Research on Quantitative Trading Strategies Based on the Turtle Trading Rule

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Abstract. Quantitative investment is a newer investment method than traditional investment methods, with features such as being free from emotions and being able to access and process large amounts of data quickly. Based on this, this paper selects fuel oil, FU2205, as the underlying for the period from May 31, 2021 to November 30, 2021 to investigate the effectiveness of the turtle trading rule in quantitative trading strategies. In this way, the effectiveness of the turtle trading rule is explored. The article first introduces the background and significance of the study, explains the current research status of several scholars on quantitative investment and the relevant theoretical background, and then conducts relevant tests on the turtle strategy in three parts. In the first part, the principles of the turtle trading strategy are reviewed, and three important steps are introduced: market entry, position addition and exit. In the second part, the turtle trading strategy is modeled, and fuel oil from the commodity futures market is selected as the sample for backtesting from May 31, 2021 to November 30, 2021. Not only does it far exceed the buy-and-hold return, the Sharpe ratio and maximum retracement are also better. Finally, after tuning the parameters of the strategy and increasing the risk ratio of the account, the total return is significantly improved, but since it is impossible to predict whether the strategy will be profitable or not, this suggests that we cannot increase the risk ratio of the account indefinitely and need to keep it in an appropriate range. The article concludes with a further summary of the study findings and provides an outlook.

Keywords: Turtle rule, Quantitative investment, Commodity future, Trend following, Strategy optimization.

1. Introduction

With the continuous development of Internet technology, many traditional industries are also changing their working mode and process and hope to get further development with the help of Internet technology. In the financial industry, stocks, and other trading types of derivatives, such as options and futures trading are undoubtedly the first to be impacted and thus changed. From Thomas Pettyfer, the father of algorithmic trading, to Simmons, the king of quantitative investment who is still active today, they were the first batch of beneficiaries of quantitative trading and the guides who showed the direction for the whole financial industry. According to the statistics of CITIC Securities, automated trading has occupied more than 60% of the turnover of the U.S. stock market in recent years. It can be said that quantitative trading continues to comply with the market changes that are taking place.

In foreign countries, the development of quantitative trading can be divided into 3 stages. The first stage is the "beginning" period that between 1971-1977. In 1971, the world's first passive quantitative fund was issued by Barclays International Investment Management, and the world's first active quantitative fund was also issued by Barclays in 1977, with an issue size of $7 billion, which was the beginning of quantitative investment in the United States. The second stage is the "development" period that between 1977-1995, with the great progress in information technology and computer technology, quantitative investment ushered in an era of rapid development. And the third stage is the "maturity" period that from 1995 to present. During this period, quantitative investment techniques have gradually matured and now account for about 50% of all investments, with all index investments using quantitative techniques and 20% to 30% of active investments using quantitative techniques.

Domestic quantitative trading started late and really emerged after the US subprime crisis, when many people Who have worked in Wall Street returned to China for development. Depending on the degree of use of quantitative trading strategies, the localized development of quantitative trading can be roughly divided into three stages, namely the ETF arbitrage era before 2010, the multi-factor alpha and high-frequency trading era from 2010 to 2015, and the diversified investment era from 2016 to now.

Compared to traditional investment methods, programmatic quantitative trading is favored by the public because it is not affected by human emotions, can eliminate human subjective judgment, overcome human weaknesses, and can greatly increase the probability of profit under the right strategy. And the strategy of quantitative trading itself is based on the improvement of the market environment and financial theory, which can be precisely constructed by balancing the risk and return ratio and regulating the variables.

2. Literature References

In 2005 Cole and Eric used a trend-following strategy on 24,000 U.S. stocks screened using liquidity metrics and back-tested for 24 years and found significant returns [1]. In 2010 Michael introduced in detail how to limit the risk in trend trading and how to carry out high profit swing operations by analyzing historical performance [2], pointing out that trend following strategies can be very profitable in both bull and bear markets . Andrew examines the profitability of trend-following strategies across 28 commodity futures, and the results of the study show that 22 commodity futures can achieve excess returns, but the returns of the strategies decrease over time [1].

Kamal and Steven built a quantitative strategy based on the London stock market using the turtle trading rule, mainly from the optimization of the parameter settings for market entry, stop loss, position addition and market exit. The test results showed that the system with optimized parameters during the period from March 2007 to April 2007 had significant results [3].

