Comparison of Two Quantitative Strategies: Momentum and Mean-reversion

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Abstract. With the development of finance and computers, the field of quantitative finance is gradually gaining attention and research. In this paper, two classic trading strategies are chosen for comparisons (namely momentum strategy and mean reversion strategy) to select the performance of Tesla and Gold in the last decade as the research object. The Tesla and Gold both performances better in momentum strategy than in the mean-reversion strategy. According to the analysis, it demonstrates that volatile stocks are more likely to generate greater profits with a momentum strategy. However, volatile equities may not regress well to the mean price, or the rate of regression may be irregular, rendering a strategy based on mean reversion ineffective. This study presents a sample for comparing momentum and mean reversion techniques and develops the features of stocks that are suited for both momentum and mean reversion strategies. These results shed light on guiding further exploration of quantitative strategy.

Keywords: momentum strategy; mean-reversion strategy; quantitative trading

1. Introduction

All secondary markets are a natural result of big capital pools. Situations and methods of investors evolve over time, necessitating early liquidity. Private equity is a class of illiquid assets, requiring investors to commit capital to private equity firms for at least ten years. Therefore, the emergence of a secondary market was both necessary and unavoidable [1]. On the secondary market, purchasers must assess and compute whether a firm is worth investing in, which entails the use of historical company data to analyze the stock's potential future performance or risk. Consequently, quantitative finance is also gaining prominence. Quantitative finance is the analysis of financial markets and securities using mathematical models and extraordinarily big datasets. Examples include the pricing of derivative securities (e.g., options and risk management), particularly in portfolio management applications [2]. It combines finance, mathematical modeling, statistics, and programming.

Quantitative makes investment strategy based only on quantitative analysis of the item of study's historical data. Due to the high cost of gathering and evaluating huge volumes of data manually, quantitative finance did not gain much public attention until the computer age. However, with the development of computers, more individuals began to use computers and financial data to create models and portfolios. Slowly, more types of criteria were added to the traditional size and profitability factors; portfolios also became more diversified. Additionally, with the proliferation of computers and AI, quantitative analysis is gradually being coupled with machine learning in order to automate trading. Quantitative finance plays an essential role in the modern financial sector. Multiple large banks, investment houses, etc., have a great demand for quantitative analysts. Quantitative analysts of high caliber are in scarce supply. The average annual income of quantitative analysts was $112,116 as of August 2022 [3]. It demonstrates the importance of quantitative analysts in the financial markets.

Quantitative trading strategy include the early but still popular momentum strategies and mean-reversion strategies, as well as the newly-emerging alternative data strategies and machine learning based trading strategies. This paper focuses on the performance of Tesla and the gold market from 2011 to August 2022 as the subject of the study. Momentum delivers the highest Sharpe ratio to investors compared to market, value, and size aspects. However, momentum has also produced the most catastrophic failures. Momentum risk is very variable yet predictable over time. Managing this risk can almost eliminate crashes and nearly double a momentum strategy's Sharpe ratio [4].

Momentum strategy and mean-reversion strategy are classical trading strategy. Therefore, comparing them and find under what conditions is it more advantageous to choose a particular strategy.

In order to compare the applicable characteristics of the momentum strategy and mean reversion, this study investigates the price fluctuations of Tesla and Gold from 2011 to 2022 August. The rest part of the paper is organized as follows. The Sec. 2 will describe the common trading strategy. The Sec. 3 will introduce the metrics in strategy. Besides, the momentum strategy and mean-reversion strategy will be analized respectively in Sec. 4 and Sec. 5. Sec. 6 will make a comparision between the momentum strategy and mena-reversion strategy. Sec. 7 will elaborate limitations and prospects. Finally, Sec .8 makes a conclusion.

2. Descriptions of Quant Strategies

2.1 Momentum strategy

The momentum strategy is one of the mainstream strategies in today's society, and it is also an investment strategy that emerged early in the mainstream. Momentum strategy capitalize on the tendency for a stock's historical performance and earnings news to forecast its future returns. The technical indicators commonly used in momentum trading are trend lines, moving average, stochastic oscillator, and average directional index (ADI). This paper mainly uses the moving regression line of technical indicators. A moving average line enables traders to discern the general trend while reducing the amount of market "noise" caused by modest price movements. When the price of an asset continuously remains at or above a moving average, it indicates the presence of an uptrend. On the other hand, it indicates a downtrend.

