WEP Warwick Evans Publishing

International Journal of Global Economics and Management

ISSN: 3005-9690 (Print), ISSN: 3005-8090 (Online) | Volume 4, Number 2, Year 2024
DOI: https://doi.org/10.62051/ijgem.v4n2.18
Journal homepage: https://wepub.org/index.php/IJGEM/index

Spillover Effects Between Exchange Rate and Stock Market: Evidence from China and the United States

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ABSTRACT

This study explores the spillover effects between exchange rates and stock markets in China and the United States, with a focus on both mean and volatility spillovers. Using a Vector Autoregression (VAR) model, this study analyzes daily data from August 2015 to December 2022, distinguishing between a stable period and the COVID-19 crisis phase. The findings reveal that the U.S. stock market has a significant mean spillover effect on the exchange rate return, whereas the impact of the Chinese stock market on the exchange rate return is weaker and only significant in crisis phase. In terms of volatility, both U.S. and Chinese stock markets exhibit strong volatility spillover effects with the exchange rate market, with increased significance during the crisis period. A cross-industry comparison shows that the mean spillover effects and predictive power of domestic-oriented stock indices in China and U.S. are comparable to those of export-oriented indices, indicating that the spillovers between the exchange and stock markets in China and the United States is mainly driven by the capital account rather than trade flows. This study underscores the significant influence of the U.S. stock market on exchange rates and highlights the importance of historical data and market dynamics in understanding global financial interconnectedness.

KEYWORDS

Stock Return; the Exchange Market; Spillover Effects

1. INTRODUCTION

1.1. Background and Motivation

The spillover effect between the stock and exchange markets has always been a popular research topic. With the development of globalization, the exposure of financial markets to foreign markets has increased, making the exploration of this topic pertinent [1]. Especially during recent years, the Covid-19 pandemic have caused significant fluctuations in the international currency and financial markets, resulting in increased global economic instability in most developed and emerging economies, such as China and the United States [2]. Therefore, estimating the spillover effects between the two markets has far-reaching implications for individual risk-hedging strategies and economic stabilization policies.

1.2. The Exchange Rate and Stock Markets

As shown in Figure 1 and Figure 2, over the past 30 years, China's stock market has been highly volatile. The Shanghai Composite Index has experienced relatively dramatic rises and falls, with the overall index showing a slow upward trend. However, for the US stock market, there are two unique turning points: one in May 2000 during the dot-com bubble and the other in October 2007 before the global financial crisis. Compared to China’s stock market, the US stock market has experienced higher growth for a longer duration, with a more stable upward trend.

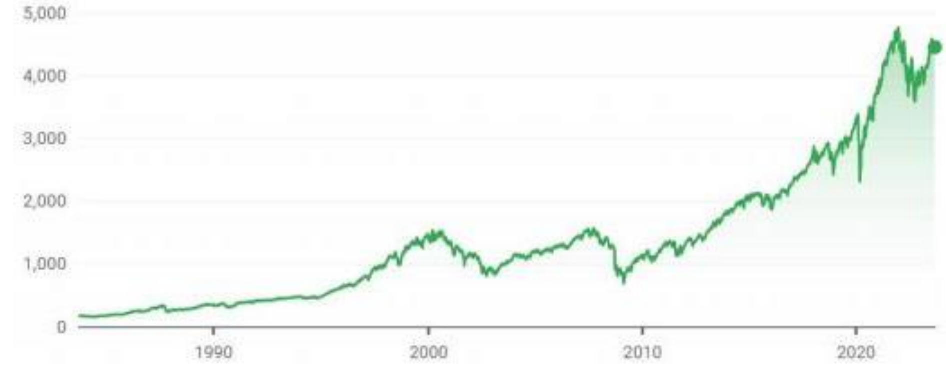


Figure 1. S&P 500 index [3]

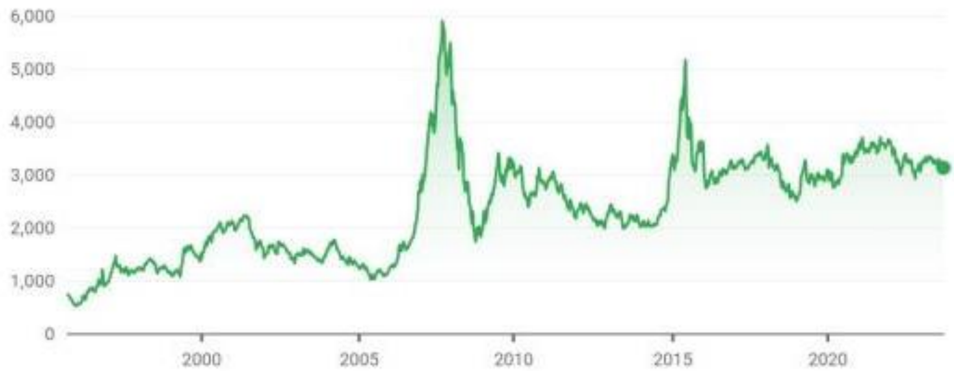


Figure 2. SSE Composite Index [4]

Regarding the exchange rate [as shown in Figure 3], China does not have a flexible exchange rate; its currency is pegged to the dollar, depending on its export needs [5]. In 1994, the yuan was pegged to the greenback at 8.28 to the dollar [6]. In July 2005, China implemented a new managed floating exchange rate system. The RMB was allowed to fluctuate within a certain range, and the exchange rate (pegged to the US dollar] was converted to a basket of currencies [7]. This reform led to the appreciation of the RMB [8]. However, by 2014, China's economic environment had changed, and the RMB exchange rate was facing pressure from depreciation. From August 11, 2015, to 2017, China continued to optimize the central parity quotation mechanism for the RMB exchange rate and gradually formed the current three-factor formula for the central parity rate: "the closing price of the previous trading day + the change in the exchange rate of a basket of currencies + the countercyclical factor" [9]. In contrast, the US uses a floating exchange rate, where the exchange rate is determined by supply and demand in the foreign exchange market [10]. Since early 2022, to mitigate inflation, the US began to continuously increase its interest rate, which has resulted in a depreciation in the dollar exchange rate [11].

Figure 3. SSE Composite Index [4]

1.3. The Relationship Between the Exchange Rate and the Stock Market

A range of studies have analyzed the relationship between the exchange rate and the stock market from different aspects, and the results are ambiguous. Some researchers found a bilateral mean spillover effect between the two markets [12], while others have found a unilateral or no correlation between the two economic variables [13, 14]. Many researchers have further discussed the second moment spillover effect between the two markets and also found mixed correlations [15-17]. Even though the correlation between the two markets is ambiguous, most studies have achieved a consensus that during a crisis, the relationship between the exchange rate and the stock market is stronger [15]. This study seeks to discuss three key problems: the first one is to explore the mean spillover, volatility spillover effects between the exchange and stock market in the US and China; secondly, this article will compare whether the relationship between the two variables are different during times of crisis and calm periods; thirdly, this article intends to further explore if these spillover effects are different between domestic-oriented markets and export-oriented stock markets.

2. LITERATURE REVIEW

2.1. First Moment Relationship: the Mean Effect

Firstly, a range of studies have investigated the first moment relationship between the exchange rate and the stock market, with mixed results. Some studies find a unilateral relationship between exchange rates and stock returns, while others reveal a bilateral relationship or no connections between the series. The majority of the first moment studies find a unilateral relationship between the exchange rate and the stock market, though it remains uncertain which series is the dominant one in the causal relationship. A range of studies find that the effect is transmitted from the stock market to the exchange market. Salimi’s [18] study proved that the stock market has a significant impact on the exchange rate in East Asian countries. Furthermore, Yang and Doong [19] proved that the stock market leads the exchange market in the first moment spillover effect in G7 countries. In contrast to the hypothesis that the stock market leads the transmission, some studies prove that the exchange market dominates the transmission mechanism. According to Saumitra and Bhaduri [20], the stock return reacts significantly to foreign exchange rate fluctuations in the post-crisis period.

Moreover, Mitra [21] and Koutmos and Martin [22] found that exchange rate risk has a significant impact on the stock market. Furthermore, Krishnan and Dagar [1] stated that although stock prices do not have a significant relationship with the exchange rate, they found a positive relationship between the exchange rate and the stock volume traded in the selected countries. On the other hand, some studies find a bilateral relationship between stock returns and exchange rates. For example, Inci and Lee [12] found a mutual causation between exchange rate changes and stock returns with the Granger causality test. Furthermore, Sikhosana and Aye [23] also reported bidirectional volatility spillovers between stock and foreign exchange markets in the short term. Additionally, some cross-sectional studies find miscellaneous results in their researched countries. Sun and Sui [24]; Dahir et al. [25]; and Chkili and Nguyen [26] all studied the link between exchange rates and stock market returns in the BRICS countries; their results indicated that the interrelationship between exchange rates and stock markets varies across different countries. In comparison, Olson and Nusair [27] found that in G7 countries, the foreign exchange market and the stock market usually influence each other in the short term. In the long run, the stock market usually influences the exchange market. Even though numerous studies have proven there is a significant relationship between the exchange rate and the stock market, Nieh and Lee [13] failed to find a long-term significant relationship between stock prices and exchange rates in G7 countries. Furthermore, Engle [28] and Zhao [16] also found there is no significant mean spillover effect between exchange rate and stock markets.

2.2. Second Moment Relationship: the Volatility Spillover Effect

Similar to research on the first moment relationship, studies on the second moment effect also find various results. Some studies have proven there is a bilateral relationship between the two markets. According to Bai and Koong [15], there is a significant parallel-inverse relationship between the US stock market and the US dollar, and the Chinese stock market and the exchange rate. Wu [17], Zhao [16], and Yadav and Sahu [29] also found a two-way volatility spillover effect between the stock and foreign exchange markets in Asian countries. Additionally, a considerable number of studies find a unilateral volatility spillover effect between stock returns and the exchange rate; some of them indicate that the volatility spillover effect is transmitted from the exchange market to the stock market. For instance, the study of Bekaert [30] indicated that past exchange rate changes and forward premiums can predict future forward market returns. Other studies suggest that the stock market is at the leading position in the transmission mechanism between the two markets. Additionally, as claimed by Yang and Doong [19], there is a significant second moment volatility spillover from the stock market to the foreign exchange market for France, Italy, Japan, and the US.

2.3. Crisis Study

As discussed in Section 1, a considerable number of studies focus on the spillover effect between the exchange rate and the stock market during crisis periods. Bai and Koong [15] and Wu [17] studied the effect of exchange rate fluctuations on the international stock market during the 1997 Asian Financial Crisis; they discovered that exchange rates fluctuated during the Asian financial crisis, and the volatility greatly affected stock market returns. Moreover, a range of studies focuses on the relationship between the two variables during the 2008 financial crisis. Sun and Sui [24], Lin [31], and Ding and Pu [32] found that during the 2008-2009 financial crisis, the magnitude of the spillovers increased significantly, suggesting that the financial crisis exacerbated the spillovers from exchange rate shocks to stock returns. In addition, more and more studies pay attention to the relationship between the two variables during the pandemic. According to the findings of Krishnan and Dagar [1] and Yadav and Sahu [29], the connection between the exchange rate and the stock market

became stronger during the Covid-19 pandemic in India and China. Yadav and Sahu [29] also found that except for CNX Nifty and INR/GBP, the attraction of stocks to the FX market strength increased in the post-Covid period. Moreover, Rehman et al., [33] also showed that exchange rate volatility and stock return volatility were connected during pandemic-induced rises in BRICS countries.

2.4. Transmission Mechanism

There are a range of empirical results proving that the stock market and the exchange market can affect each other. Numerous studies further discuss the transmission mechanism between the two variables. The two most popular hypotheses for the transmission mechanism between the two markets are the flow-oriented model and the stock-oriented model. The flow-oriented model was first proposed by Dornbusch and Fischer [34]; this model posits that exchange rate fluctuations affect international competitiveness and trade balances, which consequently influence the output of a country, and thus affect the current cash flow and future cash flow of companies. This then affects the stock price in these countries. In contrast, the stock-oriented model indicates that the exchange rate is affected by changes in stock prices through the capital account [35]. This model postulates that movements in the stock market cause funds to flow into or out of the country. This affects the demand for money, resulting in changes in currency price, and thus influences the exchange rate. Numerous researchers have investigated these two models, while many of them focused on the direction of the causality between the two variables, as discussed in sections 2.2 and 2.3. On the other hand, some researchers pay attention to different aspects of these two models. Lin [31] tested whether the relationship between the exchange rate and the stock market would vary across different industries. This study affirms that the relationship between the exchange rate and the stock market cannot be attributed to the export-oriented industry; this indicates that the co-movement between the exchange and stock markets in Asia is mainly driven by the capital account rather than trade flows, which is in line with the “stock-oriented” model.

3. METHODOLOGY

3.1. Mean and Volatility Spillover Effect: VAR Model

As suggested by Phylaktis and Ravazzolo [36], this literature will utilize the VAR model to estimate the first moment spillover effect, volatility spillover effect and the leverage spillover effect.

Where the first moment spillover is estimated by:

$$\mathrm{Ru_t} = \mu_{10} + \tau_{11}\,\mathrm{Ru_{t-1}} + \tau_{12}\mathrm{suc_{t-1}} + \tau_{13}\,\mathrm{Rc_{t-1}} + \varepsilon_{1t} \tag{1.1}$$

$$\mathrm{Suc_t} = \mu_{20} + \tau_{21}\,\mathrm{Ru_{t-1}} + \tau_{22}\mathrm{suc_{t-1}} + \tau_{23}\,\mathrm{Rc_{t-1}} + \varepsilon_{2t} \tag{1.2}$$

$$\mathrm{Rc_t} = \mu_{30} + \tau_{31}\,\mathrm{Ru_{t-1}} + \tau_{32}\mathrm{suc_{t-1}} + \tau_{33}\,\mathrm{Rc_{t-1}} + \varepsilon_{3t} \tag{1.3}$$

The expanded version of the VAR model could be shown as:

$$\begin{bmatrix} Ru_t \\ Suc_t \\ Rc_t \end{bmatrix} = \begin{bmatrix} \mu 10 \\ \mu 20 \\ \mu 30 \end{bmatrix} + \begin{bmatrix} \tau 11\, \tau 12\, \tau 13 \\ \tau 21\, \tau 22\, \tau 23 \\ \tau 31\, \tau 32\, \tau 33 \end{bmatrix} * \begin{bmatrix} Ru,_{t-1} \\ Suc,_{t-1} \\ Rc,_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} \tag{2}$$

Where Rut, Suct, Rct, are stock return on S&P500, USD/CNY exchange rate return and stock return on SSE 50 index, respectively, while Rut- 1, Suct-1, Rct-1 represents the vector of one order lagged term that contains the S&P500 return, the USD/CNY exchange rate return, and SSE50 returns. μi is the constant vector, the coefficient matrix τi is used to reflect the effect of the i(th) order lagged term of the vector Rut, Suct and Rct, the Ɛit is the random error term of the parameter in the t(th) period.

