Long-Term Cointegration and Short-Term Asymmetric Adjustment——An Empirical Study on the Linkage Between Copper Futures and Nonferrous Metals ETF Returns

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ABSTRACT

To reveal the long-term cointegration relationship and short-term asymmetric adjustment characteristics between copper futures and nonferrous metals ETF returns, this paper takes the prices of copper futures and the Southern CSI SW Nonferrous Metals ETF (512400) from January 3,2018 to December 31,2024 as the research objects for cointegration test, and the corresponding returns for short-term dynamic analysis. Based on daily data, 82 groups of monthly samples are obtained. An empirical framework of "stationarity test – cointegration test – error correction model – VAR model – Granger causality test – impulse response function – variance decomposition" is constructed to conduct an in-depth analysis of the linkage mechanism between the two. The results show that: in the long run, there exists a significant and stable cointegration relationship between copper futures price and nonferrous metals ETF price; in the short run, the relationship of their returns exhibits obvious asymmetric adjustment characteristics. The Granger causality test indicates that copper futures returns are a one-way Granger cause of nonferrous metals ETF returns, reflecting the price discovery function of the futures market. The impulse response analysis and variance decomposition results further show that the impact of copper futures returns on ETF returns is limited in the short term, but its contribution increases significantly in the medium and long term. Overall, the linkage between copper futures and nonferrous metals ETF returns presents a structure characterized by "long-term cointegration of prices, short-term asymmetric adjustment of returns, futures-market dominance, and lagged effects." The findings not only verify the linkage between commodity futures and related industry ETFs, but also provide useful references for cross-market investment decisions, risk hedging, and regulatory authorities in preventing systemic risks.

Keywords: Nonferrous Metals ETF; Long-term Cointegration; Asymmetric Adjustment; Error Correction Model; VAR Model.

1. INTRODUCTION

The commodity market serves as a crucial nexus between the real economy and financial markets. As a core nonferrous metal, copper not only functions as a "macroeconomic barometer," but also carries a high weighting in companies constituting nonferrous metals ETFs, making its futures price fluctuations easily transmissible to ETF net asset values. The Southern CSI SW Nonferrous Metals ETF (512400) is a representative ETF of China's nonferrous metals industry, whose net value is naturally linked to nonferrous metals futures prices. Global economic adjustments, financial market interconnectivity, and the financialization of commodities further reinforce the linkage between futures and ETF markets, exhibiting a pattern of "long-term equilibrium and short-term deviation."

Against this backdrop, the core questions regarding the relationship between copper futures and the nonferrous metals ETF market urgently need clarification: Can the price discovery function of copper futures be transmitted to the ETF market? Is there a long-term stable equilibrium relationship between the two? How does the market revert after short-term deviations? Is there a lagged effect of copper futures on ETF returns? Investigating these issues helps not only to clarify the linkage mechanisms between commodity futures and financial derivatives markets, but also to support optimized market resource allocation and cross-market risk prevention.

This study holds both theoretical and practical significance. Theoretically, it fills a gap in systematic research on the linkage between a single futures commodity and a specific industry ETF, providing new empirical support for price discovery theory. Practically, it offers decision-making guidance for investors engaging in cross-market investment and arbitrage hedging, and provides references for regulators in formulating cross-market risk prevention policies and maintaining financial stability. This paper focuses on the dynamic linkage structure between the two, with an emphasis on testing long-term cointegration, short-term asymmetric adjustment characteristics, and the lagged effects of dynamic shocks, comprehensively revealing the intrinsic mechanisms of their interaction.

2. LITERATURE REVIEW

The linkage between futures and financial assets has long been a research hotspot in finance, with core studies focusing on price discovery, long-term equilibrium, and dynamic shock effects. Advances in econometric methods have continuously deepened research in this field.

Theoretically, the Efficient Market Hypothesis serves as the theoretical cornerstone for research on price discovery. As proposed by Fama [1] (1970), asset prices in a market with fully flowing information can promptly reflect all available information, granting the futures market a price discovery advantage over the spot market. Methodologically, the cointegration theory and the Engle-Granger two-step approach developed by Engle and Granger [2] (1987), together with the VAR model constructed by Sims [3] (1980), have become critical tools for examining long-term equilibrium and analyzing dynamic interactions.

