Analysis of the Linkage Relationship between the Mainland Stock Market and the Taiwan Stock Market during the Post - epidemic Period Based on the VAR

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Abstract. This article use The Shanghai Composite Index, Shenzhen component Index and the Taiwan weighted stock index from January 4, 2021 to January 20 , 2023 as the sample. Establish an analysis of the connected relationship between mainland stock markets and Taiwan stock markets during the post-epidemic period. Conduct empirical analysis through stable test, Grandie Cause and effect testing, pulse response analysis, variance decomposition and other methods.The empirical results show that Taiwan's weighted stock price index is the reason for the Shanghai Composite Index and the Shenzhen Stock Exchange. The mainland stock market has a significant guiding role in the Taiwan stock market in the short term. Compared with the Shanghai Composite Index, the Shenzhen Stock Exchange Index has a closer relationship with the Taiwan's weighted stock price index.

Keywords: stock market linkage relationship, VAR model, pulse response function.

1. Introduction

Under the wave of economic globalization, the connection between financial markets in various places is more closely. Taiwan is part of China's territory. The economy of Taiwan is closely related to the mainland economy. The emergence of the epidemic has a certain impact on both. The stock market is a barometer that reflects a regional economic situation. Study the linkage relationship between different stock market indexes, which not only helps to cultivate rational investors, help them better analyze the stock market fluctuations, and make relatively reasonable Investment decisions, it also helps improve the financial risk prevention system and strengthen macro -prudential supervision.

Foreign scholars have done lots of detailed researches on the linkage relationship between different stock markets. Jeon (1991) has studied the four international securities markets of New York, London, Frankfurt and Tokyo from 1975 to 1990, and pointed out that there may Long -term equilibrium relationship exist between them.Khuong Nguyen (2010) selected some typical countries in the Gulf area such as Oman, Arab Emirates, Qatar, Saudi Arabia, and Kuwait . Based on the DCC-Garch model, the linkage effect of their stock market from 2005 to 2008 was analyzed and studied.It is found that there is a certain linkage between the stock markets of various countries in the Gulf area, but the linkage is not strong.Rathore and Tripathi (2016) took the 1987 stock market crash and the 1997 Asian financial crisis as the starting points, analyzed the correlation between stock markets in the United States and Europe, Europe and Asia, and found that the linkage between developed stock markets and emerging stock markets was significantly enhanced after the crisis.Ahmed and Huo (2017) study the linkage relationship between Shanghai stock market and Hong Kong stock market after the launch of the Shanghai-Hong Kong Stock Connect by establishing VAR, GJR-GARCH and BEKK-GARCH models, and point out the guiding role of Shanghai to Hong Kong.

Chinese scholars mainly focus on studying the interaction between Chinese and other countries' stock markets.Yu Shidian, Chen Shoudong et al. found that before 2002, there was no obvious Granger causality relationship between Chinese stock indexes and stock indexes of other stock markets, that is, "insulation". Some scholars also pointed out that after the subprime crisis in 2008, the return rate of Shanghai Composite Index would be positively impacted by the daily return rate of S&P 500 (Hu Qiuling et al. 2009). Zhang Bing et al. studied the Sino-US stock indexes from 2001 to

2009 and found that there was no long-term equilibrium relationship between the stock markets of the two countries, but there was a gradually increasing volatility spillover effect. By establishing the DCC-MVGARCH model, Li An et al. found that the international interactivity of China's stock market was continuously strengthened during the financial crisis. Liu Jialing (2017) studied the relationship between Chinese stock indexes and American and Japanese stock indexes from 2006 to 2016, and pointed out that there was a balanced relationship among the three, but domestic stock indexes had little influence on the outside world. Most domestic scholars have mainly studied the exogeneity of China's stock market, and there has been little discussion on this aspect since the epidemic. This paper focuses on the endogeneity of China's stock market in the post-epidemic period. By studying the causal relationship between the return rate of Shanghai and Shenzhen stock indexes and the return rate of Taiwan weighted Stock Index, it reveals the linkage mechanism between different stock markets in China in the special period.

