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Research on Hedging Strategies for the CSI A500 Index from the Perspective of Combined Futures Hedging

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Abstract

In September 2024, China launched the CSI A500 Index, which quickly gained popularity among investors. However, the risks faced by investors still need to be effectively mitigated through futures hedging strategies. The CSI A500 Index features a distinctive constituent structure of "large-cap core + mid-cap leaders", which is highly correlated with both the CSI 300 and CSI 500 indices, providing a practical basis for implementing a combined hedging strategy. In the absence of a stock index futures contract directly linked to the CSI A500 Index, this paper primarily constructs a dual-futures combined hedging strategy using CSI 300 Stock Index Futures (IF) and CSI 500 Stock Index Futures (IC), and examines whether this combined strategy significantly outperforms single-futures cross-hedging strategies that rely only on IF or IC. Using high-frequency 1-minute data and daily data from September 23, 2024 to December 26, 2025, we estimate and compare the optimal hedge ratios and hedging performance of three strategies (single IF, single IC, and the IF + IC combination) based on Ordinary Least Squares (OLS) and an Error Correction Model (ECM). The findings are as follows: 1) both single-futures and dual-futures hedging strategies can significantly reduce the price volatility risk of the CSI A500 Index, confirming the feasibility of futures-based hedging; 2) in most cases, the dual-futures combined strategy, especially under the ECM that incorporates long-run equilibrium relationships, delivers superior and more robust risk-hedging performance (higher VRR with lower variability) than single-futures strategies; 3) CSI 300 Stock Index Futures serve as the core hedging instrument for the A500 Index, and adding CSI 500 Stock Index Futures effectively hedges residual structural risk. These conclusions not only validate the central hypothesis, but also provide investors holding CSI A500-related assets with a more refined and robust risk management framework.

Keywords

CSI A500 Index, Combined Hedging, Optimal Hedge Ratio, Hedging Performance

1. Introduction

With the continued deepening of China's capital markets, an index system that can comprehensively and evenly reflect core A-share assets has become increasingly important. Against this backdrop, the CSI A500 Index was launched on September 23, 2024. Drawing on international mainstream broad-based index construction methodologies, it focuses on 500 leading companies by market capitalization across industries while emphasizing balanced sector allocation, earning the nickname "China's S & P 500". Since its release, the scale of ETFs and feeder funds tracking the CSI A500 Index has grown rapidly. As of November 27, 2025, the total assets of related fund products had reached RMB 272.966 billion. This highlights the strong recognition by institutional and retail investors of the CSI A500 Index's long-term investment value.

However, rapid asset growth has also created an urgent need for risk management. Compared with mature indices such as the CSI 300 and CSI 500, the CSI A500 Index currently has no directly linked stock index futures contract, leaving investors with large A500 spot positions unable to hedge systemic market risk directly. In terms of constituents, the CSI A500 Index exhibits a distinctive "bimodal distribution": its constituents overlap heavily with those of the CSI 300 and CSI 500. Specifically, 234 stocks are also constituents of the CSI 300 (78% by weight), and 207 stocks are constituents of the CSI 500 (17% by weight). This structure creates tight comovement between the CSI A500 Index and the CSI 300/CSI 500 price trends, providing a realistic basis for cross hedging using existing stock index futures (CSI 300 stock index futures, CSI 500 stock index futures, etc.). Moreover, when the two futures contracts are substitutable and exhibit a long-run equilibrium relationship, jointly using IF and IC in a combined hedging strategy may hedge risk more precisely than cross hedging with either contract alone.

The CSI A500 Index is not a single-style index. Using IF alone for cross hedging may offset most large-cap risk but may fail to effectively cover mid-cap risk exposure; similarly, using IC alone cannot fully hedge its risk either. In addition, an ideal hedging portfolio should match and offset, to the greatest extent possible, the return volatility of the hedged asset. By constructing a synthetic hedging instrument based on CSI 300 and CSI 500 futures contracts, one can more accurately replicate the CSI A500 Index's risk-return characteristics, thereby achieving lower residual risk and higher efficiency in the hedging process. Accordingly, this paper proposes the core hypothesis: for the CSI A500 Index, a dual-futures combined hedging strategy constructed with IF and IC delivers significantly better risk-hedging performance than single-futures cross-hedging strategies that use only IF or IC. Asset allocation theory likewise suggests that combining different assets can diversify and hedge risk, consistent with the objective of a dual-futures combined hedge. The empirical analysis in this study centers on this hypothesis, comparing the performance of single-futures cross hedging versus dual-futures combined hedging, and providing quantitative evidence and strategic guidance for risk management of the A500 Index.

