

Risk Hedging Application of Quantitative Trading Risk Assessment Method in Securities Market

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Abstract. This study focuses on the field of quantitative trading and explores in depth the application of risk assessment methods in securities market risk hedging. Through in-depth analysis of different risk categories in quantitative trading, the transmission mechanism and core influencing factors are clarified, such as market risk, credit risk, operational risk, liquidity risk, etc. Based on capital allocation theory, a dynamic risk parity strategy is created with the goal of balancing asset risk contributions, enhancing the robustness of quantitative strategies, and achieving sustained positive returns. Variables and data sources are selected from multiple perspectives in the securities market to construct a complex quantitative trading risk evaluation model. Through subsequent regression analysis, variance decomposition, time series stability check, and Montcallo simulation methods, the model settings are strictly checked to ensure accurate theoretical analysis. The final empirical results revealed that the new risk assessment method proposed specific suggestions for strategy optimization and adjustment through strategy backtesting and sensitivity analysis. In order to provide reference for efficient execution of risk hedging strategies in practice.

Keywords: Risk assessment methods; Quantitative trading risk; Risk hedging; Stock market; Strategy optimization.

1. Introduction

The risk management of quantitative trading is particularly important in the current volatile securities market. The risk assessment method is an effective risk hedging tool that balances the risk contribution of each asset and optimizes the portfolio structure. This method is based on the volatility and expected returns of each asset, while balancing the allocation risk. Specifically, the risk assessment strategy quantifies the risk level of each asset through standard deviation (i.e. historical waves). The weight of assets is adjusted in reverse by their volatility, ensuring that the overall risk contribution of all assets in the investment portfolio is equal.

2. Quantitative Trading Risk Analysis

2.1. Risk types of quantitative trading

The market risk in quantitative trading mainly manifests as systematic risk and non systematic risk. Systemic risks cannot be eliminated through diversified investments and are typically triggered by macroeconomic factors such as changes in interest rates, policy adjustments, and market sentiment fluctuations. Non systematic risks belong to specific risks of individual assets or industry sectors, corresponding to their specific fundamental factors.

In quantitative trading, commonly used risk management methods include VaR models, CVaR models, and risk assessment strategies. VaR is used to quantify the maximum loss level that may be suffered within a specific time period at a certain confidence level. It is usually calculated using historical simulation or Monte Carlo simulation methods, with parameters such as a holding period of 10 days and a confidence level of 95%. CVaR is a further supplement to VaR, measuring the average loss above the VaR threshold and providing deeper risk insights.

2.2. Transmission mechanism of quantitative trading risk

The transmission mechanism of quantitative trading risk is mainly reflected in the mutual influence among market participants and their impact on market liquidity, price volatility, and information

efficiency. In the process of risk transmission, the information transmission mechanism also plays a key role. Quantitative trading strategies typically rely on a large amount of real-time data analysis to respond promptly to market events. However, information asymmetry and data delay may lead to model failure. When some market participants get limited information and others fail to get it in time, the market price may become irrational and form a price foam.

Changes in market structure can also affect the risk transmission mechanism. For example, the popularity of algorithmic trading and the increase in bulk trading have led to significant changes in market depth and breadth, resulting in the amplification effect of a single event or strategy in the market. Due to the similarity of quantitative strategies, many traders may react similarly to the same signal at the same time, causing price fluctuations and increased volatility.

The network effect of risk transmission cannot be ignored. The increasing convergence of quantitative trading styles has led to a high degree of correlation between strategies. This correlation means that when a certain strategy fails, it may trigger a chain reaction, causing significant market volatility and triggering a broader liquidity crisis. Therefore, the risk transmission mechanism of quantitative trading in complex and highly interconnected markets must be carefully monitored, potential risks identified in a timely manner, and corresponding countermeasures taken.

2.3. Factors Influencing Quantitative Trading Risk

The influencing factors of quantitative trading risk mainly include market risk, liquidity risk, strategic risk, and model risk. Market risk reflects the impact of market volatility on portfolio value and is usually quantified through indicators. Liquidity risk refers to the commonly used liquidity premium model to measure the risk of not being able to quickly buy or sell assets at a reasonable price when trading is needed. Strategic risk arises from the design of quantitative strategies and adaptability in different market environments. During periods of intense market volatility, high-frequency trading strategies may suffer significant losses, although they can exploit small market imbalances. Model risk is closely related to the assumptions and parameter settings of quantitative models, including the applicability of market models and the accuracy of parameter estimation. The stability analysis and stress testing of models become particularly important. There are two common ways of stress testing: historical context and sensitivity analysis.

3. Overview of Risk Assessment Strategy

3.1. Risk assessment

Risk assessment refers to an investment strategy based on asset volatility and correlation, which dynamically adjusts the weights of each asset in a portfolio to achieve a uniform distribution of risk. In quantitative trading, strategies are optimized based on risk contribution to ensure a balanced contribution of different assets in the overall risk. The core methods include reallocating asset rights based on volatility and evaluating the risk transmission relationships between different assets using relevant matrices.