Empirically, scholars have extensively explored the linkage between commodity futures and financial assets. In the field of non-ferrous metals, Yang et al. [4] (2021) identified significant spillover effects between non-ferrous metal futures price volatility and stock returns of related industries. Zhu Chunming [5] (2010) confirmed the long-term impact of non-ferrous metal futures price volatility on the stock prices of corresponding listed companies in China's domestic futures market. Cui et al. [6] (2021) found that copper futures have a high long-term correlation with the crude oil market and are major net transmitters of extreme risk spillovers, with their linkage easily affected by global crisis events. Liu and An [7] (2011) revealed bidirectional price and volatility spillover effects between Chinese and US copper futures markets, noting that China's copper market adjusts faster to imbalances and plays an important role in the formation of international copper prices.

In the futures market research, Jiang Yang [8] (2006) documented bidirectional Granger causality and cointegration between copper futures and spot prices. Regarding the relationship between futures and ETFs, Li Jie et al. [9] (2025) verified a long-term cointegrating relationship between gold futures prices and gold ETF prices, along with unidirectional Granger causality from gold futures returns to ETF returns. Zhao Hengfei [10] (2013) found that price changes in non-ferrous metal futures are transmitted to the stock prices of related listed firms. Yang Lisheng and Yang Jie [11] (2022) pointed out that the international industrial metal market is a primary source of risk spillovers, and the risk contagion effect between this market and China's financial markets significantly intensifies under extreme events, which can be effectively hedged through dynamic investment portfolios.

Furthermore, relevant studies have been extended to other commodities such as crude oil and agricultural products, and the linkage between futures markets and related financial asset markets has been generally confirmed.

Despite the rich existing research results, there are still obvious gaps: first, the research objects are insufficient, with a lack of specialized studies on copper and non-ferrous metal ETFs; second, the analysis of impact mechanisms is not in-depth enough, with insufficient attention paid to time-lag characteristics and differences in cyclical impacts; third, the econometric analysis dimension is single, lacking layered interpretation of short-term and medium-to-long-term effects, making it difficult to fully reveal the complexity of their linkage.

Based on this, this paper takes monthly data from 2018 to 2024 as the sample, focuses on the return linkage between copper futures and the Southern CSI SW Nonferrous Metals ETF (512400), constructs a multi-dimensional empirical framework, and systematically tests their long-term cointegration, causal direction, and dynamic shock effects. It aims to fill the research gap in this sub-field and provide more timely empirical evidence for cross-market investment decisions.

3. RESEARCH DESIGN

3.1 Research Hypothesis

Based on price discovery, cointegration theory, and existing research findings on the linkage between commodity futures and financial assets, the following four hypotheses are proposed regarding the linkage mechanism between copper futures and non-ferrous metal ETF returns:

H1: There exists a long-term stable cointegration relationship between copper futures price and non-ferrous metal ETF price.

H2: Copper futures returns are a unidirectional Granger cause of non-ferrous metal ETF returns.

H3: In the case of deviation from the long-term equilibrium relationship, there is an asymmetric adjustment mechanism between copper futures returns and non-ferrous metal ETF returns, and the adjustment speed of non-ferrous metal ETF returns to deviations from the long-term equilibrium is significantly faster than that of copper futures returns.

H4: The dynamic impact of copper futures returns on non-ferrous metal ETF returns has an obvious time lag, with weak short-term impact and gradual enhancement in the medium and long term.

3.2 Data Source and Processing

This paper selects daily data of copper futures prices and unit prices of Southern China Securities Shenwan Non-Ferrous Metals ETF (512400) from January 3, 2018 to December 31, 2024 as the original sample. Among them, the copper futures price data are obtained from the CSMAR database (closing prices of the main contract of Shanghai copper futures), and the unit price data of the non-ferrous metal ETF are derived from Investing.com.

To avoid interference from short-term fluctuations in daily data, this paper takes the monthly average of the original daily data, obtaining 82 sets of monthly data. To convert the non-stationary price series into a stationary return series, this paper adopts the first-order logarithmic return difference method for processing. The specific formula is as follows: $R_{it} = ln(P_{it}) - \ln(P_{i,t-1})$, where R_{it} denotes the return rate in the t-th period (copper futures return rate or non-ferrous metal ETF return rate), P_{it} represents the monthly average price in the t-th period, and $P_{i,t-1}$ denotes the monthly average price in the (t-1)-th period.

