# An Empirical Study of the Impact of Stock Index Futures on the Spot Stock Market

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**Abstract.** Employing the closing prices of the SSE 50 stock index futures and its underlying stock index on the trading day as sample data, this study explores the influence of stock index futures on the spot stock market. In the course of the investigation, a Vector Error Correction Model (VECM) is utilized, and the outcomes reveal a long-term equilibrium relationship and dynamic reciprocal interaction between the stock index futures prices and the spot prices of the underlying index. Furthermore, through the analysis of a GARCH model, it is confirmed that the introduction of stock index futures and the trading restriction measures implemented by the China Financial Futures Exchange (CFFEX) can reduce stock market volatility. Despite the belated introduction of stock index futures in China, compared with developed countries, it has already demonstrated its ability to mitigate market volatility. To foster harmonious and robust development of the stock index futures market and the spot stock market, it is recommended to strengthen regulation of the stock index futures market, optimize market mechanisms and enhance investor quality to fully leverage the role of the capital market.

**Keywords:** Stock Index Futures; Stock Index; Vector Error Correction Model; GARCH Model

## 1 Introduction

The advent of stock index futures within China's financial landscape has stimulated substantial scholarly discourse and piqued investor curiosity. The central focus lies in their impact on the underlying equity market, specifically concerning the volatility they introduce and their association with the corresponding spot assets. The intent of this investigation is to enrich the capital market knowledge, broaden the existing academic literature, present essential insights and benchmarks for investment strategies, and foster ongoing enhancements in China's economic and financial realms.

In 2019, Li and Huang unveiled a particular link between stock index futures and their associated spot stocks, underlining the futures' superior capacity for price discovery as compared to their spot counterparts[1]. Employing the threshold vector error correction model, Tang in 2020 disclosed distinct relationships between futures and the equity market, contingent upon various basis levels[2]. In 2021, Liu and his colleagues probed into the dynamics of futures price discovery across BRICS nations, emphasizing the critical role futures assume in the price discovery mechanism within spot-futures markets in China and India, albeit less prominent in Russia[3].

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Applying the GARCH and VAR models, Gu and Zhou in 2019 inferred that the initiation of CSI 500 stock index futures has amplified the oscillations in the correlated spot stock market[4]. Srinivasan utilizing the EGARCH model, also found that the introduction of futures increased the volatility of the stock market[5]. Utilizing a difference-in-differences model, Zhou and his team in 2019 suggested that the direct effect of stock index futures' inception on the volatility of the spot stock market is minimal or even inconsequential[6]. Bohl, Diesteldorf, and Siklos by estimating multiple GARCH models, found that China's stock index futures reduced the volatility of the spot market[7]. Drimbetas and Sariannidis also found that the futures market helps stabilize the underlying spot market by reducing the impact of feedback traders[8]. Contrarily, Chen and his collaborators in 2020 discovered that the launch of the CSI 300 stock index futures effectively quells volatility in the spot stock market[9]. Concurrently, Feng in 2022 argued that the enforcement of trading restrictions contributes to the surge in the instability of the spot stock market[10].

Notwithstanding the multitude of researches conducted in this field, the interplay between stock index futures and the spot market necessitates further exploration. This requirement chiefly stems from variances in research methodologies, study durations, and macroeconomic climates, leading to a range of conclusions about the effects of stock index futures on the fluctuation of the spot market and their reciprocal relationship. To address these divergences, this study aspires to provide a comprehensive empirical examination of the implications of stock index futures on the dynamics of the spot market.

## 2 Theoretical Analysis and Research Hypotheses

Futures contracts on stock indices, belonging to a distinct category of financial derivatives, have predictive and risk-reducing capabilities regarding the movements of the spot stock market. In accordance with the Efficient Market Hypothesis, the pricing of both futures and spot stocks should embody all available public information. Assuming both markets are efficient, a stable equilibrium relationship should endure between them. This balance is upheld via an arbitrage mechanism, whereby discrepancies between predicted and actual prices of futures and spot stocks prompt arbitrageurs to engage in transactions across both markets, thus reinstating price equilibrium - the objective of arbitrage-free conditions. This forms the underpinning theory for the existence of a durable equilibrium bond between futures and spot markets over an extended duration.

