VAR model in a warmup period (you define). b) Identify dynamics of the co-integration factor using the procedures listed in the lecture slides. Use the two-scale estimator to estimate the integrated volatility of each day. Divided by the length of a day to get the averaged instantaneous variance. Take square root to get the averaged instantaneous volatility. c) See if the co-integration factor has strong auto-correlation.
4. Trading strategy using ad-hoc bands a) Design several trading strategies for a trading day (within the time period chosen). b) Choose several ad-hoc bands: buy the co-integration factor when the lower band is reached, sell the co-integration factor when the upper band is reached, liquidate the position when the end of day is reached. Set the trading cost c as the average half spread. Note, you can repeat the same heuristic and technical rules as in the first submission. This will allow you to compare the differences between trading spreads and trading co-integration factor. c) For each consecutive days/period, build the VAR model using mid-prices in the first warm up period and test the performance using the mid-prices in the second period. Do this on a rolling window and compare the performance of these trading strategies using mean, volatility, Sharpe ratio, VAR, max drawdown etc.
5. Trading strategy using optimal bands a) Write down the free boundary equations for the exiting and entering problems. Since we work on a finite time horizon, both equations are

partial differential equations. Assume the discounting factor is zero. b) Solve these two free boundary PDEs using finite difference methods (this is similar to American option pricing problem on a finite horizon). c) Find the optimal entering boundary and the optimal exiting boundary. Since we work with a finite horizon problem, both boundaries are time dependent. d) Test the performance of these optimal bands out-of-sample as in 4 b) and c). Report mean, volatility and Sharpe ratio and max draw-down. e) write a report (see below) and submit with Python code you that can be run on QuantConnect.com.

Report:

A report summarizing your findings is needed to be submitted. A report should contain following components:

1. An executive summary on what you have done and found.
2. A more detailed description of your methods and results.
3. In a separae python file, provide the all the code (both the research code, and the trading code) necessary to replicate your results on QuantConnect by the TA.

The report is limited to 3-6 Letter-size pages with fonts at least 11, and maximum of 6 tables or figures.

Submissions and Grading

Initial Submission (8 pts):

A report summarizing your findings is needed to be submitted. A report should contain following components:

1. An executive summary on what you have done and found.
2. A more detailed description of your methods and results.
3. In a separae python file, provide the all the code (both the research code, and the trading code) necessary to replicate your results on QuantConnect by the TA.

The report is limited to 3-6 Letter-size pages with fonts at least 11, and maximum of 6 tables or figures.

Grading:

1. Must be submitted by deadline (-1pt for each day delayed);
2. Executive summary clear and concise; (1 pts)
3. Report organized logically and clearly, with minimal mistakes in spelling or gramma. (3 pts)

4. Python code must logical and clear (with documentation); be error free and can be run on QuantConnect.com by the TA. (2 pts)
5. Results of the Python code must match the report. (1 pts)

Final Submission (12 pts):

A report summarizing your findings is needed to be submitted. A report should contain following components:

1. An executive summary on what you have done and found.
2. A more detailed description of your methods and results.
3. In a separae python file, provide the all the code (both the research code, and the trading code) necessary to replicate your results on QuantConnect by the TA.

The report is limited to 3-6 Letter-size pages with fonts at least 11, and maximum of 6 tables or figures.

Grading:

1. Must be submitted by deadline (-1pt for each day delayed);
2. Executive summary clear and concise; (2 pts)
3. Report organized logically and clearly, with minimal mistakes in spelling or gramma. (4 pts)
4. Python code must logical and clear (with documentation); be error free and can be run on QuantConnect.com by the TA. (4 pts)
5. Results of the Python code must match the report. (2 pts)

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