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An Empirical Study on Chinese Futures Market Based on Bollinger Bands Strategy and R

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Abstract

Quantitative investment trading is becoming more and more popular due to the gradual integration of computer technology, mathematics, and statistics. It is of great practical significance to develop a multi-species portfolio investment model that takes into account various transaction costs and conforms to live trading. In this paper, we use the free software R to program the Bollinger Bands trading strategy and test it on the historical data of the Chinese futures market. Through in-sample optimization, out-of-sample testing and correlation test, the varieties with good back testing effect are selected for risky investment portfolio to provide investors involved in the Chinese futures market with specific trading strategies that can be used for reference, and at the same time to provide investors with a way of thinking to develop quantitative investment portfolio models.

JEL classification numbers: C60.
Keywords: Quantitative investment, R language, Chinese futures market, Bollinger Bands.

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1. Introduction

1.1 Background, significance and purpose of the study

Due to the gradual convergence of computer technology, mathematics, and statistics, quantitative trading is becoming more and more popular through data mining, machine learning, and other modeling. Not only investment institutions, public or private funds, but also many individual investors are involved. Quantitative investment not only liberates traders from the burden of manual market monitoring but also offers several objective advantages that many traders cannot achieve. These advantages include a wider range of tradable assets, faster execution, immunity to emotional influences, the ability to make decisive moves, and alignment between knowledge and action.

- China's futures market has developed rapidly despite its late start. According to global turnover data from the Futures Industry Association (FIA), the Zhengzhou Commodity Exchange (ZCE), Dalian Commodity Exchange (DCE), Shanghai Futures Exchange (SFE) and China Financial Futures Exchange (CFFE) ranked 8th, 9th, 12th and 25th in the global ranking of exchanges in terms of futures and options turnover in 2022, respectively. Due to the futures market's adoption of a margin system and T+0 two-way trading, it is increasingly attractive to investors compared to China's stock market, which follows a T+1 one-way trading system. Consequently, there has been a growing influx of participants in the futures market. Research on quantitative trading strategies for Chinese futures has been increasing year by year, but it mostly focuses on the implementation and improvement of classical quantitative strategies. The development of a multi-species portfolio investment model that takes into account various transaction costs and conforms to live trading is more relevant. The research objective of this paper:
- To test whether the Bollinger Bands trading strategy is effective in the Chinese futures market using the free tool software R.

Perform in-sample optimization and out-of-sample testing of trading strategies. Select the varieties with good backtesting results for risky investment portfolios to provide investors involved in the Chinese futures market with a specific trading portfolio for reference, as well as to provide investors with an idea for developing a quantitative trading portfolio model.

1.2 Literature review

Charles Dow's Dow Theory, Elliott's Wave Theory, Markowitz's Asset Portfolio Theory (Markowitz (1952)), Sharpe's (1964) and John Lintner's (1965) and other Capital Asset Pricing Models (CAPM), Fama's Efficient Markets Theory, Stephen A. Ross' (1976) Arbitrage Pricing Theory (APT), and the option pricing theory proposed by Fischer Black et al. (1973) laid the theoretical foundation for the development of quantitative investment. Quantitative trading is the use of statistics, mathematics computer technology from a large amount of historical data to filter the trading strategy that can bring excess returns, through the computer to strictly

implement so as to obtain a stable excess return.
Edward O. Thorp founded the first quantitative investment fund in 1969, which beat the S&P for 11 consecutive years. In 1982 James Harris Simons founded the hedge fund company utilizing quantitative trading, which had an average annual return of 35% between 1989 and 2007, and even during the global financial crisis of 2008, the funds under his management returned as much as 80%. Quantitative trading began to grow rapidly in 1992 when Peter-Muller invented the alpha system strategy, before the bursting of the Internet bubble and the subprime mortgage crisis hit quantitative funds hard. As the economy has improved since 2010, quantitative trading has turned into a mainstream trading methodology. Quantitative trading includes quantitative stock picking, quantitative timing, statistical arbitrage, and high frequency trading. In this paper, we explore only the trend-following strategy of quantitative time-timing. Quantitative timing involves using various indicators to assess price trends and making buy or sell decisions based on indicator signals. If prices are rising, one opens a long position by buying; if prices are falling, one opens a short position by selling; and if prices are fluctuating within a range, a strategy of selling high and buying low is employed. The efficient market hypothesis (Eugene F. Fama, (1965,1970)) argues that in a strong efficient market all technical analysis, fundamental analysis, and insider information fail to produce excess returns, but its assumptions are difficult to meet in the real world of investing. A large number of empirical studies have found asset price overreaction (Debondt F. and Thaler R. (1985)) and underreaction, momentum effect, intraday effect, small firm phenomenon, and some other anomalies that are unexplained by many traditional finances, and so have led to the emergence of behavioral finance. Behavioral finance applies psychological theories to finance and argues that investor psychology and behavior have a significant impact on changes in the market price of securities. Irrational investor behavior has a role to play in real financial activities that cannot be ignored. Hong and Stein (1999), Burghardt and Walls (2011), Cespa and Vives (2012), Han, Yang, Zhou (2013), Neely, Rapach, Tu, and Zhou (2014) and a large number of scholars' empirical studies have shown that through technical analysis we can obtain excess returns, which has led to the rapid development of quantitative time-timing strategies based on technical analysis. The momentum effect (Jegadeesh N. and Titman S. (1993)) provides support for the effectiveness of trend-following trading strategies. Price movements in the market are characterized as upward, downward or sideways oscillations. Once a rapid rise or fall occurs, the rise or fall tends to continue for a period of time, i.e., it is presented as a trend movement, until the trend becomes unbalanced and there is a price oscillation in a certain range. Markets exhibit alternating trends and oscillations. Trends and oscillations behave differently on different time cycles. Price range oscillations on the monthly cycle may show trends and oscillations on the daily cycle. Market price range oscillations on the daily cycle may show a nice upward or downward trend on the 5-minute cycle. Trend followers use a variety of methods to capitalize on this rapid upward or downward price movement. When market prices rise (fall) to a certain standard, it is considered the emergence of an

upward (downward) trend, and traders enter long positions (short positions) while setting stop-loss and take-profit levels. Trend-following trading strategies are fundamentally not about predicting the market but rather about following market movements and taking action accordingly.

When the price is currently in an upward phase, you enter a long position by buying to align yourself with the market's direction and stay in line with the market, which is known as following the trend. By utilizing the momentum effect, you can capture profits from upward movements in the market. Allocating your capital to those assets and strategies that are expected to provide substantial returns gives you a greater advantage in terms of profitability. Matching the trading strategy to the market trend is the only way to make a profit. Trend trading does not guarantee that an investor's money will be safe and profitable, but a trend trading strategy provides an investor with a fixed method of managing risk and responding to market changes. Consistent investment over a long period of time while controlling risk and positions can lead to stable profits (Stanley Kroll, (1987)).

2. Overview of relevant knowledge

2.1 Technical analysis

2.1.1 Theoretical foundations of technical analysis

Technical analysis is the analysis method to analyze the market trend and predict the future trend of the market according to the simplest change law of supply and demand in the financial market. Its object of study is the behavior of the securities market, according to its behavior to analyze the operating trend of the securities market, and follow the cyclical changes in the trend to analyze the decision-making on how to invest. Technical analysis takes the three axioms as prerequisites (John J. Murphy (1999)).

Market behavior encompasses everything: Price fluctuations have various underlying causes, and price movements reflect all valuable information, such as war, natural disasters, politics, economic cycles, investor sentiment, and their impact on investment assets. These factors are all reflected in the market's prices, without the need to specifically identify which information is influencing prices. This is because these known or unknown factors are difficult to exhaustively identify. Regardless of the factors behind price movements, they ultimately manifest as price increases or decreases. Technical analysis can use price movements as the basis to identify patterns, analyze, and predict future market trends.

Price evolves along a trend: Trend analysis is the core of technical analysis and serves as the foundation for predicting future price movements. Although market prices are constantly changing, over a period of time, prices generally continue to move in one direction, whether it's up or down. This sustained upward or downward movement is known as a trend.

History repeats itself: Just as the sun rises in the east and sets in the west, market prices will continue to rise when the conditions for an uptrend are met and fall when the conditions for a downtrend are present. Of course, price movements are not simply repetitive or mechanical; the market allows for trends to fade, weaken, strengthen, or extend.

2.1.2 Bollinger Bands Trading Strategy

John J. Murphy (1999) describes the Bollinger Bands in detail. John Bollinger invented the Bollinger Bands technical analysis in 1980.Bollinger Band (Bollinger Band) is designed and created in accordance with the principle of standard deviation in statistics. Bollinger Band consists of three lines, the middle line (middleline) is a simple moving average of the closing price (ci) of 20 trading days:

$$middleline = \frac{\sum_{\mathrm{n}=1}^{20} c_n}{n} \tag{1}$$

Where n represents the selected time period or periods. Typically, n is set to 20 in order to calculate a 20-period simple moving average SMA as the mid-rail. This mid-rail represents the average price over a period of time and is often used to gauge the direction of the price trend. This article uses the 20-day period line to calculate the mid-rail.
The standard deviation (σ) of the closing prices of the 20 trading days is then calculated:

$$\sigma = \frac{\sqrt{\sum_{i=1}^{N}(x_i - \bar{\mathrm{x}})^{\,2}}}{\sqrt{N}} \tag{2}$$

Where: σ represents the standard deviation. Σ represents the summation. xi represents the closing price of each trading day. x̄ represents the average of the closing prices of the 20 trading days. n represents the sample size, which is here 20 trading days.
Once the standard deviation has been calculated, it can be used to determine the upper and lower Bollinger Bands. Usually the upper band (upband) is the middle band plus two times the standard deviation, and the lower band (downband) is the middle band minus two times the standard deviation, thus forming the banded area of the Bollinger Bands, which is used to identify price volatility and potential buy and sell signals:

$$upband = middleline\ +\ 2 * \sigma \tag{3}$$

$$downband = middleline -\ 2 * \sigma \tag{4}$$

John Bollinger (2001) argues that the price mostly runs between the upper and lower rails, but the price breakthrough of the upper or lower rails does not represent a price reversal, but possibly a continuation of the market. 20 trading days and 2 standard deviations are two parameters that can be adjusted and optimized depending on the market. Price rise (fall) beyond the Bollinger Bands is a small probability event. If the price breaks above (below) the upper (lower) rail, it indicates the beginning of an upward (downward) trend and the investor can open long (short) positions. Lento, Gradojevic and Wright (2007) test the profitability of Bollinger Bands (BBs) on the Toronto Stock Exchange (TSX), the Dow Jones Industrials DJIA, the Canada/U.S. Dollar spot exchange rate, and the NASDAQ. It was found that after removing transaction costs, using the top rail to sell and the bottom rail to buy was not as profitable as buying and holding, but breaking above the top rail to buy and falling below the bottom rail to sell was significantly profitable. In this article, we use the Bollinger Bands into a trend-following strategy to test it:

If the previous day's closing price is greater than the upper band of the previous day, a long position is initiated on the following day at the opening price plus 1 minimum change in the price of the commodity. The number of contracts for the long position is determined based on a risk of 2% of the initial capital. If the price reverses and the loss reaches 4% of the initial capital, the position is liquidated. If there is no stop-loss, a trailing stop for profit and loss is used, meaning the position is immediately liquidated when the lowest price falls below the middle band. The closing price is determined by subtracting 1 minimum change in the price of the commodity from the middle band price. The methods for opening and closing short positions are the exact opposite of the long positions.

2.2 Knowledge of Behavioral Finance

Traditional finance assumes that investor behavior is rational and focuses on asset pricing models. However, psychological research has found that the reality is not so, and many investors are not completely rational, thus giving rise to behavioral finance which applies psychological knowledge to finance. It focuses on how investors' psychology affects financial decisions and leads to changes in the capital market.

The phenomenon that people's cognitive results are biased due to their own or environmental factors when recognizing people or affairs is called cognitive bias. Irrational trading behavior in the financial market is caused by the following cognitive biases.

2.2.1 Recent preferences

Investors value recent experience or data over earlier experience or data. If there is a correct trading system that has compounded 20% per year for the previous 5 years and lost 10% in the last 3 months, the investor will doubt the correct trading system and may even just stop using it.

2.2.2 Anchoring effect

People's thinking when making decisions is influenced by first information that fixes the mind somewhere like a sunken anchor. This psychological effect of using a qualifying word or rule as a behavioral guide to achieve behavioral effects is called the "sunken anchor effect".

If a stock needs to be sold, the investor always uses the recent high as an "anchor", compares the current price with the previous high, and waits for the price to return to the high before he is willing to sell the stock. If the price continues to fall, the investor will continue to hold the stock. In the end, this can turn a profit into a loss (Daniel Kahneman and Amos Tversky, (1979)).

2.2.3 Sunk Cost Effects

The sunk cost effect refers to the tendency of individuals to be influenced in their subsequent decisions by their reluctance to let the costs incurred in the past, such as financial investment, time, and effort, go to waste (Hal R. Arkes, Catherine Blumer, 1985). For example, if someone buys an expensive pair of shoes but finds them very uncomfortable, the more expensive the shoes are, the more likely they are to try wearing them multiple times, even if they no longer intend to keep them. Over time, this sunk cost effect tends to weaken.

In financial markets, the sunk cost effect manifests when investors continue to hold losing stocks because they are unwilling to realize the losses associated with their initial investment. As stock prices continue to decline, investors may persist in holding these losing positions in the hope of avoiding losses, which can ultimately lead to even greater losses.

2.2.4 Disposition Effect

Shefrin and Statman (1985) found that investors are more willing to hold on to losing assets and sell profitable assets too early, an irrational behavior prevalent in financial markets called the disposition effect. Fearing the disappearance of their profits, investors sell their profitable stocks early and leave the market, failing to expand their profits. In order to prevent losses from being realized, the loss-making stock is held.

2.2.5 Outcome bias

If an investment turns out to be profitable, no matter how bad that investment decision was, the investor will consider the behavior to be correct. If a correct trading system experiences continuous losses, the investor will abandon that correct system. The investor tends to judge good and bad based on the final result rather than the quality of the decision itself. This phenomenon of investors placing more importance on the actual outcome than on the quality of the decision itself is outcome preference.

2.2.6 Herd effect

Because of the herd mentality leads to a swarm of people blindly follow and take the same action, this is the herd effect. When the price of housing has risen, the people around the buyers are making money, due to the herd effect, there will be more people to join the army of home buyers, resulting in crazy prices, until the bubble burst.

2.2.7 Loss aversion effect

If an investor purchased a stock for $10 that is now down to $5, the average investor will continue to hold on to the stock in hopes of recouping their losses when the market rebounds. If the stock is now sold at $5, the loss will actually occur. This is where the loss aversion effect comes in.

2.2.8 Law of small numbers

People often derive unsupported results from small probability events. For example, if a uniform coin is tossed 100 million times, heads and tails come up close to 50 million times, i.e., the probability of a coin coming up heads (or tails) each time the coin is tossed is 0.5. If the coin is now tossed heads 5 times in a row, on the 6th toss one would assume that the probability of tails is high. A trading strategy is treated as successful if it succeeds in 8 out of 10 tests, and the conclusion is not supported by enough information. The law of small numbers builds confidence too early.