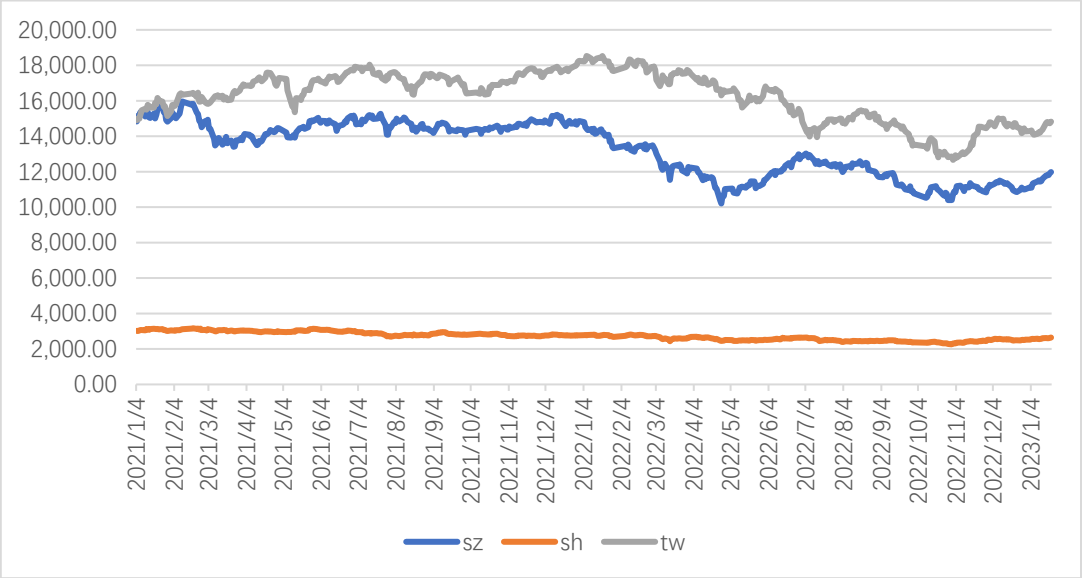

Fig 1 . Daily closing time trend chart

The above chart shows the daily closing time series trend of mainland stock index represented by Shanghai Composite Index and Shenzhen Component Index and Taiwan Weighted Share index from January 4, 2021 to January 4, 2023. As can be seen from the figure, the Shanghai Composite Index is generally stable but also has a gradual decline trend in the past two years, from 4000 points to 2000 points. The fluctuation trends of Shenzhen Component Index and Taiwan Weighted Stock index in the past two years are consistent, with the former fluctuating between 10,000 and 16,000 and the latter between 12,000 and 18,000. In early 2022, geopolitical conflicts lead to changes in commodity prices, changes in the pace of the Federal Reserve's interest rate hike and interference from overseas hedge funds. Both experienced sharp declines.

2. Setting of variables and data sources

The Shanghai Composite Index and the Shenzhen Component Index represent the stock indexes of Shanghai and Shenzhen respectively, so as to represent the mainland stock market. Taiwan Weighted Stock Index is used to represent the Taiwan stock market. Daily data of closing prices of Shenzhen Component Index, Shanghai Composite Index and Taiwan Weighted Stock Index from January 4, 2021 to January 20, 2023 were selected as research objects, and 499 pieces of data were obtained. The natural logarithm of all data is taken to calculate the rate of return. The daily rate of return is used to obtain the rate of return series data. sz, sh and tw are respectively used to represent the rate of return of Shenzhen component index, Shanghai Composite Index and Taiwan Weighted Stock Index. All three are based on the UK Financial Situation.

3. Empirical research

3.1 Descriptive statistics and Robustness test

Table 1. Descriptive statistics and Robustness test

Variable name	Maximum value	Minimum value	Mean value	Standard deviation	Jarque-Bera	ADF
sz	0.019	-0.027	-0.0002	0.006	35.87	-21.008
sh	0.015	-0.019	-0.0001	0.004	74.73	-21.037
tw	0.022	-0.019	-0.0000	0.005	45.93	-19.658

The above is the descriptive statistics and stability test table of daily returns of Shenzhen Component Index, Shanghai Composite Index and Taiwan Weighted Stock Index from January 4, 2021 to January 20, 2023. According to the descriptive statistics, the daily return rate of Shenzhen component Index since 2021 fluctuates between -2.7% and 1.9%, with skew and kurtosis of -0.33 and 4.14, respectively, in line with the characteristics of peak and thick tail. JB test shows that it does not conform to the normal distribution and belongs to the left skew, with a negative mean value, indicating losses on the whole. The Shenzhen Stock Index takes the top 500 stocks in the Shenzhen Stock Exchange in terms of average circulating market value and average transaction amount in the past six months as the initial sample. During the epidemic period, the stock prices of many top real estate enterprises, such as Vanke and Joy City, fell significantly, which is a major factor in their overall poor performance. The ADF test value of Shenzhen component index is -21.008, far less than the critical value -3.449, which is significant at the significance level of 1%, indicating that the data is stable. The relevant indicators of return of Shanghai Composite Index and Taiwan Weighted Stock Index are similar, but the extreme value of the latter has the best performance, the maximum return can reach 2.2%, and its average skew degree is less than that of Shenzhen Component Index and Shanghai Composite Index.

