



Pair Trading Implemented in Three Asset Pairs in the Finance Market

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Abstract

Arbitrage is a well-known and commonly used approach in the financial market, where large amounts of trades are associated with it. Pair-trading, one of the most prevalent statistical arbitrage methods, is used in this paper to construct a portfolio of three asset pairs, i.e., gold and silver future prices, Tesla and Bitcoin prices, and Apple and Microsoft stock prices. The data was obtained from Wind and Yahoo Finance, and the strategy's major goal is to achieve a consistent revenue ratio with minimal drawbacks. According to the back-testing, it is possible to achieve a revenue ratio of above average for each year with low risk. These results shed light on guiding further researches focusing on arbitrage.

Keywords- *arbitrage; pair-trading; stocks; Future.*

1. INTRODUCTION

Arbitrage is the technique of taking advantage of a price difference between two or more markets by making a series of matching agreements to benefit from the difference, with the profit being the difference between the market prices at which the unit is exchanged. An arbitrage, as defined by academics, is a transaction with no negative cash flow in any probabilistic or temporal state and a positive cash flow in at least one state. In other words, it is the prospect of making a risk-free profit after transaction expenses. An arbitrage opportunity exists, for example, when it is possible to buy something at a low price and sell it at a higher price in the same transaction. In theory, an arbitrage is risk-free; while in common application (e.g., statistical arbitrage), it may refer to expected profit, though losses may occur. In practice, there are still risks in arbitrage, some minor (e.g., price fluctuation lessening profit margins), some major (e.g., market volatility reducing profit margins). In academic circles, arbitrage refers to profiting from price disparities in a single asset or identical cash flows. Besides, it also refers to price discrepancies between comparable assets (relative value or convergence transactions), as in merger arbitrage.

Arbitrage is a well-known trading tactic in the stock and futures markets all over the world. This arbitrage approach was created in 1985 by a Morgan Stanley analyst. He anticipated that the difference value of the two stocks will always be around the mean value since he found two strongly linked equities to build a steady portfolio. In 1987, the American financial market generated a lot of money using this method. Due to its shorting mechanism and high market liquidity, the stock market is more suited to high frequency through statistical arbitrage approach than the existing product market.

With the fast expansion of the global financial market, an increasing number of assets are being traded worldwide using the arbitrage method. Meanwhile, statistical arbitrage method is becoming increasingly popular among academics. The following are some examples of frequent arbitrage strategies:

- Alpha Arbitrage Strategy

Alpha arbitrage is a trading strategy based on the inverse operation of the stock spot market and stock index futures to build a portfolio [1]. The benefit of this technical analysis is that it would efficiently hedge the securities market's systematic risk, resulting in more stable profits with less risk. Owing to developing markets' lower

effectiveness, professional investors are more likely to take advantage of expert management, active operations, and capital size to produce better alpha returns in these markets, beating the overall market.

- Statistical Arbitrage Strategy

Statistical arbitrage strategy has been widely used in domestic and international financial markets due to its lower risk and more stable return characteristics, especially favored by large capital and institutional investors [2]. Statistical arbitrage is the process of estimating the probability distribution of the relevant variables based on statistical analysis of historical data and combining it with fundamental data to guide arbitrage trading. Compared to risk-free arbitrage, statistical arbitrage adds a small amount of risk, but the resulting arbitrage opportunity is several times greater than risk-free arbitrage. There are many strategies belonging to the statistical arbitrage strategy, including calendar spread arbitrage strategy, cross-market arbitrage strategy, cross-species arbitrage strategy, ETF arbitrage. Statistical arbitrage is a set of quantitatively driven algorithmic trading strategies that may be applied to any market. These techniques are based on analyzing price patterns and price disparities across financial instruments to exploit the relative price movements of thousands of financial products. The goal of these tactics is to produce alpha for the trading firms. Statistical arbitrage is not a high-frequency trading strategy, as should be kept in mind [3].