Trend-following strategy does not predict the market to go up or down, it believes that the market sentiment is composed of trend and oscillations, oscillations are followed by trend and trend is followed by oscillations, and the law of price movement is just like that because of the human nature of the investor. Because investors' emotions and cognitive biases cause the market to go wrong, trend-following strategies are based on irrational market fluctuations to obtain excess returns (Clare A, et al., (2013)).

By investing according to a trending strategy, the cognitive biases mentioned above can be maximized and overcome. By approaching trading rationally from a probabilistic point of view, one can be in a good frame of mind to execute trading strategies with positive expectations.

The cyclicality of the trend of different trading varieties is not the same, the combination of multiple varieties will allow the funds to minimize the withdrawal of funds, shock market can also be correctly implement the trading strategy, will not be repeated stop-losses and stop using the strategy resulting in the loss of the big trend when the profit opportunities. Because in a few years of price fluctuation cycle, trend-following strategy will experience a long period of loss, without strong beliefs and good risk control, will be forced to exit the market. Investors tend to believe that they are smarter than others, and after a few profitable trades, they think they can beat the market and fail to objectively look at the market trend and expose their capital to great risk.

An optimized combination of trend trading strategies has the same expectations and risk control for every trade, while being prepared to lose money on every trade, analyzing the market with probability and positive expectations rather than predicting the market, to cut off losses and let profits run (Jaakko Aspara, (2015)). The gains from success far outweigh the losses from failure and ultimately generate excess returns.

2.3 Portfolio theory of risky assets

Markowitz (1952) published the paper Portfolio Selection which represents the emergence of portfolio theory. Portfolio is the allocation of assets to increase investment returns and reduce investment risk. The most classic theory of asset allocation is Markowitz's mean-variance model. When the probability of the rate of return of each trading variety is known, the investor can calculate the effective boundary, but also to determine the proportion of each variety of investment, but in practice when used to produce a portfolio is often difficult to understand, the error of the estimate is large, sensitive to the parameters and other drawbacks. Fisher Black and Robert Litterman (1992) proposed the Black-Litterman model, which improved and refined the CAMP model. The Black-Litterman model became the main tool used by Goldman Sachs and other asset management departments in asset allocation. Risk parity strategy is a risk-based asset allocation model, which puts the control of retracement in the first place for consideration. The main idea is to allocate assets to bear the same risk, by setting the expected return target and the maximum retracement, in consideration of the cost-effectiveness of the broad asset classes based on the proportion of investment in various types of assets, and the development of asset allocation and regular adjustment program. Risk parity strategy pursues a balance between return and risk. Therefore, risk parity strategy is an investment strategy that strives for a high Sharpe ratio. Risk parity is now an important strategy in portfolio practice due to its applicability.

Victor DeMiguel, et al. (2009) compare the allocation efficiency of optimal portfolios under various methods and find that the simple average allocation strategy has higher Sharpe ratio.

2.4 Theory of Futures Fund Management

Funds are the most basic element of a trader's trading, and futures fund management is the systematic control of the amount of funds to open positions to minimize risk and expand returns. The futures market uses a margin system, daily settlement, t+0 two-way trading, and leverage of about 10 times. These features improve the efficiency of the funds to enlarge the profit at the same time also expand the risk. Money management is critical to the success or failure of futures trading (Gary P. Brinson, et al, (1991)). It determines whether a trader can survive in the futures market in the long run. Van K. Tharp (2011) argues that a complete trading strategy includes entry rules, exit rules, position management rules, and risk control rules. Futures money management includes position management and risk control. Risk control is the first priority of futures trading and is reflected by stop loss and take profit. Position management is specifically reflected in the number of lots opened for each variety. First of all, investors should consider that the total number of open positions should not exceed 50% of the total capital. If the capital investment is too large, when the need for additional margin will be forced to close the position, the capital investment is too small, the capital utilization efficiency is too low, the overall rate of return will decline. Secondly, investors should implement the proportion of funds allocated to each species. If there is a low correlation of 10 varieties to invest, each variety of funds is 5% of the total funds. Finally, open positions are calculated based on their prices and margin ratios. Suppose the total capital is 1 million RMB and the variety is rebar. Each time the use of funds to open positions for 50,000, the opening price of 4,000 yuan per ton, each hand is 10 tons, the margin ratio is 10%, the opening position N is calculated as follows:

$$\mathrm{N} = \frac{100000*0.05}{4000\times10\times10\%} \approx 12 \tag{5}$$

That is rebar can only open a maximum of 12 lots of positions. The margin occupied after opening a position is RMB 48,000, and there is no capital limit exceeding RMB 50,000.

There are many ways to calculate the position. If the maximum loss amount per time is 2% of the initial funds to calculate the opening position, or rebar for example, the initial funds are 300000 yuan RMB, the opening price is 4000 yuan per ton, the strategy stop loss price is 3800, then the opening position is calculated as follows:

$$\mathrm{N} = \frac{300000*0.02}{(4000-3800)\times10} = 3 \tag{6}$$

If you open a position of 3 lots in this manner, when the stop loss occurs, you will lose $6,000, which is exactly 2% of the initial capital loss. This is a good way to control risk.

Position management strategies can be categorized into Equivalent Martingale Strategy and Inverse Equivalent Martingale Strategy. Equivalent Martingale Strategy is to increase the capital invested in the subsequent trades when there is a loss, and decrease the capital invested when there is a profit. The Inverse Equivalent Martingale Strategy is the opposite, where you put less money into the trade when there is a loss, and more money into the trade when there is a profit. If there is an infinite amount of capital, the Equivalent Harness strategy is a good strategy. In reality, the total amount of money is finite, so the inverse equivalence harness strategy is the better money management strategy. Reducing the amount of money available to open positions when losses are incurred ensures that there is always money available to participate in the trade and that all losses can be recovered when the opportunity arises. It is difficult for an investor to predict the later movement of market conditions, as long as it is a trading strategy with a positive expected value, following the rules of strategy and money management, the investor will most likely be able to succeed (Van K. Tharp (2006)).

The Kelly formula calculates the optimal percentage of money that should be invested each time in an independently repeated bet with a positive expected return. John Larry Kelly (1956) proposed the Kelly formula, which was later applied to blackjack and the stock market by Edward O. Thorp (1980), and is well known to investors (Louis M. Rotando and Edward O. Thorp, (1992)). Thorp, (1992)) is well known to investors. The formula is as follows:

$$K = W - (1 - \mathrm{W})/\mathrm{R} \tag{7}$$

where K = the amount of money invested as a percentage of the total capital, W = the probability of winning, and R = the profit/loss ratio - 1.
The Kelly formula also belongs to the Inverse Equivalence Harness strategy.

2.5 Description of the indicators for the evaluation of the strategy test

2.5.1 Examine the indicators of profitability

Annualized compounded yields quantify yields on an annual basis to facilitate direct comparison of yields.

2.5.2 Examine the indicators of stability

Profitability Ratio is the probability that the strategy will make money: Profitability Ratio = number of profits / total number of trades. Obviously the bigger the number the better.
The Profit/Loss Ratio is the ratio of the average profit per trade to the average loss per trade: Profit/Loss Ratio = (Total Profit/Profit Trades)/(Total Loss/Loss Trades). Together with the profit ratio, the profit/loss ratio constitutes the mathematical expectation E(r) that affects the profit/loss of a strategy:

$$\mathrm{E(r)} = \mathrm{PR} * \mathrm{PLR} \tag{8}$$

If E(r) > 1, the strategy return has a positive expectation.

2.5.3 Examine the indicators of risk capacity

Annualized volatility is used to measure the risk of volatility of the underlying investment:

$$\text{Eannualized volatility} = \text{standard deviation of daily returns} * 252 \tag{9}$$

Higher volatility means higher risk taken.

2.5.4 Composite indicators

The formula for calculating the Sharpe ratio is as follows:

$$\mathrm{sharpR} = \mathrm{ER} - \mathrm{Rf}\sigma \tag{10}$$

Where E(R) represents the expected annualized return of the portfolio, Rf represents the annualized risk-free rate, σ represents the standard deviation of the expected annualized return of the portfolio, and the Sharpe ratio reflects the relationship between return and risk, the higher the Sharpe ratio, the better the portfolio.
Rollinger et al. (2014) proposed that the Sharpe ratio does not distinguish between upward and downward volatility. Outliers with high returns can increase the standard deviation more than the numerator value leading to a lower Sharpe ratio. In trend-following strategy, Sharpe ratio can be increased by removing the largest positive returns. When returns are not normally distributed, the Sharpe Ratio measures risk-reward undesirably. The SortinoR (Sortino Ratio) is calculated as follows:

$$\mathrm{SortinoR} = \mathrm{ER} - \mathrm{RfSemivariance} \tag{11}$$

Similar to the Sharpe Ratio, but the Sortino Ratio utilizes the lower bias standard deviation Semivariance instead of the total standard deviation σ. Semivariance means that all expected returns less than Rf are used to calculate the standard deviation. The Sortino Ratio places more weight on the expected loss analysis of the (left) tail to distinguish between unfavorable and favorable volatility. The Sortino ratio is a more prudent indicator of valuation.

3. Empirical research

3.1 Data

3.1.1 Downloading data

Ince, O. S., & Porter, R. B. (2006) argued that the use of Thomson Datastream to collect data on individual stocks in markets outside the U.S. needs to be done with great care, and that there are flaws in the data. The CSMAR database of Chinese economic and financial research is a database that has been designed with the best practices of the University of Chicago's CRSP, Standard and Poor's Compustat, the New York Stock Exchange, TAQ, and Thomson's internationally recognized databases, and carefully designed with the Chinese context in mind. TAQ, and Thomson international famous database's successful experience, and combined with China's national conditions carefully designed database. The database is one of the most comprehensive economic and financial research databases in China. Therefore, we download our data from CSMAR for relevant futures trading data.

3.1.2 Selection of futures varieties

The mainstream financial securities trading markets in China are: bond market, stock market, futures market. The futures market is the second largest trading market after the stock market, with strong liquidity. Futures trading using the margin system, you can freely choose 1-10 times the leverage to improve the efficiency of capital utilization; at the same time, the use of bilateral position mechanism, T + 0 trading rules to ensure that investors can flexibly implement the strategy. Therefore, this paper chooses the futures market as the research object.

Trend-following strategies are speculative in nature and require a certain level of volatility and liquidity in the traded instruments. Trend-following strategies rely on megatrends to win, so it is important to choose varieties to trade that have high market volatility and smooth trends. Trend strategy relies on price movements to profit, the high volatility of the price can produce a higher possibility of profit. At the same time requires a higher risk management ability. In this paper, we choose to test varieties with good liquidity (daily turnover of the main contract is more than 100,000 lots, and the trading volume is more than RMB 1 billion), and then remove the varieties with short time and poor trend tracking, and then optimize and test the rest of the trading varieties. As of July 28, 2023, there are 74 varieties listed and traded in China's futures market, and 60 varieties are selected for testing according to the above criteria.

Trend following strategies for daily cycles are medium to long term trading strategies that often involve changing the main contract. The trading strategy involves choosing a contract index to study. Various trading programs have different methods of calculating indices. Changing the main contract sometimes there is a change in the month of the short jump and so on, resulting in trading strategy calculation deviation. Various methods of calculating indices have their own advantages and disadvantages. I refer to Jack D. Schwager (1996) to prepare the contract index method to calculate the main continuous contract: similar to the stock's front-weighted, the main contract connected to the current main contract as a standard, the previous data using the current main contract plus or minus the spread, so that the test is closer to the real market (if the front-weighted price is negative, then the back-weighted way, to ensure that the data can be used in the (Rstudio can run normally).

3.2 Data backtesting

3.2.1 Data processing

Firstly, the downloaded raw data were imported into Rstudio (see Appendix 1 and 2 for the relevant R codes for importing, cleaning and exporting of data, and install the relevant versions of R and RSTUDIO and packages that need to be used before importing the data, as described in Appendix 1).

There are a total of 1,786,847 observations in the raw data, including 72 futures contracts. The different contracts of each variety contain data on the opening, high, low, and closing prices as well as volume, positions, and turnover for each trading day. The earliest date in these data is 1998-01-05, and the last closing dates are all 2023-07-28 (see data1 in the Rstudio environment for specific information). Futures specific species names are shown in Table 1 and descriptive statistics of the data in Table 2.

Table 1: Names of the futures varieties

V1	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**	**V9**
Yellow Soybean No.1	Silver	Aluminium	Alumina	Fresh apples	Gold	Yellow Soybean No.2	Blockboard	Cathode copper
V10	V11	V12	V13	V14	V15	V16	V17	V18
Butadiene rubber	Petroleum asphalt	Corn	Cotton	Red jujube	Corn starch	Copper	Cotton yarn	Styrene
V19	V20	V21	V22	V23	V24	V25	V26	V27
Ethylene glycol	Fiberboard	Glass	Fuel oil	Hot rolled coil plate	Iron ore	CSI 500 stock index futures	Shanghai and Shenzhen 300 Index Futures	Shanghai Stock Exchange 50 Index Futures
V28	V29	V30	V31	V32	V33	V34	V35	V36
CSI 1000 stock index futures	Coke	Fresh eggs	Coking coal	Japonica rice	LLDPE	Lithium carbonate	Live pigs	Late indica rice
V37	V38	V39	V40	V41	V42	V43	V44	V45
Low sulfur fuel oil	Soybean meal	Methanol	Nickel	No. 20 adhesive	Rapeseed oil	palm oil	Lead	Spun
V46	V47	V48	V49	V50	V51	V52	V53	V54
Liquefied petroleum gas	Peanut kernels	Pumai	Polypropylene	Threaded steel	Early indica rice	Rapeseed meal	Japonica rice	Rapeseed
V55	V56	V57	V58	V59	V60	V61	V62	V63
Natural rubber	Soda ash	Medium sulfur crude oil	Ferrosilicon	Industrial silicon	Manganese silicon	tin	Bleached kraft softwood pulp	White sugar
V64	V65	V66	V67	V68	V69	V70	V71	V72
Stainless steel	PTA	Urea	Polyvinyl chloride	Strong wheat	Wire rod	Soybean oil	Steam coal	Zinc

Table 1 shows the names of the 72 futures varieties

Table 2: Descriptive statistics of raw data

Trddt	Agmtcd	Trdvar	Exhcd	Opnprc	Hiprc	Loprc	Clsprc	Volume	Opint	Turnover
Min.: 1998-01-05	Length: 1786847	Length: 1786847	Length: 1786847	Min.: 0	Min.: 0	Min.: 0	Min.: 0	Min.: 0	Min.: 0	Min.: 0
1st Qu.: 2013-01-30	Class: character	Class: character	Class: character	1st Qu.: 2510	1st Qu.: 2524	1st Qu.: 2499	1st Qu.: 2512	1st Qu.: 0	1st Qu.: 8	1st Qu.: 0
Median: 2017-06-21	Mode: character	Mode: character	Mode: character	Median: 4464	Median: 4487	Median: 4442	Median: 4464	Median: 44	Median: 472	Median: 203
Mean: 2016-04-23				Mean: 11516	Mean: 11590	Mean: 11443	Mean: 11514	Mean: 45496	Mean: 44421	Mean: 339434
3rd Qu.: 2020-11-09				3rd Qu.: 9750	3rd Qu: 9802	3rd Qu.: 9695	3rd Qu.: 9750	3rd Qu.: 3847	3rd Qu.: 13896	3rd Qu.: 24061
Max.: 2023-07-28				Max.:3 91660	Max.: 396660	Max.: 355000	Max.: 391660	Max.: 22361440	Max.: 4832902	Max.: 359888094
NA's				NA's: 720	NA's: 720	NA's: 720	NA's: 37	NA's	NA's: 26929	NA's: 76595

Column 1 of Table 2 is the specific date of the trading day, column 2 is the contract code of the futures, column 3 is the name of the futures, column 4 is the code of the exchange, and columns 5 through 11 are the daily opening, high, low, and closing prices as well as the volume, position, and turnover, respectively.

