Comparison of the Performances for the Mean-Reversion Strategy for Exchange Rate

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Abstract. Mean-reversion theory predicts that historical returns and asset price volatility will eventually return to the long-run mean or average level of the entire dataset. The mean-reversion strategy applies the fundamental idea of selling high and attracting low to stock market investment. Researchers studying the international exchange market have shown that foreign exchange rates display momentum and mean reversion behavior. This study aims to assess the effectiveness of the mean-reversion approach on exchange rates and improve it. Using historical data, the author assessed the mean-reversion method's impact on the exchange rate. According to the study, the method offers a risk-to-reward ratio that is conservative. The clear disadvantage is that for most of the exchange rate, mean-reversion methods yield lesser profits. Furthermore, the return is significantly influenced by the mean-reversion lookback period. Quantitatively, exchange rates with significant volatility and variation often outperform when using the mean-reversion approach. Overall, these results shed light on guiding further exploration of mean-revision strategy.

Keywords: Mean-reversion; exchange rate; linear regression; SMA.

1. Introduction

With trillions of dollars changing hands every day between countless parties all over the world, the foreign exchange rate market is the biggest and most liquid market [1]. Fama's "forward puzzle"[2], which contends that forward exchange prices are biased predictors of spot exchange rates, caused the trading technique for the foreign market to get increased attention [3]. Mean reversion is a finance theory that forecasts asset price volatility [4]. As a result, depending on the time series, the price is likely to vary significantly in either direction before returning to its average or key value. For example, the price of an item will not continue to rise or fall indefinitely, but will eventually revert to the value center level. Through the usage of "buy cheap, sell high," this idea may be applied to the Mean-Reversion strategy [5]. This sort of strategy typically outperforms the market by a significant margin in turbulent markets, but typically underperforms the market by a significant margin in unilateral trend markets. The strategy implements the traditional principle of selling high and attracting low in stock market investment. The U.S. dollar is the most important currency in the world of currency trading since it is one side of several common currency pairings and a reserve currency [6]. Due to the popularity of the carry trade, the Japanese yen is the most active of the Asian currencies [7].

Based on their mean values, investors utilize the mean reversion model to choose which stocks to include in their portfolios [8, 9]. Some studies add to the body of knowledge by demonstrating which portfolio investment strategy best supports the applicability of the mean reversion model [10]. Investors can earn extraordinary profits by adopting a contrarian approach. Researchers learned The "On-Line Moving Average Reversion" (OLMAR) method is a revolutionary online portfolio selection technique that overcomes the drawbacks of traditional mean reversion algorithms and yields significantly better results [11]. Additionally, it operates incredibly quickly, expanding its practical relevance to a variety of applications. Researchers studying the foreign exchange market have shown that foreign exchange prices have a tendency to mean revert. The positions that are subsequently generated in the foreign currency markets follow a pattern that is qualitatively similar to the equities markets [12]. In terms of quantitative performance, this method performs better than equity markets. Additionally, it outperforms time-tested forex trading strategies like moving average rules and carrying trades.

The mean-reversion strategy's application to exchange rates is the main topic of this paper. This study analyzes the success of the mean-reversion trading strategy and focuses on how to improve trading methods through the use of historical data for backtesting. Based on preliminary research into the mean-reversion strategy, the author combines the method employed in the prior approach and attempts to assess its performance for various rolling window moving averages utilized because the exchange rates reflect mean-reversion tendency.

This paper will be structured as follows. The Sec. 2 will introduce the datasets and the method and strategy used in this paper, e.g., linear regression and mean-variance optimization [13]. It also includes the backtesting evaluation and the improvement of the mean reversion strategy. The results and discussion will be presented in Sec. 3, including correlation and regression analysis [14], comparison and limitation. Eventually, a brief summary will be given in Sec. 5.

2. Data & Method

2.1 Data

The dataset was downloaded from yahoo finance, in this paper, the exchange rate of GBPUSD, GBPCNY, CNYUSD and EUP from 2010.1.1 to 2022.1.1 is chosen to be used. The exchange rate of Great Britain Pounds against the U.S. dollar from 2017.1.1 to 2022.1.1 was set to be the training dataset, and the exchange rate from 2010.1.1 to 2017.1.1 was the testing dataset. The absolute return is used in this paper since it is easier to do mean variance with absolute returns. The dataset contains the adjusted close price, the absolute return and the simple moving average of those exchange rates. The visulization of the data is given in Fig. 1 and Fig. 2.