To test this hypothesis, we first review hedging theory, with particular emphasis on the theoretical development of cross hedging and combined hedging. Next, in the research design, we construct three hedging strategies: 1) cross hedging using only IF; 2) cross hedging using only IC; and 3) combined hedging using both IF and IC. We conduct empirical analysis using Ordinary Least Squares (OLS) and an Error Correction Model (ECM) to estimate the optimal hedge ratios under different strategies. Finally, in the empirical results section, we use indicators such as the Variance Reduction Ratio (VRR) to systematically compare hedging performance across the three strategies and conduct robustness checks, before drawing conclusions.

The remainder of this paper is organized as follows: Section 2 reviews the literature; Section 3 describes the research design, including data, variables, and model specification; Section 4 presents empirical results and analysis; and Section 5 concludes and discusses future directions.

2. Literature Review

2.1. Hedging Theory

Hedging theory has evolved from traditional to modern approaches. Traditional theory emphasizes eliminating risk by taking futures positions that are "the same commodity, equal quantity, and opposite direction" to the spot position. However, due to basis risk, perfect hedging is difficult to achieve in practice. Working (1953) proposed the theory of basis-driven (speculative) hedging, viewing changes in the basis as the core of hedging decisions. Modern hedging theory frames the problem within a portfolio setting, aiming to maximize return for a given level of risk or minimize risk for a given level of return (Johnson, 1960). A key task is to determine the Optimal Hedge Ratio (OHR), i.e., the futures position that minimizes the variance of the hedged portfolio.

Regarding how to compute the OHR, Ordinary Least Squares (OLS) is the classic method, estimating the OHR as the slope coefficient from regressing spot returns on futures returns. Baillie & Myers (1991) show that in some cases, dynamic hedging strategies based on GARCH models can perform better. However, the OLS model assumes constant parameters and cannot capture time-varying market relationships. To address this, researchers have proposed rolling-window OLS, vector autoregression (VAR), and Error Correction Models (ECM) that incorporate long-run equilibrium and short-run dynamics. ECM is particularly suitable when price series are cointegrated, as it captures both long-run trends and short-run adjustments, providing more robust OHR estimates.

2.2. Cross Hedging and Combined Hedging

When a directly corresponding futures contract is unavailable, investors often use cross hedging, i.e., hedging with another futures instrument that is highly correlated with the spot asset price (Addae-Dapaah & Abdullah, 2020). A large body of literature confirms the effectiveness of cross hedging in equity, bond, and commodity markets (Zhang et al., 2020). However, if the spot asset's risk exposure is multidimensional, a single hedging instrument may not cover all sources of risk. In such cases, combined hedging, which constructs a hedge portfolio using multiple futures contracts, becomes a better choice.

Studies such as Chi et al. (2009) and Luan & Ju (2024) show that, for a given spot asset, combined hedging with multiple futures contracts can reduce risk more effectively than single-futures cross hedging. Wang (2019) and Li (2010), in research on hedging credit bonds, likewise find that a combined strategy using government bond futures and stock index futures outperforms a single-futures strategy. The shared logic is that different futures instruments capture different risk factors; combining them can replicate the spot asset's risk exposure more accurately and thereby minimize basis risk.

Although the theoretical advantage of combined hedging is clear, for the CSI A500 Index, a newly launched underlying with a distinctive "bimodal" constituent structure, empirical evidence on whether combined hedging outperforms cross hedging remains scarce. This study provides direct evidence for hedging practice on the A500 Index through an empirical comparison.

3. Empirical Research Design

3.1. Data Sources

The sample period in this study spans September 23, 2024 to December 26, 2025. Data are obtained from the Wind database. We use both daily data and 1-minute high-frequency data. The dataset includes closing prices for the CSI A500 Index (A500), the dominant contract of CSI 300 stock index futures (IF), and the dominant contract of CSI 500 stock index futures (IC).

We take natural logarithms of all price series and then compute first differences to obtain log returns. For example, the daily return of the CSI A500 Index is defined as $R_{A500,t} = \ln\left(P_{A500,t}\right) - \ln\left(P_{A500,t-1}\right)$.