The raw data invalid values are removed by the R code in Appendix 2, from which the main contract and the relevant variables needed for each variety are extracted and the prices are reweighted. Finally, these 72 futures main contract data are converted into a standard time series format. From the data, it can be found that some varieties such as strong wheat late volume is very small, indicating that this futures varieties are not many participants, not suitable for trading, natural rubber is a very active trading varieties, but in the early stage of the lack of data, there are also some new varieties such as lithium carbonate listed on the market in a short period of time only 25 trading days of data, as a result of these factors finally got 60 data integrity of the futures varieties. Figure 1 shows the K chart of some of the finishing futures varieties.

Figure 1: K charts of some futures varieties

As can be seen in Figure 1, the futures varieties are normal in terms of volume and price. In total, 60 data-complete futures varieties are obtained for later testing.

3.2.2 Tests for each futures variety

Firstly, according to the standard of 2.1.2 to 2.1.6, the complete code of Bollinger Bands strategy is written in Rstudio (R version 4.1.3) software, and the specific content of the code is shown in Appendix 3. Secondly, the 60 futures varieties that are organized to use the Bollinger Bands trading strategy will be tested, and the statistical results of the tested trades are shown in Table 3.

Table 3: Initial test results of Bollinger Bands trading strategy

ID	Number of transactions	Net Profit	X profit per trade	Winning percentage	Profit Loss Ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
Shanghai and Shenzhen 300 Index Futures	134	839238	6262.97	37.31	2.46	0.92	0.11	0.28	0.4	0.05
Cotton	185	835598.21	4516.75	37.3	3.32	1.24	0.07	0.1	0.74	0.08
PTA	158	796239.67	5039.49	39.87	3.28	1.31	0.08	0.08	1.01	0.1
CSI 500 stock index futures	89	764910.58	8594.5	31.46	3.21	1.01	0.17	0.36	0.48	0.07
Soybean meal	227	585838.3	2580.79	39.21	2.26	0.88	0.05	0.13	0.39	0.04
Rebar	135	543787	4028.05	46.67	2.19	1.02	0.08	0.09	0.83	0.09
Soybean oil	169	504450.65	2984.92	39.64	2.56	1.02	0.06	0.1	0.6	0.06
Coke	115	496401.94	4316.54	40	2.75	1.1	0.09	0.11	0.75	0.08
Palm oil	151	343716.09	2283.79	37.09	2.49	0.92	0.05	0.11	0.46	0.05
Hot rolled coil plate	92	292284.07	3177	41.3	2.55	1.05	0.08	0.11	0.68	0.07
Silver	109	289052.14	2651.85	28.44	3.86	1.1	0.06	0.13	0.5	0.06
Fresh apples	53	264131.69	4983.62	43.4	3.08	1.34	0.12	0.13	0.93	0.1
Aluminium	150	263936.73	1759.58	34.67	2.56	0.89	0.05	0.15	0.31	0.04
Iron ore	100	261186.26	2611.86	35	3.18	1.11	0.07	0.1	0.67	0.07
Rapeseed oil	174	254523.76	1462.78	32.18	2.76	0.89	0.04	0.13	0.32	0.04
Corn	193	205113.56	1062.76	34.72	2.26	0.79	0.03	0.13	0.23	0.03
Bleached kraft softwood pulp	45	203675.19	4526.12	26.67	5.24	1.4	0.12	0.16	0.79	0.08
Polyvinyl chloride	137	198218.9	1446.85	36.5	2.24	0.82	0.04	0.17	0.22	0.03
Natural rubber	147	188316.19	1281.06	35.37	2.41	0.85	0.04	0.11	0.33	0.04
White sugar	174	171436.41	985.27	35.06	2.23	0.78	0.03	0.12	0.23	0.03
Styrene	37	153012.97	4135.49	37.84	3.47	1.31	0.12	0.14	0.86	0.1
Manganese silicon	92	149878.8	1638.32	31.52	2.84	0.89	0.05	0.17	0.28	0.03
Fuel oil	152	147410.98	969.81	29.61	2.65	0.78	0.03	2.23	0.01	0.04
Soda ash	38	138942.99	3656.39	36.84	3.29	1.21	0.11	0.15	0.74	0.08
Medium sulfur crude oil	55	138464.05	2517.53	43.64	1.57	0.68	0.08	0.29	0.27	0.04
Nickel	81	134945.76	1666	34.57	2.73	0.94	0.05	0.14	0.34	0.04
Live pigs	21	134473.41	6403.5	38.1	5.38	2.05	0.16	0.12	1.32	0.13
Methanol	118	114225.2	968.01	34.75	2.26	0.79	0.03	0.12	0.23	0.03
Glass	112	113280.53	1011.43	36.61	2.15	0.79	0.03	0.17	0.19	0.03
Zinc	145	111345.99	767.9	35.86	2.11	0.76	0.02	0.13	0.18	0.02
Tin	83	82970.74	999.65	31.33	2.68	0.84	0.03	0.17	0.18	0.03
Stainless steel	36	81198.9	2255.53	47.22	1.84	0.87	0.07	0.13	0.52	0.05
Lead	133	72910.5	548.2	30.08	2.61	0.78	0.02	0.11	0.16	0.02
Ethylene glycol	47	67973.69	1446.25	34.04	2.61	0.89	0.05	0.15	0.32	0.04
Industrial silicon	3	56032.93	18677.64	66.67	7	4.67	0.35	0.12	2.92	0.3
Coking coal	106	53785.48	507.41	31.13	2.48	0.77	0.02	0.15	0.11	0.02

Liquefied petroleum gas	31	48689.53	1570.63	38.71	2.76	1.07	0.05	0.11	0.42	0.04
Fiber board	31	40828.82	1317.06	48.39	1.4	0.68	0.04	0.42	0.09	0.03
Gold	144	39604.63	275.03	32.64	2.19	0.72	0.01	0.15	0.06	0.01
Copper	151	26252.16	173.86	27.15	2.79	0.76	0.01	0.16	0.04	0.01
Urea	43	17921.39	416.78	32.56	2.25	0.73	0.02	0.2	0.08	0.02
Corn starch	91	10722.5	117.83	34.07	1.99	0.68	0	0.15	0.03	0.01
Ferrosilicon	96	3216.08	33.5	32.29	2.11	0.68	0	0.25	0	0.01
Red jujube	42	-2316.75	-55.16	28.57	2.47	0.71	0	0.22	-0.01	0.01
Cotton yarn	69	-2347.83	-34.03	27.54	2.61	0.72	0	0.22	-0.01	0.01
Short Fiber	26	-9360.64	-360.02	30.77	2.07	0.64	-0.01	0.15	-0.08	0
Peanut kernels	25	-11344.02	-398.9	40	1.36	0.54	-0.02	0.14	-0.11	0
polypropylene	99	-15839.28	-159.99	31.31	2.12	0.66	-0.01	0.15	-0.04	0
Fresh eggs	104	-41761.45	-401.55	28.85	2.27	0.66	-0.02	0.15	-0.1	0
LLDPE	173	-74797.58	-432.36	36.42	1.58	0.58	-0.02	0.16	-0.12	0
Cathode copper	30	-86217.36	-2873.91	23.33	1.82	0.42	-0.12	0.18	-0.67	-0.06
CSI 1000 stock index futures	10	-90593.08	-9059.31	30	1.38	0.41	-0.31	0.67	-0.46	-0.02
Rapeseed meal	120	-93387.91	-778.23	27.5	2.26	0.62	-0.04	0.23	-0.16	-0.01
Low sulfur fuel oil	37	-98207.33	-2654.25	21.62	1.87	0.4	-0.12	0.18	-0.71	-0.06
No.20 Rubber	46	-114519.95	-2489.56	23.91	1.09	0.26	-0.12	0.14	-0.85	-0.07
Petroleum asphalt	104	-128150.75	-1232.22	26.92	2.08	0.56	-0.06	0.22	-0.26	-0.01
SSE 50 Index Futures	87	-130748.01	-1502.85	34.48	1.67	0.57	-0.07	0.64	-0.11	0.02
No.1 Soybean	124	-135337.09	-1091.43	33.87	1.51	0.51	-0.06	0.28	-0.2	-0.01
Polished round-grained rice	47	-158715.44	-3376.92	17.02	2.45	0.42	-0.18	0.16	-1.1	-0.09
Sum	5726	9046498.9	91729.61	2039.59	150.66	53.46	1.63	12.62	15.23	2.05
average value	190.867	301549.9633	3057.65367	67.986333	5.022	1.782	0.054333333	0.42066667	0.507666667	0.068333

Table 3 shows the test results of the Bollinger Bands strategy loaded onto 60 futures varieties. Column 1 is the name of each futures variety. Column 2 is the number of trades (1 complete buy and sell cycle is 1 trade) for each variety during the test period. Since each variety has been on the market for a different period of time, those with a low number of trades are the newly listed varieties. The higher the number of trades, the more reliable its statistical significance. Column 3 represents the profit obtained by trading with the Bollinger Bands strategy, minus the commission, with negative numbers representing losses. The commission was increased during the test so that it was closest to the real profit of the actual trade. Column 4 shows the average profit per trade. The higher the average profit per trade, the more reliable the trade. Column 5 is the Profit Ratio. Column 6 is the Profit/Loss Ratio, which is the ratio of the average profit per trade to the average loss per trade. Column 7 is the return expectation of the strategy, the higher the value the more likely it is to be profitable in the future. Columns 8 through 10 are the annualized compounded return, annualized volatility, and annualized Sharpe ratio, respectively. The last column is the Sortino Ratio. The bottom two rows are the sum and mean of the columns.

As can be seen from Table 3, 60 trading varieties were traded using the Bollinger Bands strategy, and only 16 varieties incurred losses, except for alumina, which was listed for too short a period of time for no trades to take place, indicating that this strategy has a better generalizability. Abandon these loss-making trading varieties. Some varieties listed for a short time, the number of transactions is small. Therefore the varieties with less than 30 trades were removed. Within the remaining varieties, futures varieties with annualized compounded returns of not less than 8% are selected for optimization. In total, 11 traded varieties were obtained, as shown in Table 4.

Table 4: Futures varieties with good backtesting results for Bollinger Bands

ID	Number of transactions	Net Profit	X profit per trade	Winning percentage	Profit Loss Ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
CSI 500 stock index futures	89	764910.58	8594.5	31.46	3.21	1.01	0.17	0.36	0.48	0.07
Bleached kraft softwood pulp	45	203675.19	4526.12	26.67	5.24	1.4	0.12	0.16	0.79	0.08
Fresh apples	53	264131.69	4983.62	43.4	3.08	1.34	0.12	0.13	0.93	0.1
styrene	37	153012.97	4135.49	37.84	3.47	1.31	0.12	0.14	0.86	0.1
Soda ash	38	138942.99	3656.39	36.84	3.29	1.21	0.11	0.15	0.74	0.08
Shanghai and Shenzhen 300 Index Futures	134	839238	6262.97	37.31	2.46	0.92	0.11	0.28	0.4	0.05
Coke	115	496401.94	4316.54	40	2.75	1.1	0.09	0.11	0.75	0.08
PTA	158	796239.67	5039.49	39.87	3.28	1.31	0.08	0.08	1.01	0.1
Hot rolled coil plate	92	292284.07	3177	41.3	2.55	1.05	0.08	0.11	0.68	0.07
Rebar	135	543787	4028.05	46.67	2.19	1.02	0.08	0.09	0.83	0.09
Medium sulfur crude oil	55	138464.05	2517.53	43.64	1.57	0.68	0.08	0.29	0.27	0.04

3.2.2 In-sample optimization

The futures varieties with good backtesting results of the Bollinger Bands strategy are shown in Table 4. The data of each variety is divided into two segments, and the first half of the data is used for in-sample parameter optimization, and the second half of the data is used for out-of-sample testing. Parameters 20 and 2 of the Bollinger Bands trading strategy are optimized in these 11 futures varieties, and the specific code for optimization is shown in Appendix 4. The results after running the code are shown in Tables 5 to 15, respectively.