In 2012, Peng Ding summarized eight investment strategies, which are quantitative stock selection strategy, quantitative timing strategy, stock index futures arbitrage strategy, commodity futures arbitrage strategy, statistical arbitrage strategy, options arbitrage strategy, algorithmic arbitrage strategy, and alternative arbitrage strategy [4]. In 2013, Zirui Li tested his constructed quantitative investment model with using the historical trading data of China's stock index futures main contracts, and found that trend-based quantitative investment strategies are effective in China's stock index futures market [5]. Qianyun Zheng analyzed the reasons for the poor performance of the Turtle Rule in the domestic market and tested the optimization for the parameters in the Turtle Rule, validated the model in the stock market from 2005 to 2010 [6], proving that the optimized model has better performance. In 2015, Xiaoyan Guo adopted the trend indicator (CYE) as the breakout condition instead of the double average system in the turtle rule, improving the problem that the model sends too many operation signals in oscillating markets [7]. Yumin Zhou wrote a strategy based on China's futures market using the original turtle trading rule through trading software and conducted an empirical study using the trading data of China's futures market from 2013 to 2014 to optimize a more suitable quantitative strategy. The results show that after the optimization of the strategy, significant excess returns can be obtained [8]. In 2016, Renguang Shen conducted an empirical study on 10 randomly selected SSE 50 stocks from January 2013 to December 2015 with the core idea of turtle trading. The results of the study show that the average annualized return of the 10 stocks reached nearly 70%, which concludes that the application of the turtle trading rule in China's stock market has universal significance [9]. In 2017, Gongping Yu proved that the Turtle Rule trading strategy is not obsolete, and the applicability of the Turtle Rule strategy to commodity futures cannot be generalized but is related to the properties of commodity futures themselves [10]. Shenyu Zhou mentioned that if investors have a good mindset and self-control, they can choose a trading system with a certain subjective trading component and choose their own entry and exit points, position size and stop-loss settings. However, if there is no better self-control, the use of mechanized trading

systems, more risk control, not affected by market sentiment, better to survive in the market [11]. By analyzing the profit logic behind the common trend following strategies among quantitative trading strategies [12], Lei Tan found that the source of their profitability must be understood from the perspective of market structure and behavioral economics. It is believed that trend-following strategies will inject new vitality into the development and design of quantitative strategies in the new era. In 2018, Yulin Zhang analyzed that the market conditions can affect the effectiveness of the Turtle Trading Rule. In a bear market, the turtle trading rule can be used for active investment; in a bull market, the advantage of the turtle trading rule is not obvious. When the market environment is a bear market or in a one-sided down state, the turtle trading rule is valid. The profitability of the Turtle rule is affected by the opening and closing period [13]. In 2019, Xiaolin Yan proposed that increase the number of position additions and raise the threshold of stop loss to adapt to the domestic market quotation for the cycle parameter of the Turtle Rule, and the experimental results showed that the optimized annualized return reached 32%, which is nearly 5 times higher than the benchmark return of 6.7% annually [14].

The subject of this paper is China's commodity futures, and the commonly used methods are Keltner Channel strategy, cross-species arbitrage strategy and momentum strategy. The Turtle Trading Rule is used in this topic. The turtle rule is a trend following strategy, which can be used to monitor stock price data in real time, give instructions to the selected stocks to trade during the daily trading hours so as to make timely responses in the constantly fluctuating market conditions, and realize the turtle rule for each trading object based on the historical data after the close of each day, so as to avoid the failure of the model and ensure that the model will not become obsolete. In this thesis, For Trader trading system is used to write the programmed trading model.

In this paper, fuel oil from the Shanghai Futures Exchange is used to backtest historical data for the period May 31, 2021 to November 30, 2021. According to the back testing results, the Turtle Trend Tracking Strategy has achieved high long-term returns and relatively low risk in fuel oil futures, as fuel oil is subject to the price characteristics of the commodity, which is relatively trendy.

3. Method

The core of the Turtle strategy is trend following. To achieve trend following, the Turtle trading strategy sets up three trading phases, which are entry the market, adding to positions and exit the market.

Entry the market means to buy the first order. The timing of buying and the quantity of buying are two issues that need to be addressed at this step. As people usually knows, a good time to buy it is the price has an upward trend. And Donchian Channel is a classic technical indicator used to determine uptrends. It is a technical analysis indicator invented by Richard Donchian, an American futures trader in the last century, and is generally used to track trends. It is consisting of three lines, which are the upper, middle, and lower rails. The upper track is the highest point in the last N trading days including the current trading day. N usually takes a value of 20 in the case of short cycles and 55 in the case of long cycles. The lower track is the lowest point in the last M trading days including the current trading day. M usually takes a value of 10 in the case of short cycles and 20 in the case of long cycles. Middle track is the average of upper and lower track.