3.2. Model Specification

3.2.1. Single-Futures Hedging Model

Taking cross hedging of A500 with IF as an example, the return on the hedged portfolio is $R_{H,t} = R_{A500,t} - h_{IF} R_{IF,t}$, where is h_{IF} the hedge ratio. Minimizing the variance of the portfolio $\mathrm{Var}\left(R_{H,t}\right)$ yields the optimal hedge ratio h_{IF}^{*}. Under the OLS framework, this ratio β_{IF} corresponds to the slope coefficient in the following regression equation:

$$R_{A500,t} = \alpha_{IF} + \beta_{IF} R_{IF,t} + \varepsilon_t$$

Similarly, the optimal ratio β_{IC} for cross hedging using IC can be obtained.

Considering that a long-run equilibrium relationship may exist between the CSI A500 Index price and stock index futures prices, we introduce an ECM framework. We first test whether the log price series $\ln\left(P_{A500,t}\right), \ln\left(P_{IF,t}\right)$ are integrated of order one and whether a cointegration relationship exists. If cointegration is present, we estimate the long-run equilibrium relationship:

$$\ln\left(P_{A500,t}\right) = \alpha_0 + \alpha_1 \ln\left(P_{IF,t}\right) + e_t$$

We then obtain the residual series (i.e., the error-correction term e_{t-1}). Next, we construct and estimate an ECM that includes both short-run dynamics and long-run adjustment:

$$R_{A500,t} = \gamma + \beta_{IF} R_{IF,t} + \theta e_{t-1} + \mu_t$$

Here, the coefficient β_{IF} corresponds to the optimal hedge ratio under the ECM.

3.2.2. Combined Futures Hedging Model

Under this strategy, the return on the hedged portfolio is $R_{H,t} = R_{A500,t} - h_{IF} \cdot R_{IF,t} - h_{IC} \cdot R_{IC,t}$. The optimal hedge ratios h_{IF}^* and h_{IC}^* are obtained by minimizing portfolio variance. In the OLS framework, they are the coefficients β_{IF} and β_{IC} in the following multivariate regression:

$$R_{A500,t} = \alpha + \beta_{IF} R_{IF,t} + \beta_{IC} R_{IC,t} + \varepsilon_t$$

Under the ECM framework, we first test whether the log price series $\ln\left(P_{A500,t}\right), \ln\left(P_{IF,t}\right), \ln\left(P_{IC,t}\right)$ are integrated of order one and whether a cointegration relationship exists. If cointegration is present, we estimate the long-run equilibrium relationship:

$$\ln\left(P_{A500,t}\right) = \alpha_0 + \alpha_1 \ln\left(P_{IF,t}\right) + \alpha_2 \ln\left(P_{IC,t}\right) + e_t$$

We then obtain the residual series (i.e., the error-correction term e_{t-1}).

We construct and estimate an ECM that includes both short-run dynamics and long-run adjustment:

$$R_{A500,t} = \gamma + \beta_{IF} R_{IF,t} + \beta_{IC} R_{IC,t} + \theta e_{t-1} + \mu_t$$

Here, coefficients β_{IF} and β_{IC} correspond to the optimal hedge ratios under the ECM. Coefficient θ reflects the speed of adjustment toward the long-run equilibrium.

3.2.3. Empirical Implementation

We use a rolling-window approach to evaluate out-of-sample hedging performance. For daily data, the estimation window is 20 trading days, the forecasting window is 5 trading days, and the rolling step is 5 trading days. For 1-minute data, the estimation window is 1210 minutes, the forecasting window is 242 minutes, and the rolling step is 242 minutes.

Hedging performance is primarily measured by the Variance Reduction Ratio

(VRR), defined as:

$$\text{VRR} = \frac{\text{Var}\left(R_{unhedged}\right) - \text{Var}\left(R_{hedged}\right)}{\text{Var}\left(R_{unhedged}\right)} = 1 - \frac{\text{Var}\left(R_{hedged}\right)}{\text{Var}\left(R_{unhedged}\right)}$$

where $\text{Var}\left(R_{unhedged}\right)$ is the variance of unhedged A500 index returns and $\text{Var}\left(R_{hedged}\right)$ is the variance of returns on the hedged portfolio. A VRR closer to 1 indicates a better risk-reduction effect.