Additionally, the market for futures on stock indices is regarded as a near-perfect competitive environment characterized by an abundance of participants, negligible transaction costs, and prompt trade executions. These characteristics enable the futures market to quickly absorb and reflect market information. Consequently, changes in the prices of futures contracts may predict upcoming shifts in spot stock prices. Conversely, significant events or new data in the spot market may affect the pricing of futures on stock indices. Therefore, the relationship between the pricing of futures and spot stocks is not only a long-term equilibrium but also a dynamic, bidirectional information propagation process, emphasizing the significance of futures in price discovery.

The function of price discovery carried out by futures for spot stocks can incite stock market volatility. Although stock prices may undergo substantial short-term fluctuations, the duration of such effects is typically transient, with stock prices rapidly reverting to their trajectory post-volatility. Short-term volatility can potentially increase market risk and compromise market stability. However, over time, information shocks initiated by futures can drive spot stock prices to align with their intrinsic value, thereby fostering steady growth in the stock market. However, over time, information shocks initiated by futures can drive spot stock prices to align with their intrinsic value, thereby fostering steady growth in the stock market. This phenomenon can be exemplified by the aftermath of the 2008 Global Financial Crisis. Initially causing substantial market volatility, as time progressed, the information shocks from futures eventually drove spot stock prices to align with their intrinsic values. This led to a long-term market stability and a steady growth, evidenced by the rise of the S&P 500 index from around 676 points in 2009 to approximately 2700 points by the end of 2018.Unlike the traditional 'buy low' strategy of the stock market, the marketplace for futures adopts a bi-directional trading mechanism as well. This mechanism effectively balances bullish and bearish market forces, regulates the average daily and monthly stock market range, and promotes market stability. Consequently, the introduction of futures can contribute to reducing market volatility.

In the latter part of 2015, the China Financial Futures Exchange (CFFEX) instituted a series of restrictive measures relating to futures to curb excessive market volatility. These measures included enhancing futures hedging management, increasing margins, limiting intraday positions, adjusting fees, and ultimately curtailing trading hours by enforcing index circuit breaker rules. Fundamentally, these policies are speculative constraints designed to prevent excessive speculation and suppress market volatility. For instance, raising margins can escalate the trading expense for speculators, thereby curtailing their propensity for excessive trading. Intraday position restrictions can avert excessive market volatility and diminish short-term market risks. Index circuit breaker rules can halt trading during times of high market volatility, hence avoiding market turmoil. Thus, these measures contribute to stock market stability and reduce market turbulence.

Considering the above discussion, the following research hypotheses are proposed:

H1: A persistent equilibrium relationship and a dynamic, bidirectional interaction exist between the prices of futures and the corresponding spot index.

H2: The introduction of futures reduces the volatility in the stock market.

H3: The trading restriction measures enacted by the CFFEX lessen the instability in the stock market.

## 3 Empirical Examination of Stock Index Futures' Impact on the Spot Stock Market

### 3.1 Sample Selection and Statistical Data Analysis

This study concentrates on the SSE 50 Stock Index futures and its underlying index, given their considerable practical and symbolic importance within China's equity market. Introduced at a critical point in the market's evolution, these futures hold greater influence than their CSI 300 and CSI 500 counterparts. They comprise 50 leading shares with solid market capitalization and dependable liquidity, thus serving as a broad barometer of market trends and dynamics. Their practical significance was starkly demonstrated in the surge of trading volumes post their debut on April 16, 2015, and the substantial market downturn that ensued. The turbulence necessitated rapid regulatory action from the China Financial Futures Exchange (CFFEX), resulting in trading restrictions on September 7, 2015, underscoring their central role in market stability. Symbolically, they lead the price discovery process, incorporating and responding to new information. Their selection as this study's focus reflects their integral role in China's equity market and the repercussions their introduction had on trading dynamics and regulatory measures.