Fig. 1 The GBP/CNY from 2017 to 2022.

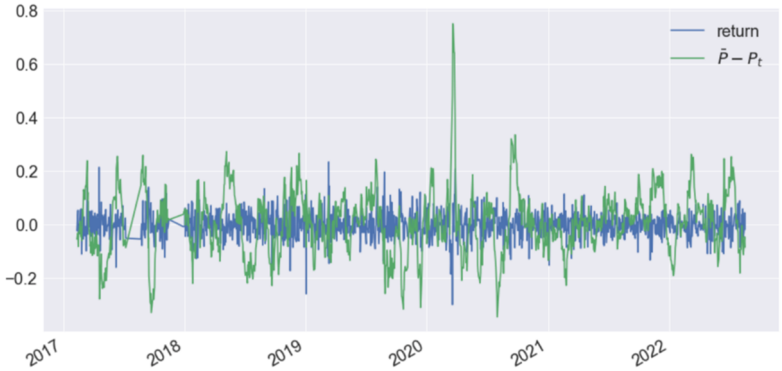

Fig. 2 the return and mean-reversion level.

2.2 Models & Strategies

Regression analysis is one of the methods most frequently used to analyze multi-factor data. A single dependent variable (usually represented by Y) and a number of additional factors are examined using this statistical method, which is employed in the disciplines of finance, investment, and other

areas (known as independent variables). In order to establish the linear relationship between two variables, linear regression utilizes the best fit line. A linear regression relationship's y-intercept reflects the value of one variable when the value of the other is zero. In this paper, the author starts from a simple linear time-series model and the model of the linear regression is of the form:

$$P_t = P_t + \lambda(\bar{P} - P_t) + \epsilon_t \quad (1)$$

Where P_t in equation (1) is the price of the asset, $\bar{P}$ is the mean-reversion level, λ is the mean-reversion speed and ϵ_t is unpredictable noise. From this section, the exact number of the parameters (λ and ε_t) in this model can be gotten.

A technical indicator called a simple moving average may help predict whether the price of an asset will rise or fall and if a bullish or bearish trend will continue. The formula for SMA is:

$$\mathrm{SMA} = \frac{\sum_{i=1}^{k} P_i}{k}, k \in (0, N) \quad (2)$$

Where k is the number of lookback periods and P is the price of an asset at period k. A simple moving average is adaptable since it may be calculated for a variety of time periods. As a result, in the linear regression technique, a lookback period was specified to compute the simple moving average (SMA), and the asset's SMA was designated as the mean-reversion threshold. In addition, the lookback period was adjusted in order to compute varied term SMA.

Investors utilize the mean-variance analysis to decide which investments to make. The risk-free rate is supposed to be zero, and then several shares were chosen to be maximized:

$$J(\theta_{t-1}) = E_{t-1}[(P_t - P_{t-1})\theta_{t-1}] - \frac{\gamma}{2} Var_{t-1}[(P_t - P_{t-1})\theta_{t-1}] = \lambda(\bar{P} - P_{t-1})\theta_{t-1} - \frac{\gamma}{2}\sigma_\epsilon^2\theta_{t-1}^2 \quad (3)$$

When the derivative of the equation(3) is equal to 0, the Optimal number of the shares is (4)

$$\hat{\theta}_{t-1} = \frac{\lambda(\bar{P} - P_{t-1})}{\gamma\sigma_\epsilon^2} \quad (4)$$

2.3 Backtesting Evaluation

The Sharpe ratio is a mathematical articulation of the idea that excess returns over time may indicate more volatility and risk rather than investing competence. The formula of the Sharpe ratio is:

$$Sharpe\ Ratio = \frac{R_P - R_f}{\sigma_p} \quad (5)$$

where R_p is the return of the portfolio and R_f is the risk-free rate and σ_p is the standard deviation of the portfolio's excess return. The Sharpe ratio is calculated to compare the different results of the mean-reversion strategy used in the different exchange rate.