2.2 Mean-Reversion Strategy

The mean reversion strategy presupposes that asset prices will tend to average out over time, i.e., fluctuate around the mean price. In the event of an abnormal rise or fall in stock prices, stock prices will eventually return to a level close to the average. However, a rise (or fall) in prices away from the mean does not necessarily indicate that prices will fall (or rise) in order to return to the original mean. Consequently, simple moving averages are typically preferred to average prices. Similar to the EUR/USD exchange rate, first the price rises away from the simple moving average, then the simple moving average rises with it, and then the two converge and continue to fluctuate around the average [5]. There are various indicators can be used to measure trade, such as Distance to SMA, Bollinger Bands, Regression Bands, Keltner Bands.

2.3 Alternative Data Strategy

Alternative data strategy is a recent innovation that arose with the advent of computers. It is not traditional financial data such as financial statements, instead it refers to the use of other observable data to react in real-time to potential fluctuations in stock prices. For example, monitoring the effectiveness of a video company can be done by monitoring data such as the number of video views per hour, the number of video followers, etc. Sources of alternative data include financial transactions, sensors, mobile devices, satellites, public records, social media, and the internet. Therefore, it might be considerably vaster and less structured than conventional financial data [6].

3. Metrics in Strategy

3.1 Sharpe ratio

The Sharpe ratio compares the return to the risk of an investment. It is a mathematical representation of the observation that excess returns over a period of time may be indicative of greater volatility and risk as opposed to investing skill [7]. Sharpe ratio is calculated by subtracting the

portfolio return from the risk-free rate and dividing by the standard deviation of the portfolio's excess return.

$$Sharp\ ratio = \frac{R_p - R_f}{\sigma_p} \tag{1}$$

$$Excess\ return = R_p - R_f \tag{2}$$

Here, R_p is the return of portfolio, R_f is the risk-free rate while σ_P is the tandard deviation of the portfolio's excess return. The risk-free rate in this project is 5%. The higher the Sharpe ratio of a portfolio, the better its risk-adjusted performance. A negative Sharpe ratio indicates that the risk-free or benchmark rate is greater than the historical or predicted return of the portfolio, or that the portfolio's return is likely to be negative.

3.2 High Water Mark and Drawdown

A high-water mark is the maximum value attained by an investment fund or account. The drawdown is the period-specific fall from peak to trough for an investment, trading account, or fund. Drawdowns are normally expressed as a percentage, but cash amounts may be used if appropriate for a particular trader. Drawdowns are a measure of volatility to the downside [8].

$$Drawdown_t = \frac{HWM_t - P_t}{HWM_t} \tag{3}$$

Here, HWM_t is High water mark at time t and P_t is the price of the stock or other assets at time t Sometimes high water mark can represent the cumulative performance of a stock, and the price is replaced by the cumulative performance at time t. One computes the cumulative performance at the n-th day as follows:

$$Cumulative\ performance_n = \prod_{i=1}^{n}(1 + r_i) - 1 \tag{4}$$

where r_i is the return at the day i. In this paper, the data of Tesla and Gold from 2011 to 2022 are used to do the analysis and compare.

4. Momentum strategy

4.1 Introduction of the process of momentum strategy

The data of Tesla and Gold price are collected to do the momentum strategy and mean-reversion strategy and compare the indicators to analysis the momentum strategy and mean-reversion strategy. The purpose of determining a stock's moving average is to assist smooth out price data by generating a constantly updated average price. Simple moving average is used in this essay.

$$SMA_n = \frac{A_1 + A_2 + A_3 + \cdots + A_n}{n} \tag{5}$$

Afterwards, one ought to carry out the regression:

$$R_{t+1} = \alpha + \beta_{5D} f_t^{5D} + \beta_{1Y} f_t^{1Y} + \beta_{5Y} f_t^{5Y} + \varepsilon_{t+1} \tag{6}$$

Here R_{t+1} is return at the time t, $f_t^{5D}, f_t^{1Y}, f_t^{5Y}$ are the simple moving average of 5 days, 1 years and 5 years at time t, respectively. Hence, one gets the mean-variance allocation:

$$x_t = \frac{\alpha + \beta_{5D} f_t^{5D} + \beta_{1Y} f_t^{1Y} + \beta_{5Y} f_t^{5Y}}{\gamma \sigma_t^2} \tag{7}$$

where x_t is the weight of long or short, γ is the risk aversion and σ_t^2 is the variance of the residuals. Subsequently, one obtians the strategy return

$$Strategy\ return = x_t \times r_t \tag{8}$$

The data from 2011 to 2022 is used to calculate the simple moving average, so the data analyzed in this paper ranges from 2016 to 2022.