4. EMPIRICAL ANALYSIS

To explore the linkage between copper futures returns and non-ferrous metal ETF returns in different periods, this paper adopts a research framework combining the Error Correction Model (ECM) and the VAR model in the empirical analysis. Specifically, it employs an empirical framework of “stationarity test - cointegration test - error correction model (ECM) - VAR model construction - Granger causality test - impulse response analysis - variance decomposition”, which not only depicts the long-term equilibrium relationship of copper futures and non-ferrous metal ETF prices but also focuses on the short-term dynamic characteristics of their returns.

In detail, for the analysis of the long-term relationship, based on the non-stationary characteristics of copper futures prices and non-ferrous metal ETF prices, this paper uses the Engle–Granger two-step method to conduct a cointegration test on the price level series, and constructs an Error Correction Model (ECM) on this basis to describe the short-term adjustment mechanism of the two after deviating from the long-term equilibrium relationship. For the short-term dynamic analysis, considering that the return series are stationary after the unit root test and that investors pay more attention to the impact effects and transmission paths at the return level, this paper constructs a VAR model based on the return series, and combines the Granger causality test, impulse response function and variance decomposition method to analyze the dynamic impact characteristics and time lag effects of copper futures returns on non-ferrous metal ETF returns.

4.1 Stationarity Test

In time series analysis, the stationarity of variables is a basic premise for subsequent empirical analysis. This paper adopts the Augmented Dickey-Fuller (ADF) unit root test method to test the stationarity of the data. The null hypothesis is “the variable has a unit root (non-stationary)”, and the alternative hypothesis is “the variable has no unit root (stationary)”.

The stationarity test of the two sets of monthly prices shows that both have obvious unit roots and belong to non-stationary series, which need to be converted into stationary series. After performing the first-order logarithmic return difference processing on the copper futures price and the unit price of the non-ferrous metal ETF respectively, the copper futures return rate and the monthly return rate of the non-ferrous metal ETF are obtained. The unit root test method is used to verify the stationarity of the return series for the differenced data, and the results are shown in Table 1. The ADF test statistic of the copper futures return rate is -19.549, and the ADF test statistic of the non-ferrous metal ETF return rate is -14.675, both of which are much smaller than the critical value (-3.535) at the 1% significance level. This indicates that the data after first-order difference is stationary, meeting the basic conditions for time series analysis.

Table 1. The unit root test results of the sequences before and after the first-order difference of the monthly data

Variable	N	ADF Test Statistic	Critical Value (1%)	Critical Value (5%)	Critical Value (10%)	p-value
Copper Futures Return Rate	82	-19.549	-3.535	-2.904	-2.587	0
Non-Ferrous Metal ETF Return Rate	82	-14.675	-3.535	-2.904	-2.587	0

4.2 Cointegration Test

The core purpose of the cointegration test is to determine whether there is a long-term equilibrium relationship between non-stationary price variables. Considering that the research objects of this paper are bivariate price sequences, the Engle-Granger (EG) two-step method is adopted to test whether there is a long-term equilibrium relationship between copper futures price and non-ferrous metal ETF price. This method is suitable for verifying the bivariate cointegration relationship: if the linear combination (residual) of the two price sequences is a stationary sequence, then there is a long-term cointegration relationship between the two prices.

First, a linear regression is performed on the copper futures price and the non-ferrous metal ETF price to construct a long-term equilibrium regression equation, and the residual sequence of this regression is further extracted. The residual represents the degree of deviation of the two sequences from the long-term equilibrium relationship. The unit root test is conducted on the residual sequence, and the test results are shown in Table 2.

Table 2. Unit Root Test Results of Residual Sequence

Test Statistic	Critical Value (1%)	Critical Value (5%)	Critical Value (10%)	Number of Observations
-14.617	-2.607	-1.95	-1.61	82

The results show that the test statistic (-14.617) of the unit root test for the residual sequence is much smaller than the 1% critical value (-2.607). The null hypothesis of "existence of unit root" is rejected at the 1% significance level, and the residual sequence is determined to be a stationary sequence. Since the residual sequence of the linear combination of copper futures prices and non-ferrous metal ETF prices is stationary, there is a long-term stable cointegration relationship between copper futures price and non-ferrous metal ETF price.