A drawdown is a peak-to-trough fall for an investment, trading account, or fund over a defined time period. The asset is assumed to have a value of just one dollar for computing the maximum drawdown, which is *MDD (T)*.

$$MDD(T) = max_{t\in(0,T)}\{0, max_{t\in(0,\tau)} \prod_{k=1}^{t}(1 + R_k) - \prod_{k=1}^{\tau}(1 + R_k)\} \quad (6)$$

The max drawdown rate is $mdd(T)$

$$mdd(T) = \frac{MDD(T)}{max_{\tau\in(0,T)} \prod_{k=1}^{t}(1+R_k)} \quad (7)$$

2.4 Improvement

The final element requires consideration of a factor during the trading procedure, which is the transaction costs. The transaction cost is 0.1% in this case, and the Sharpe ratio will decline because every trade will incur a transaction cost. A new parameter ratio has been introduced to reduce the impact of transaction costs. The ratio is calculated using the equation (8):

$$\mathrm{ratio} = {}^{P_t}/_{\bar{P}} \quad (8)$$

After getting the data of ratio, if the ratio > 1, that means the price is in a high level, and there is going to be a sell signal. Otherwise, it means the price is in a low level, and there is going to be a buy signal The next procedure is to set the percentile and make a comparison with the upper quartile and the lower quartile. Here the percentile is $[15,20,50,80,85]$. Then, one sets the three lines, is at the percentile of 15% 50% and 85% as follows:

- If the ratio is above the 85% percentile line, it is at the sell signal
- If the ratio is at the 50% percentile line, it is at the average level
- If the ratio is under the 15% percentile line, it is at the buy signal

With the signal above, buyers can make trades with their assets at the signals. A sketch of the signals is shown in Fig. 3.

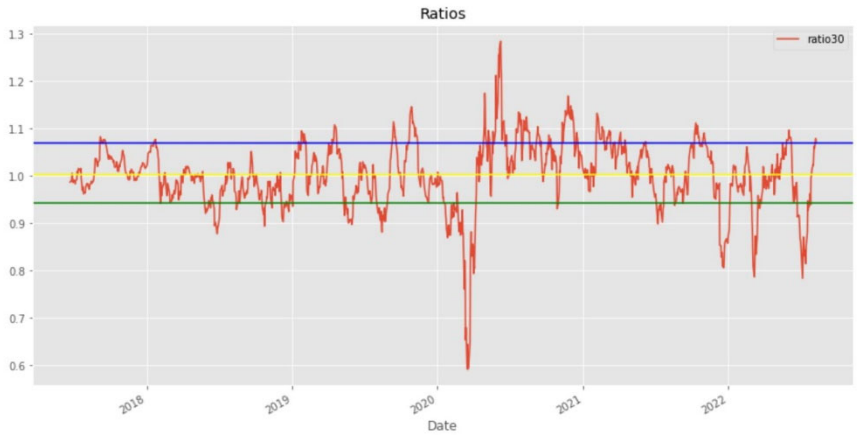

Fig. 3 The ratios.

3. Results & Discussion

3.1 Correlation & Regression Analysis

First, the exchange rate of Great Britain's pounds to the China yuan has been used. Starting from the linear regression, the mean-reversion speed is computed, where the results are shown in Table. 1. The 30-days SMA has been first used in this paper. The mean-reversion speed is 0.0406 for using 30-days SMA and the skew is -0.172 the kurtosis is 6.013.

Table. 1 Linear regression

	coef	std err	t	P>| t |	[0.025	0.975]
Mean-P	0.0406	0.011	3.589	0.000	0.018	0.063
Ominibus:	107.076		Durbin-Watson:		2.122	
Prob(Omnibus):	0.000		Jarque-Bera(JB):		516.056	
Skew:	-0.172		Prob(JB):		8.71e-113	
Kurtosis:	6.013		Cond. No.		1.00	