4.2 Comparisons

First, the Tesla and the Gold when lookback period is 1 day are compared. The Sharpe ratio of the Tesla is -5.21, while the Sharpe ratio of gold is 3.81. Besides, the Tesla's sum of the strategy return is -0.97, while the Gold's sum of the strategy return is 1.41. Additionally, the maximum drawdown of the Tesla is 62.32% and the gold's maximum drawdown is 1.13%. This may be caused by their difference trends of up and down.

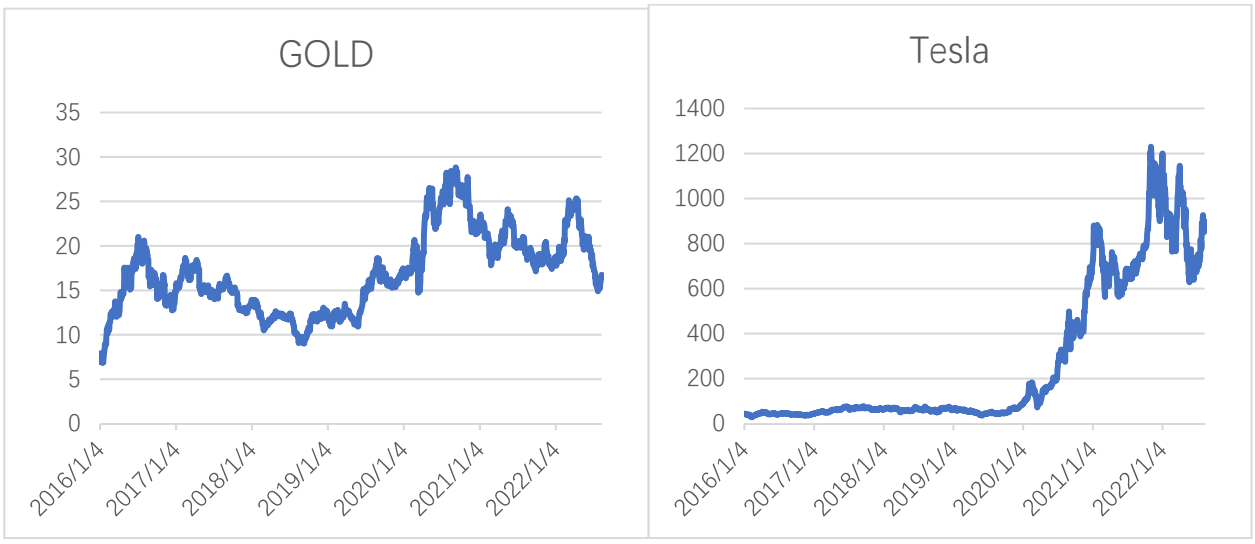

Fig. 1 Price trend of Gold and Tesla from 2016 to 2022

An asset that changes the uptrends or downtrends more frequently, in other words, it has more inflection, then the momentum strategy's Sharpe ratio will be lower. As shown in the Fig. 1, Tesla's volatility is not significant until 2020 and there are many inflection points, which is the main reason for Tesla's poor performance under the momentum strategy. Then, changing the lookback period of the Tesla from 1 day to 60 days, it will change the Sharpe ratio from -5.21 to 1.28. Besides, the sum of the return will increase from -0.97 to 2.01. Additionally, the maximum drawdown decreases by 29.29%. As illustrated in the Fig. 2, the performance of cumulatice performance and drawdown with the lookback period is 60 days is better than the perfomance with lookback period is 1 day. Therefore, if it has poor performance in momentum strategy, one may change the lookback period to obtain better performance.