- Calendar spread arbitrage

Calendar spread arbitrage is a common hedging practice in futures market. Futures market is not a completely efficient market, pricing deviation and the impact of internal and external events often cause the fluctuation of the price difference between the same futures contract in different months, which provides with opportunities for arbitrage [4]. It takes advantage of discrepancies in extrinsic value across 2 different expiration contracts of the same token, in order to make a risk-free profit. Futures price reflects the market sentiment of the subject's price.

- Cross-market arbitrage

Cross-market arbitrage in commodity futures markets is a simple type of arbitrage, which is the action of trading between different exchanges. When the same futures contract is traded on two or more exchanges, there is a certain spread between the commodity contracts due to geographical differences between regions. The trading strategy of cross-market arbitrage can be divided into cross-market risk-free forward arbitrage and cross-market trend arbitrage which follows the exchange rate fluctuations. In practice, investors are most often exposed to the financial risk of cross-market arbitrage [5].

- Cross-species arbitrage

Cross-species arbitrage is an arbitrage trade that takes

advantage of price differences between two different, but interrelated assets. The logic of cross-species arbitrage lies in finding a relatively stable relationship between commodities of different species but with some correlation, with a view to chasing profits from spreads or price fluctuations in the process of returning to a normal range from a deviated area. The success of cross-species arbitrage depends to a large extent on the degree of correlation between different commodity futures in arbitrage trading. As a matter of fact, it requires investors to select the appropriate arbitrage trading object on the basis of accurate judgment of the correlation between different futures. Moreover, it also requires investors to accurately predict the trend of the spread between the selected arbitrage species before the operation. Thereby, it increases the difficulty of cross-species arbitrage trading and makes it a relatively more difficult and risky arbitrage trading method among arbitrage trading types [6].

- ETF arbitrage

ETF arbitrage means that investors can subscribe ETF shares with a basket of stock portfolios or redeem ETF shares into a basket of stock portfolios from fund management companies through designated ETF dealers in the primary market, while at the same time buying and selling ETFs at market prices in the secondary market. ETFs have the advantages of low cost, low risk and no taxation compared to traditional futures and stock portfolios, thus making arbitrage between stock index futures and ETFs more attractive to investors [7].

- Beta Arbitrage Strategy

Traditional financial pricing theory suggests that risk and return of assets have a significant positive relationship. However, many empirical results from market empirical tests indicate that the relationship between risk and return of assets in the market does not fully comply with the traditional asset pricing model. In reality, it shows the characteristic that the higher the risk, the lower the return. When the risk level of individual stocks is measured by Beta, it reflects the Beta anomaly that low Beta stocks perform well in the future and high Beta stocks perform poorly in the future [8]. This phenomenon is manifested in higher beta assets are overvalued, whilst lower beta assets are underpriced, according to the hypothesis. According to the notion, stock prices will ultimately fall back into line with one another. This is essentially a statistical arbitrage method in which the asset prices return to the risk-adjusted median price.

- Pair Trading Arbitrage Strategy

Pair trading is a form of arbitrage by finding correlations between stock pairs [9]. Specifically, if the price movements of two stocks tend to be the same, and one stock moves in the same direction as the other. Subsequently, when the prices of these two stocks deviate, and one stock is overvalued while the other is undervalued, we can buy the undervalued stock and sell the overvalued

stock simultaneously, and wait until the deviation of the two stocks disappears and returns to normal in the future. On this basis, the purpose of arbitrage is achieved.

● A + H Stock Arbitrage Strategy

With the opening of "Shanghai-Hong Kong Stock Connect" and "ShenZhen—Hong Kong Stock Connect", investors can buy and sell shares of companies listed on the A+H Stock Exchange, and more and more investors are looking for arbitrage opportunities in the A+H Stock Exchange [10]. With the opening of "Shanghai-Hong Kong Stock Connect" and "ShenZhen- Hong Kong Stock Connect", investors can buy and sell stocks listed in A+H through them, and more and more investors are looking for arbitrage opportunities in A+H stocks. For A and H stocks of the same company, the same stock should possess same right and the price. Whereas in practice, due to the different policy environment, trading system and investor structure of the two capital markets, the trading price is often different. However, since they belong to the same company, their earnings and risk factors are the same, A and H stocks ought to have the same price trend. The price movements of A and H stocks should be highly correlated, and there are likely to be statistical arbitrage opportunities between them.