To scrutinize this relationship, the daily closing prices of the Futures of the SSE 50 Stock Index and the actual SSE 50 Stock Index, from the period of April 16, 2015, through December 31, 2022, were utilized as our research sample. For the volatility assessment, the logarithmic return series was calculated using the daily closing prices of the SSE 50 Index from the inception of January 1, 2013, to the closure of December 31, 2022. This research timeline embraces both the launch of the SSE 50 Stock Index Futures and the application of trading restriction protocols by CFFEX. Within the scope of this examination, the logarithmic return rate is designated by R, the Futures of the SSE 50 Stock Index as SIF, and the actual SSE 50 Stock Index as SI. The subsequent analysis is conducted using Eviews9 software.

As illustrated in Table 1, all three variable sequences diverge from the standard normal distribution. The logarithmic return rate of the SSE 50 exhibits significant leptokurtosis and negative skewness, indicating a daily log return rate of 0.0144% and also demonstrates marked volatility. The closing values of both the futures and the stock index present a platykurtic and positively skewed distribution, with analogous averages and fluctuation scopes; however, they reveal considerable overall volatility. Table 2 shows that the yield R sequence of sse 50 is a stable sequence, and the closing price of stock index futures and stock index are both first-order single whole sequence.

**Table 1.** Descriptive Statistics of Variables

| Variables | Mean | Std. Dev. | Skew | Kurt | JB | P-value |
|---|---|---|---|---|---|---|
| SSE 50 Returns (R) | 0.000144 | 0.0147 | -0.4675 | 8.7407 | 3425.259 | 0.0000 |
| Stock Index Futures (SIF) | 2762.381 | 434.5574 | 0.2491 | 2.4343 | 44.5092 | 0.0000 |
| Stock Index (SI) | 2777.037 | 426.8307 | 0.3051 | 2.4619 | 51.8564 | 0.0000 |

**Table 2.** ADF Unit Root Test Results for Variables

| Variables | SSE 50 Returns (R) | Stock Index Futures (SIF) | Difference Series D(SIF) | Stock Index (SI) | Difference Series D(SI) |
|---|---|---|---|---|---|
| Test Statistic | 48.55342 | 2.360005 | -33.64083 | 2.113159 | -43.14989 |
| P-Value | 0.0001 | 0.1535 | 0.0000 | 0.2396 | 0.0001 |

### 3.2 Unveiling Long-Term Equilibrium and Dynamic Interactions: A VECM Approach to SSE 50 Stock Index Futures and Spot Index

The current segment of our research applies the Johansen maximum likelihood estimation procedure for the execution of cointegration tests on the differenced series. The endeavor seeks to establish whether a persistent equilibrium link is discernible between SIF futures and the SI index. Results of the cointegration examination are combined in Table 3. The P-value of the trace statistic test in the findings validates a cointegration association in the daily trading data closing values between the SSE 50 Stock Index Futures and the SSE 50 Stock Index. Simultaneously, the maximum eigenvalue test concurs with this conclusion, indicating a long-lasting equilibrium link between SIF futures and the SI index.

**Table 3.** Results of the Johansen Cointegration Test

| Test Method | NHCV | Eigenvalue | Test Statistic | 5% Critical Value | P-Value |
|---|---|---|---|---|---|
| Trace Test | None * | 0.042709 | 90.35587 | 25.87211 | 0.0000 |
| | At most 1 | 0.004455 | 8.384558 | 12.51798 | 0.2219 |
| Max-Eigen Test | None * | 0.042709 | 81.97132 | 19.38704 | 0.0000 |
| | At most 1 | 0.004455 | 8.384558 | 12.51798 | 0.2219 |

To investigate the correlation between SIF futures and the SI index, a model that can accurately capture their dynamic relationship is required. Due to the original series exhibiting non-stationarity, it was transformed into a stationary series using first-order differencing. Consequently, through the Johansen maximum likelihood estimation method, a cointegration relationship was confirmed. This finding facilitated the implementation of a Vector Error Correction Model (VECM), a model proficient in meticulously detailing the short-term and long-term dynamic interactions of multiple cointegrated series.

Prior to establishing the VECM model, ascertaining the optimal lag order of the VAR model is vital. For this purpose, the LR, FPE, AIC, SC, and HQ information criteria are engaged to determine the lag order. As seen in Table 4, displaying the statistical results for the VAR model lag order, the SC value is minimal when the lag length is 7; the AIC and LR values are minimal when the lag length is 9. Combining these statistical findings and optimization principles, the optimal lag order is designated as 9 for the VAR model.