3.2 Model Construction

Vector autoregressive model, also known as VAR model, is an extension of AR model. In this model, the time series in a group of vectors can be considered as the lag term determined by itself, as well as the lag term of all other variables in this group of vectors. The model can be used to describe the dynamic interaction between different variables and make causal inference. Firstly, the Johansen co-integration method was used to test the established model, so as to determine the order of lag. The operating environment was stata16.

Table 2. Order of optimal lag

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1074.61				9.10E-15	-23.8135	-23.7799*	-23.7301*
1	1080.38	11.546	9	0.24	9.80E-15	-23.7414	-23.6073	-23.4084
2	1093.67	26.582*	9	0.002	8.9E-15*	-23.8371*	-23.6019	-23.2538
3	1099.66	11.973	9	0.215	9.60E-15	-23.7701	-23.4341	-22.9369
4	1105.11	10.903	9	0.282	1.00E-14	-23.6913	-23.2545	-22.608

The above optimal lag order determination table shows the main results of the lag order selection test, and * indicates that the corresponding lag order is significant at the level of 5%. LR, FPE and AIC all recommend second-order hysteresis. Therefore, VAR (2) was constructed for the three groups of data.

$$sz = -0.06sz_{t-1} - 0.12sh_{t-1} + 0.02tw_{t-1} - 0.06sz_{t-2} + 0.0000032sh_{t-2} + 0.17tw_{t-2} \quad (1)$$

$$sh = -0.034sz_{t-1} - 0.11sh_{t-1} - 0.075tw_{t-1} - 0.097sz_{t-2} + 0.036sh_{t-2} + 0.152tw_{t-2} \quad (2)$$

$$tw = 0.135sz_{t-1} + 0.015sh_{t-1} - 0.148tw_{t-1} - 0.048sz_{t-2} + 0.084sh_{t-2} + 0.03tw_{t-2} \quad (3)$$

In wald test, the first-order lag of a single equation of the Shenzhen component index is significant at the level of 10%, and the second-order lag is significant at the level of 5%. The first and second order hysteresis of single equation of Shanghai Composite Index are highly significant. The first order lag of Taiex is highly significant while the second order lag is not. As a whole of the three equations, the coefficients of each order are still significant, so it can be considered that there is a certain correlation among the three equations. The residual test results also show that the null hypothesis of "no autocorrelation of residuals" cannot be rejected, that is, the disturbance term can be considered as white noise.

3.3 System stability test

The premise of impulse response function analysis and variance decomposition is that the VAR model has stability, and the sufficient and necessary condition for the stability of the VAR model is that the reciprocal of the module corresponding to the unit root is less than 1, that is, all the eigenvalues of the coefficient matrix should be within the unit circle. Therefore, the stability test is conducted on the AR root of the VAR model equation. As can be seen from the unit root test diagram, the VAR system constructed in this paper is stable, not infinitely close to the root of the unit circle, and there is no strong and persistent impact.

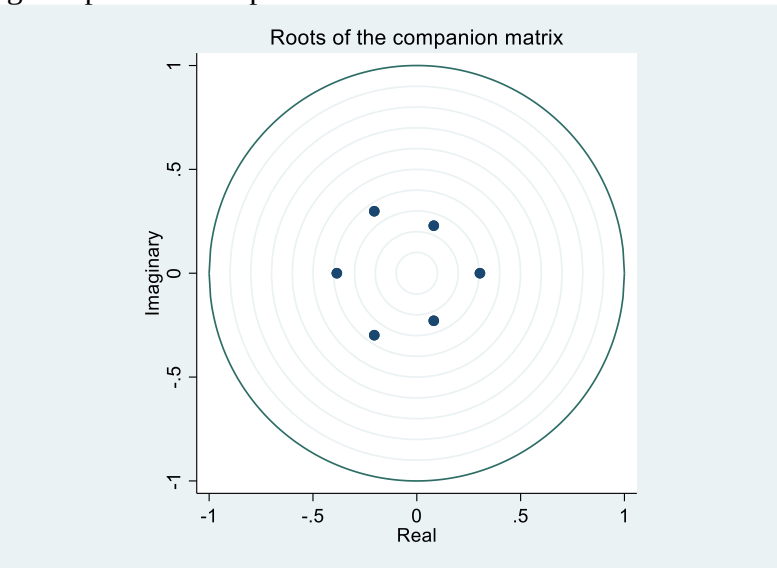

Fig 2. Unit root test

3.4 Granger causality test

Granger causality test can verify the interaction between different variables. Based on the established second-order lagged VAR model, Granger causality test is carried out on the returns of Shenzhen Component index, Shanghai Composite Index and Taiwan Weighted Stock index.