Table 5: CSI 500 stock index futures parameter optimization results

ID	BBands Opt	BBands. opt2	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit/Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
32	10	2	80	1019021	13085.64	38.75	3.03	1.17	0.45	0.46	0.98	0.13
40	18	2	51	844987.9	16920.7	33.33	3.76	1.25	0.4	0.46	0.87	0.11
42	20	2	43	810036	19187.99	32.56	4	1.3	0.39	0.48	0.8	0.11
43	21	2	39	803257	20945.78	41.03	2.9	1.19	0.38	0.49	0.78	0.11
38	16	2	52	693474.2	13684.51	36.54	2.84	1.04	0.35	0.49	0.71	0.1
41	19	2	46	691106.6	15372.94	28.26	4.32	1.22	0.35	0.48	0.73	0.1
67	14	3	16	632295	39878.85	50	4.29	2.14	0.33	0.45	0.73	0.13
16	25	1	61	315117.5	3743.54	29.51	2.87	0.85	0.2	0.71	0.28	0.07
14	23	1	63	302105.3	5151.79	30.16	2.9	0.87	0.19	1.33	0.14	0.09
66	13	3	18	266358.7	15145.89	50	2.28	1.14	0.17	0.32	0.53	0.08
70	17	3	16	261059.5	16685.26	37.5	3.38	1.27	0.17	0.56	0.3	0.08
4	13	1	98	232462	2571.55	35.71	2.04	0.73	0.15	1.94	0.08	0.11
2	11	1	107	211472.3	2188.86	30.84	2.51	0.78	0.14	1.25	0.11	0.08
3	12	1	106	181170.2	1921.58	31.13	2.45	0.76	0.13	1.22	0.1	0.08
72	19	3	11	131896.9	12356.78	27.27	4.5	1.23	0.1	0.55	0.17	0.06
9	18	1	80	122125.2	1690.32	32.5	2.25	0.73	0.09	1.06	0.08	0.06
78	25	3	12	42121.71	3334.71	41.67	1.6	0.67	0.03	0.77	0.04	0.04
93	40	3	6	32350.3	4722.41	33.33	2.34	0.78	0.03	0.48	0.05	0.03
90	37	3	7	23444.12	2824.95	28.57	2.77	0.79	0.02	0.5	0.04	0.03
111	27	4	1	-28130.2	-27884.6	0	NA	NA	-0.02	0.11	-0.22	-0.01
112	28	4	1	-29766.7	-29521.2	0	NA	NA	-0.03	0.11	-0.23	-0.01
113	29	4	1	-30949.6	-30704	0	NA	NA	-0.03	0.11	-0.24	-0.01
51	29	2	32	-32938.2	-3147.23	34.38	1.67	0.57	-0.03	37.16	0	-0.03
116	32	4	1	-35688.8	-35443.2	0	NA	NA	-0.03	0.11	-0.27	-0.02
102	18	4	2	-37619.9	-18500	0	NA	NA	-0.03	0.12	-0.27	-0.02
84	31	3	9	-40688.6	-4876.92	22.22	2.88	0.64	-0.04	1.03	-0.03	0.05
103	19	4	2	-42954.5	-21167.3	0	NA	NA	-0.04	0.12	-0.3	-0.02
104	20	4	2	-47581.6	-23480.8	0	NA	NA	-0.04	0.13	-0.33	-0.02
95	11	4	3	-67952.5	-22283.8	0	NA	NA	-0.06	0.08	-0.82	-0.06
101	17	4	3	-70905.3	-23328.5	33.33	0.09	0.03	-0.07	0.17	-0.39	-0.02
107	23	4	3	-72586.1	-23856.3	0	NA	NA	-0.07	0.21	-0.32	-0.02
97	13	4	2	-73984.3	-36611.6	0	NA	NA	-0.07	0.07	-1.02	-0.06
98	14	4	2	-73984.3	-36611.6	0	NA	NA	-0.07	0.07	-1.02	-0.06
99	15	4	2	-73984.3	-36611.6	0	NA	NA	-0.07	0.07	-1.02	-0.06
108	24	4	3	-77302.6	-25428.5	0	NA	NA	-0.07	0.21	-0.33	-0.02
6	15	1	89	-81393.2	-731.67	37.08	1.64	0.61	-0.08	19.45	0	-0.02
28	37	1	46	-83602.3	-3782.18	30.43	1.96	0.6	-0.08	10.96	-0.01	0.04
5	14	1	96	-91086	-752.92	34.38	1.84	0.63	-0.09	154.45	0	0.54
122	38	4	2	-96254.4	-47848.9	0	NA	NA	-0.09	0.21	-0.44	-0.03
47	25	2	37	-100743	-4508.86	29.73	2.03	0.6	-0.1	4.92	-0.02	0.08
86	33	3	9	-108259	-12386.5	22.22	2.24	0.5	-0.11	2.36	-0.04	0.11
80	27	3	11	-128297	-11895.2	27.27	1.63	0.45	-0.13	3.64	-0.04	0.07
79	26	3	12	-174727	-14744.5	33.33	0.97	0.32	-0.2	4.65	-0.04	0.07
56	34	2	27	-177914	-6463.16	33.33	1.59	0.53	-0.2	89.8	0	-0.03
49	27	2	34	-186219	-7456.9	32.35	1.61	0.52	-0.22	49.97	0	0.06
48	26	2	35	-242221	-8831.91	31.43	1.58	0.5	-0.34	12.97	-0.03	0.12
22	31	1	52	-282581	-7160.22	30.77	1.65	0.51	-0.51	65.7	-0.01	0.2
21	30	1	54	-355881	-8238.12	33.33	1.39	0.46	NA	125.31	NA	-0.04
62	40	2	22	-365103	-16530.4	36.36	0.95	0.35	NA	105.09	NA	-0.03
54	32	2	29	-483706	-16535.2	27.59	1.44	0.4	NA	48.45	NA	0.25

In Table 5, column 1, ID, indicates the number of sequences in the permutation of the 50 randomly selected samples, column 2 indicates that the parameter 20 for the mean of the closing price of the 20 trading days is selected between 10 and 40 trading days, column 3 is the parameter of the 2 standard deviations is selected between 1 and 4, and the other columns express the same meanings as the descriptions in Table 3.

Table 6: Bleached kraft softwood pulp parameter optimization results

BBands. opt	BBands. opt2	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit/Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
18	1	40	209157.5	5397.66	22.5	9.98	2.25	0.27	0.2	1.33	0.14
14	1	45	195950.6	4528.54	28.89	6.92	2	0.25	0.18	1.36	0.14
13	1	46	195574.4	4424.02	26.09	7.45	1.94	0.25	0.19	1.32	0.14
15	1	43	188164.3	4552.23	30.23	5.84	1.77	0.24	0.19	1.3	0.13
30	1	27	185404.8	7033.27	22.22	9.71	2.16	0.24	0.21	1.13	0.11
18	2	23	179303.6	7958.75	26.09	7.58	1.98	0.23	0.2	1.18	0.12
19	2	24	175384.5	7469.1	25	7.85	1.96	0.23	0.2	1.14	0.12
20	2	23	173120.4	7677.76	26.09	7.23	1.89	0.22	0.2	1.1	0.11
21	2	23	172765.8	7696.77	26.09	7.42	1.94	0.22	0.21	1.09	0.11
25	1	34	172180.9	5248.67	23.53	7.97	1.88	0.22	0.21	1.08	0.11
27	2	15	171732.2	11609.66	40	5.67	2.27	0.22	0.18	1.27	0.13
23	1	36	171639.8	4950.06	19.44	9.78	1.9	0.22	0.21	1.05	0.11
29	2	14	169404.3	12260.75	42.86	5.12	2.19	0.22	0.18	1.25	0.12
31	1	28	168870.4	6195.43	21.43	8.98	1.92	0.22	0.22	1	0.1
17	3	7	167509.9	24092.64	42.86	6.54	2.8	0.22	0.14	1.55	0.17
26	2	16	165833.1	10521.96	37.5	5.56	2.09	0.22	0.18	1.22	0.12
19	3	8	164742.3	20757.08	37.5	7.37	2.77	0.21	0.15	1.47	0.15
16	2	24	162070.9	6919.22	29.17	7.11	2.07	0.21	0.18	1.21	0.12
13	3	8	160129	20175.72	37.5	12.7	4.76	0.21	0.13	1.6	0.18
37	1	24	158676.3	-1888.87	20.83	2.38	0.5	0.21	0.23	0.92	0.1
25	2	18	154242	8721.9	33.33	5.87	1.96	0.2	0.18	1.11	0.11
14	3	7	152336.3	21919.65	42.86	8.43	3.61	0.2	0.14	1.48	0.16
34	2	13	151467.5	11812.65	38.46	4.94	1.9	0.2	0.19	1.06	0.11
32	2	13	150232.4	11718.98	46.15	3.64	1.68	0.2	0.19	1.06	0.1
40	2	11	131167.8	-3036.39	27.27	1.65	0.45	0.17	0.2	0.88	0.09
12	1	51	98758.35	2107.5	33.33	3.54	1.18	0.13	0.18	0.74	0.08
11	1	60	62450.3	1272.88	38.33	2.45	0.94	0.09	0.18	0.49	0.06
10	2	45	44356.79	1153.54	44.44	1.72	0.77	0.06	0.19	0.34	0.04
26	3	5	9355.06	2057.49	60	0.92	0.55	0.01	0.11	0.13	0.02
27	3	5	7694.32	1725.35	60	0.88	0.53	0.01	0.11	0.1	0.01
25	3	6	6648.76	1286.13	50	1.25	0.63	0.01	0.11	0.09	0.01
31	3	5	-2504.66	-316.26	40	1.43	0.57	0	0.11	-0.04	0
37	3	5	-8483.16	-1511.96	20	3.14	0.63	-0.01	0.11	-0.12	-0.01
40	3	5	-11795	-2174.33	20	2.82	0.56	-0.02	0.11	-0.16	-0.01
27	4	2	-12404.4	-6033.62	50	0.12	0.06	-0.02	0.04	-0.49	-0.04
28	4	2	-12644.2	-6153.52	50	0.1	0.05	-0.02	0.04	-0.5	-0.04
33	3	6	-13495.8	-2074.67	16.67	3.49	0.58	-0.02	0.11	-0.19	-0.01
29	4	1	-13884.5	-13696.6	0	NA	NA	-0.02	0.02	-1.09	-0.07
32	4	1	-13884.5	-13696.6	0	NA	NA	-0.02	0.02	-1.09	-0.07
38	4	2	-15471.5	-7567.14	0	NA	NA	-0.02	0.04	-0.61	-0.05

Table 7: Parameter optimization results for Fresh apples

ID	BBands. opt	BBands. opt2	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit/Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
41	19	2	26	197724.9	7578.7	53.85	2.92	1.57	0.21	0.16	1.28	0.13
9	18	1	41	191923.8	4705.37	41.46	3.31	1.37	0.2	0.16	1.26	0.13
40	18	2	27	189076.8	6981.78	48.15	3.33	1.6	0.2	0.16	1.26	0.13
42	20	2	26	187932	7202.1	50	3.19	1.59	0.2	0.16	1.23	0.13
43	21	2	26	170246.7	6521.99	46.15	3.3	1.52	0.18	0.16	1.12	0.12
14	23	1	33	169525.7	5131.95	36.36	4.65	1.69	0.18	0.13	1.39	0.14
5	14	1	55	166760.5	3077.32	40	3.34	1.34	0.18	0.15	1.19	0.12
6	15	1	54	164354.2	3088.06	35.19	3.59	1.26	0.18	0.15	1.17	0.12
56	34	2	13	153906.1	11675.76	53.85	3.95	2.12	0.17	0.13	1.25	0.13
38	16	2	32	153336.7	4793.5	37.5	3.79	1.42	0.17	0.15	1.12	0.12
51	29	2	20	152570.1	7570.91	40	4.35	1.74	0.16	0.17	0.97	0.1
3	12	1	63	147278.9	2392.29	42.86	2.59	1.11	0.16	0.15	1.04	0.11
2	11	1	65	142475.6	2252.21	47.69	2.17	1.03	0.15	0.16	0.99	0.1
28	37	1	21	141952.3	6696.62	42.86	3.2	1.37	0.15	0.15	1	0.1
16	25	1	33	131057.3	3967.64	30.3	4.58	1.39	0.14	0.14	1.03	0.1
32	10	2	47	126893.4	2740.28	42.55	2.44	1.04	0.14	0.15	0.95	0.1
54	32	2	17	121664.8	7059.98	41.18	3.47	1.43	0.13	0.14	0.97	0.1
48	26	2	21	121192.7	5712.92	38.1	3.63	1.38	0.13	0.16	0.86	0.09
4	13	1	61	120250.8	2022.03	39.34	2.68	1.06	0.13	0.15	0.87	0.09
62	40	2	13	119948.7	9062.81	46.15	3.27	1.51	0.13	0.15	0.89	0.09
49	27	2	21	114508.9	5398.99	33.33	4.14	1.38	0.13	0.16	0.79	0.08
47	25	2	24	99588.54	4111.37	33.33	3.69	1.23	0.11	0.16	0.7	0.07
22	31	1	29	97861.53	3360.81	31.03	3.76	1.17	0.11	0.15	0.72	0.07
21	30	1	31	90791.78	2920.31	29.03	3.89	1.13	0.1	0.15	0.68	0.07
70	17	3	12	53180.57	4548.88	41.67	2.57	1.07	0.06	0.14	0.45	0.05
90	37	3	6	47384.12	7531.78	33.33	4.97	1.66	0.06	0.12	0.47	0.05
66	13	3	14	37823.13	2561.72	21.43	5.26	1.13	0.04	0.12	0.37	0.04
67	14	3	16	32559.6	1924.12	31.25	3.06	0.96	0.04	0.12	0.33	0.03
72	19	3	11	24755.53	2377	27.27	3.57	0.97	0.03	0.15	0.2	0.02
86	33	3	7	23446.88	2942.23	42.86	1.93	0.83	0.03	0.13	0.22	0.03
99	15	4	1	2131	2212.04	100	NA	NA	0	0.02	0.15	0.02
101	17	4	1	1464.56	1545.6	100	NA	NA	0	0.02	0.1	0.01
122	38	4	2	-3510.1	-1662.83	50	0.54	0.27	0	0.05	-0.08	-0.01
116	32	4	2	-3811.93	-1813.75	50	0.43	0.21	0	0.05	-0.1	-0.01
111	27	4	1	-4460.13	-4367.02	0	NA	NA	-0.01	0.02	-0.33	-0.03
112	28	4	1	-5038.08	-4944.97	0	NA	NA	-0.01	0.02	-0.37	-0.03
113	29	4	1	-5491.61	-5398.5	0	NA	NA	-0.01	0.02	-0.4	-0.04
98	14	4	2	-9289.71	-4513.27	50	0.23	0.11	-0.01	0.03	-0.45	-0.03
93	40	3	4	-10170.9	-3163.84	25	0.57	0.14	-0.01	0.07	-0.19	-0.01
97	13	4	1	-11896.2	-11714.1	0	NA	NA	-0.01	0.02	-0.77	-0.05
78	25	3	6	-19414.9	-3735.32	16.67	1.28	0.21	-0.02	0.08	-0.3	-0.02
80	27	3	5	-21302	-4875.04	20	0.8	0.16	-0.03	0.08	-0.33	-0.02
84	31	3	6	-24748.7	-4628.51	33.33	0.7	0.23	-0.03	0.09	-0.34	-0.02
79	26	3	6	-24774.6	-4628.61	16.67	1	0.17	-0.03	0.08	-0.37	-0.03

Table 8: Parameter optimization results for styrene

ID	BBands. opt	BBands. opt2	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit/Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
3	12	1	41	200721	4956.39	48.78	2.93	1.43	0.32	0.17	1.85	0.2
2	11	1	42	161561.5	3907.14	47.62	2.77	1.32	0.26	0.16	1.64	0.18
32	10	2	34	150498.3	4491.21	41.18	3.93	1.62	0.25	0.15	1.68	0.19
4	13	1	44	148813.6	3445.46	36.36	3.47	1.26	0.24	0.18	1.33	0.15
40	18	2	19	145161.4	7708.41	36.84	5.49	2.02	0.24	0.17	1.42	0.16
38	16	2	21	144018.1	6924.49	33.33	5.54	1.85	0.24	0.16	1.45	0.17
41	19	2	19	139226.2	7391.96	36.84	5.19	1.91	0.23	0.17	1.36	0.15
5	14	1	43	138112.4	3275.64	30.23	4.48	1.36	0.23	0.18	1.25	0.14
43	21	2	16	133231.2	8396.74	43.75	3.58	1.56	0.22	0.17	1.28	0.14
42	20	2	17	132168.5	7843.03	41.18	3.89	1.6	0.22	0.17	1.28	0.14
70	17	3	5	131275	26342.26	40	7.67	3.07	0.22	0.14	1.52	0.18
9	18	1	37	117418.8	3237.14	32.43	3.73	1.21	0.2	0.19	1.02	0.11
21	30	1	19	112199.2	6026.16	31.58	5.3	1.67	0.19	0.19	0.98	0.1
22	31	1	19	112080.7	6019.44	31.58	5.08	1.6	0.19	0.19	0.99	0.11
28	37	1	17	106316.9	6383.96	35.29	4.26	1.5	0.18	0.2	0.91	0.1
16	25	1	24	100651.2	4297.89	25	5.55	1.39	0.17	0.19	0.9	0.1
6	15	1	42	99862.31	2441.71	26.19	4.54	1.19	0.17	0.2	0.85	0.1
14	23	1	27	94849.29	3613.29	25.93	4.9	1.27	0.16	0.2	0.81	0.09
62	40	2	9	91648.81	10894.07	33.33	6.24	2.08	0.16	0.18	0.88	0.09
80	27	3	6	80544.1	13503.64	50	3.15	1.57	0.14	0.16	0.84	0.09
108	24	4	1	53462.89	53527.42	100	NA	NA	0.09	0.12	0.81	0.09
107	23	4	1	53230.49	53295.01	100	NA	NA	0.09	0.11	0.81	0.09
67	14	3	4	48991.37	12333.35	25	8.33	2.08	0.09	0.12	0.69	0.08
66	13	3	5	45533.79	9183.24	20	9.9	1.98	0.08	0.13	0.64	0.08
111	27	4	2	42901.48	21535.13	50	4.15	2.08	0.08	0.13	0.59	0.07
47	25	2	13	42507.22	3336.76	38.46	2.64	1.01	0.07	0.17	0.43	0.05
113	29	4	2	41214.45	20691.61	50	4.03	2.01	0.07	0.13	0.57	0.06
112	28	4	2	41171.72	20670.25	50	4.03	2.01	0.07	0.13	0.57	0.06
116	32	4	2	37113.63	18641.2	50	3.73	1.86	0.07	0.13	0.51	0.06
51	29	2	11	36124.41	3884.74	45.45	2.02	0.92	0.06	0.17	0.37	0.04
72	19	3	6	35202.28	5951.13	33.33	3.77	1.26	0.06	0.14	0.44	0.05
122	38	4	2	30702.36	15435.57	50	3.26	1.63	0.05	0.13	0.42	0.05
84	31	3	5	27778.77	5616.75	20	7.12	1.42	0.05	0.16	0.31	0.04
48	26	2	13	25805.54	2504.78	38.46	2.29	0.88	0.05	0.18	0.26	0.03
78	25	3	5	25793.27	5242.36	40	2.47	0.99	0.05	0.15	0.31	0.04
49	27	2	13	19692.48	2034.76	38.46	2.1	0.81	0.04	0.18	0.19	0.03
56	34	2	10	14491.92	2098.25	30	3.06	0.92	0.03	0.18	0.14	0.02
86	33	3	5	13366.42	2733.52	20	5.14	1.03	0.02	0.16	0.15	0.02
79	26	3	6	11902.87	2062.19	33.33	2.47	0.82	0.02	0.15	0.14	0.02
54	32	2	11	10332.67	1535.46	27.27	3.28	0.9	0.02	0.18	0.1	0.02
90	37	3	6	-1200.92	-139.9	16.67	4.93	0.82	0	0.17	-0.01	0.01
93	40	3	5	-7519.69	-1440.81	20	3.43	0.69	-0.01	0.17	-0.08	0