**Table 4.** Determining the Optimal Lag Order for the VAR Model

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 1 | -16942.0 | NA | 259813.4 | 18.14347 | 18.15532 | 18.14784 |
| 2 | -16885.7 | 112.3128 | 245670.9 | 18.0875 | 18.1112 | 18.09623 |
| 3 | -16869.6 | 32.0611 | 242513.4 | 18.07457 | 18.11011 | 18.08766 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | -16852.9 | 33.27046 | 239236.4 | 18.06096 | 18.10835 | 18.07842 |
| 5 | -16830.3 | 45.1096 | 234500.2 | 18.04097 | 18.1002 | 18.06279 |
| 6 | -16812.4 | 35.60086 | 231032.3 | 18.02607 | 18.09715 | 18.05226 |
| 7 | -16794.7 | 35.06566 | 227676.8 | 18.01144 | **18.09437*** | 18.04199 |
| 8 | -16785.9 | 17.41175 | 226514.4 | 18.00632 | 18.10109 | **18.04124*** |
| 9 | -16779.0 | **13.57936*** | **225822.9*** | **18.00326*** | 18.10988 | 18.04254 |
| 10 | -16777.1 | 3.841209 | 226321.3 | 18.00546 | 18.12394 | 18.04911 |

Upon deciding the lag order, an 8-order lag VECM model based on the VAR(9) model is formulated. Inspecting the root distribution diagram in Figure 1, the stability of the 8-order lag VECM model is confirmed by the placement of all inverse roots within the unit circle.

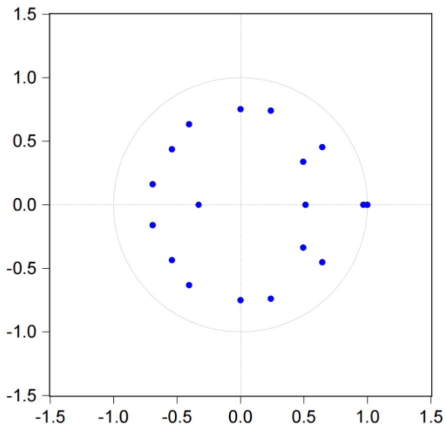


**Fig. 1.** Inverse of Eigenvalues for VECM(8) Model

By employing the stable VECM model, the investigation further explores the dynamic relationship between SIF futures and the SI index. During this process, the impulse response function aids in illustrating the interactive effects between the two variables. Analysis outcomes of the impulse response are depicted in Figure 2. The response of SIF futures to the SI index initiates strong, subsequently declining and stabilizing over time. This indicates that stock index futures wield a significant impact on the stock index, an impact that eventually lessens and stabilizes. Conversely, the SI index's response to SIF futures commences low, gradually heightens, and stabilizes over time. This denotes that the stock index also exerts influence on the stock index futures, an influence that escalates and stabilizes over time. Thus, a specific reciprocal influence between the stock index futures and their corresponding stock indices emerges, an influence that stabilizes over time and preserves a long-term stable connection.

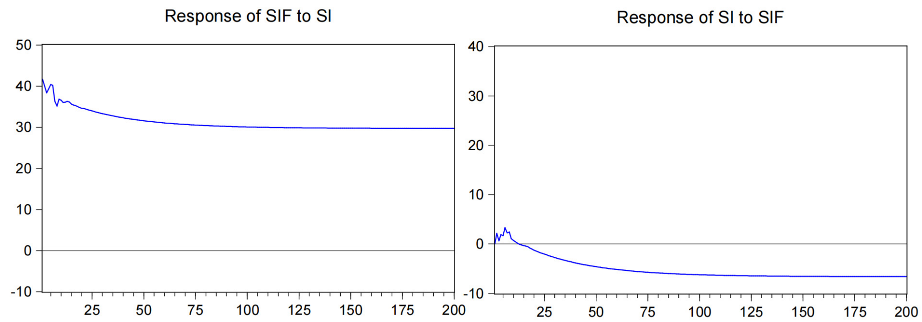


**Fig. 2.** Impulse Response Function

However, the impulse response function, while capable of illustrating one variable's impact path on another, lacks the ability to detail the magnitude of the effect. Hence, this research further applies the variance decomposition method to delve into the extent of influence that the SI index exercises on SIF futures in greater detail. The results of the variance decomposition are as follows:

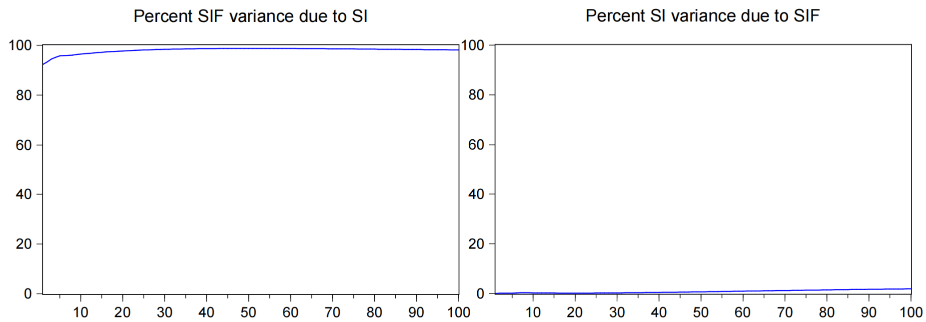


**Fig. 3.** Variance Decomposition Results

Figure 3 showcases the results, revealing that in the variance decomposition of the SSE 50 Index SI, the contribution rate of the first period SI index to itself is 100%, and it stabilizes at about 96.92% in the 200th period. In the variance decomposition of the SSE 50 Futures SIF, the contribution rate of the first-period SIF futures to the SI index is 92.35%, and it stabilizes at about 97.00% in the 200th period. These statistics suggest that the SSE 50 Stock Index contributes significant explanatory power for the fluctuations of both the stock index and stock index futures, whereas the explanatory power of the SSE 50 Stock Index Futures is somewhat lesser. Consequently, a substantial shift in the corresponding SSE 50 Stock Index Futures can be anticipated subsequent to the fluctuation of the SSE 50 Stock Index.

In closing, this research affirms Hypothesis H1: a lasting equilibrium relationship and a dynamic, bidirectional interaction prevail between the prices of stock index futures and the corresponding spot index. Simultaneously, it is noted that the reciprocal interaction is inclined to stabilize over time.

### 3.3 Deciphering Market Volatility: The Role of SSE 50 Stock Index Futures' Introduction and CFFEX's Trading Restrictions

To adeptly depict the course of the stationary series R, we deploy the ARMA (2, 2) model, the choice of which is justified by the application of the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). Post-regression, the residual series is extracted and examined for an ARCH effect. The resultant F-statistic (59.46085) and the chi-square statistic (57.51675), both displaying a P-value of 0, suggest the existence of an ARCH effect in the residual series. Previous research endorses that the GARCH (1, 1) model accurately captures variable volatility, thereby leading to the application of a GARCH model. Tables 5 and 6 manifest the results of the regression.

**Table 5.** GARCH Model Estimation Results with the Introduction of SSE 50 Stock Index Futures

| Variable | Coefficient | Std. Error | Z-Statistic | Prob. |
|---|---|---|---|---|
| α0 | 3.90E-06 | 9.23E-07 | 4.228694 | 0.0000 |
| α1 | 0.084479 | 0.005424 | 15.57565 | 0.0000 |
| β1 | 0.908162 | 0.005176 | 175.4618 | 0.0000 |
| φ | -1.95E-06 | 7.78E-07 | -2.508715 | 0.0121 |

**Table 6.** GARCH Model Estimation Results with Enforcement of Trading Restriction Measures

| Variable | Coefficient | Std. Error | Z-Statistic | Prob. |
|---|---|---|---|---|
| λ0 | 4.42E-06 | 9.94E-07 | 4.447051 | 0.0000 |
| λ1 | 0.08407 | 0.005447 | 15.4353 | 0.0000 |
| σ1 | 0.907281 | 0.005263 | 172.3954 | 0.0000 |
| θ | -2.39E-06 | 8.31E-07 | -2.881905 | 0.0040 |

Within this phase of the analysis, dummy variables var01 and var02 are introduced. Here, var01=0 represents the return pattern before the initiation of the SSE 50 stock index futures as denoted by the SSE 50 index, while var01=1 indicates the return series following the launch.