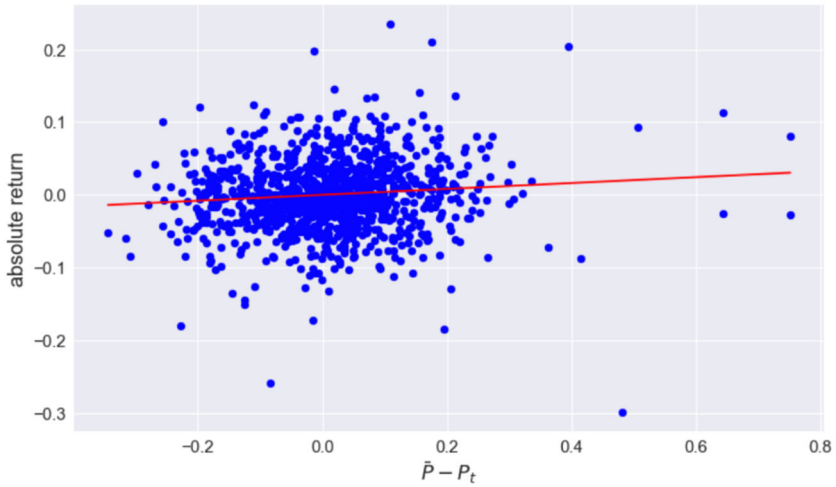

Fig. 4 Linear regression

The Fig. 4 depicts the line of the best fit using ordinary least squares. Then the everyday optimized position of this strategy is calculated by using mean-variance optimization. The risk aversion was set to be 1, and the mean-reversion speed (0.0406) is got in the last step. The variance of the noise is calculated by the residuals when running the linear regression, its variance can be sigma square, and then the strategy return can be gotten by multiplying the position and the absolute return. The strategy return and expected position are illustrated in Fig. 5.

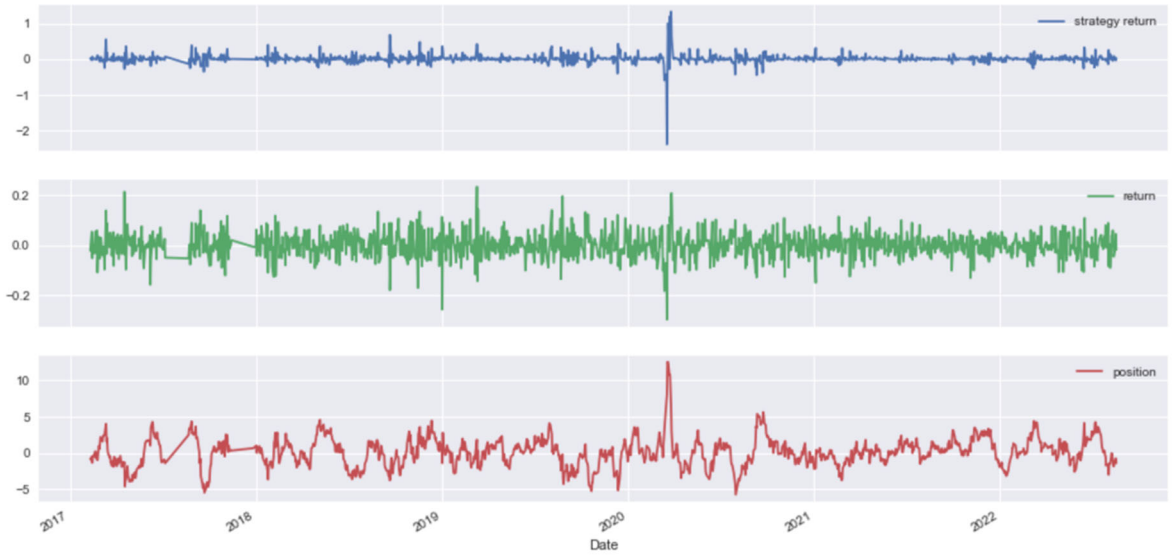

Fig. 1 the strategy return, absolute return, and the expected position

3.2 Evaluation & Comparison of the Strategy

According to the Table 2, The Sharpe ratio of the strategy used on the GPBCNY exchange rate is 0.073525, and the kurtosis is 106.086718, it is a quite large number. That means the strategy is leptokurtosis. The max drawdown is 0.1648, the max drawdown rate is 15.21%. They are quite a small number which means the exchange rate has little risk to draw down in the short-term period. By changing the lookback period, the author got different terms for SMA such as SMA5, SMA30, and SMA120. The mean of the exchange rate is also used to be one example of the mean reversion level. From the result in the Table 2, it is obvious to see that when the mean is used to do the strategy, the largest Sharpe ratio (0.096719) can be calculated, and it also had the least kurtosis. Shorter period seems to have a smaller Sharpe ratio which means long-term mean-reverting seems to have better performance.