The main motivation for studying and writing this article is that we have a certain curiosity and enthusiasm

after learning relevant content. Therefore, it is necessary to have a deeper understanding of pair trading through writing this article. Meanwhile, we hope that through our own research and learning, one can have a more accurate and detailed understanding of different operations of pair trading and some detailed operation processes. The rest part of the paper is organized as follows. The Sec. II will introduce the data source and analysis methods. The Sec. III will display the results of the study. The Sec. IV will discuss the results. Eventually, the Sec. V will make a brief conclusion of the whole paper.

2. METHODOLOGY

In order to grasp every opportunity for arbitrage, the whole data of the three asset pairs (Gold & Silver, Apple & Microsoft, Tesla & Bitcoin) for back-testing is gathered from Wind and Yahoo finance under low-frequency. Moreover, the time span of the data is from 2020-01-01 to 2022-03-18 and the time frequency is one day. Since the data volume is massive, to vividly visualize the data, the trend of close price is illustrated in Fig. 1, Fig. 2 and Fig. 3, provided in the following to show how the price of the three asset pairs vary over time. In the following, AAPL and MSFT are short for Apple and Microsoft. Gold and silver are short for Au and Ag. BTC is short for Bitcoin.

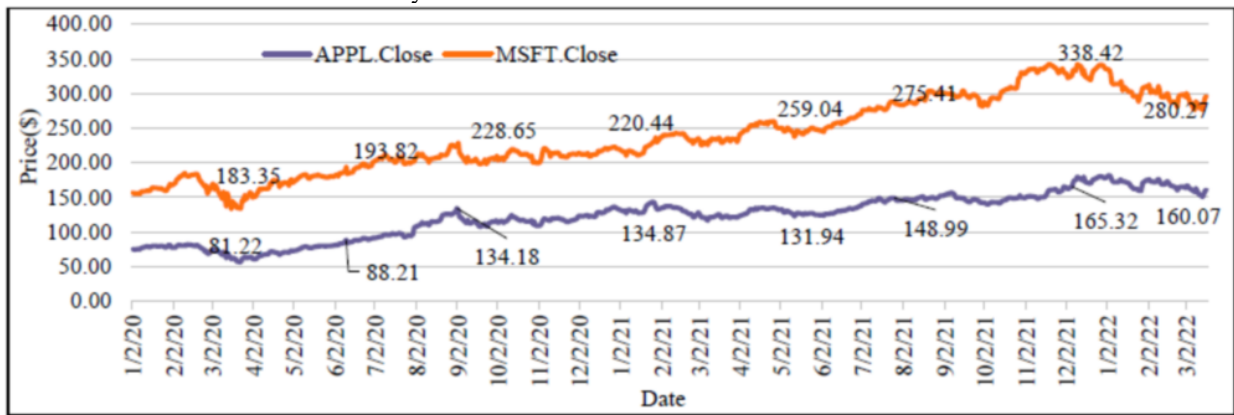


Figure 1. Close Price of AAPL and MSFT

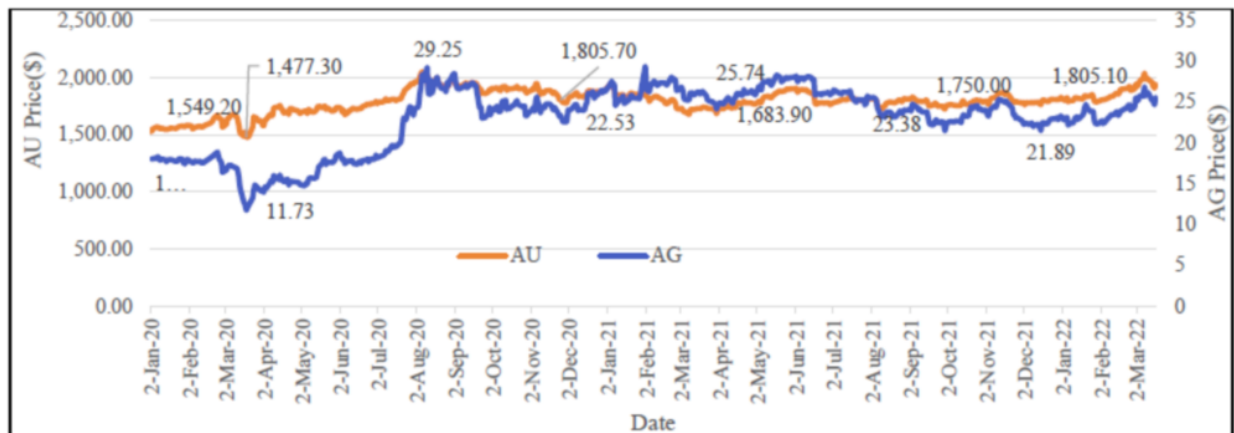


Figure 2. Close price of AU and AG.

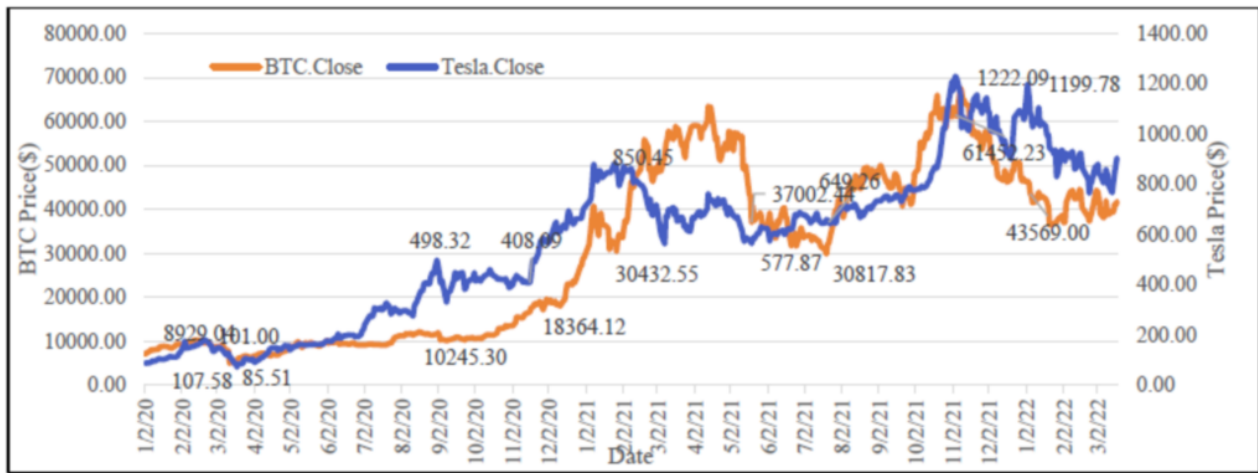


Figure 3. Close price of BTC and Tesla.