Table 9: Parameter optimization results for Soda ash

ID	BBands. opt	BBands. opt2	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit/ Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
62	40	2	9	78118.46	2484.74	55.56	1.25	0.69	0.14	0.16	0.87	0.09
70	17	3	5	53992.18	2530.84	40	2.06	0.82	0.1	0.12	0.8	0.09
72	19	3	5	48308.62	1394.13	40	1.78	0.71	0.09	0.12	0.71	0.08
56	34	2	12	46819.3	515.13	33.33	2.19	0.73	0.09	0.17	0.52	0.06
28	37	1	18	43111.09	-477.57	27.78	2.3	0.64	0.08	0.18	0.44	0.05
48	26	2	15	40703.84	37.58	33.33	2.01	0.67	0.08	0.17	0.44	0.05
41	19	2	20	39928.6	12.95	35	1.86	0.65	0.07	0.16	0.45	0.05
93	40	3	2	38232.46	-434.55	50	0.93	0.46	0.07	0.11	0.62	0.08
42	20	2	20	37600.23	-103.47	30	2.28	0.68	0.07	0.17	0.42	0.05
21	30	1	18	36968.14	-813.86	27.78	2.2	0.61	0.07	0.18	0.38	0.05
22	31	1	18	35719.17	-882.45	22.22	2.92	0.65	0.07	0.18	0.36	0.04
54	32	2	13	35379.94	-396.72	38.46	1.49	0.57	0.07	0.17	0.38	0.05
43	21	2	20	34154.17	-275.92	30	2.19	0.66	0.06	0.17	0.37	0.05
40	18	2	22	33274.58	-279.55	31.82	2.02	0.64	0.06	0.17	0.36	0.04
51	29	2	14	28829.77	-821.91	35.71	1.51	0.54	0.05	0.17	0.32	0.04
49	27	2	15	21605.44	-1235.15	26.67	2.14	0.57	0.04	0.18	0.23	0.03
32	10	2	34	17581.29	250.61	41.18	1.54	0.64	0.03	0.15	0.23	0.03
38	16	2	27	17151.02	-805.04	29.63	1.94	0.57	0.03	0.18	0.18	0.03
9	18	1	30	13623.4	-1170.4	30	1.7	0.51	0.03	0.19	0.13	0.02
67	14	3	8	12342.5	-3586.58	25	1.29	0.32	0.02	0.13	0.17	0.02
16	25	1	23	11373.61	-1217.24	39.13	1.17	0.46	0.02	0.2	0.11	0.02
95	11	4	1	5451.83	5619.92	100	NA	NA	0.01	0.05	0.21	0.03
47	25	2	17	4923.04	-2058.4	23.53	2.17	0.51	0.01	0.18	0.05	0.01
14	23	1	24	3530	-1485.52	37.5	1.19	0.45	0.01	0.2	0.03	0.01
90	37	3	3	1899.61	-3449.85	33.33	1.13	0.38	0	0.09	0.04	0.01
84	31	3	5	-1468.8	-2676.34	40	0.96	0.38	0	0.11	-0.03	0
6	15	1	35	-5413.22	-721.68	37.14	1.32	0.49	-0.01	0.18	-0.06	0
86	33	3	5	-5957.75	-3574.41	40	0.78	0.31	-0.01	0.11	-0.1	0
5	14	1	36	-10170.9	-833.77	33.33	1.54	0.51	-0.02	0.19	-0.1	0
116	32	4	1	-13357.7	-13187.1	0	NA	NA	-0.03	0.02	-1.18	-0.07
79	26	3	5	-15888.8	-5586.78	20	1.53	0.31	-0.03	0.1	-0.3	-0.03
3	12	1	44	-18715.2	-855.9	31.82	1.6	0.51	-0.04	0.19	-0.19	-0.01
2	11	1	48	-19705.8	-795.41	33.33	1.53	0.51	-0.04	0.19	-0.2	-0.01
78	25	3	4	-21488.6	-5265.53	25	1.29	0.32	-0.04	0.09	-0.48	-0.04
80	27	3	6	-26051.1	-6325.31	16.67	1.49	0.25	-0.05	0.1	-0.49	-0.05
66	13	3	7	-32687.1	-4552.57	28.57	0.69	0.2	-0.06	0.08	-0.8	-0.06
4	13	1	40	-40903.4	-1512.04	32.5	1.25	0.41	-0.08	0.19	-0.43	-0.03

Table 10: Optimization results for Shanghai and Shenzhen 300 Index Futures

ID	BBands. Opt	BBands. opt2	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit/Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
21	30	1	73	1135858	14985.33	39.73	3.74	1.49	0.28	0.37	0.75	0.08
28	37	1	55	1078707	18759.52	45.45	2.98	1.35	0.27	0.39	0.68	0.08
16	25	1	83	1027551	12664.86	43.37	2.68	1.16	0.26	0.31	0.85	0.09
22	31	1	70	1007580	13783.06	41.43	3.09	1.28	0.26	0.4	0.64	0.08
14	23	1	86	958404.5	11434.85	43.02	2.44	1.05	0.25	0.31	0.8	0.09
41	19	2	65	907780	13978.66	38.46	3.46	1.33	0.24	0.31	0.79	0.09
40	18	2	69	857974	12724.29	34.78	3.94	1.37	0.23	0.3	0.77	0.09
48	26	2	48	750986.5	15188.91	41.67	3.08	1.28	0.22	0.37	0.59	0.07
9	18	1	114	750047.4	6867.83	39.47	2.42	0.95	0.22	0.31	0.69	0.08
42	20	2	63	726019.6	11531.26	38.1	3.14	1.19	0.21	0.35	0.6	0.07
43	21	2	61	664922.4	10900.13	34.43	3.44	1.18	0.2	0.37	0.55	0.07
47	25	2	51	587135.5	11452.32	35.29	3.45	1.22	0.18	0.39	0.47	0.06
49	27	2	49	586559.6	11527.46	34.69	3.42	1.19	0.18	0.46	0.4	0.06
90	37	3	8	546526.2	68612.93	62.5	3.1	1.94	0.18	0.28	0.63	0.07
78	25	3	15	520637	35025.18	46.67	3.7	1.73	0.17	0.28	0.61	0.07
62	40	2	33	499845.3	14361.57	39.39	2.62	1.03	0.17	0.57	0.29	0.05
79	26	3	18	489028.1	27481.48	38.89	3.8	1.48	0.16	0.31	0.52	0.06
72	19	3	17	475082	28280.89	47.06	2.6	1.23	0.16	0.27	0.58	0.07
93	40	3	10	468199.3	47109.56	50	3.25	1.62	0.16	0.3	0.53	0.06
38	16	2	85	450385.4	5585.09	36.47	2.52	0.92	0.15	0.39	0.4	0.06
32	10	2	128	444285.9	3753.29	37.5	2.18	0.82	0.15	0.34	0.45	0.06
80	27	3	18	406560.5	22898.94	33.33	4.15	1.38	0.14	0.32	0.44	0.06
86	33	3	13	379085.8	29473.06	38.46	3.67	1.41	0.14	0.35	0.38	0.05
51	29	2	48	371551.7	7282.97	27.08	4.02	1.09	0.13	0.69	0.19	0.05
54	32	2	44	364051.1	7753.26	31.82	3.09	0.98	0.13	0.55	0.24	0.05
3	12	1	154	361349.5	2645.39	39.61	1.82	0.72	0.13	0.37	0.36	0.05
56	34	2	41	359811.8	8192.98	29.27	3.45	1.01	0.13	0.67	0.2	0.05
5	14	1	142	344507.7	2725.32	40.14	1.8	0.72	0.13	0.39	0.32	0.05
70	17	3	23	332445.3	14771.38	39.13	2.87	1.12	0.12	0.34	0.37	0.05
6	15	1	135	323568.4	2692.44	37.78	1.97	0.75	0.12	0.43	0.28	0.05
67	14	3	27	270033.4	10305.36	37.04	2.81	1.04	0.11	0.39	0.27	0.05
2	11	1	169	214813.9	1564.4	37.28	1.89	0.71	0.09	0.45	0.19	0.04
84	31	3	16	195765.5	12562.85	31.25	3.24	1.01	0.08	0.41	0.2	0.04
4	13	1	150	98131.28	954.92	40	1.6	0.64	0.05	0.41	0.11	0.03
66	13	3	24	88846.71	4004.97	33.33	2.5	0.83	0.04	0.5	0.08	0.04
116	32	4	1	39466.45	39657.01	100	NA	NA	0.02	0.06	0.35	0.04
99	15	4	4	35403.69	9200.8	50	1.85	0.93	0.02	0.12	0.15	0.02
104	20	4	1	31173.1	31363.66	100	NA	NA	0.02	0.04	0.37	0.06
113	29	4	1	23939.13	24129.69	100	NA	NA	0.01	0.04	0.28	0.04
111	27	4	1	23903.77	24094.33	100	NA	NA	0.01	0.04	0.28	0.04
98	14	4	3	23715.3	8249.71	66.67	1.12	0.74	0.01	0.08	0.16	0.02
112	28	4	1	22127.62	22318.18	100	NA	NA	0.01	0.04	0.26	0.04
97	13	4	3	15556.43	5530.09	66.67	0.93	0.62	0.01	0.07	0.12	0.02
103	19	4	2	4183.93	2333.93	50	1.17	0.58	0	0.06	0.04	0.01
95	11	4	2	-10537.9	-4937.59	50	0.39	0.19	-0.01	0.04	-0.15	-0.01
101	17	4	3	-55349.4	-18164.3	0	NA	NA	-0.03	0.07	-0.47	-0.03
102	18	4	3	-57871.6	-19005	0	NA	NA	-0.03	0.06	-0.51	-0.04
122	38	4	2	-98792.8	-49161.1	50	0.28	0.14	-0.06	0.2	-0.3	-0.01

Table 11: Parameter optimization results for coke

ID	BBands. opt	BBands. opt2	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit/Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
9	18	1	99	485311	5029.29	28.28	6.29	1.78	0.18	0.16	1.11	0.11
42	20	2	50	483460.1	9799.47	44	4.09	1.8	0.18	0.14	1.28	0.13
41	19	2	54	460407.4	8656.9	40.74	4.16	1.7	0.17	0.14	1.22	0.12
47	25	2	40	455386	11514.69	45	4.73	2.13	0.17	0.14	1.24	0.12
14	23	1	80	448966.3	5740.38	28.75	6.04	1.74	0.17	0.15	1.08	0.1
22	31	1	65	448216.1	7026.09	33.85	5.53	1.87	0.17	0.15	1.11	0.1
43	21	2	47	445018.3	9602.45	44.68	3.64	1.62	0.17	0.16	1.06	0.1
49	27	2	41	440462.4	10875.41	41.46	4.58	1.9	0.16	0.14	1.16	0.11
40	18	2	60	440171.6	7463.41	35	4.84	1.69	0.16	0.14	1.17	0.12
21	30	1	68	438004.6	6571.22	30.88	6.1	1.88	0.16	0.15	1.08	0.1
51	29	2	38	435105.7	11582.22	44.74	4.31	1.93	0.16	0.14	1.17	0.11
48	26	2	42	433870.7	10464.21	42.86	4.41	1.89	0.16	0.14	1.15	0.11
16	25	1	77	421063.1	5597.65	31.17	5.2	1.62	0.16	0.16	1.02	0.1
28	37	1	52	418539.8	7793.29	38.46	4.79	1.84	0.16	0.16	1.01	0.1
54	32	2	32	414596.3	13085.1	46.88	4.4	2.06	0.16	0.14	1.11	0.1
56	34	2	31	414514	12846.41	45.16	4.44	2.01	0.16	0.15	1.07	0.1
4	13	1	127	334024.2	2755.94	33.86	3.68	1.24	0.13	0.14	0.94	0.09
6	15	1	122	319794.9	2747.73	31.15	4.14	1.29	0.13	0.16	0.83	0.08
62	40	2	29	317888.1	10384.49	51.72	2.71	1.4	0.13	0.15	0.87	0.08
72	19	3	19	310585.7	16461.22	52.63	5.15	2.71	0.13	0.12	1.08	0.11
5	14	1	127	309184.8	2559.98	33.07	3.57	1.18	0.13	0.16	0.81	0.08
78	25	3	16	301047.5	18975.74	68.75	3.09	2.12	0.12	0.12	1.03	0.1
86	33	3	13	298772.3	23168.18	61.54	4.42	2.72	0.12	0.12	1.02	0.1
90	37	3	13	296602.3	22988.35	69.23	4.45	3.08	0.12	0.13	0.97	0.09
93	40	3	11	282828.2	25889.6	81.82	2.55	2.08	0.12	0.13	0.94	0.09
3	12	1	139	259110.9	1992.45	30.22	3.74	1.13	0.11	0.16	0.69	0.07
84	31	3	13	231016.5	17938.01	69.23	3.11	2.15	0.1	0.12	0.83	0.08
79	26	3	15	228359.7	15379.16	66.67	2.68	1.79	0.1	0.13	0.77	0.08
38	16	2	71	225710.6	3307.7	40.85	2.48	1.01	0.1	0.15	0.66	0.07
104	20	4	3	224191.6	74900.8	100	NA	NA	0.1	0.08	1.22	0.14
80	27	3	13	210543.2	16359.38	69.23	2.97	2.05	0.09	0.13	0.75	0.08
67	14	3	30	191067.8	6495.99	56.67	2.07	1.17	0.09	0.1	0.85	0.09
70	17	3	24	184063.3	7783.56	54.17	2.79	1.51	0.08	0.11	0.8	0.08
66	13	3	28	178612	6502.93	64.29	1.68	1.08	0.08	0.1	0.83	0.09
2	11	1	151	163188.8	1210.54	33.77	2.72	0.92	0.08	0.16	0.47	0.05
98	14	4	4	129217.5	32485.35	100	NA	NA	0.06	0.07	0.96	0.16
97	13	4	4	120690.2	30353.52	100	NA	NA	0.06	0.06	0.92	0.16
32	10	2	104	117868.1	1265.84	32.69	2.76	0.9	0.06	0.18	0.33	0.04
99	15	4	3	90602.52	30363.97	100	NA	NA	0.05	0.04	1.04	0.13
101	17	4	3	81515.49	27361.63	66.67	5.13	3.42	0.04	0.05	0.83	0.09
103	19	4	2	70573.14	35455.7	100	NA	NA	0.04	0.04	0.92	0.12
102	18	4	1	63903.36	64137.21	100	NA	NA	0.03	0.04	0.94	0.13
95	11	4	2	27416.83	13997.79	50	3.39	1.7	0.01	0.07	0.22	0.05
107	23	4	1	10071.7	10176.1	100	NA	NA	0.01	0.02	0.29	0.04
108	24	4	1	9864.29	9968.69	100	NA	NA	0.01	0.02	0.28	0.04
122	38	4	1	-3158.44	-3000.44	0	NA	NA	0	0.03	-0.06	0