For testing whether the result fits most of the situation, the testing data was used in this strategy, but the result is completely different. The result is shown in the Table 3. The exchange rate of GBP against CNY from 2010.01.01 to 2017.01.01 shows that when using the 5 days SMA to do this strategy, the author got the highest Sharpe ratio (0.147775), thus one got a higher return with the same risk. When using other exchange rates to do the strategy, the result is shown in Table 4. The GBPCNY exchange rate can get the highest SR compared to other exchange rates, but the exchange rate in relation to pounds had large kurtosis. The exchange rate with a high fluctuation trend has a more mean-reverting tendency and thus can get a higher return when taking the same level of risk.

Table. 1 Comparison between using different rolling window

GBPCNY=X	Sharpe ratio	kurtosis
MA5	0.048166	92.258568
MA30	0.073525	106.08672
MA120	0.074135	58.19304
mean	0.096719	12.669464

Table. 2 Comparison using testing dataset

	Sharpe ratio	kurtosis
GBPCNY=X	0.073525	106.08672
GBPUSD=X	0.021963	113.2174
CNY=X	0.041283	29.374472
EURUSD=X	0.026224	13.840405

Table. 3 Comparison between exchange rate

GBPCNY=X	Sharpe ratio	kurtosis
MA5	0.147775	625.78449
MA30	0.108306	366.8407
MA120	0.089186	76.876054
mean	0.075833	51.091083

3.3 Improvement

For the improvement, since it is quite difficult for us to compute the return after considering the transaction cost, the author use the buy and sell signals. By trading based on these signals in Fig. 6, the times of trading can be reduced and thus can reduce the impact of the transaction cost.

Fig. 2 The buy and sell signals.

3.4 Limitations & Prospects

The mean-reversion strategy has some flaws. For example, the high water mark is more commonly used to calculate the drawdown of the asset price, but it is difficult to compute the high water mark in this strategy because the absolute return is used to calculate the strategy return, so the cumulative return cannot be calculated. This study uses a different method to calculate the drawdown instead and the drawdown rate. Furthermore, the author evaluated transaction cost in backtesting, and the ratio in section 2.4 is utilized to establish the buy and sell signal. However, various numbers of transactions will result in varying amounts of transaction cost, therefore when backtesting, the frequency of trading should be more specific. Data-snooping bias may have an impact on backtests in historical markets. It should be emphasized that the datasets were selected without considering the suggested approaches based on the body of previous research. The dataset selection issue could come up in the testing, even if the author is careful about it. The British pound was one among the currencies that the COVID-19 had an impact on for the dataset in question, hence starting in 2021, the GBP exhibited a decreasing trend rather than a tendency toward mean reversion.

Mean reversion trading techniques in the market are usually built on a specific type of indicator. These indicators can be in the form of technical oscillators, fundamentals, economic indicators, or sentiment-based indicators. If the mean-reversion strategy is combined with those indicators, the strategy can be better improved. For example, certain technical indicators are examples of technical

research-based that provide overbought and oversold signals. Essentially, these overbought and oversold signals tell us when a price movement within a particular market is excessively up in the case of overbought values, or excessively down in the case of oversold values.

4. Conclusion

In summary, the mean-reversion strategies are very conservative in terms of risk-reward, with Sharpe ratios less than one but greater than zero for several of the exchange rates backtested, which essentially helps improve the strategy's average win rate. The exchange rate market tends to trend markets most of the time since mean reversion strategies are best applied in the context of range-bound markets, which are in this context nearly 70% of the time, Therefore, the mean reversion strategy will have more trading opportunities compared to the trend trading setup. On average, Mean-reversion has a shorter holding period.

As pointed out above, mean-reversion strategies tend to be very conservative in their risk-reward ratio. This is a broad generalization, however, it is typical of many mean reversion techniques. The obvious downside to this is that mean-reversion strategies yield smaller returns for most of the exchange rate. The low Sharpe ratio for most of the exchange rates shows that the mean-reversion can only get little return when the risk is taken. Besides, the shorter look-back period of SMA can usually get a higher return. In addition, those exchange rates with high volatility and fluctuation frequently perform better when using the mean-reversion strategy.

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