Correspondingly, var02=0 signifies the return pattern linked to the SSE 50 index preceding the imposition of trading limitations on CFFEX stock index futures dated September 7, 2015, and var02=1 designates the return series after this specified date.

Table 5 outlines the GARCH (1, 1) model estimation results for the return series of the SSE 50 stock index futures. The combined worth of α1 and β1 is 0.992641, nearing 1, confirming the model's aptness and the persistence of the shocks' influence, beneficial for predicting future trends. The coefficient φ serves as the estimation of the variable, with a value of 0 before the launch of the SSE 50 stock index futures and 1 post its initiation. Its statistically significant value, less than 0, posits that the introduction of SSE 50 stock index futures has mitigated the volatility of the SSE 50 index, thus validating Hypothesis H2.

In the later months of 2015, the China Financial Futures Exchange (CFFEX) instated several limiting measures on stock index futures trading, including enhanced hedge management, margin increment, intraday opening constraints, and fee modifications. These strategies have notably influenced stock market volatility.

Table 6 displays the GARCH model estimation results post the enforcement of these trading restrictions. The summation of λ1 and σ1 is 0.991351, closely approximating 1, denoting the model's dependability and the constancy of the shocks' influence, useful for future trend forecasting. θ represents the regression coefficient estimate of the variable, recording a value of 0 before the institution of CFFEX's trading restrictions and 1 following it. Its statistically significant value, less than 0, infers that the trading restriction actions implemented by CFFEX on September 7, 2015, have curbed the volatility of the SSE 50 index. This finding corroborates Hypothesis H3.

## 4 Conclusions and Policy Recommendations

### 4.1 Conclusions

This examination validates the enduring balance and dynamic liaison between the prices of SSE 50 stock index futures and their respective spot prices. The deployment of the impulse response function along with variance decomposition analysis has proven crucial in identifying the steadiness of shock reactions between these financial entities over time. Remarkably, the SSE 50 stock index induces considerable variations in both the index and futures, although futures display a relative lack of sensitivity to information alterations.

The introduction of the SSE 50 stock index futures exhibits a moderated influence on stock market volatility, despite its significant contribution towards market stability. Empirical evidence highlights a reduction in market volatility following the launch of stock index futures on April 16, 2015. Moreover, the imposition of trading restriction protocols by CFFEX during the later part of 2015 has further contributed to a reduction in market volatility, albeit modestly.

These findings underscore the correlation between stock index futures and the spot equity market. The advent of stock index futures and the execution of CFFEX's trading restriction protocols have collectively assisted in diminishing the stock index's volatility. Despite the belated introduction of the SSE 50 stock index futures compared to developed nations, their efficacy in curbing market volatility is evident, with the SSE 50 stock index playing a significant directional role in the market behavior of stock index futures.

### 4.2 Policy Recommendations

The assessment of the mutual influence between SSE 50 stock index futures and the actual SSE 50 stock index implies that the effect of stock index futures on the spot equity market is fairly measured. To capitalize on the synergistic relationship between these two markets, China ought to strengthen its capital trading market, formulate cohesive and robust policies, stimulate market vitality, and enforce stringent risk controls.

In light of these findings, this paper proposes the following policy recommendations: First, the application of cautious, rational, and effective market regulations can amplify positive market influences and neutralize potential adverse impacts. Second, diversifying the trading market through the launch of valid structured financial products can counterbalance excessive leverage. This approach will not only assist in market regulation but also mitigate potential risks. Lastly, prioritizing the enhancement of investor education, disseminating training and alerts across diverse platforms can guide investors towards rational trading behaviors. Balancing the investor structure among hedgers, speculators, and arbitrageurs will foster a healthy market evolution. Moreover, these measures will protect the rights and privileges of investors, thereby fostering the steady growth of China's capital market.

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