Table 12: Parameter optimization results for PTA

ID	BBands. opt	BBands. opt2	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit/Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized SharpeRatio	Sortino Ratio
28	37	1	59	736718.4	12700.38	45.76	4.81	2.2	0.17	0.11	1.59	0.16
14	23	1	107	676259.7	6501.22	41.12	4.07	1.67	0.16	0.12	1.37	0.13
16	25	1	100	669904.2	6880.01	43	3.9	1.68	0.16	0.11	1.42	0.14
54	32	2	43	642612.3	15089.64	55.81	3.66	2.05	0.15	0.11	1.4	0.14
43	21	2	59	642198.4	11102.64	50.85	3.88	1.97	0.15	0.1	1.48	0.15
42	20	2	65	639888.5	10052.98	49.23	3.82	1.88	0.15	0.1	1.47	0.15
56	34	2	42	632461.4	15203.69	52.38	3.91	2.05	0.15	0.11	1.43	0.15
22	31	1	82	619697	7737.42	42.68	3.85	1.64	0.15	0.11	1.35	0.13
21	30	1	83	591598.8	7322.27	42.17	3.77	1.59	0.15	0.11	1.33	0.13
6	15	1	147	581033	4060.78	38.1	3.58	1.36	0.14	0.11	1.33	0.13
5	14	1	156	565436	3733.43	39.74	3.27	1.3	0.14	0.11	1.31	0.13
41	19	2	78	562808	7417.18	46.15	3.29	1.52	0.14	0.11	1.25	0.13
62	40	2	40	558613.1	14105.17	50	3.9	1.95	0.14	0.11	1.22	0.12
4	13	1	162	551340.2	3513.41	41.36	2.93	1.21	0.14	0.1	1.33	0.13
40	18	2	79	547701.3	7133.99	46.84	3.26	1.53	0.14	0.11	1.31	0.13
47	25	2	64	547061.8	8692.77	46.88	3.21	1.51	0.14	0.11	1.23	0.12
9	18	1	137	541896	4062.15	39.42	3.29	1.3	0.14	0.11	1.23	0.12
38	16	2	86	533664.1	6401.82	45.35	3.24	1.47	0.14	0.1	1.33	0.13
51	29	2	53	527839.7	10105.16	52.83	2.94	1.55	0.13	0.11	1.24	0.13
49	27	2	59	518912.7	8938.78	45.76	3.38	1.54	0.13	0.11	1.23	0.13
48	26	2	63	518827.6	8381.31	47.62	3	1.43	0.13	0.11	1.18	0.12
2	11	1	187	482484.5	2692.48	37.43	2.98	1.12	0.13	0.11	1.19	0.12
3	12	1	182	453787.8	2605.04	35.71	3.15	1.13	0.12	0.11	1.08	0.11
90	37	3	16	416648	26212.12	68.75	4.19	2.88	0.11	0.1	1.14	0.12
86	33	3	16	402326.7	25309.23	62.5	4.32	2.7	0.11	0.1	1.1	0.11
93	40	3	16	375331	23625.38	68.75	4.1	2.82	0.11	0.11	1	0.1
32	10	2	140	368521.4	2801.45	45	2.2	0.99	0.11	0.12	0.89	0.09
80	27	3	18	316908.6	17776.74	61.11	3.2	1.96	0.09	0.1	0.93	0.1
79	26	3	18	315116.3	17673.9	66.67	2.84	1.89	0.09	0.1	0.97	0.1
78	25	3	16	297228.1	18745.89	68.75	2.88	1.98	0.09	0.1	0.94	0.1
84	31	3	16	284069.1	17919.5	62.5	3.01	1.88	0.09	0.11	0.81	0.08
72	19	3	14	183731.4	13274.61	64.29	2.75	1.77	0.06	0.08	0.73	0.08
70	17	3	17	145583.3	8711.45	64.71	1.89	1.22	0.05	0.08	0.64	0.07
66	13	3	22	57095.81	2758.48	50	1.69	0.85	0.02	0.08	0.29	0.03
67	14	3	21	30318.44	1608.94	42.86	1.8	0.77	0.01	0.07	0.16	0.02
97	13	4	2	12626.58	6589.25	100	NA	NA	0.01	0.03	0.2	0.02
98	14	4	2	11349.18	5950.55	100	NA	NA	0	0.03	0.18	0.02
99	15	4	2	9566.41	5059.16	100	NA	NA	0	0.03	0.15	0.01
95	11	4	2	2483.92	1517.92	50	1.94	0.97	0	0.01	0.07	0.01
111	27	4	1	2187.19	2269.49	100	NA	NA	0	0.02	0.04	0
112	28	4	1	1108.66	1190.96	100	NA	NA	0	0.02	0.02	0
113	29	4	1	72.88	155.18	100	NA	NA	0	0.02	0	0
101	17	4	2	-1165.11	-387.17	50	0.82	0.41	0	0.06	-0.01	0
102	18	4	2	-2963.64	-1286.44	50	0.56	0.28	0	0.06	-0.02	0
103	19	4	2	-5554.13	-2581.69	50	0.31	0.15	0	0.06	-0.04	0
116	32	4	1	-12164.3	-12046.2	0	NA	NA	-0.01	0.01	-0.52	-0.03

Table 13: Parameter optimization results for Hot_rolled_coil_plate

ID	BBands. opt	BBands. opt2	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit/Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
62	40	2	16	363317.4	21288.75	75	4.1	3.07	0.19	0.14	1.38	0.13
54	32	2	26	304233.2	11373.81	50	4.07	2.04	0.17	0.14	1.16	0.11
56	34	2	23	300376.4	12113.33	47.83	4.51	2.16	0.17	0.14	1.17	0.11
51	29	2	30	298620.2	9604.87	46.67	4.26	1.99	0.16	0.14	1.16	0.11
48	26	2	31	278424.1	8651.32	48.39	3.83	1.85	0.16	0.14	1.08	0.1
49	27	2	31	275550.6	8557.78	45.16	4.11	1.86	0.15	0.15	1.06	0.1
47	25	2	32	250661.9	7515.73	50	3.14	1.57	0.14	0.14	1.01	0.1
43	21	2	41	233227.4	5464.74	46.34	2.72	1.26	0.14	0.14	1	0.1
72	19	3	16	230103.8	14295.66	62.5	4.17	2.61	0.13	0.11	1.27	0.13
28	37	1	45	224809.9	4568.77	28.89	4.82	1.39	0.13	0.17	0.79	0.08
86	33	3	11	221088.4	17956.65	63.64	4.79	3.05	0.13	0.12	1.08	0.1
80	27	3	11	215108.3	19377.2	72.73	5.31	3.86	0.13	0.13	1	0.1
79	26	3	12	209120.2	17275.89	66.67	4.13	2.75	0.12	0.12	1	0.1
78	25	3	12	208534	17227.05	66.67	4.18	2.79	0.12	0.12	1	0.1
41	19	2	45	199454.8	4241.4	42.22	2.87	1.21	0.12	0.13	0.93	0.09
42	20	2	44	196471.1	4266.12	43.18	2.79	1.2	0.12	0.13	0.9	0.09
90	37	3	10	191359.7	16771.26	60	3.69	2.21	0.12	0.12	0.95	0.09
84	31	3	11	187053.7	16823.68	63.64	4.31	2.74	0.11	0.12	0.91	0.09
67	14	3	12	181701.5	14988.44	75	3.9	2.93	0.11	0.09	1.21	0.13
22	31	1	53	181107.2	3273.28	30.19	4.14	1.25	0.11	0.17	0.66	0.07
16	25	1	66	163203	2388.94	31.82	3.48	1.11	0.1	0.17	0.6	0.06
66	13	3	17	160493.8	9371.14	52.94	3.72	1.97	0.1	0.09	1.07	0.11
70	17	3	15	152107	10058.18	66.67	2.43	1.62	0.09	0.1	0.95	0.1
21	30	1	58	143754.1	2364.1	25.86	4.41	1.14	0.09	0.18	0.51	0.06
38	16	2	51	136497.5	2529.56	41.18	2.35	0.97	0.09	0.12	0.71	0.07
93	40	3	10	135099.7	13677.04	60	2.72	1.63	0.09	0.13	0.68	0.07
107	23	4	3	133024.1	43261.91	100	NA	NA	0.08	0.11	0.75	0.08
40	18	2	48	121730.6	2362.96	39.58	2.44	0.97	0.08	0.13	0.62	0.06
14	23	1	74	118729.9	1538.03	31.08	3.04	0.95	0.08	0.17	0.45	0.05
116	32	4	3	112623.9	37725.56	100	NA	NA	0.07	0.12	0.62	0.06
103	19	4	3	101808.1	34120.31	100	NA	NA	0.07	0.09	0.73	0.07
104	20	4	3	99976.58	33509.8	100	NA	NA	0.07	0.09	0.72	0.07
9	18	1	86	52013.65	550.38	30.23	2.63	0.8	0.04	0.16	0.22	0.03
32	10	2	85	38351.58	415.54	31.76	2.39	0.76	0.03	0.14	0.2	0.03
108	24	4	2	36865.27	16719.85	100	NA	NA	0.03	0.04	0.62	0.06
111	27	4	2	32130	16247.81	100	NA	NA	0.02	0.04	0.55	0.05
112	28	4	2	31425.69	15895.65	100	NA	NA	0.02	0.04	0.53	0.05
113	29	4	2	30732.44	15549.03	100	NA	NA	0.02	0.04	0.52	0.05
101	17	4	2	9700.03	5011.3	50	4.23	2.11	0.01	0.07	0.11	0.01
102	18	4	2	9240.73	4781.65	50	3.55	1.78	0.01	0.07	0.1	0.01
97	13	4	2	8483.94	4424.78	50	2.62	1.31	0.01	0.03	0.23	0.03
98	14	4	2	6613.17	3489.39	50	2.1	1.05	0	0.03	0.17	0.02
99	15	4	2	4927.25	2646.43	50	1.73	0.86	0	0.03	0.13	0.02
4	13	1	109	-16647.4	-146.63	30.28	2.22	0.67	-0.01	0.17	-0.07	0
6	15	1	99	-17111.6	-202.67	29.29	2.29	0.67	-0.01	0.16	-0.08	0
2	11	1	122	-25956.6	-193.06	30.33	2.17	0.66	-0.02	0.18	-0.11	0
5	14	1	101	-27246.4	-278.65	30.69	2.09	0.64	-0.02	0.17	-0.13	0
3	12	1	118	-49469.5	-404.62	28.81	2.21	0.64	-0.04	0.18	-0.22	-0.01

Table 14: Parameter optimization results for Rebar

ID	BBands. opt	BBands. opt2	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit/Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
21	30	1	69	605981.3	8876.47	39.13	4.65	1.82	0.17	0.14	1.25	0.12
48	26	2	41	579453.4	14365.44	56.1	3.38	1.9	0.17	0.13	1.34	0.13
51	29	2	37	579043.6	15880.42	56.76	3.54	2.01	0.17	0.12	1.36	0.14
16	25	1	82	571993.1	7087.52	41.46	3.76	1.56	0.17	0.13	1.25	0.12
9	18	1	107	570950.7	5349.91	42.06	3.6	1.51	0.17	0.12	1.37	0.14
49	27	2	40	556524.7	14143.78	52.5	3.74	1.97	0.16	0.12	1.32	0.13
54	32	2	34	555089	16554.11	61.76	3.34	2.06	0.16	0.13	1.25	0.12
28	37	1	55	553235.1	10161.95	43.64	4.23	1.84	0.16	0.14	1.15	0.11
22	31	1	67	551797.1	8278.64	38.81	4.41	1.71	0.16	0.14	1.13	0.11
56	34	2	32	530416.6	16809.3	59.38	3.29	1.95	0.16	0.13	1.18	0.12
47	25	2	45	522498.6	11842.92	48.89	3.75	1.83	0.16	0.13	1.24	0.12
14	23	1	89	522263	5984.09	40.45	3.55	1.44	0.16	0.13	1.2	0.12
3	12	1	149	519744.3	3534.72	39.6	3.17	1.26	0.16	0.13	1.19	0.12
6	15	1	128	502856	3976.13	41.41	2.99	1.24	0.15	0.13	1.21	0.12
43	21	2	55	494688.8	9225.47	49.09	3.21	1.58	0.15	0.12	1.3	0.13
42	20	2	60	467788.2	8028.01	51.67	2.77	1.43	0.15	0.12	1.26	0.13
4	13	1	147	449354.7	3101.4	36.73	3.2	1.18	0.14	0.13	1.05	0.11
5	14	1	137	447261.4	3300.11	37.96	3.1	1.18	0.14	0.14	1.02	0.1
62	40	2	31	442828.7	14518.24	58.06	2.89	1.68	0.14	0.14	0.99	0.1
38	16	2	81	420334.5	5297.2	45.68	2.74	1.25	0.13	0.12	1.12	0.12
41	19	2	68	418948.1	6255.7	45.59	2.88	1.31	0.13	0.12	1.12	0.12
40	18	2	72	397682.5	5624.02	44.44	2.78	1.23	0.13	0.12	1.08	0.11
78	25	3	19	337944.3	18020.88	63.16	3.21	2.03	0.12	0.11	1.01	0.1
80	27	3	17	324196.5	19303.72	47.06	5.33	2.51	0.11	0.11	1	0.1
79	26	3	19	315524.9	16839.92	52.63	4.62	2.43	0.11	0.12	0.93	0.1
2	11	1	165	286897.9	1775.56	38.18	2.44	0.93	0.1	0.14	0.74	0.08
86	33	3	17	252194.3	15077.31	52.94	3.62	1.92	0.09	0.13	0.69	0.07
32	10	2	119	247542.1	2090.93	36.97	2.6	0.96	0.09	0.13	0.7	0.07
84	31	3	18	246052.2	13916.7	44.44	4.39	1.95	0.09	0.13	0.7	0.07
66	13	3	24	178606.1	7665.6	45.83	2.92	1.34	0.07	0.1	0.67	0.08
70	17	3	23	177642.1	7956.28	47.83	3.1	1.48	0.07	0.11	0.66	0.07
67	14	3	21	175796.3	8596.15	47.62	2.8	1.33	0.07	0.1	0.66	0.07
93	40	3	15	175684.5	11960.45	46.67	3.46	1.62	0.07	0.13	0.51	0.05
111	27	4	5	167535.6	33760.27	80	3.21	2.57	0.07	0.07	0.9	0.1
90	37	3	17	166977.7	10065.18	41.18	3.55	1.46	0.07	0.13	0.5	0.05
72	19	3	23	165004	7405.72	47.83	2.79	1.33	0.07	0.11	0.61	0.07
107	23	4	4	152140.1	38279.68	75	13.57	10.18	0.06	0.07	0.89	0.1
112	28	4	4	150096.3	37788.59	75	3.87	2.9	0.06	0.07	0.82	0.09
108	24	4	5	134576.8	27166.08	60	5.56	3.34	0.06	0.07	0.76	0.08
113	29	4	3	115831	38914.64	66.67	4.59	3.06	0.05	0.07	0.65	0.07
104	20	4	3	85117.67	28593.98	66.67	14.87	9.91	0.04	0.06	0.64	0.08
116	32	4	1	62484.57	62798.89	100	NA	NA	0.03	0.05	0.57	0.06
122	38	4	2	48238.62	24352.62	50	6.42	3.21	0.02	0.05	0.41	0.04
103	19	4	2	16719	8529.86	50	7.19	3.59	0.01	0.02	0.34	0.03
95	11	4	1	1239.77	1435.29	100	NA	NA	0	0.01	0.05	0.01
97	13	4	1	-546.26	-350.73	0	NA	NA	0	0.01	-0.02	0
99	15	4	1	-1168.77	-973.25	0	NA	NA	0	0.01	-0.04	0
98	14	4	1	-1219.08	-1023.56	0	NA	NA	0	0.01	-0.04	0
101	17	4	1	-2015.98	-1820.45	0	NA	NA	0	0.01	-0.08	-0.01
102	18	4	1	-2533.05	-2337.52	0	NA	NA	0	0.01	-0.1	-0.01