The portfolio in this paper is built using a pair-trading approach. The method of building the statistics variable is split into two parts in this situation. The spread must be obtained as the first stage. The spread equation can be described as follows

$$P_{spread} = price_A - price_M \tag{1}$$

where $price_A$ is the closing price of AAPL at time t ; $price_M$ is the close price of MSFT at time t ; P_{spread} is the difference between AAPL and MSFT at time t . Following that, the spread should be standardized, with the standardization methodology being stated as follows:

$$m_{spread} = P_{spread} - \text{mean}(P_{spread}) \tag{2}$$

$$\delta_{spread} = \text{standard deviation of Spread}_t \tag{3}$$

Here, m_{spread} is the difference between P_{spread} and its mean value. δ_{spread} is the standard deviation of m_{spread} , and is also the basic value we set threshold at (for example: in the pair trading of AAPL and MSFT, δ_{spread} and $2\delta_{spread}$ stands for open and close position correspondingly). Besides, a particular procedure is established to back - test the final profit. The back testing has the following variables

$$\begin{aligned} \text{holdprice}_A &= price_A; \text{holdprice}_M = price_M; \\ \text{holdstate}; \text{profit} \end{aligned} \tag{4}$$

where holdprice_A is the price of AAPL at time t ; holdprice_M is the holding price of MSFT at time t ; holdstate is whether we should short AAPL long MSFT or short MSFT long AAPL (it is set with -1 or 1 correspondingly); profit is the value we earn during the trade, and is also the back testing result that we calculate during the whole process. In this technique, we check whether hold_price meets the requirement of the threshold we set for each pair, so that we could decide whether continue the position or close the position to stop loss. The other trades follow the same procedure.