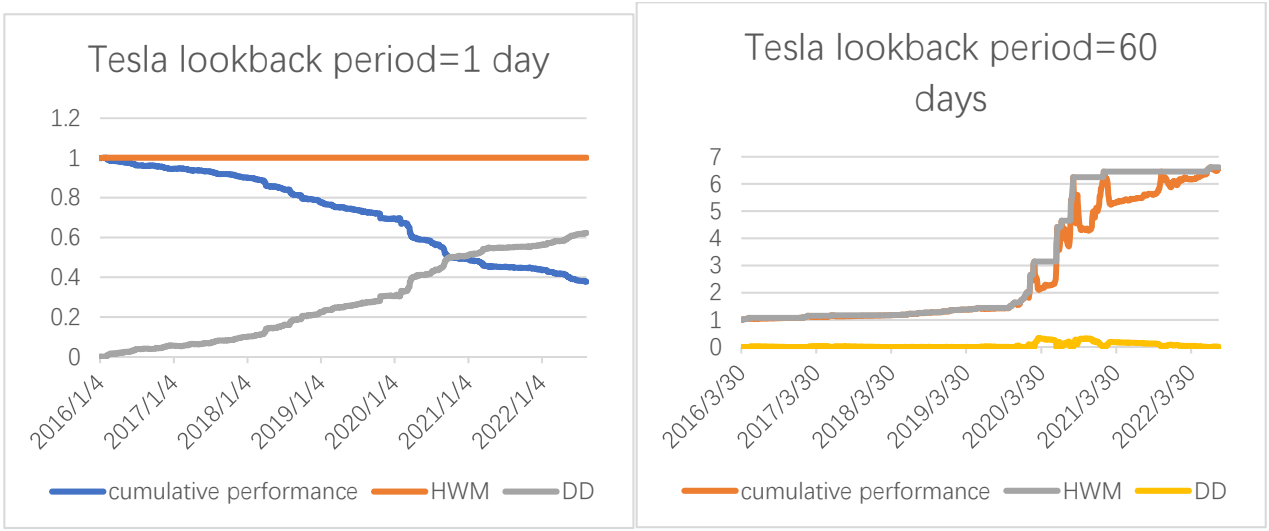

Fig. 2 Comparison when lookback period is 1 day and 60 days

5. Mean-reversion strategy

As for this strategy, the regression can be as follows

$$P_{t+1} = P_t + \lambda(\bar{P} - P_t) + \epsilon_{t+1} \tag{9}$$

Here, $\bar{P}$ is the mean reversion level while λ is the mean reversion speed. Thus one gets the mean-variance allocation

$$x_t = \frac{\lambda(\bar{P} - P_t)}{\gamma\sigma_\epsilon^2} \tag{10}$$

In the Tesla, while the $\bar{P}$ is the past ten days price average, the Sharpe ratio is -0.015 and the sum of the strategy return is -7.03. As the $\bar{P}$ change to the past one-year price average, the Sharpe ratio changes to -0.016 and the sum of strategy return change to -6.07. It changes little in both indicators. In the Gold, it also has a poor performance as Tesla. While the $\bar{P}$ is the past ten days price average, the Sharpe ratio is -0.023 and the sum of the strategy return is -10.52. As the $\bar{P}$ change to the past one-year price average, the Sharpe ratio changes to -0.021 and the sum of strategy return change to -8.94. In Tesla and Gold, the strategy returns are almost negative. They all show poor performance under the mean-reversion strategy. Fig. 3 and Fig. 4 exhibit that regardless of whether the average was obtained over the past 10 days or the past 60 days, the prices of Tesla and Gold have not regressed well to the average and the speed of regression has been erratic. These are the two main reasons for the poor performance of the mean-reversion strategy.