The volatility spillover effect is estimated by:

$$vru_t = \alpha_{10} + \beta_{11} vru_{t-1} + \beta_{12} vsuc_{t-1} + \beta_{13} vrc_{t-1} + u_{1t} \quad (3.1)$$

$$vsuc_t = \alpha_{20} + \beta_{21} vru_{t-1} + \beta_{22} vsuc_{t-1} + \beta_{23} vrc_{t-1} + u_{2t} \quad (3.2)$$

$$vrc_t = \alpha_{30} + \beta_{31} vru_{t-1} + \beta_{32} vsuc_{t-1} + \beta_{33} vrc_{t-1} + u_{3t} \quad (3.3)$$

Where vru_t, $vsuc_t$, vrc_t are the volatility of the stock return on S&P500, USD/CNY exchange rate return and stock return on SSE 50, respectively, while $vru_{t-1}, vsuc_{t-1}, vrc_{t-1}$ represent the vector of one order lagged term that contain the volatility of the stock return on S&P500, USD/CNY exchange rate return and stock return on SSE 50. The α_i is the constant vector, the coefficient matrix β_i is used to reflect the effect of the i(th) order lagged term of the vector vru_t, $vsuc_t$, vrc_t, the u_{it} is the random error term of the parameter in the t(th) period.

3.2. Across Industry Study

As suggested by Lin (31), this study will further test whether the spillover effect is stronger in specific industries/companies compared with domestic industries/companies. The method is to create an index for a list of companies that focus on the domestic market with limited imports or exports. Then another stock return index will be constructed for a range of companies that focus on the trade between China and the United States, the spillover effect will be compared across these two indexes.

Where the first moment spillover for the export oriented and domestic oriented stock market and the exchange market are estimated by Equation 4 and Equation 5, respectively:

$$Reu_t = \mu'_{10} + \tau'_{11} Reu_{t-1} + \tau'_{12} suc_{t-1} + \tau'_{12} Rdu_{t-1} + \varepsilon'_{1t} \quad (4.1)$$

$$Suc_t = \mu'_{20} + \tau'_{21} Reu_{t-1} + \tau'_{22} suc_{t-1} + \tau'_{23} Rdu_{t-1} + \varepsilon'_{2t} \quad (4.2)$$

$$Rec_t = \mu'_{30} + \tau'_{31} Reu_{t-1} + \tau'_{32} suc_{t-1} + \tau'_{33} Rdu_{t-1} + \varepsilon'_{3t} \quad (4.3)$$

$$Rdu_t = \mu''_{10} + \tau''_{11} Rdu_{t-1} + \tau''_{12} suc_{t-1} + \tau''_{12} Rdu_{t-1} + \varepsilon''_{1t} \quad (4.4)$$

$$Suc_t = \mu''_{20} + \tau''_{21} Rdu_{t-1} + \tau''_{22} suc_{t-1} + \tau''_{23} Rdu_{t-1} + \varepsilon''_{2t} \quad (4.5)$$

$$Rdc_t = \mu''_{30} + \tau''_{31} Rdu_{t-1} + \tau''_{32} suc_{t-1} + \tau''_{33} Rdu_{t-1} + \varepsilon''_{3t} \quad (4.6)$$

Where Reut, Rect, are stock return index on Unites States export-oriented companies and stock return on Chinese export-oriented companies respectively, while Rdut, Rdct represent the domestic-oriented indexes. While Reut- 1 Rect- 1; and Rdut- 1 Rdct- 1 represents the vector of one order lagged terms. μ'i and μ''i is the constant vector, the coefficient matrix τ'i and τ''i is used to reflect the effect of the i(th) order lagged terms, the Ɛ'it and Ɛ''it is the random error term of the parameter in the t(th) period.

And the volatility result is shown as:

$$vreu_t = \alpha'_{10} + \beta'_{11} vreu_{t-1} + \beta'_{12} vsuc_{t-1} + \beta'_{13} vrec_{t-1} + u'_{1t} \quad (6.1)$$

$$vsuc_t = \alpha'_{20} + \beta'_{21} vreu_{t-1} + \beta'_{22} vsuc_{t-1} + \beta'_{23} vrec_{t-1} + u'_{2t} \quad (6.2)$$

$$vrec_t = \alpha_{30} + \beta'_{31} vreu_{t-1} + \beta'_{32} vsuc_{t-1} + \beta'_{33} vrec_{t-1} + u'_{3t} \quad (6.3)$$

$$\mathrm{vreu_t} = \alpha''_{10} + \beta''_{11}\mathrm{vreu_{t-1}} + \beta''_{12}\mathrm{vsuc_{t-1}} + \beta''_{13}\mathrm{vrec_{t-1}} + u''_{1t} \quad (7.1)$$

$$\mathrm{vsuc_t} = \alpha''_{20} + \beta''_{21}\mathrm{vreu_{t-1}} + \beta''_{22}\mathrm{vsuc_{t-1}} + \beta''_{23}\mathrm{vrec_{t-1}} + u''_{2t} \quad (7.2)$$

$$\mathrm{vrec_t} = \alpha''_{30} + \beta''_{31}\mathrm{vreu_{t-1}} + \beta''_{32}\mathrm{vsuc_{t-1}} + \beta''_{33}\mathrm{vrec_{t-1}} + u''_{3t} \quad (7.3)$$

Where vreut, vrect, are stock return index on Unites States export-oriented companies and stock return on Chinese export-oriented companies respectively, while vrdut, vrdct represent the domestic-oriented indexes. While vreut-1, vrect-1 and vrdut-1 , vrdct-1 represents the vector of one order lagged terms. α'i and α"i is the constant vector, the coefficient matrix β'i and β"i is used to reflect the effect of the i(th) order lagged terms, the u'it and u''it is the random error term of the parameter in the t(th) period.

4. DATA SELECTION AND EMPIRICAL FINDINGS:

4.1. The mean Spillover Effect

I aim to use daily data on the USD/CNY nominal exchange rate return, the US SP500 return and the China SSE50 return. The data for nominal exchange rate are selected from Wind [37], and the stock return are selected from Yahoo Finance [3, 4]. As suggested by Zeng et al., (2022), the daily returns are calculated by the following equation: rt = 100% ln (Pt/Pt-1), where Pt is the close price on day t.

4.1.1. Data

I am going to analyse three sub-periods based on changes in market conditions. The first stage is the moderation period, from China's announcement of the third exchange rate reform to the beginning of the Covid- 19 pandemic (from August 12 2015 to December 1, 2019). After the third exchange rate reform, the RMB exchange rate was closer to a floating rate, more

accurately reflecting the influence of the market. The second phase is from December 1 2019 to December 31 2022, which is the Covid-19 period.

Table 1. Descriptive statistics of stock return and exchange rate returns

(a) Full sample: August 12, 2015 - December 31, 2022

	Ru	Rc	Suc
Mean	-1.78316E-05	0.000508643	0.000306312
Median	0.000630502	0.000672495	0.000515385
Standard Deviation	0.01195767	0.009918958	0.00737917
Variance	0.000142986	9.83857E-05	5.44521E-05
Minimum	-0.084906521	-0.035649753	-0.0302
Maximum	0.05711413	0.034335693	0.0303
25th Percentile	-0.005523345	-0.003516292	-0.00265
50th Percentile	0.000630502	0.000672495	0.000515385
75th Percentile	0.00562196	0.005600355	0.00375
Skewness	-0.872517399	-0.356441906	-0.015934548
Kurtosis	6.152772088	1.592881802	3.036378987

(b) Sample 2: August 12, 2015 - December 1, 2019

	Ru	Rc	Suc
Mean	-2.18928E-05	0.000459676	0.000494269
Median	0.000750155	0.000642827	0.0006
Standard Deviation	0.012500343	0.008359611	0.007030346
Variance	0.000156259	6.98831E-05	4.94258E-05
Minimum	-0.084906521	-0.032864176	-0.0295
Maximum	0.056004679	0.034335693	0.0303
25th Percentile	-0.004990517	-0.002457327	-0.00224
50th Percentile	0.000750155	0.000642827	0.0006
75th Percentile	0.004974691	0.004570474	0.003925
Skewness	-0.989722249	-0.526016699	-0.13931622
Kurtosis	7.100751954	2.461252974	3.683070326

(c) Sample 3: December 1, 2019 - December 31, 2022

	Ru	Rc	Suc
Mean	-1.21582E-05	0.000577048	4.37404E-05
Median	0.000134608	0.000724675	0.00015
Standard Deviation	0.011160938	0.011759798	0.007836178
Variance	0.000124567	0.000138293	6.14057E-05
Minimum	-0.077244308	-0.035649753	-0.0302
Maximum	0.05711413	0.034056426	0.0302
25th Percentile	-0.005818729	-0.006303611	-0.003475
50th Percentile	0.000134608	0.000724675	0.00015
75th Percentile	0.006523935	0.007500104	0.003385
Skewness	-0.630376985	-0.257652749	0.128295209
Kurtosis	3.72014584	0.629983481	2.357872326

As shown in above, in the full sample period (August 12, 2015 - December 31, 2022), the volatility of stock returns for both the US and China (`Ru` and `Rc`) is notably high, with `Ru` exhibiting a larger standard deviation and variance compared to `Rc`, indicating a more pronounced fluctuation. In contrast, the exchange rate return (`Suc`) shows the lowest volatility, suggesting relative stability throughout this period. During the stable period (August 12, 2015 - December 1, 2019) a reduction in the volatility of `Rc` reflects more stable market conditions, whereas the volatility of `Ru` slightly increases. The crisis period (December 1, 2019 - December 31, 2022) reveals a substantial rise in the volatility of both `Ru` and `Rc`, with `Rc` experiencing a significant increase in standard deviation and variance, indicating heightened market instability. The exchange rate return also displays increased volatility during this period, underscoring a broader trend of heightened market fluctuations. The data suggests that market volatility was lower during the stable period and significantly elevated during the crisis period, which is align with the previous studies' results, that the market returns would fluctuated more dramatically during crisis period. And this research will further discuss the potential reason of that.

4.1.2. Empirical Results:

Table 2. Results of ADF Stationarity Test

(a) Full sample: August 12, 2015 - December 31, 2022

Column	Ru	Rc	Suc
ADF Statistic	-27.69551134	-26.12904313	-21.89648388
p-value	0	0	0
Lags Used	1	2	27
Number of Observations Used	2697	2696	2671
Critical Value (1%)	-3.432776969	-3.43277787	-3.432800616
Critical Value (5%)	-2.862612256	-2.862612654	-2.8626227
Critical Value (10%)	-2.567340798	-2.56734101	-2.567346358

(b) Sample 2: August 12, 2015 - December 1, 2019

Column	Ru	Rc	Suc
ADF Statistic	-21.85154815	-11.8801612	-19.29004029
p-value	0	6.20495E-22	0
Lags Used	1	8	5
Number of Observations Used	1571	1564	1567
Critical Value (1%)	-3.43451933	-3.434538021	-3.43452999
Critical Value (5%)	-2.863381509	-2.863389759	-2.863386215
Critical Value (10%)	-2.567750387	-2.56775478	-2.567752893

(c) Sample 3: December 1, 2019 - December 31, 2022

Column	Ru	Rc	Suc
ADF Statistic	-15.71401667	-8.492865244	-10.63899664
p-value	1.34871E-28	1.29921E-13	4.98611E-19
Lags Used	2	14	19
Number of Observations Used	1123	1111	1106
Critical Value (1%)	-3.43618643	-3.436249616	-3.436276349
Critical Value (5%)	-2.864117117	-2.86414499	-2.864156782
Critical Value (10%)	-2.568142129	-2.568156974	-2.568163255

I conducted the Augmented Dickey-Fuller (ADF) test to assess the stationarity of the log returns for the SSE 50 Index, SPX 500 stock index, and the exchange rate return between US and China. The lag length was selected according to the Schwarz Criterion (SC). The results, presented in Table 2, indicate that the ADF statistics for all variables are significantly lower than their corresponding critical values, with p-values far below common significance levels, and the ADF statistics are well below the 5% critical values, demonstrating that the time series for all three samples across different periods are stationary.

Table 3. Vector Autoregression Model

(a) Full sample: August 12, 2015 - December 31, 2022

	SUC	RU	RC
SUC(-1)	0.3205969... 0.0193034... [16.6083]	-0.0096091... 0.0269571... [-0.35646]	0.0294175... 0.0321079... [0.91621]
SUC(-2)	0.1371886... 0.0192206... [7.13758]	-0.0144311... 0.0268414... [-0.53764]	-0.0432858... 0.0319701... [-1.35395]
RU(-1)	-0.0851117... 0.0138548... [-6.14311]	0.2915097... 0.0193481... [15.0665]	0.1792341... 0.0230451... [7.77754]
RU(-2)	0.0261677... 0.0140707... [1.85973]	0.0829375... 0.0196497... [4.22081]	-0.0198584... 0.0234042... [-0.84850]
RC(-1)	0.0118989... 0.0116944... [1.01749]	-0.0118112... 0.0163311... [-0.72323]	0.2673452... 0.0194516... [13.7441]
RC(-2)	-0.0158405... 0.0115866... [-1.36714]	-0.0039109... 0.0161807... [-0.24171]	0.0912695... 0.0192724... [4.73576]
C	0.0001940... 0.0001299... [1.49333]	0.0003254... 0.0001814... [1.79310]	-9.1011271... 0.0002161... [-0.42104]

(b) Sample 2: August 12, 2015 - December 1, 2019

	SUC	RU	RC
SUC(-1)	0.3115458... 0.0250798... [12.4221]	-0.0356735... 0.0306131... [-1.16530]	0.0321341... 0.0456367... [0.70413]
SUC(-2)	0.1405982... 0.0250014... [5.62360]	-0.0052117... 0.0305174... [-0.17078]	-0.0048786... 0.0454940... [-0.10724]
RU(-1)	-0.0884133... 0.0208642... [-4.23756]	0.3056367... 0.0254673... [12.0011]	0.2834725... 0.0379656... [7.46655]
RU(-2)	0.0479644... 0.0212958... [2.25230]	0.0885205... 0.0259942... [3.40539]	-0.0308393... 0.0387510... [-0.79583]
RC(-1)	-0.0042991... 0.0140049... [-0.30697]	-0.0232918... 0.0170947... [-1.36251]	0.2354742... 0.0254841... [9.24002]
RC(-2)	-0.0079770... 0.0137884... [-0.57853]	0.0002695... 0.0168305... [0.01602]	0.0815284... 0.0250902... [3.24941]
C	0.0002893... 0.0001637... [1.76667]	0.0002979... 0.0001999... [1.49016]	-0.0001526... 0.0002980... [-0.51227]

(c) Sample 3: December 1, 2019 - December 31, 2022

	SUC	RU	RC
SUC(-1)	0.3400353... 0.0306203... [11.1049]	0.0271407... 0.0483011... [0.56191]	0.0318233... 0.0444745... [0.71554]
SUC(-2)	0.1256305... 0.0304473... [4.12616]	-0.0282608... 0.0480282... [-0.58842]	-0.0754169... 0.0442232... [-1.70537]
RU(-1)	-0.0813443... 0.0189782... [-4.28620]	0.2835078... 0.0299366... [9.47028]	0.1097297... 0.0275649... [3.98077]
RU(-2)	0.0112317... 0.0192053... [0.58482]	0.0795053... 0.0302949... [2.62438]	-0.0125072... 0.0278948... [-0.44837]
RC(-1)	0.0424181... 0.0210761... [2.01262]	0.0105524... 0.0332458... [0.31741]	0.3072408... 0.0306120... [10.0366]
RC(-2)	-0.0369507... 0.0210036... [-1.75925]	-0.0158163... 0.0331316... [-0.47738]	0.1074643... 0.0305068... [3.52263]
C	5.9195325... 0.0002115... [0.27980]	0.0003655... 0.0003337... [1.09532]	-5.7838406... 0.0003072... [-0.18823]

Standard errors in ( ) & t-statistics in [ ]

The empirical analysis demonstrates that each variable: the exchange rate return (SUC), US S&P 500 stock returns (RU), and Chinese SSE 50 stock returns (RC) has a significant impact on itself across all time periods, regardless of whether the lag is one period or two periods.

