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*Original Paper*

# Research on Cross-Variety Arbitrage Strategy of Metal Futures in China

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***Abstract***

*With the vigorous development of China's futures market, the number of varieties is gradually increasing, the number of investors is increasing, and the liquidity of futures is getting better and better. The "T+0" trading mechanism of the futures market makes arbitrage traders prefer to carry out arbitrage in the futures market. Cross-variety arbitrage is one of the main ways of arbitrage in China's futures market, and its key is to find the appropriate variety combination and arbitrage strategy. The purpose of this paper is to conduct scientific and detailed research and analysis on futures cross-variety arbitrage, so that investors can have a comprehensive and in-depth understanding of it to enhance investor education, and on this basis, find appropriate variety combinations and design cross-variety arbitrage strategies and empirically test the effect of the strategies, so as to provide reference for investors and enrich the existing research on futures cross-variety arbitrage strategies.*

***Keywords***

*cross-variety arbitrage, futures investment*

## 1. Introduction

In recent years, China's futures market has developed well, with an increase in the number of investors and high investment activity. The arbitrage demand for the futures market has also increased. The investors of arbitrage trading have also changed. In the period of imperfect development of the futures market, the main investors of the futures market are physical production and trading enterprises for hedging. At this stage, the proportion of financial institutional investors in the futures market is increasing, and the proportion of physical delivery in the futures market is also gradually decreasing. Taking the data of rebar in 2022 as an example, the Shanghai Futures Exchange traded 525.1781 million rebar futures in the whole year, and 2.1702 million rebar futures were physically delivered in

the whole year, with a delivery ratio of 0.41%. The low delivery ratio usually means that the proportion of hedging traders in the futures market is low, while the proportion of speculators and arbitrageurs is high.

Arbitrage is different from investment. The key lies in the tolerance of risk. The key to the success of arbitrage is the risk of arbitrage. Unlike ordinary investments, there are relatively few opportunities to meet arbitrage, the required return space is relatively low, and the stop-loss point is strictly set, so the arbitrage itself means that the income is relatively limited. Such preconditions mean that the vast majority of arbitrageurs are risk averse, and risk control means that the conditions for arbitrage and position building need to be strictly set. With the characteristics of low risk and stable income, arbitrage is increasingly favored by institutional investors and even a few individual investors. Due to the characteristics of low risk of arbitrage, developed futures markets offer margin preference system for arbitrage trading. The margin of arbitrage is lower than the sum of the margin required for the actual trading of two futures contracts, which can help the arbitrageurs expand the scale of arbitrage by times under the capital constraints.

The cross-variety arbitrage in the futures market is simply to buy one or more contracts in a delivery month and sell one or more other contracts in the same delivery month. Before arbitrage, it is necessary to find a pair of arbitrage varieties, and consider that the price trend of the two varieties is related or related. Based on the price of one variety, determine whether the price of the other variety is relatively overvalued or undervalued. If the price is considered to be relatively high (low), buy the relatively undervalued futures contracts, sell the relatively overvalued futures contracts, and close the positions of the two varieties at the same time when the price returns to a reasonable range. In order to avoid other unnecessary risks, futures contracts with active trading and the same maturity months are usually traded.

Compared with agricultural varieties and industrial materials, metals themselves are chemical elements, belong to natural resources, and have fixed reserves in nature. Under the current technical background, most of them cannot be synthesized by artificial synthesis, but can only be extracted by minerals. Therefore, the supply of metal products is basically at a stable level, and the price is mainly related to the cost of metal extraction. Compared with other types of commodity futures, it is less affected by natural factors, and the price is more stable. Among China’s futures varieties, the arbitrage model of metal futures arbitrage is the most mature and stable. Therefore, this paper selects metal varieties to do cross-variety arbitrage research.

## 2. Method

### *2.1 Research Ideas*

This paper aims to design the strategy of cross-variety arbitrage and guide investment. Therefore, the arbitrage strategy is selected based on the relevant variety portfolio of the metal futures market. In order to determine the appropriate portfolio, all active metal varieties traded in the previous period are

used as the alternative pool. Through the correlation coefficient matrix of the portfolio, the varieties with high correlation coefficient are found and the portfolio is established.