4.3 Error Correction Model (ECM)

The cointegration test confirms that there exists a long-term stable equilibrium relationship between copper futures prices and non-ferrous metal ETF prices, yet it fails to reveal the dynamic adjustment mechanism after the two deviate from the equilibrium in the short run. As a core tool linking long-run equilibrium and short-run fluctuations, the ECM can quantify the adjustment speed of short-term deviations and the interaction effects of short-term variables. Its core logic is that when variables deviate from the long-run equilibrium, the error correction term will drive the system to adjust reversely, so that the variables gradually return to the equilibrium state. Combined with the Engle-Granger two-step method, this paper constructs an ECM to examine the short-term dynamic relationship between them.

4.3.1 Model Specification

Based on the results of the cointegration test, the ECM is initially specified as follows:

$$\Delta Y_t = \alpha + \lambda ECM_{t-1} + \sum_{i=0}^{p} \beta_i \Delta X_{t-i} + \sum_{j=0}^{q} \gamma_i \Delta Y_{t-j} + \varepsilon_t \tag{1}$$

where: ΔY_t is the dependent variable (the prices of non-ferrous metal ETFs and copper futures, respectively); ECM_{t-1} is the error correction term (the one-period lagged residual from the cointegrating regression, reflecting the degree of deviation from the long-run equilibrium in the previous period); $\Delta X_{t-i}$is the short-run fluctuation term of the independent variable; ΔY_{t-j} is the lagged term of the dependent variable; λ is the error correction coefficient; ε_t is the random disturbance term.

4.3.2 Analysis of Empirical Results

This paper constructs a two-way Error Correction Model (ECM) by taking the prices of non-ferrous metal ETFs and copper futures as the dependent variable respectively. The regression results are presented in Table 3.

Table 3. Regression Results of the Error Correction Model (ECM)

Dependent Variable	Explanatory Variable	Coefficient	Std. Error	Significance
ETF	Error correction term	-0.4586	0.1001	***
	Short-run fluctuation of copper futures	-0.0128	0.0229	Not significant
	Lagged fluctuation of copper futures	-0.0229	—	Not significant
	Constant term	—	—	—
	R^2	0.162	—	—
	Adjusted R^2	0.147	—	—
Copper futures	Error correction term	-0.2916	0.3678	Not significant
	Short-run fluctuation of ETF	-0.6538	0.0842	***
	Lagged fluctuation of ETF	-0.0842	—	Not significant
	Constant term	—	—	—
	R^2	0.341	—	—
	Adjusted R^2	0.33	—	—

Note: *** denotes significance at the 1% level; the error correction term is generated by the one-period lagged residuals from the cointegrating regression.

4.3.3 Result Analysis

1. Short-Run Adjustment Mechanism of Long-Run Equilibrium

In the model with the log return of the ETF as the dependent variable, the coefficient of the error correction term is -0.4586, which is significantly negative at the 1% significance level, consistent with the reverse adjustment mechanism. This indicates that when the price of the non-ferrous metal ETF deviates from its long-run equilibrium relationship with the copper futures price, it will adjust back to the equilibrium state in the short run at a speed of approximately 45.86%, representing a relatively strong adjustment intensity.

2. Interactive Effects of Short-Run Variables

For short-run fluctuations in the ETF, the absolute values of the coefficients for the contemporaneous and lagged fluctuations of copper futures are small and statistically insignificant, suggesting that short-run changes in copper futures prices exert weak short-term impacts on ETF prices. A possible reason is that, as a fund product, the ETF price is also affected by multiple factors such as constituent stock prices and industrial policies, making it difficult to fully follow fluctuations in the futures market in the short run.

For short-run fluctuations in copper futures, the coefficient of the contemporaneous fluctuation of the non-ferrous metal ETF is -0.6538, significant at the 1% level, indicating that short-run changes in ETF returns exert a significant negative short-term impact on copper futures returns.