In terms of cross-variable effects, the US stock return exhibits a consistently significant influence on the exchange rate return (SUC) across all periods, irrespective of the lag length. This suggests a stable and robust relationship between the US stock market and the exchange rate return. However, the impact of the US stock return on Chinese stock returns (RC) is significant only in the case of a one-period lag, with no significant effect observed for the two-period lag across any of the periods analyzed.

Regarding the impact of Chinese stock returns (RC) on other variables, the exchange rate return (SUC) is significantly influenced by Chinese stock returns solely during the crisis period. There is no significant effect during the full sample or stable periods.

While the exchange market fail to show any significance influence on other markets in all three period.

Table 4. VAR Lag Exclusion Wald Tests

(a) Full sample: August 12, 2015 - December 31, 2022

Chi-squared test statistics for lag exclusion:
Numbers in [ ] are p-values

	D(SUC)	D(RU)	D(RC)	Joint
DLag 1	675.47497... [0.0000]	237.38472... [0.0000]	422.72850... [0.0000]	1229.1793... [0.0000]
DLag 2	128.67873... [0.0000]	43.589508... [0.0000]	82.186013... [0.0000]	236.44431... [0.0000]
df	3	3	3	9

(b) Sample 2: August 12, 2015 - December 1, 2019

Chi-squared test statistics for lag exclusion:
Numbers in [ ] are p-values

	SUC	RU	RC	Joint
Lag 1	180.02456... [0.0000]	146.93357... [0.0000]	163.48093... [0.0000]	460.05082... [0.0000]
Lag 2	36.296417... [0.0000]	11.979625... [0.0075]	10.789090... [0.0129]	60.079662... [0.0000]
df	3	3	3	9

(c) Sample 3: December 1, 2019 - December 31, 202

Chi-squared test statistics for lag exclusion:
Numbers in [ ] are p-values

	D(SUC)	D(RU)	D(RC)	Joint
DLag 1	274.65008... [0.0000]	23.978763... [0.0000]	255.19612... [0.0000]	509.15744... [0.0000]
DLag 2	57.361069... [0.0000]	9.3499457... [0.0250]	33.178644... [0.0000]	91.378615... [0.0000]
df	3	3	3	9

As shown above, the Wald test results indicate that all lagged terms included in the model are statistically significant in the three sample periods, both individually and jointly. This supports the robustness of the model's specification, emphasizing that the lag structure effectively captures the temporal dynamics between the Chinese stock market, the U.S. stock markets and the exchange market.

Table 5. Granger Causality Test:

(a) Full sample: August 12, 2015 - December 31, 2022

Dependent Variable	Excluded Variable	Chi-sq	df
SUC	RU	19.0492311	2
	RC	0.560014357	2
RU	SUC	1.756453504	2
	RC	1.980580229	2
RC	SUC	0.520130387	2
	RU	57.93957355	2

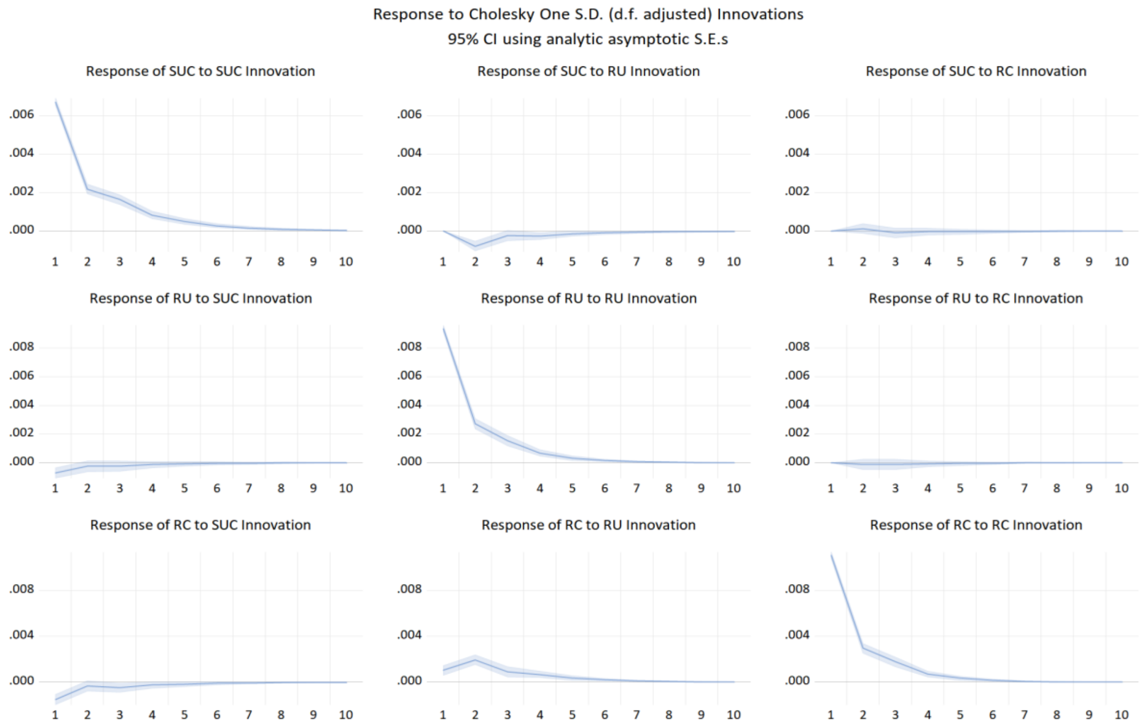
(b) Sample 2: August 12, 2015 - December 1, 2019

Dependent Variable	Excluded Variable	Chi-sq	df
SUC	RU	19.0492311	2
	RC	0.560014357	2
RU	SUC	1.756453504	2
	RC	1.980580229	2
RC	SUC	0.520130387	2
	RU	57.93957355	2

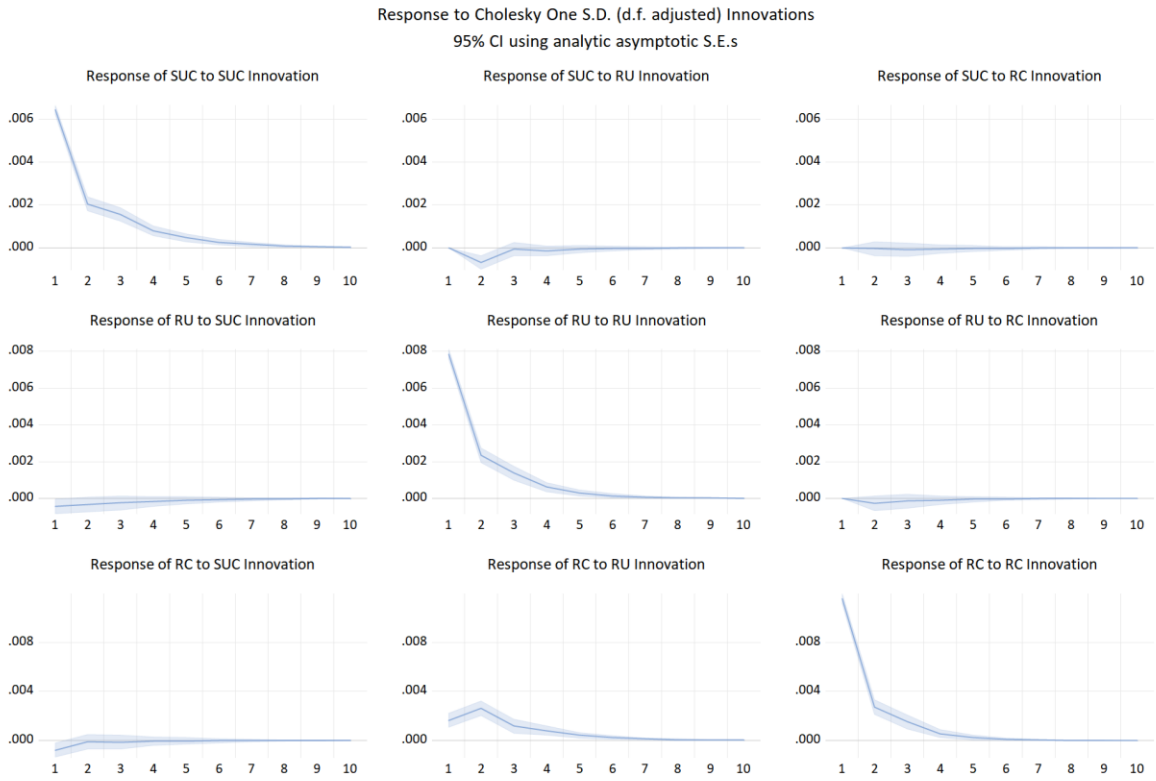
(c) Sample 3: December 1, 2019 - December 31, 2022

Dependent Variable	Excluded Variable	Chi-sq	df
SUC	RU	18.82787159	2
	RC	5.294416143	2
RU	SUC	0.476782029	2
	RC	0.252740738	2
RC	SUC	2.911408371	2
	RU	16.37416044	2

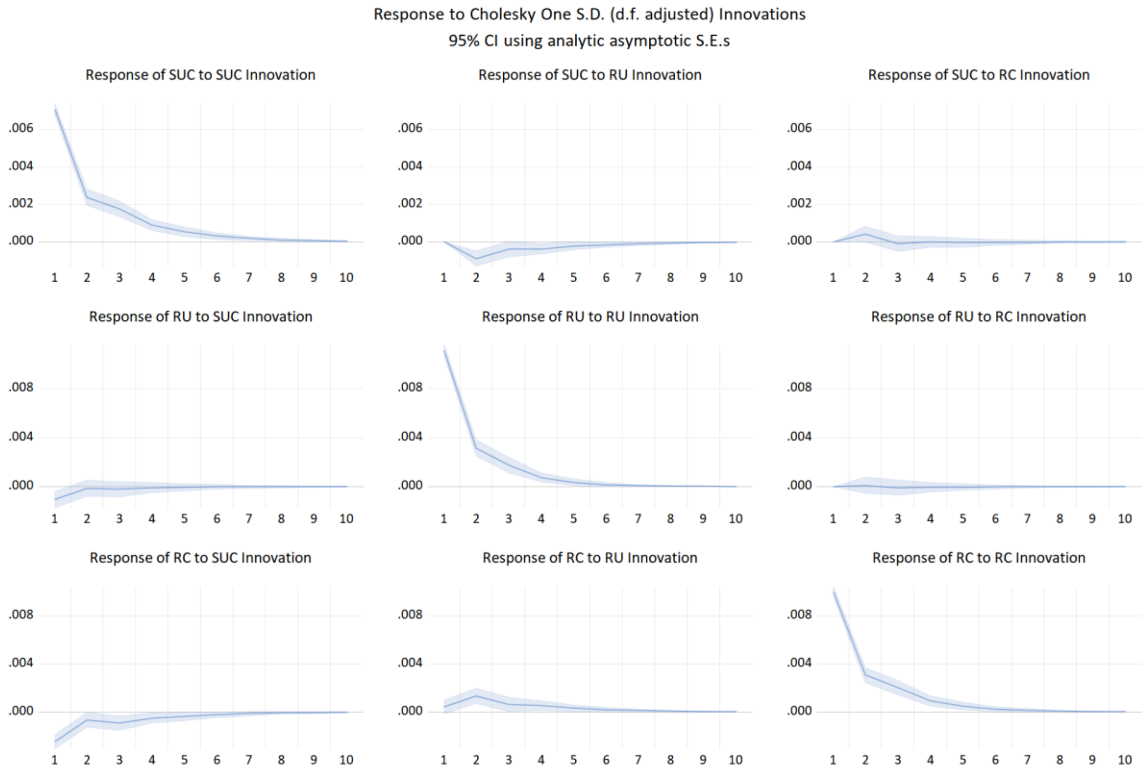
As shown above, the United Stock market shows a significant predictive ability on exchange market and Chinese Stock market in three periods. Furthermore, China stock market shows a weak significant influence on future exchange rate return only in crisis period. While exchange rate return fail to show any significant predictive ability on the stock markets in both countries. The result is consistent with the VAR test result, the spillover effect is proved to be transmitted from the stock to the exchange market, and during crisis period, the relationship between the stock market and exchange market could be more significant.



(a) Full sample: August 12, 2015 - December 31, 2022



(b) Sample 2: August 12, 2015 - December 1, 2019



(c) Sample 3: December 1, 2019 - December 31, 2022

Figure 4. Impulse Response Result

Based on the impulse response analysis results, this research observed the dynamic response characteristics of the exchange rate return, US stock returns, and Chinese stock returns when facing shocks. In the short term, all variables exhibit significant volatility in response to their own and other variables' shocks, which then gradually stabilize at a new level. This indicates that the market's response to short-term shocks is quite pronounced, but through self-adjustment mechanisms, the impact of these shocks tends to stabilize over the long term.

In addition, the exchange market and China stock market show volatility in response to United States stock markets, while the response is not considerable and stabilize in a short period.