4. Empirical Results and Analysis

4.1. Descriptive Statistics

Figure 1 plots the daily closing price series of the A500 Index, CSI 300 stock index futures, and CSI 500 stock index futures. The plot shows that the A500, IF, and IC price series move closely together, especially around key turning points such as the drawdown in April 2025 and the upswing starting in July, supporting hedging feasibility. Meanwhile, IC exhibits substantially larger price fluctuations than IF and A500, further confirming its higher-risk characteristics.

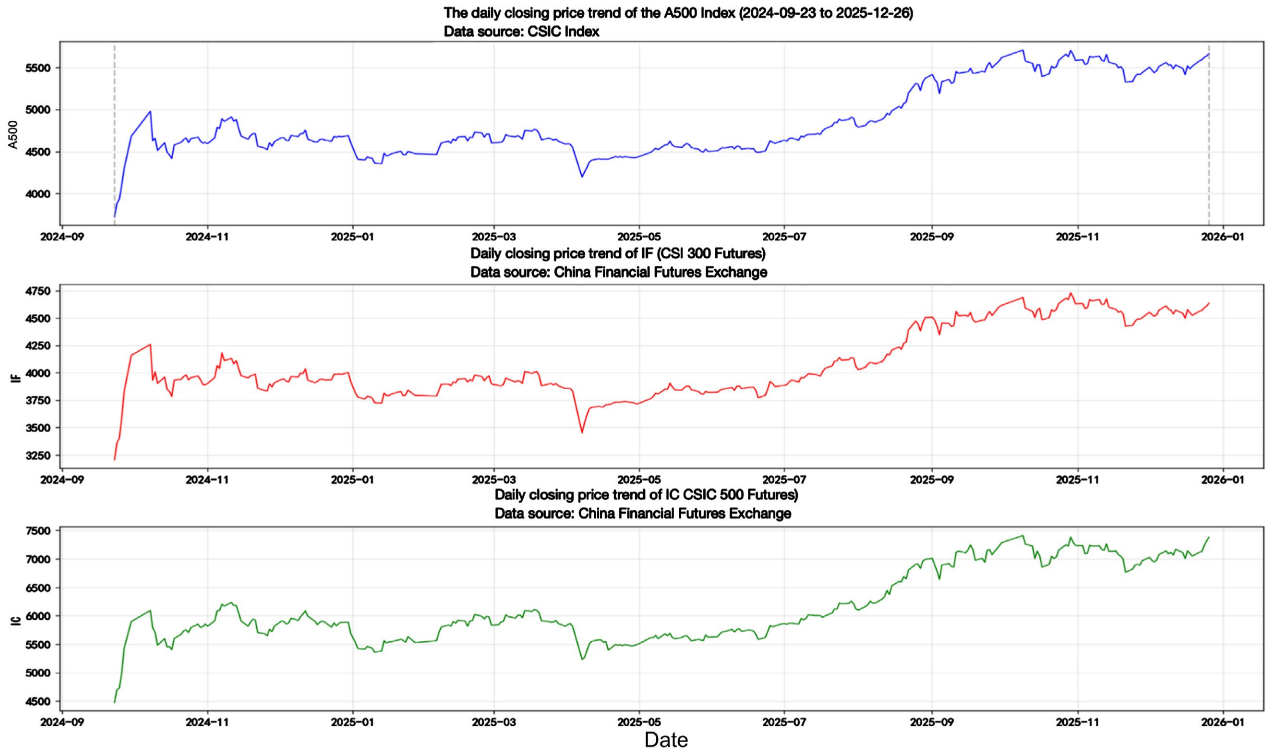

Figure 1. Price trends of the CSI A500 Index, CSI 300 stock index futures, and CSI 500 stock index futures.

Table 1 reports descriptive statistics of the return series at daily and 1-minute frequencies. From the daily data (Table 1), the three series have similar mean returns, but differ in volatility: IC has the highest standard deviation (1.641%), indicating the highest risk; IF is next (1.467%); and A500 is the lowest (1.393%). All series exhibit pronounced leptokurtosis (kurtosis far above 3), implying that extreme events occur more frequently than under a normal distribution, posing challenges for risk management.

Table 1. Descriptive statistics of daily returns.