4.3.4 Economic Implications

The results of the ECM further verify that the short-run co-movement between copper futures and the non-ferrous metal ETF exhibits dynamic adjustment effects and obvious asymmetry. In the long run, the two variables are constrained by the cointegration relationship and maintain equilibrium. In the short run, when deviating from equilibrium, the ETF market adjusts rapidly through the error correction mechanism, whereas the futures market relies more on its own fluctuations and short-run shocks from the ETF.

This asymmetry stems from differences in the trading attributes of the two markets: the futures market is dominated by institutional investors, with high information transmission efficiency and significant leverage effects, leading to more independent short-run fluctuations. In contrast, the ETF market includes a large number of individual investors, who exhibit time lags in digesting price signals from the futures market and thus need the error correction mechanism to return to equilibrium.

4.4 VAR Model Specification and Dynamic Effect Analysis

4.4.1 VAR Model Specification and Stability Test

The VAR model treats all variables in the system as endogenous variables and explains the current value using the lagged terms of both the variable itself and other variables. It is suitable for analyzing dynamic relationships among multivariate time series, and can effectively reveal the dynamic response characteristics and information transmission mechanism between copper futures returns and non-ferrous metal ETF returns.

The bivariate VAR model employed in this paper is specified as follows:

$$\begin{pmatrix} R_{CU,t} \\ R_{ETF,t} \end{pmatrix} = c + \sum_{i=1}^{p} A_i \begin{pmatrix} R_{CU,t-i} \\ R_{ETF,t-i} \end{pmatrix} + \begin{pmatrix} \varepsilon_{CU,t} \\ \varepsilon_{ETF,t} \end{pmatrix} \tag{2}$$

where c is the constant vector, A_i is the coefficient matrix of the i-th lag order, p is the lag order of the VAR model, and $\varepsilon_{CU,t}$ and $\varepsilon_{ETF,t}$ are random disturbance terms, assumed to be zero-mean and serially uncorrelated.

The key to constructing a VAR model lies in determining the optimal lag order, which requires a trade-off between model goodness-of-fit and degrees of freedom. This paper selects the optimal lag based on six criteria: log-likelihood (LL), likelihood ratio (LR), final prediction error (FPE), Akaike information criterion (AIC), Hannan-Quinn information criterion (HQIC), and Schwarz Bayesian information criterion (SBIC). The results are reported in Table 4.

Table 4. Optimal Lag Order Selection for the VAR Model

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	448.454				4.20E-08	-11.3026	-11.2786	-11.2427
1	479.778	62.647	4	0	2.10E-08	-11.9944	-11.9223	-11.8144

Table 4. (continued) Optimal Lag Order Selection for the VAR Model

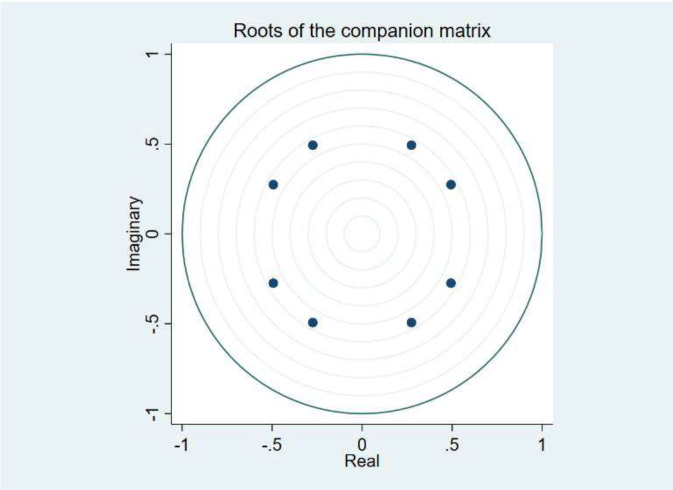
Lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC
2	502.939	46.323	4	0	1.30E-08	-12.4795	-12.3593	-12.1795
3	512.337	18.795	4	0.001	1.10E-08	-12.6161	-12.4479	-12.1962
4	522.026	19.378*	4	0.001	9.9e-09*	-12.7601*	-12.5439*	-12.2203*

(* indicates the optimal lag order under the corresponding criterion)

Based on a comprehensive evaluation of all criteria, the FPE, AIC, HQIC, and SBIC all reach their minimum values at lag order 4. Therefore, the VAR (4) model is adopted for subsequent analysis.