4.2. The volatility Spillover Effect

4.2.1. Data

The volatility was calculated by the following equation:

$$v_{daily} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(\text{Return}_i - \overline{\text{Return}})^2} \quad (8)$$

4.2.2. Empirical Results

Table 6. Descriptive statistics

(a) Full sample: August 12, 2015 - December 31, 2022

	vrc	vru	vsuc
Mean	0.00842361	0.007294555	0.004546005
Median	0.006990685	0.005832575	0.003521346
Standard Deviation	0.006659328	0.005189267	0.004353245
Variance	4.43467E-05	2.69285E-05	1.89507E-05
Minimum	2.0957E-05	0.000108283	1.00E-16
Maximum	0.065815393	0.030140803	0.02201297
25th Percentile	0.004241217	0.003330327	0.000789633
50th Percentile	0.006990685	0.005832575	0.003521346
75th Percentile	0.010753649	0.010132266	0.006977179
Skewness	2.143901928	1.089363481	1.027605097
Kurtosis	7.635977103	0.807338355	0.526769164

(b) Sample 2: August 12, 2015 - December 1, 2019

	vrc	vru	vsuc
Mean	0.00863575	0.006018969	0.004291046
Median	0.006842601	0.004754972	0.003225695
Standard Deviation	0.007417895	0.004454763	0.004233052
Variance	5.50252E-05	1.98449E-05	1.79187E-05
Minimum	2.0957E-05	0.000108283	1.00E-16
Maximum	0.065815393	0.026863868	0.018607216
25th Percentile	0.003888335	0.00277805	0.000726722
50th Percentile	0.006842601	0.004754972	0.003225695
75th Percentile	0.011044177	0.007775721	0.006540499
Skewness	2.116814	1.359262421	1.056407149
Kurtosis	6.892030081	1.615037132	0.381593953

(c) Sample 3: December 1, 2019 - December 31, 2022

	vrc	vru	vsuc
Mean	0.008127256	0.009076523	0.004902179
Median	0.007195737	0.008089965	0.004103431
Standard Deviation	0.005414222	0.005603325	0.004493527
Variance	2.93138E-05	3.13972E-05	2.01918E-05
Minimum	5.47953E-05	0.000177326	7.13E-01
Maximum	0.04059502	0.030140803	0.02201297
25th Percentile	0.004851739	0.00464381	0.001002199
50th Percentile	0.007195737	0.008089965	0.004103431
75th Percentile	0.010309141	0.012700988	0.007447076
Skewness	1.817407311	0.754370704	0.980158661
Kurtosis	5.854342285	0.156508201	0.639489808

The above descriptive statistics for daily volatility data reveal the market's volatility characteristics and response patterns across different time periods. During the full sample period, the market exhibited high volatility and extreme values. In contrast, volatility was lower during the stable period. During the crisis period, market volatility increased significantly, and the distribution characteristics of the data indicated a heightened sensitivity to extreme events.

Table 7. Results of ADF Stationarity Test and Johansen Cointegration Test

(a) Full sample: August 12, 2015 - December 31, 2022

Column	vrc	vru	vsuc
ADF Statistic	-6.509849571	-5.217901797	-5.531103186
p-value	1.1074E-08	8.08157E-06	1.79E-06
Critical Value (1%)	-3.432801535	-3.432798781	-3.432801535
Critical Value (5%)	-2.862623105	-2.862621889	-2.862623105
Critical Value (10%)	-2.567346574	-2.567345926	-2.567346574

(b) Sample 2: August 12, 2015 - December 1, 2019

Column	vrc	vru	vsuc
ADF Statistic	-5.543223823	-5.855906181	-5.533981094
p-value	1.68325E-06	3.50069E-07	1.76165E-06
Critical Value (1%)	-3.434573182	-3.434546083	-3.43458138
Critical Value (5%)	-2.863405278	-2.863393318	-2.863408897
Critical Value (10%)	-2.567763044	-2.567756675	-2.567764971

(c) Sample 3: December 1, 2019 - December 31, 2022

Column	vrc	vru	vsuc
ADF Statistic	-6.437941823	-4.458433931	-6.220584238
p-value	1.63506E-08	0.000233593	5.23529E-08
Critical Value (1%)	-3.436249616	-3.436270983	-3.43628711
Critical Value (5%)	-2.86414499	-2.864154415	-2.864161529
Critical Value (10%)	-2.568156974	-2.568161994	-2.568165783

Based on the ADF test results, similar to the mean, the daily volatility of U.S. and Chinese stock returns, and exchange rate return are stationary across all sample periods (ADF statistics are well below the critical values, and p-values are significantly less than 0.05).

Table 8. Vector Autoregression Model

(a) Full sample: August 12, 2015 - December 31, 2022

	VSUC	VRU	VRC
VSUC(-1)	0.8430588... 0.0189542... [44.4787]	-0.0008804... 0.0174630... [-0.05042]	-0.0228641... 0.0232228... [-0.98455]
VSUC(-2)	-0.0917015... 0.0249009... [-3.68265]	-0.0844135... 0.0229418... [-3.67945]	-0.0740327... 0.0305087... [-2.42660]
VSUC(-3)	-0.0151662... 0.0250130... [-0.60633]	0.0013009... 0.0230451... [0.05645]	0.0280540... 0.0306461... [0.91542]
VSUC(-4)	0.0038839... 0.0249516... [0.15566]	0.0324745... 0.0229886... [1.41263]	0.0014479... 0.0305709... [0.04736]
VSUC(-5)	-0.1425156... 0.0249084... [-5.72158]	0.0343042... 0.0229488... [1.49482]	0.0626679... 0.0305180... [2.05348]
VSUC(-6)	0.1996184... 0.0189516... [10.5330]	-0.0065455... 0.0174607... [-0.37487]	-0.0586483... 0.0232197... [-2.52580]
VRU(-1)	0.0857370... 0.0208130... [4.11938]	0.9167375... 0.0191756... [47.8074]	0.0956761... 0.0255003... [3.75196]
VRU(-2)	-0.0439417... 0.0282614... [-1.55483]	-0.0502233... 0.0260380... [-1.92884]	-0.0549538... 0.0346261... [-1.58706]
VRU(-3)	-0.0929047... 0.0282889... [-3.28414]	-0.0299073... 0.0260633... [-1.14749]	-0.1198015... 0.0346597... [-3.45650]
VRU(-4)	0.0548221... 0.0283433... [1.93421]	-0.0147897... 0.0261134... [-0.56636]	0.0409374... 0.0347264... [1.17885]
VRU(-5)	-0.0195566... 0.0282462... [-0.69236]	-0.0905200... 0.0260240... [-3.47832]	0.0784854... 0.0346075... [2.26787]
VRU(-6)	0.0532501... 0.0208996... [2.54790]	0.1580683... 0.0192553... [8.20905]	0.0113966... 0.0256063... [0.44507]
VRC(-1)	0.0570131... 0.0156095... [3.65245]	0.0475767... 0.0143815... [3.30819]	0.9817259... 0.0191249... [51.3322]
VRC(-2)	-0.0033305... 0.0218071... [-0.15273]	-0.0670443... 0.0200914... [-3.33695]	-0.1327742... 0.0267182... [-4.96942]
VRC(-3)	-0.0383385... 0.0219370... [-1.74766]	0.0632145... 0.0202111... [3.12770]	-0.0078561... 0.0268773... [-0.29229]
VRC(-4)	-0.0274172... 0.0219515... [-1.24899]	-0.0360613... 0.0202245... [-1.78305]	0.0323157... 0.0268951... [1.20155]
VRC(-5)	-0.0115416... 0.0218303... [-0.52870]	0.0275592... 0.0201129... [1.37023]	-0.1658026... 0.0267467... [-6.19898]
VRC(-6)	0.0307295... 0.0156345... [1.96549]	0.0002774... 0.0144045... [0.01926]	0.1491780... 0.0191555... [7.78772]
C	0.0005912... 0.0001292... [4.57410]	0.0006204... 0.0001190... [5.20996]	0.0011166... 0.0001583... [7.05086]

(b) Sample 2: August 12, 2015 - December 1, 2019

	VSUC	VRU	VRC
VSUC(-1)	0.8902740...	-0.0336388...	-0.0247785...
	0.0248951...	0.0197591...	0.0332183...
	[35.7609]	[-1.70244]	[-0.74593]
VSUC(-2)	-0.1373612...	-0.0550012...	-0.0568913...
	0.0334469...	0.0265466...	0.0446292...
	[-4.10685]	[-2.07187]	[-1.27475]
VSUC(-3)	-0.0204183...	0.0041673...	0.0040242...
	0.0336767...	0.0267290...	0.0449359...
	[-0.60630]	[0.15591]	[0.08956]
VSUC(-4)	0.0136532...	0.0103724...	0.0154501...
	0.0336359...	0.0266966...	0.0448815...
	[0.40591]	[0.38853]	[0.34424]
VSUC(-5)	-0.1634485...	0.0710103...	0.0454843...
	0.0334251...	0.0265293...	0.0446001...
	[-4.88999]	[2.67667]	[1.01982]
VSUC(-6)	0.2038680...	-0.0466636...	-0.0461331...
	0.0250089...	0.0198494...	0.0333701...
	[8.15182]	[-2.35088]	[-1.38247]
VRU(-1)	0.0824564...	0.9059982...	0.1264406...
	0.0314580...	0.0249680...	0.0419754...
	[2.62116]	[36.2863]	[3.01225]
VRU(-2)	-0.0727469...	-0.0320549...	-0.0490641...
	0.0424961...	0.0337290...	0.0567039...
	[-1.71185]	[-0.95037]	[-0.86527]
VRU(-3)	-0.0471638...	-0.0523502...	-0.1648874...
	0.0425442...	0.0337671...	0.0567681...
	[-1.10858]	[-1.55033]	[-2.90458]
VRU(-4)	0.0170063...	-0.0133352...	0.0311077...
	0.0426455...	0.0338475...	0.0569033...
	[0.39878]	[-0.39398]	[0.54668]
VRU(-5)	0.0206268...	-0.1358173...	0.1909289...
	0.0425477...	0.0337699...	0.0567728...
	[0.48479]	[-4.02184]	[3.36304]
VRU(-6)	0.0151168...	0.1859309...	-0.0677796...
	0.0312447...	0.0247987...	0.0416908...
	[0.48382]	[7.49758]	[-1.62577]
VRC(-1)	0.0439007...	0.0431459...	0.9826509...
	0.0188645...	0.0149726...	0.0251715...
	[2.32716]	[2.88164]	[39.0382]
VRC(-2)	0.0002364...	-0.0318123...	-0.1313590...
	0.0263787...	0.0209366...	0.0351980...
	[0.00896]	[-1.51946]	[-3.73200]
VRC(-3)	-0.0458735...	0.0286372...	-0.0282525...
	0.0264985...	0.0210317...	0.0353578...
	[-1.73117]	[1.36162]	[-0.79905]
VRC(-4)	-0.0100974...	-0.0245172...	0.0452022...
	0.0264842...	0.0210203...	0.0353387...
	[-0.38126]	[-1.16635]	[1.27912]
VRC(-5)	-0.0126466...	0.0222442...	-0.1293328...
	0.0263488...	0.0209129...	0.0351581...
	[-0.47997]	[1.06366]	[-3.67860]
VRC(-6)	0.0208884...	0.0126795...	0.1291551...
	0.0189482...	0.0150391...	0.0252832...
	[1.10239]	[0.84310]	[5.10832]
C	0.0008574...	0.0006342...	0.0010044...
	0.0001689...	0.0001340...	0.0002254...
	[5.07592]	[4.73041]	[4.45592]

(c) Sample 3: December 1, 2019 - December 31, 2022

	VSUC	VRU	VRC
VSUC(-1)	0.7691989...	0.0421076...	-0.0139766...
	0.0295418...	0.0312582...	0.0316151...
	[26.0376]	[1.34709]	[-0.44209]
VSUC(-2)	-0.0428254...	-0.1146473...	-0.0921331...
	0.0374461...	0.0396217...	0.0400742...
	[-1.14365]	[-2.89355]	[-2.29906]
VSUC(-3)	0.0002427...	-0.0119422...	0.0626159...
	0.0375538...	0.0397357...	0.0401894...
	[0.00646]	[-0.30054]	[1.55802]
VSUC(-4)	-0.0071161...	0.0517077...	-0.0086864...
	0.0373948...	0.0395675...	0.0400193...
	[-0.19030]	[1.30682]	[-0.21706]
VSUC(-5)	-0.1200458...	-0.0029030...	0.0927680...
	0.0374566...	0.0396328...	0.0400854...
	[-3.20493]	[-0.07325]	[2.31426]
VSUC(-6)	0.1824696...	0.0381927...	-0.0707781...
	0.0293506...	0.0310558...	0.0314105...
	[6.21690]	[1.22981]	[-2.25333]
VRU(-1)	0.0930996...	0.9093069...	0.0796528...
	0.0284012...	0.0300513...	0.0303945...
	[3.27801]	[30.2584]	[2.62063]
VRU(-2)	-0.0265710...	-0.0656768...	-0.0581815...
	0.0383107...	0.0405365...	0.0409994...
	[-0.69357]	[-1.62019]	[-1.41908]
VRU(-3)	-0.1260868...	-0.0140976...	-0.0984683...
	0.0383599...	0.0405886...	0.0410521...
	[-3.28694]	[-0.34733]	[-2.39861]
VRU(-4)	0.0819097...	-0.0177152...	0.0510800...
	0.0383899...	0.0406204...	0.0410842...
	[2.13362]	[-0.43612]	[1.24330]
VRU(-5)	-0.0472087...	-0.0615126...	-0.0004496...
	0.0381972...	0.0404165...	0.0408780...
	[-1.23592]	[-1.52197]	[-0.01100]
VRU(-6)	0.0823162...	0.1228705...	0.0738865...
	0.0286477...	0.0303121...	0.0306583...
	[2.87339]	[4.05351]	[2.41000]
VRC(-1)	0.1037719...	0.0520403...	0.9657307...
	0.0277639...	0.0293770...	0.0297125...
	[3.73765]	[1.77146]	[32.5025]
VRC(-2)	-0.0154969...	-0.1288395...	-0.1315979...
	0.0381712...	0.0403889...	0.0408502...
	[-0.40599]	[-3.18997]	[-3.22148]
VRC(-3)	-0.0216687...	0.1290385...	0.0195307...
	0.0384756...	0.0407110...	0.0411759...
	[-0.56318]	[3.16962]	[0.47433]
VRC(-4)	-0.0597480...	-0.0587737...	0.0063102...
	0.0385860...	0.0408278...	0.0412941...
	[-1.54844]	[-1.43955]	[0.15281]
VRC(-5)	-0.0151240...	0.0449036...	-0.2278123...
	0.0383774...	0.0406071...	0.0410708...
	[-0.39409]	[1.10581]	[-5.54681]
VRC(-6)	0.0714790...	-0.0223285...	0.1623327...
	0.0279931...	0.0296195...	0.0299577...
	[2.55345]	[-0.75384]	[5.41872]
C	3.4725130...	0.0010142...	0.0013885...
	0.0002265...	0.0002397...	0.0002424...
	[0.15327]	[4.23097]	[5.72690]

Standard errors in ( ) & t-statistics in [ ]

From the Table 8, the USD/CNY exchange market demonstrates a relatively stable spillover effect on U.S.SPX 500 stock market during stable periods, with significance observed in approximately four out of six lags, while the influence of exchange return on China SSE 50 stock return is unstable, it shows higher significance during crisis period.