To confirm the purchase quantity, a special calculation method is used so that the purchase quantity can be flexibly adjusted for the purpose of risk control. In order to better understand the core of the purchase quantity calculation, several important indicators are import that are Volatility Range (TR), Average Volatility Range (ATR) and Exponential Moving Average (EMA). The calculation formula is as follows:

$$TR = Max(|H - L|, |H - PDC|, |PDC - L|) \quad (1)$$

Where H is the highest price of the day, L is the lowest price of the day, and PDC is the closing price of the day before.

$$EMA_N(x_n) = \frac{2}{N+1}x_n \times \sum_{k=0}^{\infty}(\frac{N-1}{N+1})^k \times x_{n-k} \quad (2)$$

$$EMA_N(x_n) = \frac{2}{N+1}x_n + \frac{N-1}{N+1}EMA_N(x_{n-1}) \quad (3)$$

Where N is the number of periods and x_n is the closing price of the nth day.

$$ATR = EMA(TR, N) \quad (4)$$

$$purchase\ quantity = \frac{1\%\ of\ total\ account\ funds}{ATR} \quad (5)$$

The real meaning of this equation is volatility of the entire position is equal to 1% of the total account funds.

Adding the position means that if the price continues to rise after entering the market, then continue to buy orders. Again, there is a need to determine an appropriate timing and amount of position addition here. As mentioned above, Donchian Channel is a way to determine the uptrend when entering the market. However, in determining whether to execute adding position, as long as the price has increased by more than 0.5 ATR compared to the last purchase price, the adding position will be executed. And so on, multiple adding position can be executed. But the more position added, and the more risk people will undertake. To control the risk, the strategy will set the limit of number of buy-in, and it general default is 4 times.

$$purchase\ quantity = \frac{Total\ account\ funds \times risk\ ration\ of\ account}{ATR} \quad (6)$$

Exit is the execution of closing a position when there is an unfavorable price trend. And it will close the position if the price falls by more than 2 ATR compared to the last buy price. The price of the current trading day has broken through the lower rail of the Donchian Channel, indicating that the lowest price point of the past M trading days has been reached, at which point it is considered that the price trend may be reversed and need to close the position and exit. In general, as long as one of the two conditions, stop loss and stop profit, is met, the position will be closed immediately. Exiting the market is the selling of all positions already held. Once exited, a complete turtle trade is finished. To continue trading, must start again from the entry the market.

4. Strategy design for programmed trading

The object should meet specific volatility and liquidity requirements because the turtle trading rule method is primarily a trend following technique. The more volatile the species, the more broadly applicable the turtle trading strategy will be. The selection of the object in this paper mainly considers commodity futures on China's futures exchanges. The national futures market can be broadly divided into commodity futures and financial futures. Commodity futures such as gold, agricultural products and crude oil belong to commodity futures, while the more popular financial futures are foreign exchange, interest rates, etc. After selection, this article focuses on the energy chemical futures with contract code FU2205 on the Shanghai Futures Exchange, fuel oil. Table 1 below shows the contract information about the fuel oil.

Table 1. Fuel Oil Contract Specifications

Definition	Content
Product	Fuel Oil
Contract Size	10 metric tons/lot
Price Quotation	Yuan (RMB)/metric ton (exclusive of tax)
Minimum Price Fluctuation	1 Yuan/metric ton
Daily Price Limit	Within 5%of the settlement price of the preceding trading day
Listed Contracts	Monthly contract for the most recent 12 months
Trading Hours	9:00 a.m.to 11:30 a.m.,1:30 p.m.to 3:00 p.m.,and other hours specified by the Exchange(Beijing Time)
Last Trading Day	The last trading day of the month before the contract month, subject to adjustment by the Exchange in case of legal holidays in China
Delivery Period	Three consecutive business days after the last trading day
Grade and Quality Specifications	Marine fuel oil of grade RMG 380(sulfur content level I or ll) or higher grades(refer to Appendix for detailed quality standards)
Delivery Venue	Delivery venues designated by the Exchange
Minimum Trading Margin	8%of contract value
Settlement Type	Physical delivery
Delivery Unit	10 metric tons
Contract Symbol	FU
Listing Exchange	Shanghai Futures Exchange

Source: Shanghai Futures Exchange [15]

The calculation results for the upper and lower tracks may be different for different periods. Therefore, the first thing to do is to determine the calculation period. In this article, the short period, i.e. the highest price point in the last 20 trading days, is used as the breakout condition for market entry.