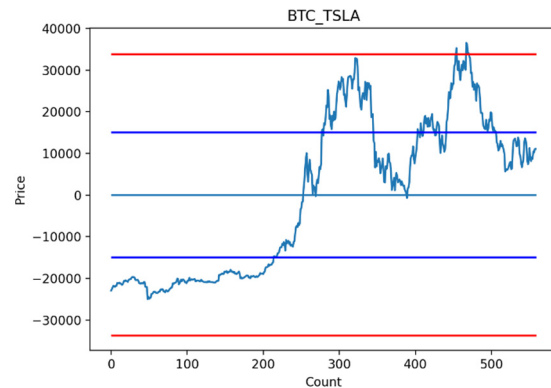


Figure 4. Price spread of the difference between BTC & TSLA

3. RESULTS

We collected daily data from 1/1/2020 to 3/18/2022 using Yahoo Finance and put those three pairs of data into Jupyter to write the code. We calculated the spread and its standard deviation (sigma) for the three pairs of data first. Afterwards, we set the threshold of each pair and drew the graphs of their spread using red lines and blue lines to represent whether we should close and open. The threshold for three pairs is: BTC&TSLA 0.8 sigma open & 1.8 sigma close; AAPL&MSFT 1 sigma open & 2 sigma close; AU & AG 1.3 sigma open & 1.9 sigma close. (As shown by blue line for opening threshold and red line for closing threshold in Figs 4-6).

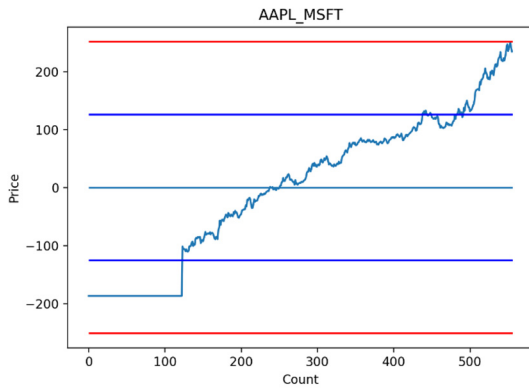


Figure 5. Price spread of the difference between AAPL & MSFT

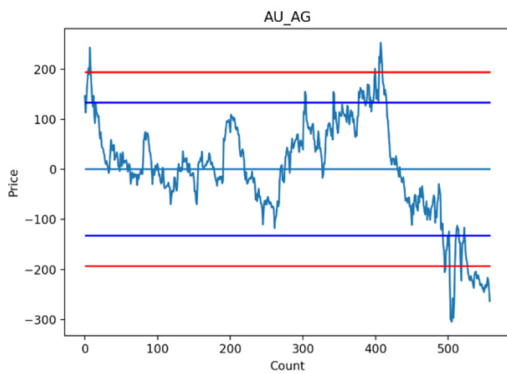


Figure 6. Price spread of the difference between AU & AG

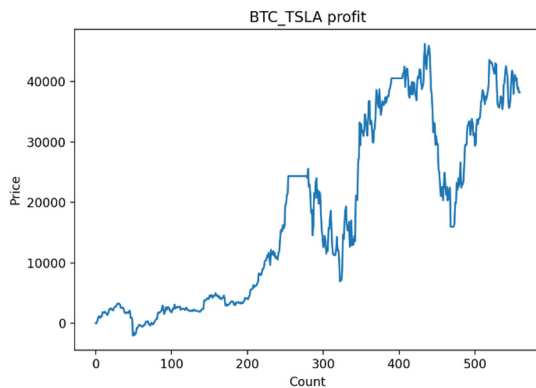


Figure 7. BTC_TSLA profit

Finally, a back-testing is set to check whether the pair trading works. The idea is that when the figure is greater than the opening threshold (hold status) or smaller than minus opening threshold (not in a hold status), we would short A long B or short B long A correspondingly. Then we would look at the data next day. When we are in a hold status, if the data is smaller than zero or exceeds the closing threshold, we would start over the whole process. Also, when we are not in a hold status, if the data is bigger than zero or smaller than minus closing threshold, we