What's more, SPX 500 indicates a significant volatility spillover effect on SSE 50 return and the USD/CNY exchange rate return. Moreover, its volatility spillover on the exchange rate return is stronger during crisis period.

In addition, the effect of China stock market on exchange return is consistently stable across different periods, while it only shows stable significant impact on US stock market in crisis period; China stock market's impact on the exchange rate return is stable only during the first two lag periods, indicating a lack of sustained influence beyond these periods, while it exhibits a significant effect on the U.S. stock market primarily during volatile periods.

Table 9. VAR Lag Exclusion Wald Tests

(a) Full sample: August 12, 2015 - December 31, 2022

	D(VSUC)	D(VRU)	D(VRC)	Joint
DLag 1	45.199003... [0.0000]	7.6729972... [0.0533]	37.461873... [0.0000]	88.526448... [0.0000]
DLag 2	54.437605... [0.0000]	52.188165... [0.0000]	8.2311853... [0.0415]	114.34014... [0.0000]
DLag 3	56.745443... [0.0000]	56.993255... [0.0000]	39.348813... [0.0000]	143.64079... [0.0000]
DLag 4	25.907736... [0.0000]	40.278820... [0.0000]	17.171024... [0.0007]	79.171758... [0.0000]
DLag 5	161.60268... [0.0000]	105.62303... [0.0000]	109.68628... [0.0000]	371.21938... [0.0000]
DLag 6	12.591178... [0.0056]	6.3368158... [0.0963]	13.781554... [0.0032]	31.567081... [0.0002]
df	3	3	3	9

(b) Sample 2: August 12, 2015 - December 1, 2019

	VSUC	VRU	VRC	Joint
Lag 1	1303.4735... [0.0000]	1329.4853... [0.0000]	1538.5184... [0.0000]	4158.0176... [0.0000]
Lag 2	20.288116... [0.0001]	7.3442089... [0.0617]	15.839803... [0.0012]	42.003717... [0.0000]
Lag 3	4.3378984... [0.2272]	4.5731825... [0.2059]	8.8008248... [0.0321]	17.660848... [0.0393]
Lag 4	0.5064642... [0.9175]	1.6242578... [0.6539]	1.9593257... [0.5809]	4.1112816... [0.9039]
Lag 5	24.205532... [0.0000]	24.304166... [0.0000]	27.870430... [0.0000]	78.986593... [0.0000]
Lag 6	69.470956... [0.0000]	60.425519... [0.0000]	30.195126... [0.0000]	161.93470... [0.0000]
df	3	3	3	9

(c) Sample 3: December 1, 2019 - December 31, 2022

	VSUC	VRU	VRC	Joint
Lag 1	761.90226... [0.0000]	955.19289... [0.0000]	1084.8556... [0.0000]	2728.9301... [0.0000]
Lag 2	2.0698653... [0.5580]	22.297822... [0.0001]	18.516165... [0.0003]	39.132323... [0.0000]
Lag 3	11.060109... [0.0114]	10.281164... [0.0163]	8.1946280... [0.0422]	28.563294... [0.0008]
Lag 4	7.1340902... [0.0677]	3.7892829... [0.2851]	1.5871607... [0.6623]	12.146819... [0.2052]
Lag 5	12.448941... [0.0060]	3.5677253... [0.3121]	35.207906... [0.0000]	53.019006... [0.0000]
Lag 6	65.333132... [0.0000]	19.533392... [0.0002]	38.007510... [0.0000]	117.44705... [0.0000]
df	3	3	3	9

From the Table presented, it is evident that across the three sample periods, the significance levels are non stable, the lags 1 contribute significantly to the model's explanatory capacity in all three samples, while other lag 2 to lag 6 show mixed result among the three periods.

Table 10. Granger Causality Test

(a) Full sample: August 12, 2015 - December 31, 2022

Dependent Variable	Excluded Variable	Chi-sq	df
VSUC	VRU	43.44776757	6
	VRC	35.09217227	6
VRU	VSUC	46.07092767	6
	VRC	30.75369043	6
VRC	VSUC	29.73179968	6

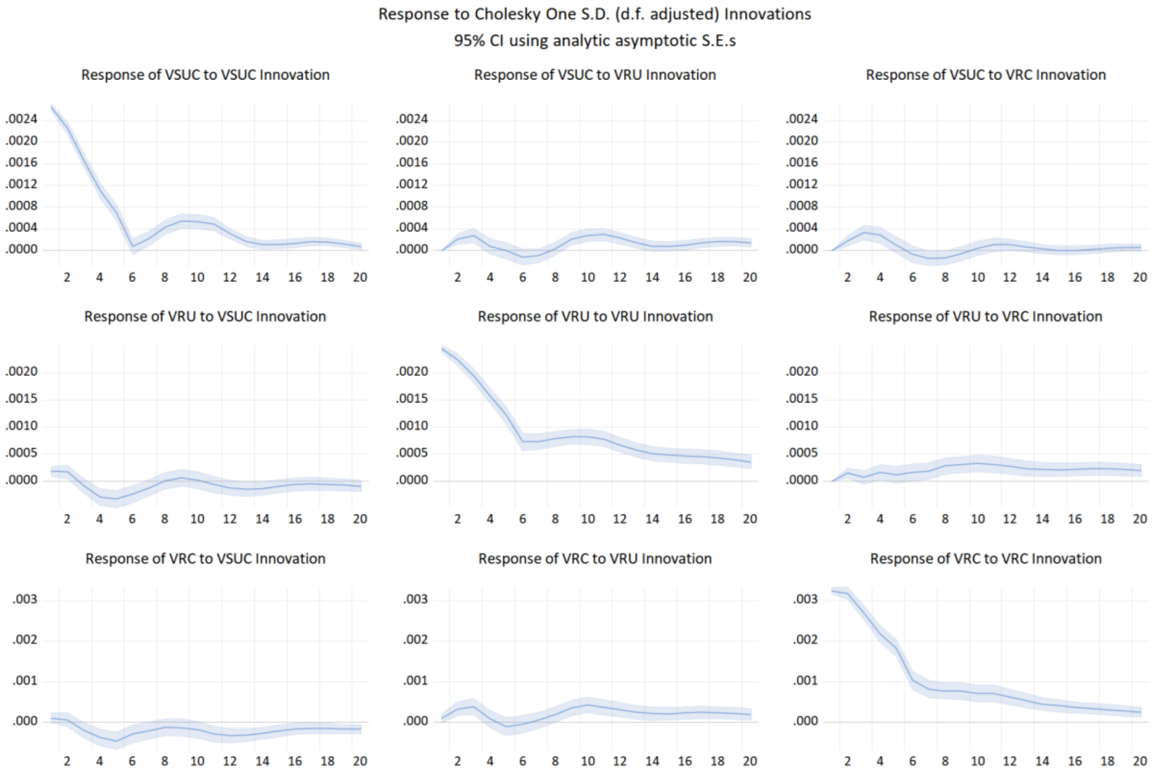
(b) Sample 2: August 12, 2015 - December 1, 2019

Dependent Variable	Excluded Variable	Chi-sq	df
VSUC	VRU	11.34723438	6
	VRC	17.01499373	6
VRU	VSUC	43.07824263	6
	VRC	33.38673376	6
VRC	VSUC	12.09309698	6

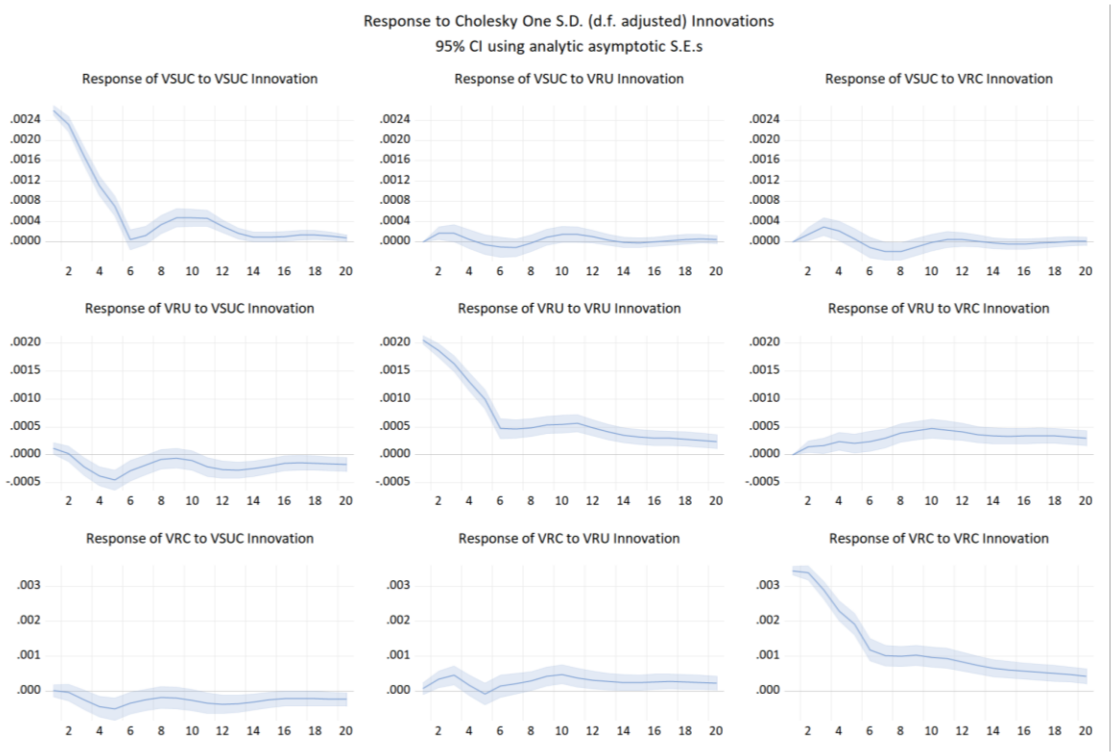
(c) Sample 3: December 1, 2019 - December 31, 2022

Dependent Variable	Excluded Variable	Chi-sq	df
VSUC	VRU	36.62866889	6
	VRC	30.82922781	6
VRU	VSUC	17.91874848	6
	VRC	14.58569902	6
VRC	VSUC	18.67350515	6

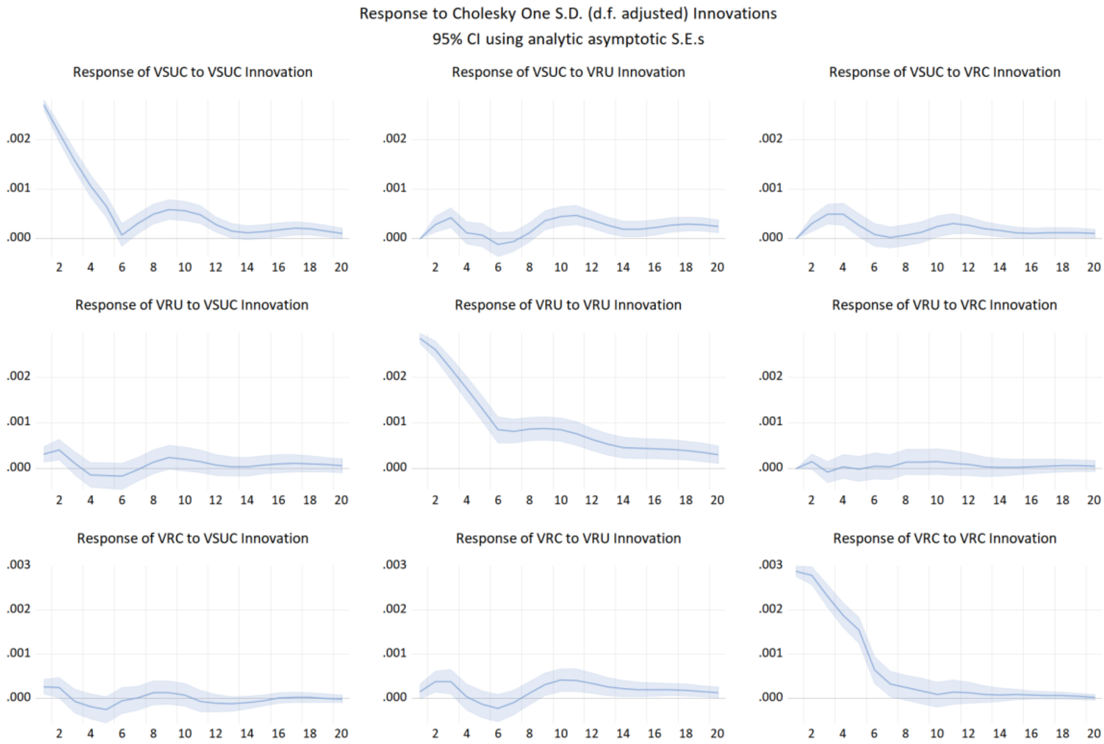
As shown above, the stock market in China and U.S. and the exchange market show strong significant causal relationship with each other, and with higher significance level during crisis period in comparing with the stable period.



(a) Full sample: August 12, 2015 - December 31, 2022



(b) Sample 2: August 12, 2015 - December 1, 2019



(c) Sample 3: December 1, 2019 - December 31, 2022

Figure 5. Impulse Response Result

The impulse response results indicate that both the exchange market and the stock market exhibit increased volatility in response to innovations from other markets during crisis periods. Additionally, the volatility spillover impulse analysis reveals that the effects of shocks between variables persist for a significantly longer duration before stabilizing compared to the mean spillover impulse.

4.3. Cross Industry Study

4.3.1. Mean Spillover Effect

(1) Data

Different with Lin (31), this study selected 30 companies that focus on the domestic market with limited imports or exports in China and U.S. respectively, to create the U.S. and China's export-oriented stock return indexes, and selects other 60 domestic-oriented companies (30 companies each country) to create the domestic-oriented stock return indexes.

The data includes daily closing prices and market capitalization figures for each company, and they are selected from Wind [37].

To compute daily returns indexed, this research uses the logarithmic return formula:

$$r_{i,t} = \ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right) \tag{9}$$

Where P i, t represents the closing price of company i on day t, and P i, t-1 is the closing price on the previous day.

Market capitalization weights are calculated for each company as:

$$w_{i,t} = \frac{M_{i,t}}{\sum_{j=1}^{N} M_{j,t}} \quad (10)$$

Where $M_{i,t}$ denotes the market capitalization of company i on day t, and N is the total number of companies in the respective market index.