As long as

$$\text{close price of the day} > \text{last buy price} + 0.5\text{ATR} \tag{7}$$

$$\text{total amount of adding} < 4 \tag{8}$$

these two conditions are satisfied.

It need satisfy two conditions, which are:

Stop Loss:

$$\text{Close price of the day} < \text{last buy price} - 0.5\text{ATR} \tag{9}$$

Stop Profit: Close price of the day breakout the lower track of the Donchian Channel. It means the lowest price point in the last 10 trading days, is used as the breakout condition for market exit.

5. Results

The Table 2 generated by the For Trader decision trading system shows that the quantitative trading strategy completed seven trades, with two open positions and two closed positions, during the six-month interval from May 31 to November 30, 2121, for a 50%-win rate for the period. The benchmark return was 2.7% and the strategy returned 11.41%, which indicates that the strategy delivered a return of 11.41% during this six-month period, an improvement of 8.71% compared to the benchmark return of 2.7%.

Table 2. Returns of Strategy

Strategy Gain	Annualized Return	Benchmark Returns	Benchmark Annualized Return	All closed trades	Winning Ratio	Sharp Ratio	Maximum Retracement	Average Trade
11409.81	24554.81	/	/	2	50%	1.27	8800.00	6343.40
11.41%	24.55%	2.7%	5.57%	/	/	/	7.32%	6.34%

In order to analyze the returns of the Turtle Rule trading strategy in detail, the following graph plots the cumulative returns, profit/loss and turnover records of all trades recorded for this rule during the backtest period, which is used to observe the growth in returns compared to the profit/loss of each trade. The graph shows that the overall return curve has an upward trend and has the characteristics of slow retracement and fast growth. In addition, from the histogram of profit and loss records, also can finding that most of the losses are small, but a small portion of the profits are high gains, it helps us to validate the idea of turtle trading, which is to obtain high gains by capturing large trends.