Table 3. Granger causality test

Equation	Excluded	chi2	df	Prob>chi2
sz	sh	1.5588	2	0.459
sz	tw	7.0182	2	0.03
sz	ALL	8.8507	4	0.065
sh	sz	0.5048	2	0.777
sh	tw	14.533	2	0.001
sh	ALL	15.014	4	0.005
tw	sz	5.2966	2	0.071
tw	sh	0.9707	2	0.615
tw	ALL	9.2516	4	0.055

According to Granger causality test table, in the equation with the return of Shenzhen Component index as the explained variable, if the significance of impact on it is tested, the chi-square statistic of return of Shanghai Composite index is 1.5588, and the corresponding p value is greater than 10%. Therefore, the null hypothesis cannot be rejected, that is, the impact of return of Shanghai Composite Index on the return of Shenzhen component index is not significant. Similarly, the impact of the return rate of Taiwan weighted Stock Index on the return rate of Shenzhen Component index is significant at the level of 5%, and the impact of the system on the Shenzhen component index is significant at the level of 10%. The Taiex yield is the Granger reason for the return of the Shanghai Composite index while the Shenzhen component is not. In the equation with the Taiwan weighted stock index yield as the explained variable, the Shenzhen component index and the system at the significance level of 10% is its Granger reason while the Shanghai Composite index is not its Granger reason. Therefore, in general, the internal linkage effect of the mainland stock market is not significant during the epidemic period, while the one-way spillover effect of the Taiwan stock market on the Shanghai and Shenzhen stock markets is obvious, and the overall effect of the mainland stock market has a significant impact on the Taiwan stock market. It can be considered that the mainland stock market has a certain guiding role in the Taiwan stock market in the post-epidemic period.

4. Analysis of empirical results

4.1 Impulse response analysis

The impulse response function graph can show the dynamic response of each variable in the model to the impact from itself and other variables in different periods. The solid line in the graph is the response path of the impulse response function after a unit impulse impact is applied, and the gray part is the 95% confidence interval range.