The domestic and international market indices are constructed by aggregating the weighted returns of the companies in each index:

Domestic market index:

$$I_{domestic,t} = \sum_{i=1}^{30} w_{i,t} \cdot r_{i,t} \quad (11)$$

International market index:

$$I_{international,t} = \sum_{i=1}^{30} w'_{i,t} \cdot r'_{i,t} \quad (12)$$

Indices are periodically reviewed and adjusted to maintain their representativeness of the respective markets. The performance of these indices is analyzed over time to understand market dynamics and to evaluate the impact of market focus on stock returns.

(2) The export-oriented companies' mean spillover effect

All data series were tested for stationarity using the Augmented Dickey-Fuller (ADF) test, and the results are provided in the Appendix 1 and 2.

Table 11. The VAR model Results

(a) Full sample: August 12, 2015 - December 31, 2022

	SUC	REU	REC
SUC(-1)	0.3234362...	0.0361143...	-10.983505...
	0.0190873...	0.0431466...	7.2439003...
	[16.9451]	[0.83702]	[-1.51624]
SUC(-2)	0.1411975...	-0.0245603...	14.745541...
	0.0190606...	0.0430862...	7.2337668...
	[7.40781]	[-0.57003]	[2.03843]
REU(-1)	0.0279802...	-0.5716318...	-1.9575764...
	0.0083453...	0.0188645...	3.1671785...
	[3.35279]	[-30.3019]	[-0.61808]
REU(-2)	0.0168853...	-0.2124636...	-3.0010581...
	0.0083546...	0.0188854...	3.1706897...
	[2.02108]	[-11.2501]	[-0.94650]
REC(-1)	-5.5924142...	0.0001234...	-0.5343481...
	4.9992636...	0.0001130...	0.0189728...
	[-0.11186]	[1.09247]	[-28.1638]
REC(-2)	-4.7260349...	6.2792657...	-0.1782854...
	5.0000512...	0.0001130...	0.0189758...
	[-0.09452]	[0.55556]	[-9.39538]
C	0.0001621...	-7.8101846...	-0.0012210...
	0.0001302...	0.0002944...	0.0494393...
	[1.24509]	[-0.02652]	[-0.02470]

(b) Sample 2: August 12, 2015 - December 1, 2019

	SUC	REU	REC
SUC(-1)	0.3126264... 0.0249689... [12.5206]	0.0021039... 0.0443143... [0.04748]	-13.314530... 11.576846... [-1.15010]
SUC(-2)	0.1435014... 0.0249596... [5.74933]	0.0008851... 0.0442978... [0.01998]	12.081227... 11.572542... [1.04396]
REU(-1)	0.0328757... 0.0138808... [2.36842]	-0.5487994... 0.0246355... [-22.2768]	-0.8129436... 6.4358691... [-0.12631]
REU(-2)	0.0395727... 0.0138835... [2.85033]	-0.2369253... 0.0246402... [-9.61539]	-5.2065578... 6.4371034... [-0.80884]
REC(-1)	1.4110388... 5.3622346... [0.26314]	0.0001039... 9.5167776... [1.09224]	-0.5660103... 0.0248619... [-22.7661]
REC(-2)	-1.1513347... 5.3637751... [-0.21465]	3.6909063... 9.5195117... [0.38772]	-0.1943103... 0.0248691... [-7.81332]
C	0.0002694... 0.0001637... [1.64570]	-1.5078067... 0.0002906... [-0.05188]	0.0005877... 0.0759224... [0.00774]

(c) Sample 3: December 1, 2019 - December 31, 2022

	SUC	REU	REC
SUC(-1)	0.3365906... 0.0296256... [11.3615]	0.0751538... 0.0804253... [0.93446]	-7.9053887... 7.3832483... [-1.07072]
SUC(-2)	0.1370626... 0.0295323... [4.64111]	-0.0535049... 0.0801720... [-0.66738]	17.303213... 7.3599976... [2.35098]
REU(-1)	0.0247959... 0.0107876... [2.29856]	-0.5825059... 0.0292853... [-19.8907]	-2.6303056... 2.6884690... [-0.97837]
REU(-2)	0.0051029... 0.0108146... [0.47186]	-0.2019155... 0.0293588... [-6.87751]	-1.8397560... 2.6952137... [-0.68260]
REC(-1)	-9.7269101... 0.0001185... [-0.82026]	0.0002337... 0.0003219... [0.72605]	-0.4053957... 0.0295530... [-13.7176]
REC(-2)	6.6357832... 0.0001186... [0.55934]	0.0001296... 0.0003220... [0.40242]	-0.1315915... 0.0295660... [-4.45077]
C	1.8813936... 0.0002126... [0.08848]	1.1218646... 0.0005772... [0.01943]	-0.0006323... 0.0529937... [-0.01193]

The VAR analysis indicate that in the three periods, the U.S. export-oriented stocks return index seems to have a significant impact on the exchange market, while the nature of this impact is not consistent over time and may diminish after a certain lag. In addition, the exchange market seems to have a significant spillover effect on the China's export-oriented companies in the full sample and crisis period.

Table 12. VAR Lag Exclusion Wald Test

(a) Full sample: August 12, 2015 - December 31, 2022

	SUC	REU	REC	Joint
Lag 1	302.43394... [0.0000]	923.77366... [0.0000]	794.90585... [0.0000]	2030.9396... [0.0000]
Lag 2	58.426359... [0.0000]	127.71681... [0.0000]	93.272122... [0.0000]	282.89066... [0.0000]
df	3	3	3	9

(b) Sample 2: August 12, 2015 - December 1, 2019

	SUC	REU	REC	Joint
Lag 1	163.95271... [0.0000]	503.96437... [0.0000]	521.63875... [0.0000]	1192.7305... [0.0000]
Lag 2	41.068470... [0.0000]	93.680530... [0.0000]	62.575146... [0.0000]	200.90979... [0.0000]
df	3	3	3	9

(c) Sample 3: December 1, 2019 - December 31, 2022

	SUC	REU	REC	Joint
Lag 1	137.77804... [0.0000]	396.64692... [0.0000]	189.45818... [0.0000]	729.45986... [0.0000]
Lag 2	22.002940... [0.0001]	47.705610... [0.0000]	25.729407... [0.0000]	96.602628... [0.0000]
df	3	3	3	9

As shown above, the Wald test results indicate that all lagged terms included in the model are statistically significant in the three sample periods, both individually and jointly. This supports the robustness of the model's specification, emphasizing that the lag structure effectively captures the temporal dynamics between the Chinese stock market, the U.S. stock markets and the exchange market.

Table 13. Granger Causality Test:

(a) Full sample: August 12, 2015 - December 31, 2022

Dependent Variable	Excluded Variable	Chi-Sq	df
SUC	REU	11.48798662	2
	REC	0.014933605	2
REU	SUC	0.775191749	2
	REC	1.198134872	2
REC	SUC	4.800816593	2

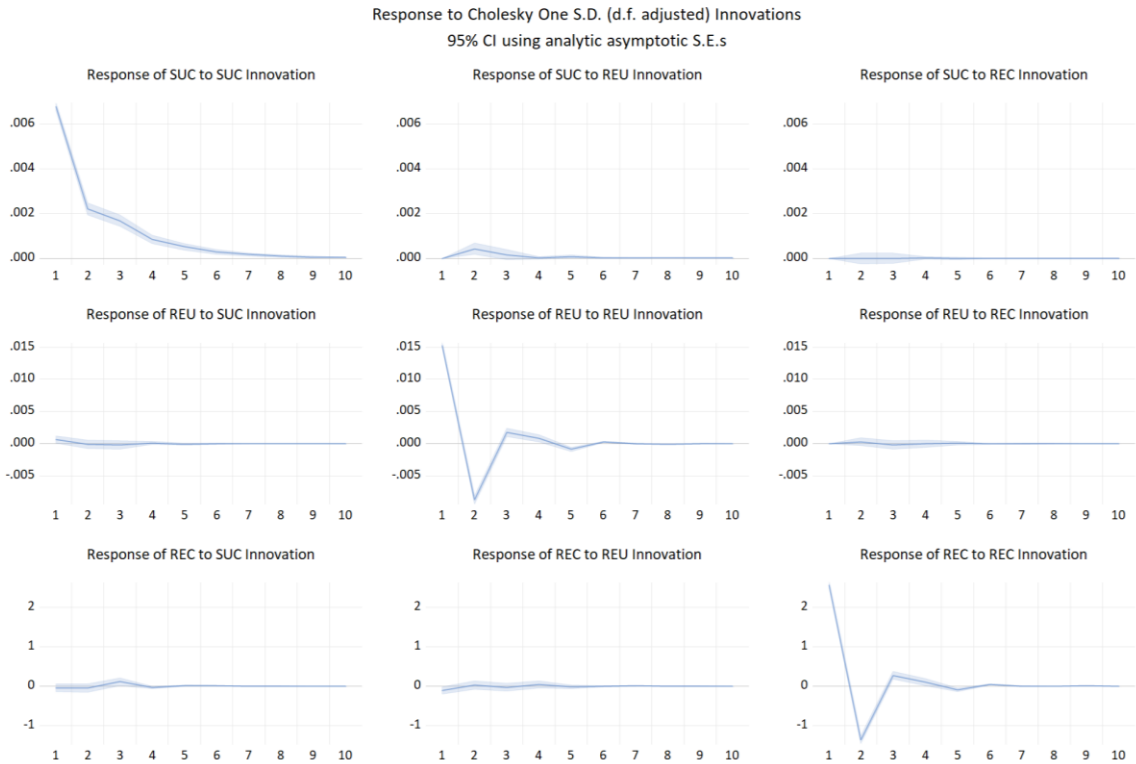
(b) Sample 2: August 12, 2015 - December 1, 2019

Dependent Variable	Excluded Variable	Chi-Sq	df
SUC	REU	9.642822565	2
	REC	0.217261538	2
REU	SUC	0.00387641	2
	REC	1.214276415	2
REC	SUC	1.768463301	2

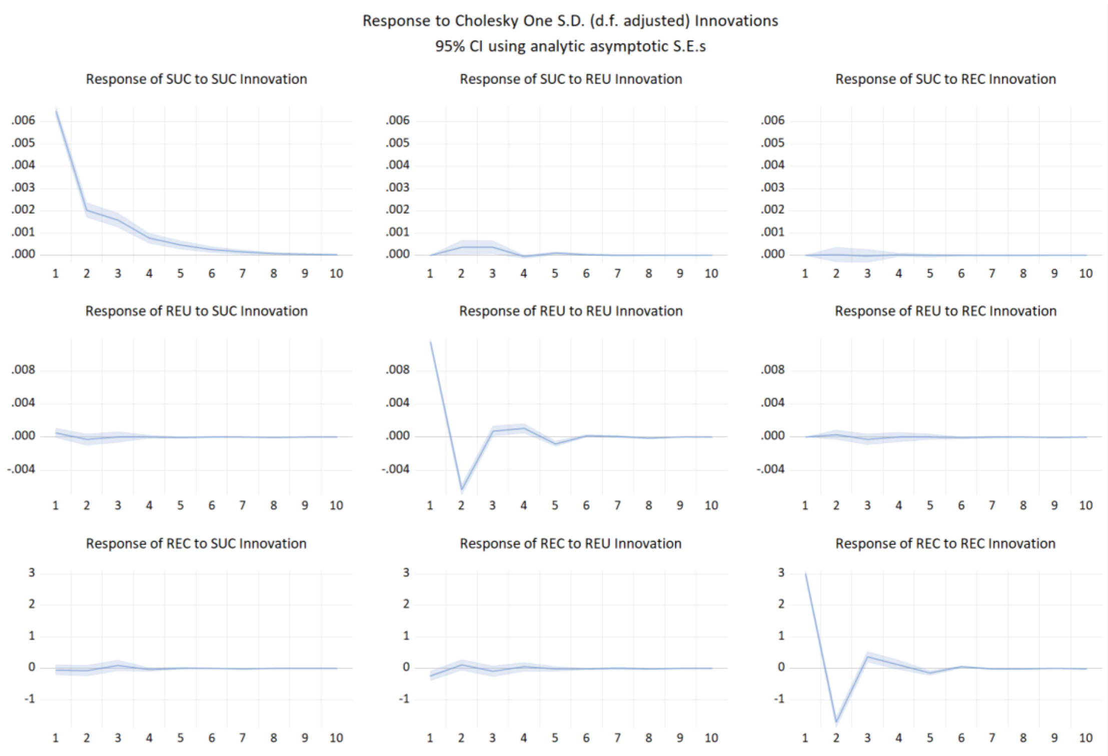
(c) Sample 3: December 1, 2019 - December 31, 2022

Dependent Variable	Excluded Variable	Chi-Sq	df
SUC	REU	5.82799776	2
	REC	1.506641164	2
REU	SUC	0.980935496	2
	REC	0.55050838	2
REC	SUC	5.554289228	2

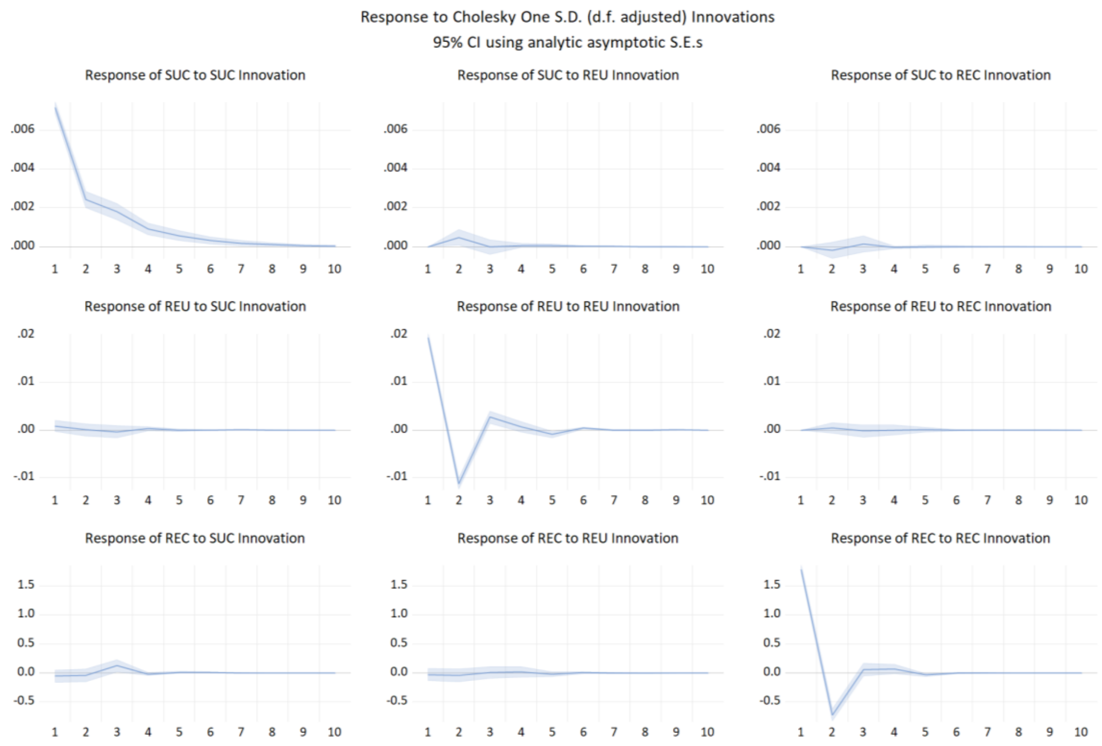
From the above result, it could be seen that the pronounced significant causal relationship among the three periods is the U.S. export-oriented stock return's predictive ability of the exchange rate return. The exchange rate return also show a weak predictive ability on the return index of China's export-oriented companies in the full sample and crisis period, however, China's stock index does not exhibit a significant predictive ability on the exchange rate return. While China's export-oriented companies' stock return index fail to show any causal relationship with the U.S. stock return index.