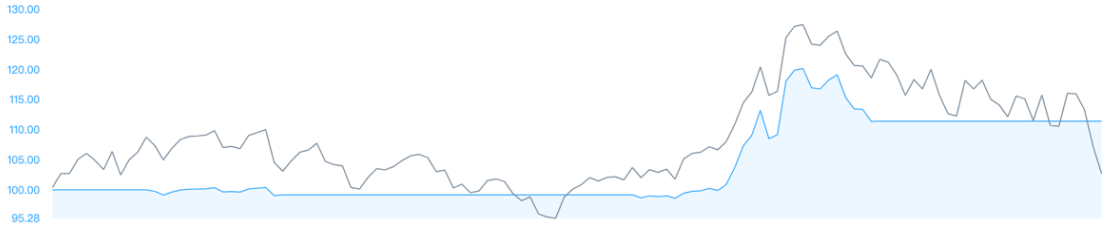


Fig 1. Cumulative Returns

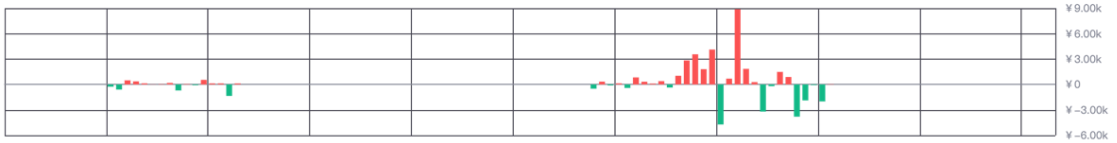


Fig 2. Profit/Loss Record

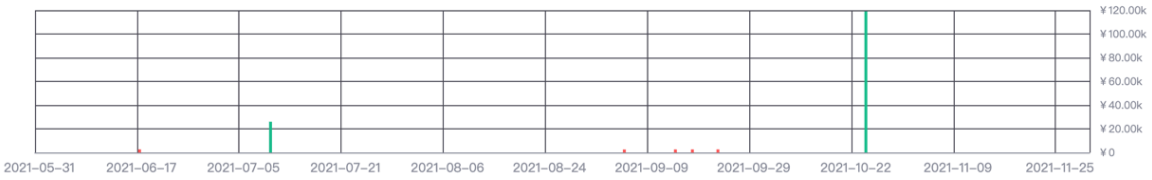


Fig 3. Turnover Record

Every strategy has risk, and the Turtle Trading Rule is no exception. Among the risk indicators for a strategy, the three most important dimensions to evaluate are the maximum retracement of assets, the win ratio and the Sharpe ratio. In the process of selecting a strategy, investors must make a thorough assessment of the risk of the strategy. The maximum asset retracement margin is the maximum value of the net worth retracement when the strategy's net worth goes to its lowest point by advancing backwards at any point in the backtesting cycle. It can be interpreted as the maximum magnitude of loss that can occur and represents the worst-case scenario that can occur with a trading strategy. Even if the strategy is profitable in the long run, it cannot be used. Winning ratio is number of profitable trades divided by total number of trades. All else being equal, the higher the winning ratio, the lower the risk of the strategy. Sharpe ratio, calculated as

$$Sharp\ ration = \frac{R_p - R_f}{\sigma_p} \tag{10}$$

Where R_p is return of portfolio, R_f is risk-free rate and σ_p is standard deviation of the portfolio's excess return.

The Sharpe Ratio represents how many points of excess return an investor can get for each additional point of risk taken; if it is greater than 1, it means that the return is greater than the volatility risk; if it is less than 1, it means that the operational risk is greater than the return. In this way, each portfolio can calculate the Sharpe Ratio, which is the ratio of investment return to more risk, the higher the ratio, the better the portfolio.

The analysis of the risk table of the Turtle Rule trading strategy shows that the maximum asset retracement of the system trading from May 31, 2021 to November 30, 2021 is 7.2% and the Sharpe ratio is 1.27. This means that the strategy is able to maintain a low risk that is acceptable to investors while maintaining a Sharpe ratio greater than 1.

The backtest performance of this strategy is already very good, but the strategy parameters are the most used values, not necessarily the optimal values under the current market conditions, we can continue to adjust the parameters to achieve a better strategy. The adjustable parameters in the Turtle trading strategy can be divided into three categories: Donchian channel related parameters, ATR related parameters, and other constant parameters.

There are two parameters that can affect the Donchian Channel, namely the upper and lower track periods. Take the upper rail period as an example. A long period means that the historical data covered in the calculation of the upper rail is older and reflects the highest price point in a longer period. A short period, on the other hand, reflects the price highs in the short term.

As shown in the chart below, the blue track has a period of 55 and the red track has a period of 20



Fig 4. Comparison of parameters related to Donchian Channel

In general, the longer the period, the wider the orbit. If the period is too long, it will cause the price to have a hard time breaking out of the track, thus missing some of the up and down trends. If the period is too short, it will result in prices breaking out easily, but probably due to random fluctuations and the trend will be less credible. According to the experience summed up by the turtle trading strategy, the upper and lower rails are tuned to the upper rail period range between 20-55, and the lower rail period between 10-20.

The parameter that can affect the ATR is also its calculation period. The idea of tuning the ATR period is similar, it should be neither too short nor too long.

As shown in the figure, all other things being equal, the upper ATR period is 5 days and the lower one is 50 days. The variation in the upper ATR is significantly more dramatic.