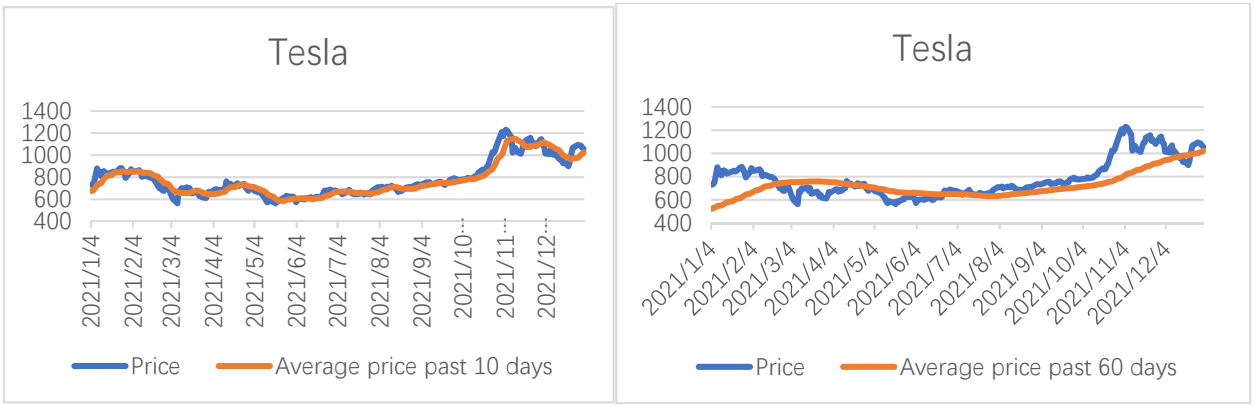

Fig. 3 Tesla's deviation between price and average price.

Fig. 4 Gold's deviation between price and average price.

6. Comparison

Both Tesla and gold outperformed the mean reversion strategy in the momentum strategy. Momentum trading's primary advantage is that it can be profitable in a relatively brief period of time if executed correctly and consistently. However, momentum strategy has some disadvantages. They take advantage of market volatility to generate returns. The momentum strategy performs better in stocks that are continuously falling or rising. However, if a stock changes its up or down trend frequently, the momentum strategy may perform poorly. Daily monitoring of market details is required of momentum investors, which may result in high labor cost.

The mean reversion strategy uses the assumption that the value of a stock will fall or rise to around the mean after a period of time, and short or long the stock during that time to make a profit. However, some stocks (e.g., Tesla and gold, the subjects of this paper) don't effectively fall or rise to the mean, which causes the mean reversion strategy to fail combined with the erratic rate of fall. Although, these strategies have a win rate of greater than 65% typically, it might face significant drawdown [9]. The distribution of mean-reversion strategies is not normal. They have thin right tails and fat left tails which is opposite to the momentum strategy that have thin left tails and fat right tails [10]. The most important thing is to choose the right strategy according to the characteristics of the stock to obtain the maximum profit.

7. Limitations & Prospects

In this paper, there are two research subjects are chosen to carry out the analysis. This may not be an accurate depiction of the two strategies and may be somewhat biased. Moreover, this paper only examines a single investment object and does not develop a study of portfolios. Different portfolios may also perform differently for these two strategies. Additionally, in this paper, a strategy used only one regression model to get the weights of the allocation. More models can be used to observe the difference between the momentum strategy and the mean-reversion strategy.

In future research, the performance of different portfolios under these two strategies can be analyzed and made comparisons. A more comprehensive representation of the characteristics and profitability of the momentum and mean reversion strategies in the face of different portfolios. It is also possible to change the allocation models to investigate the difference of the strategy performance. For example, one can try to short all or long all, when it declines or increases, which means the weights of allocation is 1 when the price goes up and the weights of allocation is -1 when the price goes down.

8. Conclusion

In conclusion, this study collects the data of Tesla and Gold to analyzes their performance under the momentum strategy and mean-reversion strategy. Tesla and Gold both performances better in momentum strategy than in mean-reversion strategy. It shows that volatile stocks are more likely to get more profit in momentum strategy. However volatile stocks may not regress well to the mean price, or the speed of regression may be erratic, resulting in a mean-reversion strategy that is ineffective. The mean reversion loss is higher, which also confirms that it has a normal distribution shifted to the right, left tails fat and right tails thin, existing big losers. The small number of subjects in this paper and the absence of a portfolio as an object of study, coupled with the small number of allocation models used, may make the results inapplicable to a small number of special cases. In the future, more regression models and methods of assigning weights can be added to the study for comparison to draw more general conclusions. This paper provides a sample for comparing the momentum and mean reversion strategies. Moreover, it derives the characteristics of stocks suitable for both momentum strategy and mean-reversion strategy and possible reasons for their unsuitability. Overall, these results offer a guideline for quantitative strategy implementation.

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