The stability of the VAR model is a prerequisite for impulse response analysis and variance decomposition. This paper examines model stability using the unit circle test. As shown in Figure 1, all characteristic roots of the VAR(4) model lie inside the unit circle, with none on or outside the circle, indicating that the model structure is stable. Accordingly, impulse response analysis and variance decomposition can be further conducted on this basis.

Figure 1. Unit Circle Test of the VAR (4) Model



4.4.2 Granger Causality Test

The Granger causality test is employed to determine the direction of causal relationships between variables. Its core logic is that if the lagged values of variable A can significantly explain the changes in variable B, then A is the Granger cause of B. The null hypothesis is that one variable is not the Granger cause of the other. The test results are presented in Table 5.

Table 5. Granger Causality Test

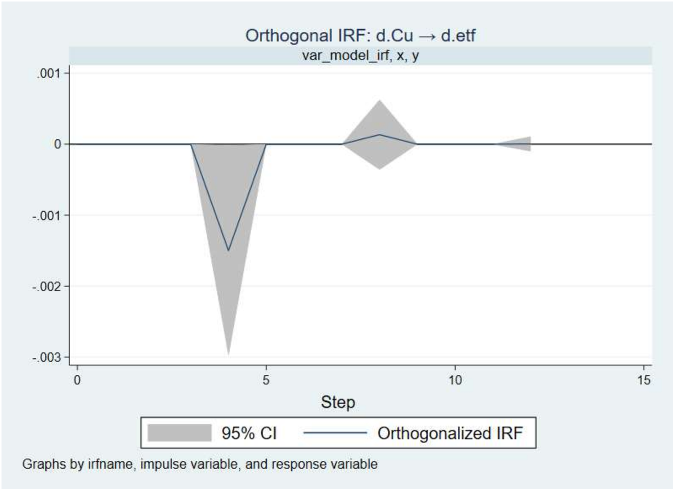
Equation	Excluded	Chi2	Df	Prob > chi2
Y	X	4.0448	1	0.044
Y	ALL	4.0448	1	0.044
X	Y	0.118	1	0.731
X	ALL	0.118	1	0.731

The results show that, at the 5% significance level, copper futures returns are the Granger cause of non-ferrous metal ETF returns, whereas non-ferrous metal ETF returns are not the Granger cause of copper futures returns. Copper futures returns have a unidirectional predictive power over non-ferrous metal ETF returns, reflecting the price discovery function of the futures market. Changes in returns in the copper futures market lead those in the non-ferrous metal ETF market, providing a reference for ETF investors to forecast short-term returns.

4.4.3 Impulse Response Analysis

The impulse response function is used to describe the dynamic impact path and duration of a one-standard-deviation shock of one variable on another variable. Based on the VAR (4) model, this paper constructs an impulse response function to test the dynamic impact effect of copper futures returns on non-ferrous metal ETF returns. The results are shown in Figure 2.

Figure 2. Impulse Response Graph of Copper Futures Returns on Non-Ferrous Metal ETF Returns



Note: The horizontal axis represents the lag order after the shock, the vertical axis represents the response amplitude of non-ferrous metal ETF returns, and the shaded area represents the 95% confidence interval.

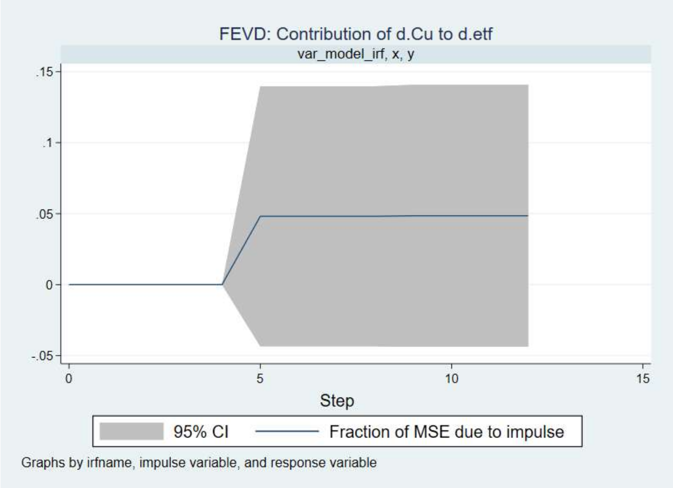
It can be seen from Figure 2 that when a positive one-standard-deviation shock is given to copper futures returns, the non-ferrous metal ETF returns show a weak negative response in the initial stage, a positive effect appears after the 5th period, and the impact effect gradually decays with fluctuations, basically converging to 0 after the 12th period.