Table 15: Optimization results for medium sulfur crude oil

ID	BBands. opt	BBands. opt2	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit/Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
5	14	1	52	349138.3	6652.26	40.38	3.14	1.27	0.35	0.27	1.31	0.13
4	13	1	55	333053.5	6002.82	40	3.06	1.22	0.34	0.26	1.28	0.13
3	12	1	56	301540.9	5337.42	39.29	2.91	1.14	0.31	0.26	1.18	0.12
14	23	1	32	261308.4	7975.42	37.5	3.46	1.3	0.28	0.26	1.05	0.11
2	11	1	59	260948.8	4242.21	37.29	2.75	1.02	0.28	0.29	0.96	0.1
28	37	1	21	255183.2	12363.3	42.86	4.42	1.9	0.27	0.27	0.98	0.1
22	31	1	26	239123.7	9409.59	46.15	2.68	1.24	0.26	0.27	0.93	0.1
21	30	1	27	218621.9	8310.56	40.74	3.07	1.25	0.24	0.27	0.87	0.09
9	18	1	45	215998.3	4728.12	35.56	3.26	1.16	0.23	0.28	0.83	0.09
16	25	1	33	208575.9	6530.34	36.36	3.34	1.22	0.23	0.28	0.82	0.09
43	21	2	24	178112.1	7630.67	41.67	2.89	1.2	0.2	0.25	0.78	0.08
42	20	2	26	159999.9	6356.9	46.15	2.13	0.99	0.18	0.25	0.73	0.08
6	15	1	51	145517.8	2817.15	35.29	2.71	0.96	0.17	0.26	0.63	0.07
48	26	2	21	143831.1	7055.97	42.86	2.52	1.08	0.16	0.27	0.6	0.07
47	25	2	21	115697.3	5723.15	38.1	2.66	1.01	0.14	0.28	0.48	0.06
54	32	2	16	111813.9	7193.92	43.75	2.24	0.98	0.13	0.26	0.5	0.06
32	10	2	47	107628.5	2229.73	29.79	3.12	0.93	0.13	0.28	0.45	0.06
49	27	2	21	87146.83	4357.77	38.1	2.36	0.9	0.1	0.29	0.37	0.05
51	29	2	20	54665.98	2938.84	30	2.96	0.89	0.07	0.28	0.24	0.04
40	18	2	30	49999	1864.11	43.33	1.61	0.7	0.06	0.26	0.24	0.04
38	16	2	32	49764.39	1766.17	37.5	1.99	0.75	0.06	0.27	0.23	0.03
41	19	2	30	11295.55	573.83	43.33	1.39	0.6	0.01	0.27	0.05	0.02
62	40	2	14	8257.96	808.32	42.86	1.45	0.62	0.01	0.31	0.03	0.02
67	14	3	8	-12525	-1370.68	62.5	0.43	0.27	-0.02	0.14	-0.12	0
107	23	4	1	-13740.5	-13623.6	0	NA	NA	-0.02	0.04	-0.51	-0.03
108	24	4	1	-13740.5	-13623.6	0	NA	NA	-0.02	0.04	-0.51	-0.03
111	27	4	1	-13740.5	-13623.6	0	NA	NA	-0.02	0.04	-0.51	-0.03
112	28	4	1	-13740.5	-13623.6	0	NA	NA	-0.02	0.04	-0.51	-0.03
113	29	4	1	-13740.5	-13623.6	0	NA	NA	-0.02	0.04	-0.51	-0.03
56	34	2	17	-34562.8	-1822.31	41.18	1.19	0.49	-0.05	0.29	-0.16	0
70	17	3	7	-45281.8	-6259.15	57.14	0.18	0.1	-0.06	0.15	-0.41	-0.03
66	13	3	11	-61603.2	-5410.13	27.27	0.85	0.23	-0.09	0.16	-0.55	-0.04
90	37	3	6	-118747	-19569.4	0	NA	NA	-0.18	0.16	-1.15	-0.09
93	40	3	6	-123490	-20359.9	0	NA	NA	-0.19	0.16	-1.18	-0.09
80	27	3	8	-127393	-15720.9	0	NA	NA	-0.19	0.23	-0.86	-0.07
86	33	3	7	-128588	-18163	0	NA	NA	-0.2	0.16	-1.2	-0.09
84	31	3	8	-145487	-17967.8	0	NA	NA	-0.23	0.2	-1.14	-0.09
72	19	3	10	-148110	-14609.3	20	0.16	0.03	-0.23	0.2	-1.15	-0.09
79	26	3	9	-154117	-16923	0	NA	NA	-0.24	0.27	-0.91	-0.07
78	25	3	9	-164815	-18112.6	0	NA	NA	-0.27	0.27	-0.98	-0.08

In Table 5-15, some varieties have not been on the market long enough to generate fewer trades and no losses, so the profit/loss ratios and expected values appear to have invalid values. Some samples did not generate trades, so there are less than 50 observations. Some have invalid values in the calculation of the annualized compounded rate of return and Sharpe ratio formula because the loss exceeded the initial capital of $300,000.

According to the optimization results, the size of the net profit is the most important selection basis, and at the same time refer to the average profit per time, profit expectation, Sharpe ratio, Sortino ratio comprehensive analysis, to select the best parameters for each futures variety to carry out out out-of-sample testing.

In Table 5, based on the results shown in Table 5, the parameters of CSI 500 stock index futures are best tested by taking 10 and 2 respectively (the largest net profit, the largest average profit per time, the highest profit expectation, and larger Sharpe and Sortino ratios). The results of the optimized parameters are indicated:

When using the Bollinger Bands trading strategy in CSI 500 stock index futures, take the average of the closing prices of the 10 trading days as the middle rail, add or subtract 2 standard deviations to calculate the upper and lower rails, and buy a long order when the price is greater than or equal to the upper rail, and close the long position and leave the market when the lowest price is less than or equal to the middle rail. When the price is lower than the lower rail when selling short orders, when the price is greater than or equal to the center rail when the short single closed out of the market.

Based on the above methodology, the optimal parameters for each of the varieties in Tables 6 to 15 were selected: the optimal parameters for Bleached kraft softwood pulp were 18,1. the parameters for Fresh apples were 19,2. the parameters for styrene were 12,1. the parameters for soda ash were 40,2. the optimal parameters for Shanghai and Shenzhen 300 Index Futures were 30,1. coke was 20,2. the parameters for PTA were 37,1. the parameters for Hot rolled coil plate were 37,1. Shenzhen 300 Index Futures is 30,1. Coke is 20,2. pta is 37,1. Hot rolled coil plate is 40,2. rebar is 26,2. medium sulfur crude oil is 14,1.

3.2.3 Out-of-sample testing

The optimal parameters of the Bollinger Bands trading strategy screened on different futures varieties are shown in Table 16.

Table 16: Optimal parameters of the Bollinger Bands strategy for each species

Name	Parameter N of Bollinger channel	Parameter sd of standard deviation
CSI_500_stock_index_futures	10	2
Bleached_kraft_softwood_pulp	18	1
Fresh_apples	19	2
styrene	12	1
Soda_ash	40	2
Shanghai_and_Shenzhen_300_Index_Futures	30	1
coke	18	1
PTA	37	1
Hot_rolled_coil_plate	40	2
Rebar	26	2
Medium_sulfur_crude_oil	14	1

According to the data within Table 16 set the parameters on each variety separately and backtest the second half of the data for the corresponding variety, the code is shown in Appendix 5 and the results of the backtest are shown in Table 17.

Table 17: Out-of-sample test results for optimization parameters

ID	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio
CSI 500 stock index futures	77	5973.52	77.58	38.96	1.58	0.61	0	0.5	0.01	0.03
Bleached kraft softwood pulp	45	20295.57	451.01	26.67	3.08	0.82	0.03	0.14	0.2	0.02
Fresh apples	26	118230.2	4547.31	42.31	3.42	1.45	0.13	0.15	0.9	0.1
styrene	48	-17292.3	-360.26	29.17	2.13	0.62	-0.03	0.17	-0.19	-0.01
Soda ash	8	126345.1	15793.14	50	5.71	2.86	0.22	0.14	1.6	0.15
Shanghai and Shenzhen 300 Index Futures	89	-128351	-1442.15	30.34	2.09	0.63	-0.08	38.68	0	0.02
Coke	112	198374.4	1771.2	36.61	2.48	0.91	0.09	0.21	0.42	0.05
PTA	94	108210	1151.17	30.85	2.77	0.86	0.04	0.22	0.17	0.03
Hot rolled coil plate	25	105438.6	4217.54	48	2.09	1	0.07	0.18	0.39	0.04
Rebar	59	26703.8	452.61	38.98	1.71	0.66	0.01	0.17	0.07	0.01
Medium sulfur crude oil	62	-410546	-6621.71	29.03	1.46	0.42		34.02		-0.05

Column 1 is the name of the traded futures variety. Column 2 is the number of trades. Column 3 is the net profit and column 4 indicates the average profit per trade. Column 5 indicates the winning percentage. Column 6 is the profit/loss ratio and column 7 is the profit expectation. Columns 8 and 11 denote the annualized compounded rate of return, annualized volatility, annualized Sharpe ratio, and Sortino ratio, respectively.

4. Empirical results

The Bollinger Bands trading strategy was tested on 60 futures varieties. Since the margin for 1 lot of Shanghai and Shenzhen 300 Index Futures is about 150,000 RMB, the initial capital for each variety is set at 300,000 RMB in order to ensure that each variety can open a position. The maximum stop-loss amount for each transaction is four percent of the initial capital. So that each variety of risk control consistent, easy to compare each other. Futures contract commission is set at five ten thousandths, higher than the actual commission, the purpose is to offset the slippage of the transaction, so that it is closer to real trading.

4.1 Comparison of sample test results

Out-of-sample tests were conducted on the above 11 varieties using the original parameters (Test Code Appendix 6), and the results of the out-of-sample tests of the optimized parameters and those of the original parameters were placed under the same table for comparative analysis, as shown in Table 18.

Table 18: Comparison of out-of-sample test results for optimal and original parameters

ID	Number of transactions	Net Profit	Profit per trade	Winning percentage	Profit Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio	Corresponding parameters
PTA	171	119760.27	700.35	35.09	2.23	0.78	0.04	0.2	0.21	0.03	37,1
PTA	92	135329.15	1470.97	32.61	2.72	0.89	0.05	0.18	0.27	0.04	20,2
coke	117	64322.98	549.77	41.03	1.62	0.66	0.03	0.22	0.15	0.02	18,1
coke	65	-30627.53	-471.19	36.92	1.57	0.58	-0.02	0.22	-0.08	0	20,2
Fresh apples	51	56441.59	1106.7	33.33	2.72	0.91	0.07	0.14	0.48	0.06	19,2
Fresh apples	26	91745.42	3528.67	38.46	3.15	1.21	0.1	0.15	0.71	0.08	20,2
Soda ash	34	36524.29	1074.24	29.41	3.3	0.97	0.07	0.12	0.57	0.06	40,2
Soda ash	16	102678.99	6417.44	37.5	4.81	1.8	0.18	0.13	1.37	0.13	20,2
styrene	32	14568.81	455.28	37.5	1.93	0.72	0.03	0.14	0.19	0.02	12,1
styrene	19	16945.21	891.85	31.58	2.78	0.88	0.03	0.14	0.22	0.03	20,2
Bleached kraft softwood pulp	41	14108.41	190.01	36.59	1.84	0.67	0.02	0.12	0.17	0.02	18,1
Bleached kraft softwood pulp	21	37417.9	1781.8	28.57	3.42	0.98	0.05	0.12	0.44	0.04	20,2
CSI 500 stock index futures	77	5973.52	77.58	38.96	1.58	0.61	0	0.5	0.01	0.03	10,2
CSI 500 stock index futures	44	-3531.53	-80.26	31.82	2.13	0.68	0	0.54	-0.01	0.03	20,2
Hot rolled coil plate	85	-16126.49	-189.72	31.76	2.01	0.64	-0.01	0.16	-0.08	0	40,2
Hot rolled coil plate	47	78202.96	1663.89	38.3	2.25	0.86	0.05	0.16	0.33	0.04	20,2
Rebar	138	-25776.53	-186.79	34.78	1.78	0.62	-0.01	0.15	-0.09	0	26,2
Rebar	75	64096.35	854.62	42.67	1.6	0.68	0.03	0.16	0.18	0.02	20,2
Medium sulfur crude oil	49	-79176.72	-1615.85	32.65	1.77	0.58	-0.11	0.59	-0.19	0.01	14,1
Medium sulfur crude oil	28	-29933.96	-1069.07	39.29	1.44	0.57	-0.04	0.48	-0.08	0.01	20,2
Shanghai and Shenzhen 300 Index Futures	131	-415557.34	-3172.19	29.77	1.76	0.52		26.12		0.14	30,1
Shanghai and Shenzhen 300 Index Futures	69	122807.15	1779.81	37.68	1.86	0.7	0.06	0.54	0.1	0.04	20,2

In Table 18, the red words represent the out-of-sample test results using the optimized parameters and the black words represent the out-of-sample test results for the original parameters. Out-of-sample test results of the Bollinger Bands trading strategy on styrene using the optimized parameters (12,1): 48 trades with a net profit loss of RMB 17,292, a profit expectation of 0.62, an annualized compounded rate of return of -0.03, an annualized volatility of 0.17, an annualized Sharpe Ratio of -0.19, and an annualized Sortino Ratio of -0.01. This result reflects the existence of an overfitting Risk. Due to the small amount of data, the small number of trades, and the trending nature of the market can affect the correctness of the results, the optimized and original parameters were tested and compared over the same time period. Out-of-sample test results for the original parameters (20,2): 19 trades with a net profit of RMB 16,945, profit expectation of 0.88, annualized compounded rate of return of 0.03, annualized volatility of 0.14, annualized Sharpe Ratio of 0.22, and annualized Sortino Ratio of 0.03. All the indicators are better than the optimized parameters. Based on this, the Bollinger Bands trading strategy ended up choosing the original parameters. Comparing the other instruments in the same way, the result is that Bleached kraft softwood pulp, styrene, Shanghai and Shenzhen 300 Index Futures, PTA, Rebar and Medium sulfur crude oil use the original parameters and optimized parameters for CSI 500 stock index futures, Fresh apples, Soda ash, coke, and Hot rolled coil plate.