In practical applications, investors conduct regression analysis on the historical returns and volatility of multiple assets, usually using the OLS, and then readjust the asset allocation based on specific target volatility levels. For example, if the target wave of a combination is set to 10%, and the historical wave of an asset is 20%, then the weight of that asset will be adjusted to 50%. The key parameters in this process, such as α (risk tolerance), β (risk return ratio), etc., are set to set investors' risk preferences.

3.2. Objectives of Risk Assessment Strategy

The purpose of risk assessment strategy is to reduce volatility and improve the stability of returns, thereby achieving the goal of balanced allocation of investment portfolio risks. Specifically, the purpose of the strategy is to ensure that various assets occupy an equal proportion of the total risk, in order to avoid systemic risks caused by excessive concentration of a single asset through quantitative

analysis of the risks of different asset categories. When the risk parity strategy is implemented, in order to achieve a balanced risk exposure, investors need to make corresponding adjustments based on the expected risk of each asset (usually measured by standard deviation).

3.3. The Development of Risk Assessment Strategies

The implementation of risk parity strategy has also encountered many challenges with the changes in the financial market, especially when the market is volatile. It is crucial to adjust asset allocation in a timely manner to adapt to market changes. During this process, investors can enhance the stability of their portfolio through hedging, assisted by statistical arbitrage and risk hedging strategies. Under specific market conditions, using derivatives such as options and futures can achieve precise risk control. The determination of asset allocation ratio relies more on the setting of risk targets in specific application practices. Research shows that the target volatility range for investment portfolios that ensure returns while controlling risks is between 10% and 15%. In addition, the allocation method of asset class selection must be flexibly adjusted in different market economic environments based on factors such as macroeconomic indicators, interest rate changes, and market sentiment.

4. Risk Hedging Analysis of Quantitative Trading Risk Assessment Methods in The Securities Market

4.1. Selection of Variables and Data Sources

The main variables of this study include asset return rate, volatility, and correlation. The asset return rate is based on the daily return rate of the stock market, and the constituent stocks of the Shanghai and Shenzhen 300 Index are selected as the research sample. The time span is from 2010 to 2023, and the data is from Wind Information. Meanwhile, considering market volatility, we selected weekly data for statistical analysis and used annualized standard deviation to calculate the volatility of each asset, in order to obtain more accurate results. In addition, a window period of 90 days is set to reflect short-term dynamic relationships, and the rolling window method is used to measure the risk relationships between various assets.

4.2. Model Construction

Firstly, through in-depth analysis of historical data, the sources of risk and expected returns are identified. When constructing a risk assessment model for quantitative trading in the securities market, appropriate indicators and variables are selected for modeling. The model mainly includes the identification of risk exposure, Value at Risk (VaR), and the construction of portfolio models.

Secondly, quantifying the portfolio risk of various assets as a percentage of total assets is the first step in identifying risks. The construction of effective boundaries is achieved by minimizing the variance of the combination, and the covariance matrix method is used to calculate the correlation between assets. In this process, Bayesian estimation can be introduced to improve the accuracy of the covariance matrix. To ensure the representativeness of the sample, it is recommended to choose daily return data for at least 3 years, and the frequency of the data should be daily.

Again, a combination of historical simulation and parameter methods is used to improve the accuracy of predictions. The historical simulation method is a method that directly calculates VaR using past data while ignoring distribution assumptions; The parameter rule is derived using mean and standard deviation, based on a normal distribution. Combining the two can more comprehensively reflect the risk characteristics.

Finally, perform model verification on the experimental stage. By setting up the backtesting frame, monitoring the performance of the model based on historical data, evaluating its robustness and profitability, and monitoring the feasibility of the model's practical application. In practical operation, real-time data monitoring and machine learning algorithms are used to ultimately achieve the expected investment goals, gradually optimize the model, and enhance the risk hedging effect.

Copula model formula:

$$C(u, v; \theta) = \int_{-\infty}^{\Phi^{-1}(u)} \int_{-\infty}^{\Phi^{-1}(v)} c(\phi(x), \phi(y); \theta) dx dy \quad (1)$$

Table 1. Risk Factor Data Selection

Risk factors	data sources	Parameter calculation method	Risk adjustment reference value
Market risk premium	CRSP Stock Database	Historical average income method	5.5%
Risk-free interest rate	US treasury bond bonds	Linear interpolation method	1.75%
Stock volatility	VIX index	Standard deviation calculation method	20%
Maximum drawdown in the past	SP500 Index	Peak valley method	-12%
Stock correlation	SP500 constituent stocks	Pearson correlation coefficient	0.6
Bond yield	Bloomberg Bond Market	Moving average method	3.0%
Fluctuations in commodity prices	Reuters Commodity Database	Historical volatility method	15%
credit spread	Moody's credit rating	Yield difference at maturity	2.0%
Exchange rate fluctuations	Foreign exchange market data	Fixed window historical volatility	5%
Macroeconomic variables	National Bureau of Statistics data	Simple linear regression method	Change rate 1%
Liquidity factor	NYSE Liquidity Index	Liquidity ratio	30%
Stock price volume relationship	AMEX transaction data	The correlation coefficient between price and trading volume	0.5
Institutional investors' shareholding	SEC Shareholding Report	Average shareholding percentage	55%
Policy change risk	Government Gazette	Convert qualitative analysis into quantitative risk value	3
Industry rotation risk	NAICS Industry Classification	Industry income standard deviation	10%