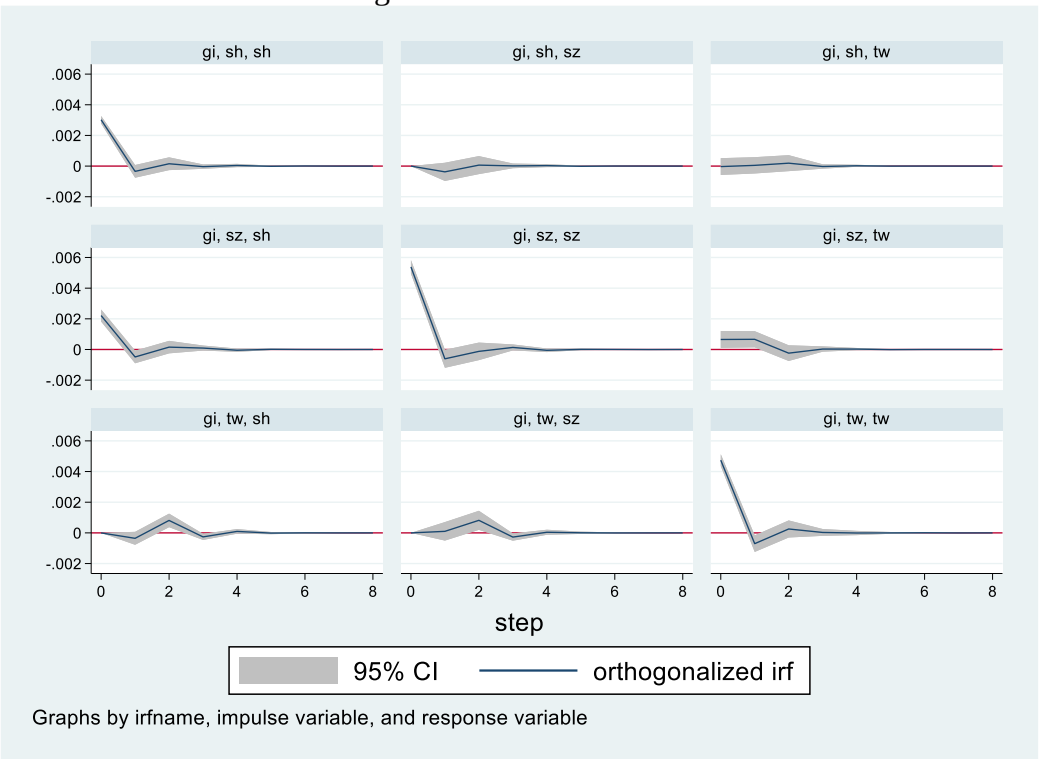

Fig 3. Impulse response diagram

In terms of the endogenous relationship of the mainland stock market, it can be seen from the impulse response diagram that the impact of the Shanghai Composite Index on itself and the Shenzhen component index reaches the maximum in the first phase, gradually drops to negative value in the first to second phase, rises to 0 value in the second phase, and the impact effect is completely absorbed after the third phase. For the Shenzhen component index, its impact on the Shanghai Composite Index

is not significant, and its impact on itself reaches the maximum in the first period, then gradually declines, and is completely absorbed after the fourth period. Therefore, there was a significant linkage between Shanghai stock market and Shenzhen stock market in the post-epidemic period, which was mainly reflected in the short-term impact, and the former had a greater impact on the latter.

In terms of the linkage relationship between Taiwan stock market and mainland stock market, the impact paths of mainland and Taiwan stock market are basically the same. After being impacted by the new interest rate of one unit of Shanghai Composite Index and Shenzhen Component index, Taiex reached the maximum value in the second or third period, and then gradually declined to zero. After the fourth period, Taiex was completely absorbed. The Taiex has a positive impact on the Shanghai and Shenzhen indexes in the short term, but it is not strong. In general, the mean spillover effect of the mainland stock market on the Taiwan stock market is obvious in the post-epidemic period, and the latter has a positive effect on the former, but it is not strong and the duration is not long.

4.2 Variance decomposition analysis

On the basis of establishing VAR model, in order to obtain the dynamic changes of mean spillover effect, variance decomposition can be further carried out. Variance decomposition is to decompose the mean square error of prediction of any variable into the contribution of different variables in the whole system to its impact. Variance decomposition can help us intuitively see the contribution of each variable to the forecast variance, so as to judge the importance of the impact of different variables that change variables in the model. According to the above analysis, we focus on the variance decomposition of the Taiwan Weighted stock price index as the response variable.

Table 4. Variance decomposition

step	(1) fevd	(2) fevd	(3) fevd
0	0	0	0
1	0.005695	0.013002	0.981303
2	0.013316	0.023296	0.963389
3	0.013235	0.027008	0.959757
4	0.013235	0.027069	0.959696
5	0.013279	0.027072	0.959649
6	0.013281	0.027073	0.959646
7	0.013282	0.027073	0.959646
8	0.013282	0.027073	0.959646

(1) Irfname=gi, impulse=sh, and respone=tw
(2) Irfname=gi, impulse=sz, and respone=tw
(3) Irfname=gi, impulse=tw, and respone=tw

In the table, the first and second columns respectively show the impact of Shanghai Composite Index and Shenzhen Component index on Taiex, and the third column shows the impact of Taiex on Taiex itself. It can be seen from the table that the Taiex was most influenced by itself, which was above 95% in all eight periods, but it was most obvious in the beginning and gradually weakened in the later period. The impact of the Shenzhen component index on the Taiex was greater than that of the Shanghai Composite Index. The former reached the maximum in the third period, with a contribution of 2.7008%, while the latter reached the maximum in the second period, with a contribution of 1.3316%, indicating a stronger correlation between Shenzhen and Taiwan.

5. Conclusion and suggestion

In this paper, the return rate data of Shanghai Composite Index and Shenzhen Component index from January 4, 2021 to January 20, 2023 are used to measure the mainland stock market, and the return rate of Taiwan weighted stock index in the same period is used to measure the Taiwan stock

market. By establishing VAR model, Granger causality test, impulse response analysis and variance decomposition analysis are carried out. It describes the linkage relationship between the mainland stock market and Taiwan stock market in the post-epidemic period.

The empirical results show that, first of all, Taiwan weighted stock index is the Granger cause of Shanghai composite index and Shenzhen component index, while Shenzhen component index is the Granger cause of Taiwan weighted stock index and Shanghai Composite index is not. Secondly, the mainland stock index has a positive impact on the Taiex in the short term, indicating that the mainland stock market has a significant guiding effect on the Taiwan stock market. The Taiex has little influence on the mainland stock index, which is mainly reflected in the impact on the Shenzhen component index in the short term. Finally, both impulse response and variance decomposition pointed out that there was a correlation between the mainland stock market and Taiwan stock market in the post-epidemic period, but compared with the Shanghai Composite index, the Taiwan weighted stock index was more closely related to the Shenzhen component index.

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