(a) Full sample: August 12, 2015 - December 31, 2022



(b) Sample 2: August 12, 2015 - December 1, 2019



(c) Sample 3: December 1, 2019 - December 31, 2022

Figure 6. Impulse Impact

The impulse response analysis depicted in the graphs show a similar trend with Figure 4: all variables exhibit significant volatility in reaction to their own shocks with these effects gradually stabilizing over time. While the three markets' response to the innovations on other markets are relatively moderate and tends to stabilize within a short period.

(3) The domestic-oriented companies' mean spillover effect

Table 14. The Vector Autoregression Analysis

(a) Full sample: August 12, 2015 - December 31, 2022

	SUC	RDU	RDC
SUC(-1)	0.3300215... 0.0190462... [17.3274]	-0.0306085... 0.0580392... [-0.52738]	0.0494596... 0.0720503... [0.68646]
SUC(-2)	0.1402540... 0.0190283... [7.37080]	-0.0107185... 0.0579846... [-0.18485]	0.0421462... 0.0719825... [0.58551]
RDU(-1)	0.0222290... 0.0062412... [3.56166]	-0.4789996... 0.0190187... [-25.1857]	0.0296859... 0.0236099... [1.25735]
RDU(-2)	0.0126444... 0.0062517... [2.02255]	-0.1660337... 0.0190508... [-8.71529]	-0.0202375... 0.0236498... [-0.85572]
RDC(-1)	0.0034822... 0.0050041... [0.69588]	-0.0242092... 0.0152490... [-1.58759]	-0.4686237... 0.0189302... [-24.7553]
RDC(-2)	-0.0170834... 0.0050074... [-3.41163]	-0.0130716... 0.0152589... [-0.85665]	-0.1904482... 0.0189426... [-10.0540]
C	0.0001605... 0.0001298... [1.23684]	9.8780524... 0.0003955... [0.02497]	-2.8714032... 0.0004910... [-0.05847]

(b) Sample 2: August 12, 2015 - December 1, 2019

	SUC	RDU	RDC
SUC(-1)	0.3180606... 0.0250059... [12.7194]	-0.0539383... 0.0820975... [-0.65700]	0.0116967... 0.0989272... [0.11824]
SUC(-2)	0.1434204... 0.0250021... [5.73632]	0.0419788... 0.0820851... [0.51141]	0.0566140... 0.0989123... [0.57237]
RDU(-1)	0.0208054... 0.0076263... [2.72809]	-0.3904561... 0.0250383... [-15.5943]	0.0379236... 0.0301711... [1.25695]
RDU(-2)	0.0129164... 0.0076412... [1.69037]	-0.1495952... 0.0250870... [-5.96305]	-0.0325326... 0.0302298... [-1.07618]
RDC(-1)	-0.0017566... 0.0062815... [-0.27965]	-0.0171548... 0.0206230... [-0.83183]	-0.4621684... 0.0248506... [-18.5978]
RDC(-2)	-0.0123811... 0.0062904... [-1.96826]	-0.0064727... 0.0206522... [-0.31341]	-0.1853343... 0.0248859... [-7.44736]
C	0.0002662... 0.0001636... [1.62705]	-7.8913777... 0.0005371... [-0.01469]	-5.6522332... 0.0006473... [-0.08732]

(c) Sample 3: December 1, 2019 - December 31, 2022

	SUC	RDU	RDC
SUC(-1)	0.3445117...	0.0188095...	0.0965445...
	0.0294946...	0.0798107...	0.1055645...
	[11.6805]	[0.23568]	[0.91455]
SUC(-2)	0.1348908...	-0.0821397...	0.0223009...
	0.0293862...	0.0795171...	0.1051762...
	[4.59028]	[-1.03298]	[0.21203]
RDU(-1)	0.0242387...	-0.6228458...	0.0194703...
	0.0107627...	0.0291231...	0.0385208...
	[2.25211]	[-21.3866]	[0.50545]
RDU(-2)	0.0124568...	-0.2204982...	-0.0048375...
	0.0107765...	0.0291605...	0.0385702...
	[1.15593]	[-7.56152]	[-0.12542]
RDC(-1)	0.0106912...	-0.0389533...	-0.4774999...
	0.0081593...	0.0220786...	0.0292030...
	[1.31031]	[-1.76430]	[-16.3510]
RDC(-2)	-0.0237657...	-0.0271038...	-0.1979990...
	0.0081919...	0.0221669...	0.0293198...
	[-2.90111]	[-1.22272]	[-6.75307]
C	1.9036600...	1.2912037...	3.1041884...
	0.0002113...	0.0005718...	0.0007563...
	[0.09008]	[0.02258]	[0.04104]

The analysis shows that all three periods has a significance spillover on their U.S. domestic-oriented stock return index has a stable and significant spillover effect on the exchange rate return through all three periods. While the China domestic-oriented stock return index exhibit significant spillovers on the exchange rate return only during the second lag period among the three samples. China domestic-oriented stock return index has a weak significant spillover on the U.S. stock return index during crisis period.

Table 15. VAR Lag Exclusion Wald Test

(a) Full sample: August 12, 2015 - December 31, 2022

	SUC	RDU	RDC	Joint
Lag 1	311.54098...	639.21140...	613.33413...	1560.8553...
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Lag 2	68.937749...	77.160047...	102.83816...	247.89729...
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
df	3	3	3	9

(b) Sample 2: August 12, 2015 - December 1, 2019

	SUC	RDU	RDC	Joint
Lag 1	166.53151...	245.31260...	346.13999...	755.48398...
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Lag 2	38.302231...	36.756724...	57.882223...	132.34348...
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
df	3	3	3	9

(c) Sample 3: December 1, 2019 - December 31, 2022

	SUC	RDU	RDC	Joint
Lag 1	144.96065... [0.0000]	460.47788... [0.0000]	267.79292... [0.0000]	876.41937... [0.0000]
Lag 2	31.186800... [0.0000]	58.807942... [0.0000]	45.766070... [0.0000]	135.76141... [0.0000]
df	3	3	3	9

As shown above, same as previous studies, the VAR Lag Exclusion Wald Tests shows that both Lag 1 and Lag 2 are statistically significant for the model, implying that both Lag 1 and Lag 2 are crucial for capturing the dynamics between the three markets.

Table 16. Granger Causality Results

(a) Full sample: August 12, 2015 - December 31, 2022

Dependent Variable	Excluded Variable	Chi-Sq	df
SUC	RDU	13.06869995	2
	RDC	16.5638014	2
RDU	SUC	0.452297891	2
	RDC	2.583775008	2
RDC	SUC	1.310793709	2

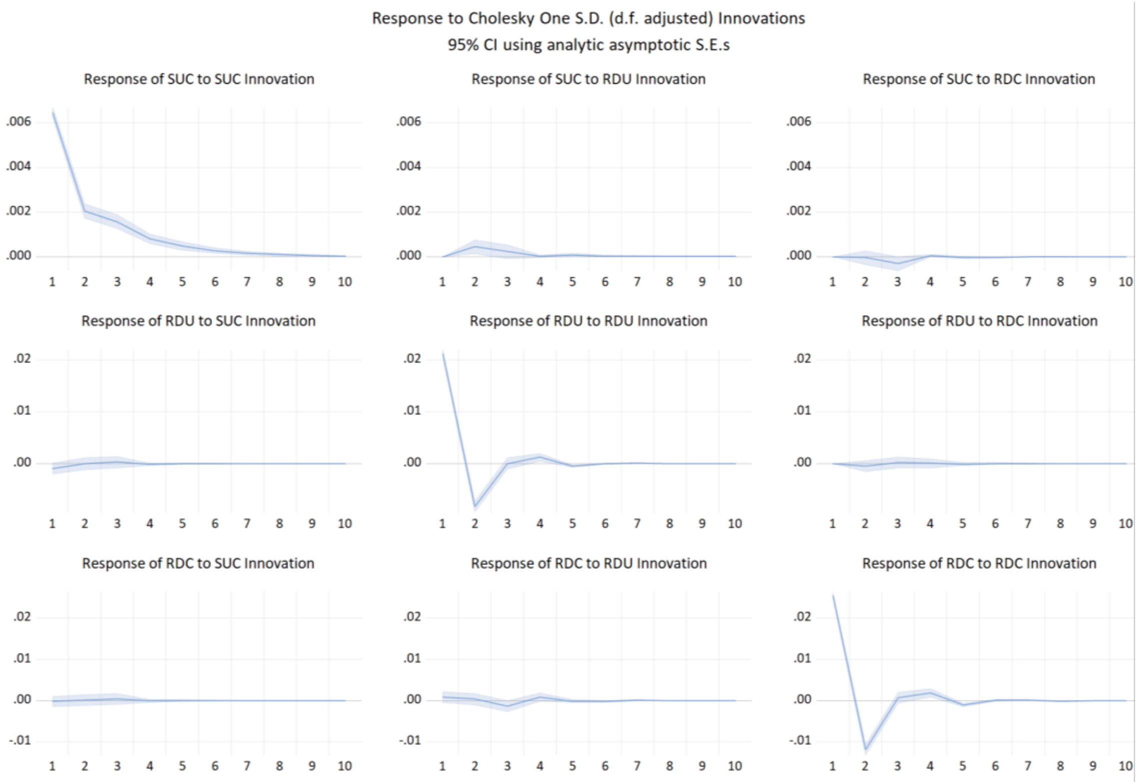
(b) Sample 2: August 12, 2015 - December 1, 2019

Dependent Variable	Excluded Variable	Chi-Sq	df
SUC	RDU	8.111882441	2
	RDC	4.154728567	2
RDU	SUC	0.514905448	2
	RDC	0.692083101	2
RDC	SUC	0.454043031	2

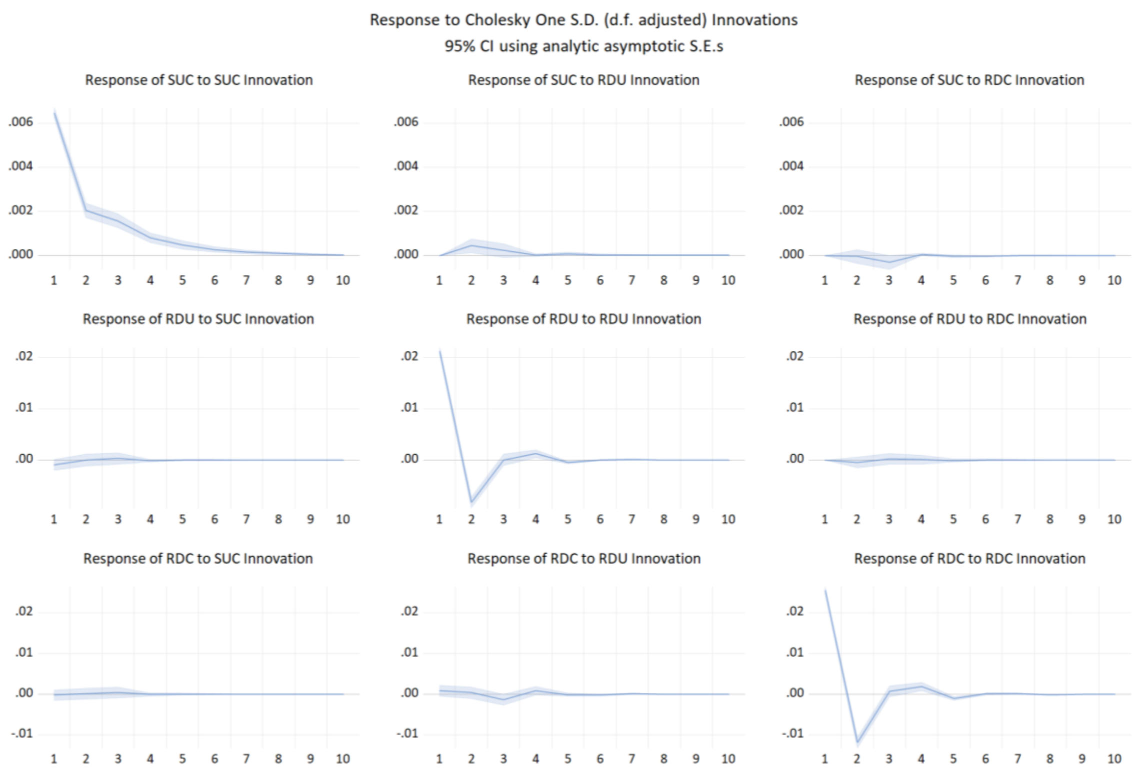
(c) Sample 3: December 1, 2019 - December 31, 2022

Dependent Variable	Excluded Variable	Chi-Sq	df
SUC	RDU	5.072073629	2
	RDC	15.66864866	2
RDU	SUC	1.101152467	2
	RDC	3.432145798	2
RDC	SUC	1.221931324	2

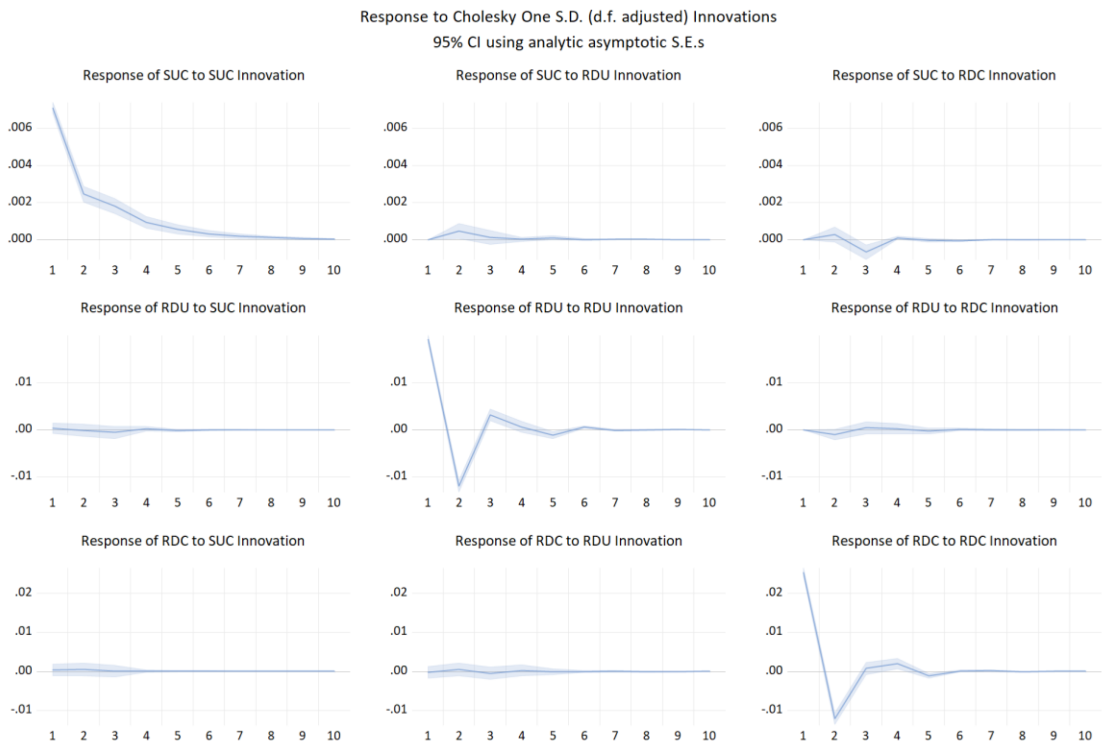
These results suggest that the China's domestic-oriented stock return index and U.S. domestic-oriented stock return index both have significant Granger-causality effects on the exchange rate return in different periods, with U.S. domestic-oriented stock return index being significant in the full sample and crisis period, and China's domestic-oriented stock return index being significant across all periods.