would also do the process again. At the end of the back testing, we checked the profit of each pair at each moment and collected them into three profit graphs as demonstrated in Figs 7-9. Among those profit figures, one sees that all three pairs of data are fluctuating and will finally going back to 0 after the back testing.

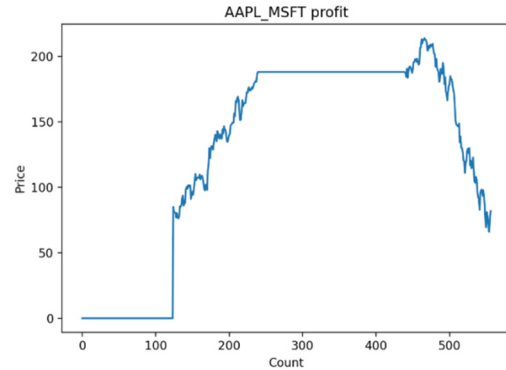


Figure 8. AAPL_MSFT profit

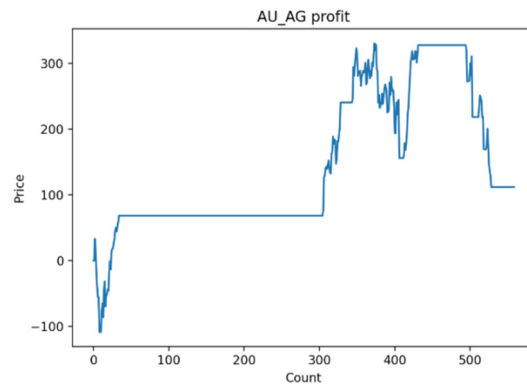


Figure 9. AU_AG profit

4. DISCUSSION

Obviously, single revenue lines fluctuate with time. If one just has RB or HC, it will face a tremendous risk. The portfolio's line, on the other hand, is consistent. With no disadvantage, the returning curve is steadily climbing. This study does, however, have significant drawbacks. The transaction cost is mostly ignored in the study, which might have an impact on the ultimate revenue.

This paper investigates the effects of arbitrage strategies in different asset pairs based on three teams of assets traded in the stock exchange. The results are depicted in Figs 4, -6, indicating the price differences between the stocks. Fig 6 shows the differences between the stores, Fig 4 indicates the stock price differences between BTC and Tesla, and Fig 5 shows the price differences between the two stocks. These results denote that the use of arbitrage strategies for different asset pairs increases the prices of the stocks for the investors. Pairs trading can be beneficial, yet it requires critical

examination, close checking, clear principles, and discipline. It is necessary to strictly use relevant models and data analysis to operate each pair of transactions. We hope investors can have a thorough understanding and basic understanding of Pair Trading through this article. In the meantime, master some basic operations of pair trading.

This study has some limitations and defects. The study was based on a very short data frequency and the quantity of data was very small. As all the data is one year while the frequency is daily, both the frequency and the data size are very small. Therefore, the research results are biased to some extent. In addition, the subjects were also not very representative.

5. CONCLUSION

Based on back-testing, three pair trading portfolios are analyzed, which all show different yield curves and different opening or selling times. Apparently, the total amount of data is too small, and the frequency is not high enough, which may lead to some deviation. Thus, it reminds us that the size and frequency of data is very important when we do research. The final decision must not be based on some partial or very low frequency data. It can only play a supporting role. Meanwhile, it is impossible for pair trading to be 100% profitable in any way. As a matter of fact, one can only reduce the risk as much as possible through the careful analysis and rigorous investment logic. In a word, investment trading has a loss and a win but should not excessively pursue the perfect profit. Overall, these results offer a guideline for further exploration of pair-trading strategies.

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