The short-term impact effect of copper futures returns on non-ferrous metal ETF returns is weak and of short duration. It is speculated that the reason is that the information transmission efficiency of the copper futures market is high, and the ETF market can quickly digest the impact of copper futures, without obvious information lag.

4.4.4 Variance Decomposition

Variance decomposition further reveals the explanatory power of copper futures returns on the fluctuations of non-ferrous metal ETF returns by quantifying the contribution degree of different variables to the prediction error variance of the dependent variable. The results are shown in Figure 3.

Figure 3. Variance Decomposition Graph of Copper Futures Returns on Non-Ferrous Metal ETF Returns



Note: The horizontal axis represents the prediction lag order, the vertical axis represents the contribution degree of copper futures returns to the prediction error variance of ETF returns, and the shaded area represents the 95% confidence interval.

In the short term (lag order < 4), the contribution degree of copper futures returns to non-ferrous metal ETF returns is close to 0, indicating that the impact of copper futures returns has extremely weak explanatory power on the prediction error variance of non-ferrous metal ETF returns in the short term, and the short-term fluctuations of the latter are mainly dominated by other factors. In the medium and long term (lag order ≥ 5), the contribution degree of copper futures returns to non-ferrous metal ETF returns rises sharply, stabilizes at a high level after the 5th period, and the 95% confidence interval widens significantly. In the medium and long term, the impact of copper futures returns becomes an important source of explaining the prediction error variance of non-ferrous metal ETF returns. The variance results reveal that the contribution of copper futures returns to the prediction error variance of non-ferrous metal ETF returns has obvious time-lag characteristics.

5. RESEARCH CONCLUSIONS AND ANALYSIS

In summary, this paper systematically examines the co-movement relationship between copper futures and non-ferrous metal ETFs from both long-term and short-term perspectives, distinguishing the research objects of price series for cointegration analysis and return series for short-term dynamic analysis. The research results show that there is a stable cointegration relationship between copper futures price and non-ferrous metal ETF price in the long run, reflecting that the futures market and the ETF market are driven by common fundamental factors, and their price trends have long-term consistency. In the short run, when the prices deviate from the long-term equilibrium level, the non-ferrous metal ETF returns assume the main adjustment responsibility through a significant error correction mechanism, while the copper futures returns are weakly constrained by the long-term equilibrium of prices, showing obvious short-term asymmetric adjustment characteristics of returns. At the same time, the Granger causality test verifies the unidirectional guiding effect of copper futures returns on non-ferrous metal ETF returns, reflecting the dominant position of the futures market in price discovery. Further impulse response analysis and variance decomposition results show that the impact of copper futures returns on ETF returns is relatively limited in the short term, but gradually strengthens in the medium and long term, with significant time-lag characteristics. Overall, a co-movement structure based on long-term cointegration of prices and characterized by short-term asymmetric adjustment of returns has been formed between copper futures and non-ferrous metal ETFs. This conclusion provides new empirical evidence for understanding the price transmission mechanism between the futures market and the ETF market.

6. FUTURE OUTLOOK

Future research can proceed in several directions. First, the scope of dependent variables can be expanded by selecting multiple non-ferrous metal ETFs with different sizes and tracking targets to compare the impact of copper futures returns on different ETFs. Second, external control variables can be introduced to construct a multivariate empirical model and examine the moderating effects of factors such as macroeconomic conditions and industrial policies on their co-movement.

Third, high-frequency data (e.g., daily or weekly) and more advanced econometric methods can be applied to further analyze short-term dynamic co-movement and risk spillover effects. Finally, heterogeneity analysis under different market conditions (bull, bear, and volatile markets) can be conducted to explore how the co-movement relationship changes across market environments and to provide more targeted investment insights.

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