Variable	Mean	Standard Deviation	Median	Skewness	Kurtosis
R_A500	0.137%	1.393%	0.108%	−0.040	11.537
R_IF	0.120%	1.467%	0.090%	−0.738	15.790
R_IC	0.163%	1.641%	0.133%	−0.149	9.6785

4.2. Hedge Ratio Estimation

Using daily data, we estimate optimal hedge ratios under different strategies and models; the results are summarized in Table 2 and Table 3.

Table 2. Summary statistics of optimal hedge ratios for single-futures hedging.

Strategy	Mean	Standard Deviation
OLS-IF	0.760	0.119
OLS-IC	**0.551**	**0.113**
ECM-IF	0.895	0.135
ECM-IC	**0.431**	**0.082**

Table 3. Summary statistics of optimal hedge ratios for combined hedging.

Strategy	IF Coefficient	IC Coefficient
OLS-Multi	0.5733	0.1792
ECM-Multi	0.6763	0.1401

From the results, we obtain several key findings:

1) IF is the core hedging instrument: across all single-contract strategies, the hedge ratio for IF (e.g., 0.760 under OLS and 0.895 under ECM) is significantly higher than that for IC (0.551 under OLS and 0.431 under ECM), consistent with the fact that A500's constituent weights are heavily concentrated in CSI 300 constituents.

2) The combined strategy exhibits a "primary-secondary structure": in the dual-contract strategy, the coefficient on IF is consistently much larger than that on IC (e.g., 0.5733 vs 0.1792 under OLS), showing a clear structure of "IF as primary, IC as auxiliary". This indicates that IF plays the central role in hedging A500's main systemic risk, while IC serves as an auxiliary tool to hedge remaining structural risk tilted toward mid-cap style.

3) Model differences: IF hedge ratios estimated by the ECM are generally higher than those from OLS, while IC ratios are lower. This may suggest that after accounting for long-run equilibrium, the model attributes stronger long-run linkage between A500 and IF, whereas IC's contribution is more pronounced in short-run adjustments.

Figure 2 shows rolling estimates of hedge ratios using daily data. Hedge ratios are not constant; they vary with market conditions, highlighting the limitations of static models (full-sample OLS) and the need for dynamic adjustment. In the figure, IF hedge ratios (blue and green lines) are generally higher than IC ratios (red and purple lines) and exhibit smaller fluctuations, again underscoring IF's core role. The sharp coefficient volatility in the middle of the sample (roughly May-July 2025) may be related to changes in market conditions, suggesting that in practice hedge ratios may need to be constrained or smoothed.

