QF 621 Quantitative Trading Strategies
Project Proposal

Pairs Trading: Comparison on Machine Learning and GARCH Model in Foreign Exchange Market

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1. Introduction

Pairs Trading is a popular trading strategy among hedge funds and investment banks. It can generate earnings regardless of market direction. This is performed by a two-step process. First, a pair of assets whose prices have previously moved together is identified. The spread between the two asset prices is then continuously monitored, if the equilibrium relationship would exist in the future. If it deviates from its historical mean, the investor shorts the inflated asset and purchases the cheap one. Both positions are closed when the price converges.

This project's main contributions are a novel framework based on the use of Principal Component Analysis (PCA) followed by the clustering algorithm to find promising pair combinations; a novel forecasting-based trading model experimented with GARCH model; and empirical evidence of the suitability of the foreign exchange market.

2. Methodology

A. Principal Component Analysis (PCA)

PCA is a statistical process that applies an orthogonal transformation to turn a set of possibly correlated observations into a set of linearly uncorrelated variables, known as principal components. Each component can be seen as indicating a risk factor.

We advocate the use of PCA in the normalized return series, defined a

$$R_{i,t} = \frac{P_{i,t} - P_{i,t-1}}{P_{i,t-1}}$$

Where:

$R_{i,t} =$ Rate of return of foreign exchange i at day t

$P_{i,t} =$ Price of foreign exchange i at day t

$P_{i,t-1} =$ Price of foreign exchange i at day $t-1$

B. GARCH Model

The GARCH model includes conditional variance h_t and is expressed as:

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta_1 h_{t-1}$$

Where:

$h_t =$ The conditional variance of the error term at time t

α_0, α_1 and β_1 are GARCH model coefficients

$\epsilon_{t-1}^2 =$ The squared previous error term

3. Pairs Selection Criteria

After generating the asset clusters from which to select candidate pairs, a set of rules must be defined to determine which are qualified for trading. It is crucial that the pairings' equilibrium holds. To accomplish this, we recommend unifying the approaches used in separate research projects. According to the proposed criteria, a couple is chosen if it meets the four conditions specified below.

A. Correlation Coefficient

The correlation coefficient is a useful tool for assessing the strength of the relationship between variables. For stock pairs to be traded together, it's crucial that they have a long-term equilibrium relationship. Thus, by using the correlation coefficient, we can evaluate how closely related foreign exchange pairs are and use this information to initially screen potential pairs for trading.

$$\rho = \frac{\sigma_{12}^2}{\sigma_1 \sigma_2}$$

Where:

$\rho =$ Correlation coefficient

$\sigma_{12}^2 =$ Covariance of foreign exchange 1 and 2

$\sigma_1 =$ Standard deviation of foreign exchange 1

$\sigma_2 =$ Standard deviation of foreign exchange 2

B. Engle-Granger Test

A pair is chosen for selection only if both securities within the pair exhibit cointegration. To assess this criterion, we recommend using the Engle-Granger test, as suggested by Engle and Granger in

1987, due to its straightforwardness. To address the test's dependency on the chosen variable, we suggest conducting the test with both potential choices for the dependent variable. The combination that yields the lowest t-statistic is then chosen.

4. Evaluation Metrics

In conclusion, we aim to compare the two approaches outlined in this project by utilizing various evaluation metrics. These metrics include Maximum Drawdown, Sharpe Ratio, Information Ratio, Sortino Ratio, and Win Rate, which will facilitate a comprehensive comparative analysis.

References

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