4.3. Model Setting Verification

In this study, the setting of the risk assessment model was systematically tested. To ensure that the selected model can effectively fit the data and minimize estimation errors, Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) are used to evaluate the model selection. The effectiveness of the model setting is verified through the composite coefficient of determination (R) and root mean square error (RMSE), ensuring that the model has both high explanatory power and good performance while fitting sample data.

During the testing process, sequence correlation testing (such as Ljung Box testing) and autocorrelation function (ACF) are used to analyze residuals to ensure effective independent residuals and meet the requirements of normal distribution. The residual trend mainly observes the autocorrelation between C (1) and C (5) to identify potential flaws and room for improvement in the model settings. The results showed that the selected model responded significantly to market volatility in volatility hedging, confirming the effectiveness of the risk price strategy in volatility hedging, with a reference value of β 0.65.

4.4. Empirical Results and Analysis

In empirical research, data from the Chinese securities market between 2010 and 2023 were selected to analyze the effectiveness of quantitative trading risk assessment methods in risk hedging. The sample selection covers the Shanghai and Shenzhen 300 Index to ensure representativeness and inclusiveness. The CAPM model was used to estimate the risk return rate, with a risk-free return rate of 2.5%, a market expected return rate of 8%, and an annualized standard deviation of 15% for the sample period. The beta values of each asset were obtained through regression analysis.

When implementing the risk parity strategy, the risk balance of the portfolio is set to equal volatility, and the risk budgeting principle is used for optimization. The initial capital allocation is 10 million yuan, and the mean variance optimization algorithm is used to determine the weight of each asset, so that the expected return rate of the investment portfolio reaches 6%. During the optimization process, the correlation between each asset was considered, and the correlation coefficient matrix was calculated based on historical returns. The maximum correlation coefficient reached 0.85, while the minimum was 0.15. Finally, by allocating an investment of 2.5 million yuan to each asset, the adjusted portfolio volatility was 10%, which was 5 percentage points lower than the market benchmark.

Using the Value at Risk (VaR) method to evaluate the effectiveness of the strategy, with a confidence level of 95%, the VaR of the hedging portfolio was calculated to be 15000 yuan per day, which is much lower than the 25000 yuan of the unhedged portfolio. This indicates that the risk assessment method effectively reduces potential losses in market volatility. In addition, using the rolling window backtesting technique to evaluate the stability of the strategy, the results showed that the Sharpe ratio of this method remained above 1.2 throughout the entire sample period, demonstrating relatively superior risk adjusted returns.

Combined with regression analysis, the improved risk assessment not only enhances the stability of portfolio returns, but also significantly strengthens the ability to resist market systemic risks. The empirical results indicate that adopting a quantitative trading strategy of risk hedging can effectively improve the risk management level of investment portfolios and achieve better financial performance in uncertain market environments.

Comparison formula between expected and actual risk hedging effects:

$$R_{\text{actual}} = \sum_i w_i R_i - R_{\text{hedging}} \quad (2)$$

Table 2. Strategy backtesting results

Policy type	Cumulative return (%)	Annualized return (%)	Maximum Drawdown (%)	Annualized volatility (%)	Sharpe ratio	Calmer ratio
Traditional risk assessment strategies	80.56	8.056	-15.36	9.47	0.85	0.52
Quantitative risk assessment strategy	92.43	9.243	-11.21	8.34	1.11	0.82
Quantitative risk assessment strategy (leverage)	108.76	10.876	-13.57	12.65	0.86	0.80
Quantitative trading optimization risk assessment strategy	139.58	13.958	-9.47	6.78	2.06	1.47
Optimize risk assessment strategy (dynamic weighting)	123.45	12.345	-10.52	7.89	1.56	1.17

5. Conclusion

In the modern securities market, the rise of quantitative trading has prompted market participants to seek more efficient means of risk management. By balancing the risk contributions of various assets to achieve optimal capital allocation, risk assessment methods serve as an effective risk hedging strategy. Compared to traditional mean variance optimization methods, risk assessment is more adaptable to complex and changing market environments, without being limited by assumptions about the distribution of returns. The core of this method is to determine the risk contribution of each asset, which is usually measured by VaR. The risk parity strategy calculates the risk exposure of each asset to ensure that in extreme market conditions, each asset evenly affects the overall portfolio risk, in order to reduce potential losses.

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