4.2 Multispecies combination

The best parameters were obtained for 11 varieties by comparison. To facilitate the observation of each parameter, it was made into Table 19.

Table 19: Parameter results of the final screening of the varieties

ID	Number of transactions	Net. Profit	Profit per trade	Winning percentage	Profit Loss ratio	Expectation of the Profit	Annualized Return	Annualized StdDev	Annualized Sharpe Ratio	Sortino Ratio	Corresponding parameters
CSI 500 stock index utures	77	5973.52	77.58	38.96	1.58	0.61	0	0.5	0.01	0.03	10,2
Soda ash	8	126345.12	15793.14	50	5.71	2.86	0.22	0.14	1.6	0.15	40,2
Fresh apples	26	118230.15	4547.31	42.31	3.42	1.45	0.13	0.15	0.9	0.1	19,2
Coke	112	198374.44	1771.2	36.61	2.48	0.91	0.09	0.21	0.42	0.05	18,1
Hot rolled coil plate	25	105438.6	4217.54	48	2.09	1	0.07	0.18	0.39	0.04	40,2
Rebar	75	64096.35	854.62	42.67	1.6	0.68	0.03	0.16	0.18	0.02	20,2
Medium sulfur crude oil	28	-29933.96	-1069.07	39.29	1.44	0.57	-0.04	0.48	-0.08	0.01	20,2
Bleached kraft softwood pulp	21	37417.9	1781.8	28.57	3.42	0.98	0.05	0.12	0.44	0.04	20,2
Styrene	19	16945.21	891.85	31.58	2.78	0.88	0.03	0.14	0.22	0.03	20,2
Shanghai and Shenzhen 300 Index Futures	69	122807.15	1779.81	37.68	1.86	0.7	0.06	0.54	0.1	0.04	20,2
PTA	92	135329.15	1470.97	32.61	2.72	0.89	0.05	0.18	0.27	0.04	20,2

4.2.1 Species correlation test

Correlation analysis was done for 11 futures varieties using R's GGally package (see Appendix 7 for the code) and the results are shown in Figure 2 and Table 20.

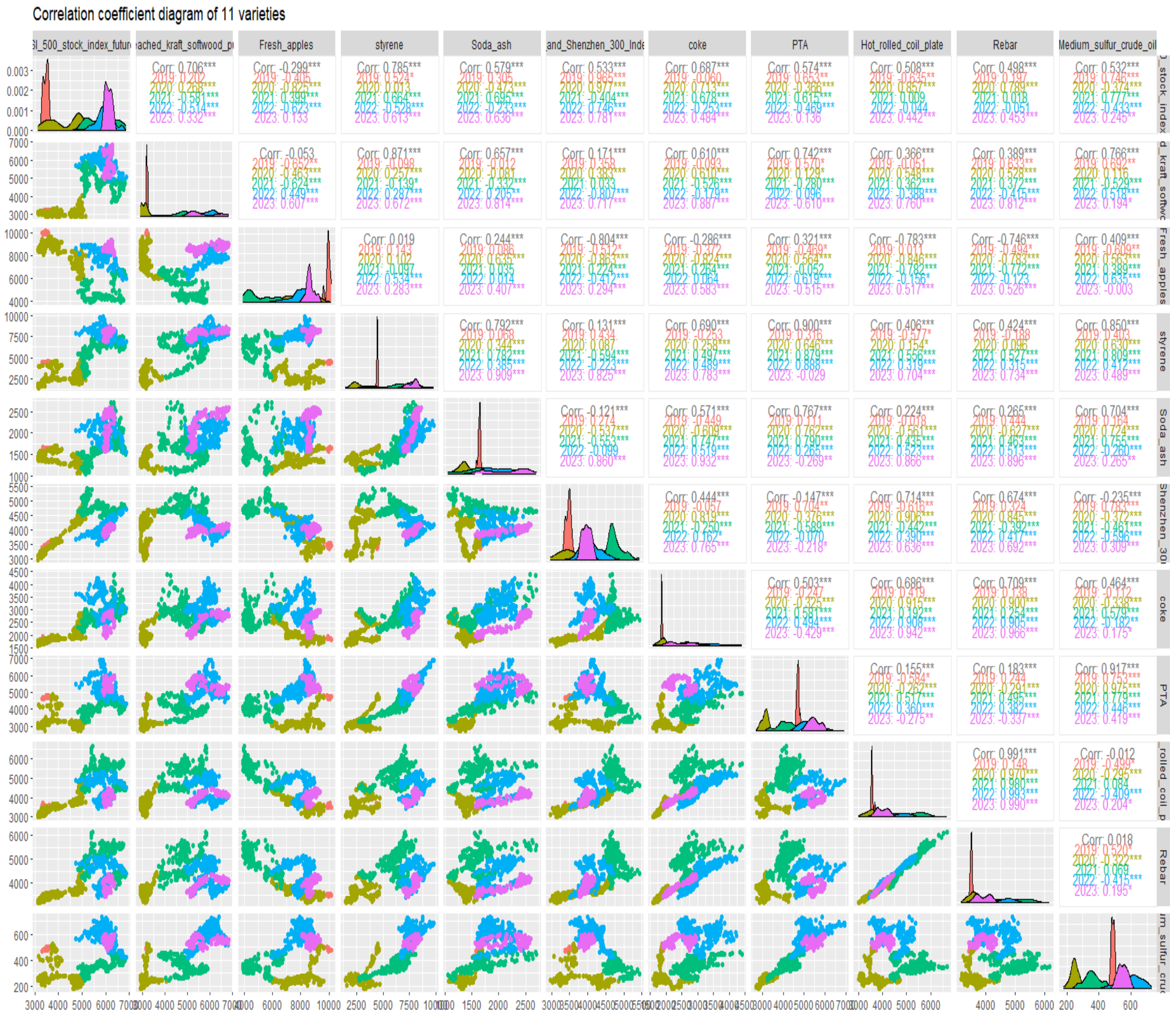

Figure 2: Scatter plot of correlation coefficients for each specie

Table 20: Correlation coefficients for each species

	CSI 500 stock index futures	**Bleached kraft softwood pulp**	**Fresh apples**	**Styrene**	**Soda ash**	**Shanghai and Shenzhen 300 Index Futures**	**Coke**	**PTA**	**Hot rolled coil plate**	**Rebar**	**Medium sulfur crude oil**
CSI 500 stock index futures	1	0.705662896	-0.299206303	0.785184397	0.579275237	0.532938752	0.686768823	0.57449101	0.507696354	0.498178576	0.53182927
Bleached kraft softwood pulp	0.705662896	1	-0.053014485	0.87149919	0.657321676	0.171279595	0.610315791	0.742239764	0.365756666	0.38893687	0.766052705
Fresh apples	-0.2992063	-0.053014485	1	0.018585494	0.243633588	-0.803606511	-0.285908583	0.320786726	-0.78300539	-0.746270263	0.40924822
Styrene	0.785184397	0.87149919	0.018585494	1	0.79191061	0.130666116	0.689655845	0.900380507	0.405937205	0.424234505	0.850304596
Soda ash	0.579275237	0.657321676	0.243633588	0.79191061	1	-0.120925172	0.571423678	0.767386673	0.22427794	0.264579155	0.704099053
Shanghai and Shenzhen 300 Index Futures	0.532938752	0.171279595	-0.803606511	0.130666116	-0.120925172	1	0.44377267	-0.146925409	0.714050942	0.67439339	-0.234815878
Coke	0.686768823	0.610315791	-0.285908583	0.689655845	0.571423678	0.44377267	1	0.503098572	0.685502101	0.70938745	0.464063392
PTA	0.57449101	0.742239764	0.320786726	0.900380507	0.767386673	-0.146925409	0.503098572	1	0.154983082	0.183116722	0.916631145
Hot rolled coil plate	0.507696354	0.365756666	-0.78300539	0.405937205	0.22427794	0.714050942	0.685502101	0.154983082	1	0.990888262	-0.01220998
Rebar	0.498178576	0.38893687	-0.746270263	0.424234505	0.264579155	0.67439339	0.70938745	0.183116722	0.990888262	1	0.017524476
Medium sulfur crude oil	0.53182927	0.766052705	0.40924822	0.850304596	0.704099053	-0.234815878	0.464063392	0.916631145	-0.01220998	0.017524476	1

The graphs show the correlation between the 11 varieties two by two. Since each variety has an inconsistent listing date, the shortest variety was taken as the criterion and grouped by year for comparison. Usually, a correlation coefficient close to 1 indicates a strong positive correlation between two variables, close to -1 indicates a strong negative correlation, and close to 0 indicates no linear correlation. From the scatter plot, we can see that Shanghai and Shenzhen 300 Index Futures and Fresh apples are negatively correlated, with a correlation coefficient of -0.804. Forming a portfolio with such varieties can better reduce the risk. Rebar and hot rolled coil plate Scatter Plot Rebar and Hot rolled coil plate Scatterplot are nearly straight lines with a correlation coefficient of 0.991, which is statistically significant. If real trading, choose a better effect from the two varieties to form a portfolio, or two varieties accounted for half of the other varieties of funds to manage funds, can better avoid risk. Based on the above method, the 11 varieties were compared and analyzed, and try to choose the relatively small correlation coefficient or negative correlation of the varieties for the combination.

4.2.2 Building a multi-species portfolio model

Based on the screened futures varieties, the combination of futures varieties is constructed by referring to the actual relationship of their underlying, combined with the correlation coefficient. Financial futures contain two varieties CSI 500 stock index futures, Shanghai and Shenzhen 300 Index Futures. their correlation coefficients are 0.533, so they are divided into two groups. Compare the size of their correlation coefficients with the other 9 commodity futures respectively, and combine the varieties with small correlation coefficients together. Two groups of portfolios are obtained:

The first group is Shanghai and Shenzhen 300 Index Futures, Medium sulfur crude oil, PTA, Hot rolled coil plate, styrene and coke.

The second group is CSI 500 stock index futures, Fresh apples, Rebar, Bleached kraft softwood pulp, Soda ash.

The correlation coefficient between PTA and Medium sulfur crude oil within the first group is 0.917, PTA is a by-product of Medium sulfur crude oil processing, and the two are highly correlated and not suitable to be placed in one group. Therefore, PTA is adjusted to the second group. According to this way of comparing and analyzing one by one, the final combination of the two groups of varieties is:

The first group is 5 varieties: Shanghai and Shenzhen 300 Index Futures, Medium sulfur crude oil, Hot rolled coil plate, styrene and coke.

The second group is a combination of six varieties: CSI 500 stock index futures, Fresh apples, Rebar, Bleached kraft softwood pulp, PTA and Soda ash.

Conclusions

In this paper, the Bollinger Bands strategy, a classic trend-following trading strategy, was selected to test all 60 varieties being traded in the Chinese futures market on July 27, 2023 (12 varieties with incomplete data from inactive trading were removed). On each variety, equal amounts of capital were used to stop out at 0.04

of the initial capital each time a position was opened. After the listing of each variety in accordance with the Bollinger Bands trading strategy to remove the transaction costs of 44 varieties can produce positive returns, only 16 varieties of losses, the cumulative profit of 301,550 yuan, the average annualized compound interest rate of 0.05, the Sharpe ratio of 0.37. This shows that the Bollinger Bands trading strategy is effective in China's futures market.

The same strategy also produces significant differences when traded on different futures varieties. Therefore, choosing a combination of futures varieties that test well will result in a greater likelihood of profitability at a later stage. Futures varieties that trend well on the daily cycle with small oscillations perform well on the trend following strategy. In this paper, the varieties with good trading results are selected based on the corresponding indicators, and then these varieties are optimized in-sample and tested out-of-sample to select the best parameters. Finally, based on the correlation of varieties, two groups of multi-variety combination patterns are formed for real trading.

Trend-following strategy in accordance with the market price trend for trading, the price rises to a certain position that the upward trend is established and go long, the price falls to a certain standard that the downward trend appears and go short. When a large number of traders follow the same method of trading it can lead to dramatic fluctuations in market prices and a herd effect in the market. This strengthens the effect of the strategy. This repeated occurrence of trading behavior changes the underlying state of the market and manifests itself as a trader effect, resulting in a strategy that will no longer be effective. The results tested in this paper show that this well known trading strategy still produces good returns in the Chinese futures market. Because the Sharpe Ratio and Sortino Ratio of these strategies are very low, most of them are less than 1. This indicates that these strategies are risky and have many retracements. It is difficult for participants to stick to the trade and abandon these correct trading methods after multiple stop losses. When using these strategies, it is important to control the amount of money used, to avoid repeated stop-losses in the oscillator market will lose all the money and miss the trend of the market profit.

There is no holy grail in the trading world. Each strategy has its own adaptation to the market and trading varieties. Therefore, you have to choose the market and species that are more favorable to you to trade. It is also important to be aware of the impact of random events during trading. A combination of multiple varieties can better minimize the impact of random events.

With the popularity of quantitative investment and programmed trading, there are more and more theoretical studies and the development of quantitative strategies has become more and more perfect, but the strategies with real practical value are in a non-public state. Some public strategies mostly originate from developed markets in Europe and the United States. How effective these strategies are in emerging markets is a direction worth exploring and researching. China's futures market has an increasing share in the world's futures market, and there are more and more varieties. Therefore, this paper makes a preliminary exploration of China's futures market. Most of the time the market quotation is oscillating, the trend following strategy will be in loss most of the time, which is a great test for the confidence and patience of traders. This is a great test of traders' confidence and patience, and requires strong endurance on the part of the user. The development of oscillator trading strategy and trend-following strategy for a combination of better able to reduce the withdrawal of funds, reduce risk. At the same time should also increase the combination of different cycles of trading: such as intraday 5, 15, 30-minute trading strategy and daily, weekly, monthly trading strategy combination, so that we can try to diversify the risk, resulting in a better combination of strategies. In addition, the construction of multi-species multi-strategy investment portfolio, each variety of fixed the same funds and each variety and strategy are independent of each other, resulting in a lack of linkage and interaction between different trading strategies and varieties. In future research, the interaction between different strategies and varieties can be considered, and the funds can be dynamically adjusted to compare their trading effects.

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