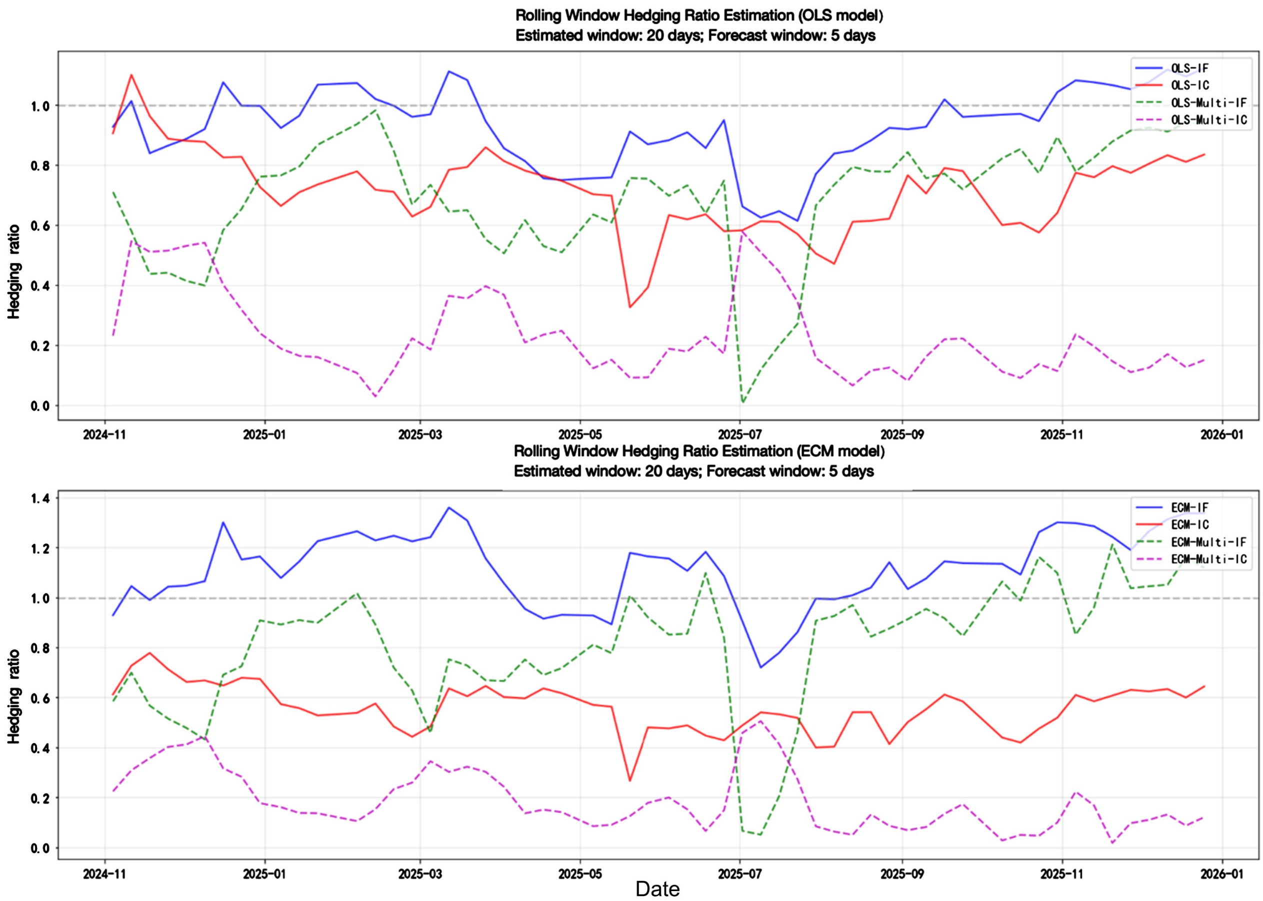

Figure 2. Rolling-window estimates of hedge ratios.

4.3. Comparative Analysis of Hedging Performance

This section provides the key test of the central hypothesis. Using a rolling-window approach, we compute dynamic VRR series for different strategies based on daily data, and summarize their statistics in Table 4.

Table 4. Rolling-window VRR metrics for daily data.

Strategy	Mean VRR	Standard Deviation of VRR
OLS-IF	**0.8287**	0.2866
OLS-IC	0.4985	1.1756

Continued

OLS-Multi (IF + IC)	0.8268	0.3498
ECM-IF	0.7707	0.3896
ECM-IC	0.5794	0.7497
ECM-Multi (IF + IC)	**0.8188**	0.3806

From the daily-data results (Table 4):

1) Hedging is effective overall: except for the IC-only strategy, the other strategies have average VRR values above 0.77, consistent with findings in the stock index futures hedging literature and indicating that using IF or the IF + IC combination can effectively reduce A500 position risk.

2) The IC-only strategy entails higher risk: the OLS-IC strategy has an average VRR of only 0.4985 with a standard deviation of 1.1756, implying that relying solely on IC may amplify risk in some periods and should be approached with caution.

3) The advantage of the combined strategy emerges: under the ECM framework, OLS-Multi (0.8268) and OLS-IF (0.8287) have nearly identical average VRR values, indicating that the combined strategy's advantage is not evident in the short run. However, when long-run equilibrium is considered, ECM-Multi's average VRR (0.8188) is markedly higher than ECM-IF (0.7707), providing initial support for our core hypothesis.

To test whether the improvement in VRR from the dual-futures (IF + IC) strategy over single-futures strategies is statistically significant, we conduct paired t-tests on the rolling-window VRR series. The null hypothesis is that there is no difference in mean VRR between the dual-futures strategy and the corresponding single-futures strategy $H0: E\left[VRR_{Multi} - VRR_{Single}\right] = 0$.

As shown in Table 5, under the OLS framework, the difference between the dual-futures strategy and the IF-only strategy is not significant (t = −0.0930, p = 0.9263), suggesting that adding IC does not statistically improve IF's risk-hedging effectiveness. However, the dual-futures strategy shows a significant improvement over the IC-only strategy (t = 2.5716, p = 0.0128), indicating that hedging with IC alone is clearly less efficient than the dual-futures allocation that includes IF.