*2.2 Research Method*

Based on empirical analysis, this paper analyzes and compares the performance of traditional arbitrage strategy and new strategy in the new data back-test through historical data modeling and new data back-test. The transaction data used in this paper mainly comes from the pioneer trading software. According to the research needs, the collected data is processed in data format using Python programming software, and the invalid information is removed, the valid information is retained, and the database in CSV format is formed, which is convenient for later analysis using relevant software. At the same time, the paper uses Excel, Python and other relevant software to test and analyze the effect of the paper's strategy back test in order to achieve the purpose of scientific and normative research.

*2.3 Design of Cross-Variety Arbitrage*

In this paper, the correlation analysis and parameter estimation of the futures varieties of the Shanghai Futures Exchange in 2021 are used. In terms of data frequency selection, taking into account the accuracy and data availability, the frequency of one-minute closing price data is selected. The data is from TB Pioneer Futures Trading Software. Before the correlation analysis, the data of all varieties in the public trading time are filtered and sorted out, and the correlation coefficient matrix is calculated using Python.

After the strategy is established, the one-minute data in the first half of 2022 is used for the strategy back-test.

2.3.1 Selection of Arbitrage Varieties

Related varieties refer to the combination of two varieties that are not in the same industry chain, but the price data is highly correlated. It is precisely because of this historical correlation that we have reason to believe that the prices of the two products will also have a certain correlation in the future, so that the prices of the products conform to a certain law. If the future price of the two products breaks this rule, it may be because of the temporary distortion of the price and will be repaired in the future. Then when the price is distorted, build a position to carry out cross-variety arbitrage and wait for the distortion to be repaired. When the price returns to normal, it will be profitable. For example, the copper and aluminum variety combination that has been studied extensively in China's cross-variety arbitrage belongs to related variety arbitrage. It is worth noting that the correlation of varieties is not static. The strong correlation in the past cannot fully represent the strong correlation in the present. When the correlation between varieties weakens, the effect of arbitrage may be greatly reduced. Therefore, arbitrage of related varieties is usually effective in a short time. Varieties with strong correlation a few years ago may not meet the requirements of cross-variety arbitrage for correlation.

Through the one-minute high-frequency data of the main contracts of the main varieties of the Shanghai Futures Exchange in 2021, the correlation analysis of the remaining 11 futures products of the Shanghai Futures Exchange was carried out, and the correlation coefficient matrix was obtained. The

results are shown in Table 1:

**Table 1. Correlation Coefficient Matrix of All Varieties**

| variety | rb | ni | bu | hc | al | ag | zn | au | cu | sn | pb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| rb | 1.00 | 0.91 | 0.82 | 0.98 | 0.82 | 0.64 | 0.92 | 0.45 | 0.88 | 0.91 | 0.85 |
| ni | 0.91 | 1.00 | 0.70 | 0.92 | 0.80 | 0.75 | 0.96 | 0.51 | 0.86 | 0.94 | 0.86 |
| bu | 0.82 | 0.70 | 1.00 | 0.80 | 0.58 | 0.43 | 0.73 | 0.21 | 0.84 | 0.68 | 0.70 |
| hc | 0.98 | 0.92 | 0.80 | 1.00 | 0.84 | 0.63 | 0.94 | 0.44 | 0.89 | 0.94 | 0.87 |
| al | 0.82 | 0.80 | 0.58 | 0.84 | 1.00 | 0.68 | 0.85 | 0.60 | 0.69 | 0.87 | 0.69 |
| ag | 0.64 | 0.75 | 0.43 | 0.63 | 0.68 | 1.00 | 0.71 | 0.89 | 0.40 | 0.69 | 0.38 |
| zn | 0.92 | 0.96 | 0.73 | 0.94 | 0.85 | 0.71 | 1.00 | 0.52 | 0.87 | 0.97 | 0.90 |
| au | 0.45 | 0.51 | 0.21 | 0.44 | 0.60 | 0.89 | 0.52 | 1.00 | 0.17 | 0.55 | 0.15 |
| cu | 0.88 | 0.86 | 0.84 | 0.89 | 0.69 | 0.40 | 0.87 | 0.17 | 1.00 | 0.84 | 0.94 |
| sn | 0.91 | 0.94 | 0.68 | 0.94 | 0.87 | 0.69 | 0.97 | 0.55 | 0.84 | 1.00 | 0.86 |
| pb | 0.85 | 0.86 | 0.70 | 0.87 | 0.69 | 0.38 | 0.90 | 0.15 | 0.94 | 0.86 | 1.00 |