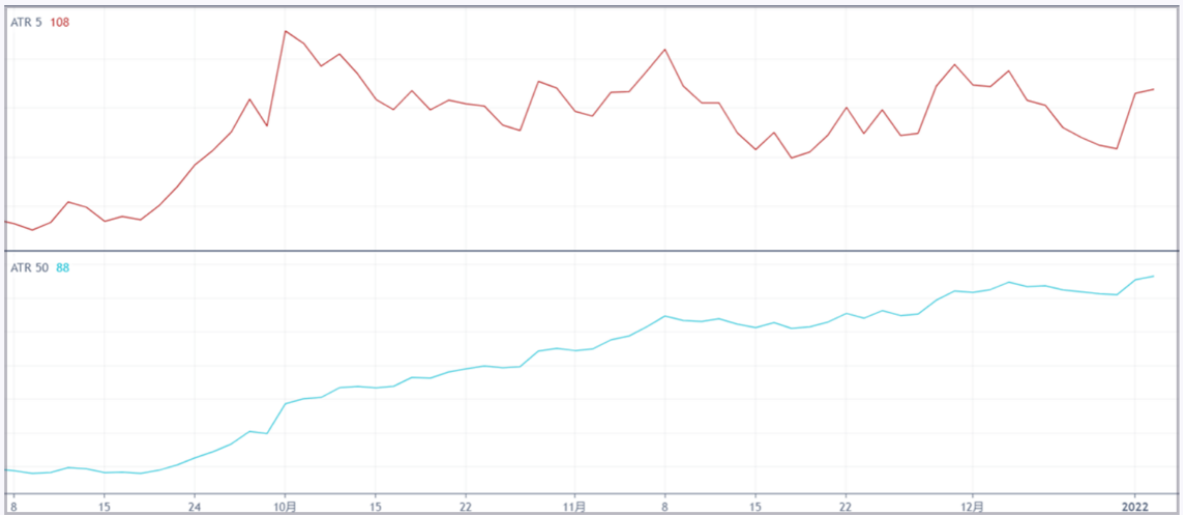


Fig 5. Comparison of ATR indicators (different periods)

As the graph shows, the shorter the period, the more dramatic the ATR value changes. If the period is too short, the ATR fluctuations are too sharp for us to control the risk of our positions. However, if the period is too long, the timeliness of the data decreases and the volatility levels from a long time ago are not representative of the current moment and may be misleading. So, the recommended parameter range for the ATR cycle is between 20 and 50.

And other constant parameters include volatility factor for position addition, maximum number of buys, volatility factor for stop loss and account risk ratio.

The first attempt that tried in this paper is adjusts the period of the upper and lower rails of the Donchian channel. This paper tried the different combinations of the value of 20, 55 for upper rails and 10, 20 for lower rails. did not make the backtest results better, which means the initial parameters taken are already a more reasonable combination. Then this paper adjusted the account risk ratio from 0.01 to 0.02 then to 0.03, and the results of the backtest indicate that the highest return is achieved when account risk ratio is 0.03, increasing from 11.41% to 46.54%, but the maximum asset retracement from 7.2% increase to 19.37%. It's unsurprised, based on the formula for the number of buys

$$Number\ of\ buys = \frac{Total\ account\ funds \bullet Account\ Risk\ Ratio}{ATR} \tag{11}$$

When the risk ratio of the account is expanded by a few times, the number of buys increases equally by a few times. As long as the strategy is profitable, the more we buy, the higher we returns will naturally be. However, all this assumes that we are backtesting, means we already know that the strategy is profitable. However, when trading live, we cannot predict whether the strategy will be profitable or losing. Once the strategy loses money, the excessive account risk ratio will make us buy a large number of orders, at which point the losses will be equally magnified. So, by turning up the account risk ratio, the strategy's gains and losses will be magnified, which essentially increased investment risk.

6. Conclusion

In this paper, we study the turtle trading method in quantitative trading strategy. Firstly, we introduce the current situation of quantitative trading in China, and select the commodity futures of Shanghai Futures Exchange, fuel oil, as the main object of the study. Then, the Turtle Rule trading strategy, which has been a great success in the U.S. commodity futures market, is selected, and the For Trader trading system is used as the basis to write the Turtle Rule programmed trading strategy.

In this paper, the Turtle Rule programmed trading strategy was backtested using historical transaction data between May 31, 2021, and November 30, 2021 as the sample. The results from the test show that the turtle trading strategy performed well on the sample, obtaining a strategy return of

11.41%, which exceeding the benchmark return, 2.7%. Reaching a return of 4.2 times. The annualized return is 24.55%, which is 4.4 times the annualized return of the benchmark. This shows that the turtle rule trading strategy is not outdated and has practical application value, which can help investors gain more returns.

In order to maximize the benefits, this paper also carries out parameter tuning, mainly in two aspects: the Donchian channel-related parameters and the account risk ratio. Comparing the strategy before and after optimization, we found that the optimized strategy performed significantly better than the strategy before optimization, which means that the optimization of the strategy significantly increased the return, but at the same time also increased the investment risk. Because we already know in advance that the strategy is profitable when doing backtesting of parameter optimization, however, this is unpredictable in live trading, so it reveals that we cannot increase the account risk ratio indefinitely, even though the operation is profitable in the sample interval.

This article is an exploration of the turtle rule of quantitative trading, which allows us to use different trading strategies to achieve higher returns when trading in practice. For the turtle trading rule, it is more applicable to the futures market because it is good at capturing trends, buying when there is an uptrend and selling when there is a downtrend. In addition, the quantitative trading rule can help the emotionally driven people to maximize their returns because it is free of personal feelings and subjective judgments that making the risk manageable.

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