Table 5. Statistical tests of VRR.

Model Framework	Comparison	t-statistic	p-value	Conclusion (5% level)
OLS	Dual-futures vs IF	−0.0930	0.9263	Not significant
OLS	Dual-futures vs IC	2.5716	0.0128	Significant
ECM	Dual-futures vs IF	2.9198	0.0050	Significant
ECM	Dual-futures vs IC	2.8920	0.0054	Significant

Under the ECM framework, the dual-futures strategy exhibits significant advantages over both the IF-only and IC-only strategies (dual vs IF: t = 2.9198, p = 0.0050; dual vs IC: t = 2.8920, p = 0.0054). This indicates that after accounting for long-run equilibrium and the error-correction mechanism, the IF + IC combination better absorbs structural differences and thus significantly improves risk-reduction efficiency in hedging.

4.4. Robustness Checks

To examine the robustness of the above conclusions, we repeat the performance evaluation using 1-minute high-frequency data. High-frequency data contain more market microstructure noise, making the test of hedging strategies more stringent.

The results using 1-minute data (Table 6) further strengthen our conclusions:

1) Overall performance declines: average VRR values for all strategies are lower than those based on daily data, reflecting the erosion of hedging effectiveness by high-frequency noise.

Table 6. Rolling-window VRR metrics for 1-minute data.

Strategy	Mean VRR	Standard Deviation of VRR
OLS-IF	0.6481	0.2965
OLS-IC	0.5218	0.3815
OLS-Multi (IF + IC)	**0.6651**	0.2797
ECM-IF	0.6159	0.3952
ECM-IC	0.5211	0.2422
ECM-Multi (IF + IC)	**0.6564**	0.3264

2) The combined strategy's advantage is clearer: in the high-frequency setting, under both OLS and ECM, the combined strategy (OLS-Multi: 0.6651; ECM-Multi: 0.6564) consistently delivers higher average VRR than the corresponding IF-only strategy (OLS-IF: 0.6481; ECM-IF: 0.6159). In addition, OLS-Multi has one of the lowest standard deviations (0.2797) among all strategies, indicating that the combined strategy is not only more effective but also more stable in high-frequency markets.

Taken together, the evidence from daily and 1-minute data supports a robust conclusion: the combined hedging strategy using both IF and IC outperforms cross hedging using only IF or only IC in both effectiveness and stability. The core research hypothesis is strongly supported by the empirical results.

5. Conclusion

Addressing the practical challenge that the CSI A500 Index currently lacks a direct hedging instrument, this paper systematically studies and compares the performance of single-futures cross hedging and dual-futures combined hedging using existing stock index futures (IF and IC). Based on empirical analysis of daily and high-frequency data from 2024-2025, the main conclusions are as follows:

1) Hedging feasibility is confirmed: hedging with IF and IC, which have substantial constituent overlap with the A500 Index, is fully feasible. Among them, IF is the core hedging tool and explains the vast majority of the A500 Index's systemic risk.

2) The combined hedging strategy is significantly superior: the central hypothesis is validated. The dual-futures (IF + IC) combined hedging strategy consistently outperforms single-futures cross hedging in both the extent of risk reduction (higher average VRR) and the stability of outcomes (lower VRR volatility). This advantage is particularly pronounced under the ECM model that accounts for long-run equilibrium and in the high-frequency data.

3) IC functions as a "risk corrector": hedging with IC alone performs poorly and entails very high risk. Within the combined strategy, however, IC plays an important auxiliary role by hedging the residual, mid-cap-tilted structural risk that IF does not cover, enabling a more accurate risk profile and hedge for the A500 Index.

This paper provides institutional investors holding substantial CSI A500-related assets (e.g., ETFs) with a rigorously validated and more granular risk-management framework. Investors should not stop at a rough cross hedge using only IF; instead, they should adopt the IF + IC combination and dynamically adjust hedge ratios to achieve better risk-control outcomes.

Several extensions remain for future work. First, the sample period is relatively limited; future research could incorporate longer horizons covering different bull/bear regimes and style rotations to test long-run effectiveness. Second, this paper primarily uses OLS and ECM; future studies could introduce more complex nonlinear models or machine-learning methods to capture richer market dynamics. Finally, this study does not account for trading costs, margin usage, or liquidity impacts, which must be addressed when translating research findings into a tradable strategy.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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