It can be seen from the above table that the combination with the highest correlation is rebar (rb) - hot rolled coil (hc), with a correlation coefficient of 0.98; Both deformed steel and hot-rolled coil are made of steel. Although they are not in the same industry chain, there is no clear price relationship, but there is a logical correlation. After comprehensive consideration, the author believes that the two varieties are the most suitable for cross-variety arbitrage, so the two products are selected as the arbitrage combination.

2.3.2 Construction of Arbitrage Strategy

On the basis of the arbitrage of the selected rebar and hot coil varieties, the establishment of the traditional price difference arbitrage strategy requires a reasonable estimate of the price difference. When the price difference is in the opening range, carry out the arbitrage operation in the corresponding direction, and when the price difference returns to the closing range, carry out the closing. The product price difference in 2021 is shown in Figure 1:


**Figure 1. Trend Chart of Price Difference between Hot-Rolled Coil and Deformed Steel in 2021**

Through the analysis of the data in the above Figure, we can see that the price difference between the two products is in the range of 100 to 500 as a whole, and the overall trend of the whole year is on the rise. Statistical analysis of the price difference shows the following results:

**Table 2. Correlation Coefficient Matrix of All Varieties**

| mean | median | mode | Standard deviation | kurtosis | skewness | minimum | maximum | sample size |
|---|---|---|---|---|---|---|---|---|
| 227.6 | 196.0 | 177.0 | 88.0 | -0.3 | 0.5 | 27.0 | 495.0 | 91079 |

According to the data, the average price difference between hot coil and deformed steel bar in 2021 is 227.6, and the standard deviation is 88.0. Take the opening range outside the two times of the standard deviation near the mean value, that is, the range outside (51.6,403.6), and take 51 and 403 as the threshold value. When the price difference exceeds 403, short the hot rolled coil and make multiple deformed steel; When the price difference is less than 30, make long hot rolled coil and short deformed steel; When the price difference regression average is one time the standard deviation interval, that is, (139.6,315.6), take 139 and 315 as the threshold to complete the closing, and the theoretical return of the strategy is one time the standard deviation of the price difference data. The strategic warehouse building is based on the principle that rebar and hot-rolled coil account for 350000 yuan each.

## 3. Result

Based on the established investment strategy, the basic back-test framework is built using Python, and the back-test is realized by translating the strategy idea into program code. In order to visually display the return of the strategy, the effect of the strategy is displayed in the form of net value curve, and the initial capital is normalized to obtain the following effect diagram:

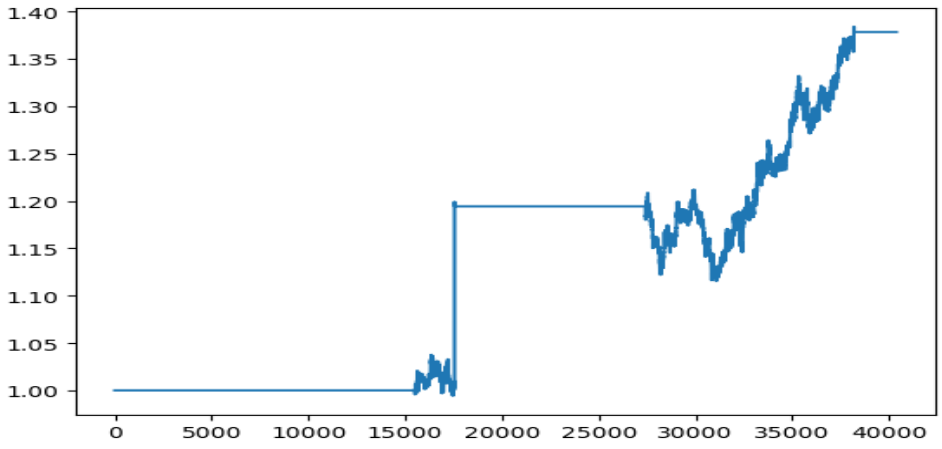


**Figure 2. Effect Chart of Arbitrage Strategy Income**

Through the calculation and analysis of relevant indicators on the yield data, the results are shown in Table 3:

**Table 3. Income Risk of Traditional Price Difference Strategy**

| Maximum fallback | Yield | standard deviation | sharpe ratio |
|---|---|---|---|
| 9.66% | 37.83% | 12.35% | 2.80 |

## 4. Discussion

Through the analysis of the back-test data, it can be observed that the arbitrage strategy generally works well in the first half of 2022, with high yield, moderate standard deviation and good winning rate. The drawback is that the back-test is large. Because the trend of price spread expansion cannot be accurately predicted, it is often necessary to bear certain losses before waiting for the return of price spread after entering the market; The position of price difference regression can not be accurately determined, which limits the performance of the strategy to some extent. Figure 3 shows the trend of price difference between the two varieties in the first half of 2022.

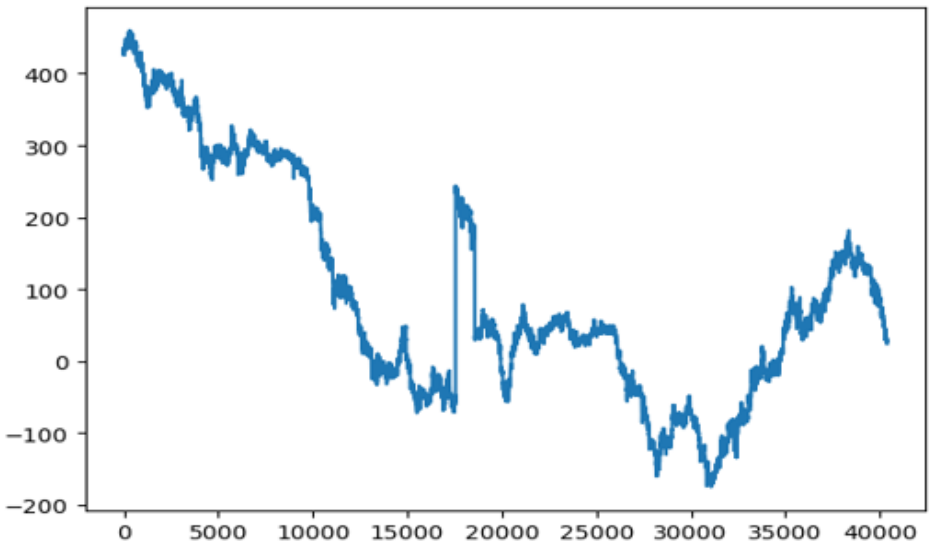


**Figure 3. Trend Chart of Price difference between Hot Coil and Deformed Steel in the First Half of**

The profit point of the arbitrage strategy is the return of the price difference to the average value. When the price difference forms a continuous upward or downward trend, the strategy will not only fail to make profits, but also cause large losses. For example, in the range of 25000 to 30000 minutes, the price difference between the two varieties continues to decrease and has a certain trend. If the price difference is predicted to return and the position is constructed, the loss caused by the continuation of

the trend will be borne first. Even the best performing traditional price difference strategy can not recognize this part of risk and bear certain losses. Therefore, in the actual operation of the traditional price difference strategy, it is necessary to manually judge the change of the price difference trend.

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