(a) Full sample: August 12, 2015-December 31, 2022



(b) Sample 2: August 12, 2015 - December 1, 2019



(c) Sample 3: December 1, 2019 - December 31, 2022

Figure 7. Impulse Response results

Same as previous impulse responses: all variables exhibit significant volatility in reaction to their own shocks. while the three markets' response to the innovations on other markets are relatively moderate. Notably, the Chinese domestic-focused stock index demonstrates significantly smaller fluctuations in response to innovations compared to the export-oriented market stock returns.

4.3.2. volatility spillover effect

(1) Data

The volatility of the domestic-oriented stock return and export-oriented stock return was calculated by the following equation:

$$\mathbf{v_{daily}} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(\mathbf{Return}_{\,i} - \overline{\mathbf{Return}})^2} \tag{13}$$

(2) Export Oriented Companies' Volatility Spillover

Descriptive statistics for stock returns volatility, exchange rate returns volatility,, and the results of the ADF test are provided in the Appendix 3 and 4.

Table 17. VAR Analysis

(a) Full sample: August 12, 2015 - December 31, 2022

	VSUC	VREU	VREC
VSUC(-1)	0.8519975...	-0.0917354...	-5.5213338...
	0.0192553...	0.0273480...	6.9377167...
	[44.2474]	[-3.35437]	[-0.79584]
VSUC(-2)	-0.0688869...	-0.0218165...	12.582590...
	0.0253775...	0.0360432...	9.1435630...
	[-2.71448]	[-0.60529]	[1.37611]
VSUC(-3)	-0.0413685...	0.0730713...	1.8252787...
	0.0250131...	0.0355257...	9.0122635...
	[-1.65387]	[2.05686]	[0.20253]
VSUC(-4)	-0.0030601...	0.0243747...	-0.4081944...
	0.0248907...	0.0353519...	8.9681716...
	[-0.12294]	[0.68949]	[-0.04552]
VSUC(-5)	-0.1505092...	0.0454321...	6.2601892...
	0.0248722...	0.0353256...	8.9615134...
	[-6.05129]	[1.28609]	[0.69856]
VSUC(-6)	0.2325814...	-0.0040283...	14.973239...
	0.0250362...	0.0355585...	9.0205842...
	[9.28979]	[-0.11329]	[1.65990]
VSUC(-7)	0.0549802...	-0.0866693...	-21.711218...
	0.0254011...	0.0360768...	9.1520773...
	[2.16448]	[-2.40235]	[-2.37227]
VSUC(-8)	-0.1141745...	0.0351773...	-2.9956701...
	0.0192386...	0.0273243...	6.9317189...
	[-5.93464]	[1.28740]	[-0.43217]
VREU(-1)	0.0394047...	1.0044543...	5.8390698...
	0.0136275...	0.0193550...	4.9100308...
	[2.89154]	[51.8964]	[1.18921]
VREU(-2)	0.0186421...	-0.1057321...	-3.6928482...
	0.0193055...	0.0274193...	6.9558207...
	[0.96564]	[-3.85611]	[-0.53090]
VREU(-3)	-0.0304721...	-0.0083946...	-4.1137497...
	0.0191265...	0.0271651...	6.8913241...
	[-1.59318]	[-0.30902]	[-0.59695]
VREU(-4)	-0.0359987...	-0.0077135...	-1.2013761...
	0.0189806...	0.0269579...	6.8387610...
	[-1.89660]	[-0.28613]	[-0.17567]
VREU(-5)	-0.0001281...	-0.1757325...	14.514704...
	0.0189984...	0.0269831...	6.8451553...
	[-0.00675]	[-6.51268]	[2.12043]
VREU(-6)	0.0037031...	0.2217683...	-17.208618...
	0.0191697...	0.0272264...	6.9068873...
	[0.19318]	[8.14532]	[-2.49152]
VREU(-7)	0.0364282...	-0.0489400...	18.030993...
	0.0193730...	0.0275152...	6.9801506...
	[1.88035]	[-1.77865]	[2.58318]
VREU(-8)	-0.0148739...	0.0409395...	-11.596583...
	0.0136978...	0.0194547...	4.9353422...
	[-1.08586]	[2.10434]	[-2.34970]
VREC(-1)	7.3067208...	6.1734922...	0.9638007...
	5.2917353...	7.5157600...	0.0190661...
	[1.38078]	[0.82141]	[50.5503]
VREC(-2)	8.3249443...	1.5792106...	-0.1134619...
	7.3671584...	0.0001046...	0.0265439...
	[1.13001]	[0.15093]	[-4.27449]
VREC(-3)	-3.0484087...	-0.0001677...	0.0429878...
	7.1573090...	0.0001016...	0.0257878...
	[-0.42592]	[-1.64999]	[1.66698]
VREC(-4)	-0.0001468...	3.5590245...	0.0181930...
	6.7987824...	9.6561929...	0.0244960...
	[-2.16050]	[0.36857]	[0.74269]
VREC(-5)	-2.4779566...	6.2510791...	-0.4142603...
	6.8039080...	9.6634726...	0.0245145...
	[-0.36420]	[0.64688]	[-16.8985]
VREC(-6)	8.2197323...	5.2751939...	0.3344321...
	7.1551703...	0.0001016...	0.0257801...
	[1.14878]	[0.51909]	[12.9725]
VREC(-7)	6.3930190...	1.1749601...	-0.1145389...
	7.3562018...	0.0001044...	0.0265044...
	[0.86907]	[0.11246]	[-4.32149]
VREC(-8)	-4.1354660...	-0.0001052...	0.1776028...
	5.2930704...	7.5176562...	0.0190709...
	[-0.78130]	[-1.40030]	[9.31272]
C	0.0008827...	0.0008944...	0.0555480...
	0.0001077...	0.0001529...	0.0388057...
	[8.19637]	[5.84729]	[1.43144]

(b) Sample 2: August 12, 2015 - December 1, 2019

	VSUC	VREU	VREC
VSUC(-1)	0.8794193...	-0.0877896...	-1.4513217...
	0.0252155...	0.0307340...	11.039441...
	[34.8761]	[-2.85643]	[-0.13147]
VSUC(-2)	-0.1038594...	0.0083529...	8.9838329...
	0.0336790...	0.0410498...	14.744785...
	[-3.08380]	[0.20348]	[0.60929]
VSUC(-3)	-0.0471337...	-0.0068327...	3.4324891...
	0.0333936...	0.0407020...	14.619866...
	[-1.41146]	[-0.16787]	[0.23478]
VSUC(-4)	0.0138200...	0.0942040...	2.3690216...
	0.0331163...	0.0403639...	14.498437...
	[0.41732]	[2.33386]	[0.16340]
VSUC(-5)	-0.1757895...	0.0302390...	7.0849377...
	0.0330990...	0.0403429...	14.490874...
	[-5.31101]	[0.74955]	[0.48892]
VSUC(-6)	0.2007949...	-0.0609829...	23.937382...
	0.0333609...	0.0406621...	14.605549...
	[6.01885]	[-1.49975]	[1.63892]
VSUC(-7)	0.1032387...	-0.0712647...	-31.923696...
	0.0336883...	0.0410612...	14.748884...
	[3.06452]	[-1.73557]	[-2.16448]
VSUC(-8)	-0.1459453...	0.0432565...	0.4022215...
	0.0252314...	0.0307534...	11.046425...
	[-5.78426]	[1.40656]	[0.03641]
VREU(-1)	0.0448826...	1.0060302...	16.260937...
	0.0209273...	0.0255073...	9.1620610...
	[2.14469]	[39.4407]	[1.77481]
VREU(-2)	0.0120771...	-0.1261327...	-3.6370967...
	0.0296800...	0.0361756...	12.994011...
	[0.40691]	[-3.48668]	[-0.27991]
VREU(-3)	-0.0410596...	-0.0215136...	-9.6749342...
	0.0293913...	0.0358237...	12.867617...
	[-1.39700]	[-0.60054]	[-0.75188]
VREU(-4)	-0.0103049...	-0.0004484...	-3.3485713...
	0.0290909...	0.0354576...	12.736120...
	[-0.35423]	[-0.01265]	[-0.26292]
VREU(-5)	-0.0253025...	-0.2064361...	30.958475...
	0.0290487...	0.0354061...	12.717616...
	[-0.87104]	[-5.83052]	[2.43430]
VREU(-6)	0.0065475...	0.2223237...	-36.109860...
	0.0294229...	0.0358623...	12.881480...
	[0.22253]	[6.19937]	[-2.80324]
VREU(-7)	0.0538331...	0.0073173...	39.048748...
	0.0297114...	0.0362139...	13.007782...
	[1.81186]	[0.20206]	[3.00195]
VREU(-8)	-0.0470057...	-0.0150375...	-22.542579...
	0.0208997...	0.0254737...	9.1499964...
	[-2.24910]	[-0.59032]	[-2.46367]
VREC(-1)	0.0001072...	9.2512568...	0.9660299...
	5.7474889...	7.0053500...	0.0251626...
	[1.86685]	[1.32060]	[38.3914]
VREC(-2)	9.8590146...	-1.1063778...	-0.1208234...
	7.9781013...	9.7241409...	0.0349283...
	[1.23576]	[-0.11378]	[-3.45918]
VREC(-3)	-1.4185123...	-0.0001016...	0.0204769...
	7.7471270...	9.4426169...	0.0339171...
	[-0.18310]	[-1.07629]	[0.60373]
VREC(-4)	-0.0001975...	2.1792703...	0.0201973...
	7.4096640...	9.0312987...	0.0324397...
	[-2.66644]	[0.24130]	[0.62261]
VREC(-5)	5.1922909...	2.6665978...	-0.3811488...
	7.4250317...	9.0500297...	0.0325070...
	[0.06993]	[0.29465]	[-11.7251]
VREC(-6)	8.2456141...	0.0001414...	0.3330440...
	7.7475537...	9.4431370...	0.0339190...
	[1.06429]	[1.49816]	[9.81879]
VREC(-7)	8.0891944...	-6.3768131...	-0.1270238...
	7.9658260...	9.7091791...	0.0348746...
	[1.01549]	[-0.65678]	[-3.64230]
VREC(-8)	-3.9076869...	-3.7875784...	0.1666249...
	5.7539554...	7.0132317...	0.0251910...
	[-0.67913]	[-0.54006]	[6.61446]
C	0.0011070...	0.0011351...	-0.0090138...
	0.0001509...	0.0001840...	0.0660925...
	[7.33353]	[6.16920]	[-0.13638]

(c) Sample 3: December 1, 2019 - December 31, 2022

	VSUC	VREU	VREC
VSUC(-1)	0.8116952...	-0.1138743...	-6.7833044...
	0.0300004...	0.0487573...	6.9840111...
	[27.0561]	[-2.33553]	[-0.97126]
VSUC(-2)	-0.0276984...	-0.0441260...	16.269765...
	0.0387765...	0.0630204...	9.0270566...
	[-0.71431]	[-0.70019]	[1.80233]
VSUC(-3)	-0.0377224...	0.1468831...	-0.7794018...
	0.0380289...	0.0618056...	8.8530391...
	[-0.99194]	[2.37653]	[-0.08804]
VSUC(-4)	-0.0208445...	-0.0537490...	-2.1512267...
	0.0379998...	0.0617581...	8.8462442...
	[-0.54854]	[-0.87032]	[-0.24318]
VSUC(-5)	-0.1182817...	0.0523721...	2.9260138...
	0.0380272...	0.0618027...	8.8526230...
	[-3.11045]	[0.84741]	[0.33053]
VSUC(-6)	0.2639893...	0.0646128...	2.9787095...
	0.0382085...	0.0620974...	8.8948495...
	[6.90916]	[1.04051]	[0.33488]
VSUC(-7)	0.0074054...	-0.0928017...	-8.4422092...
	0.0390235...	0.0634220...	9.0845752...
	[0.18977]	[-1.46324]	[-0.92929]
VSUC(-8)	-0.0932983...	0.0059103...	-0.8289744...
	0.0300684...	0.0488678...	6.9998386...
	[-3.10287]	[0.12094]	[-0.11843]
VREU(-1)	0.0360192...	0.9955731...	0.3666645...
	0.0184832...	0.0300394...	4.3028560...
	[1.94875]	[33.1422]	[0.08521]
VREU(-2)	0.0200850...	-0.0905422...	-3.7708595...
	0.0260485...	0.0423346...	6.0640224...
	[0.77106]	[-2.13872]	[-0.62184]
VREU(-3)	-0.0285925...	-0.0070111...	0.3784537...
	0.0257980...	0.0419276...	6.0057216...
	[-1.10832]	[-0.16722]	[0.06302]
VREU(-4)	-0.0486415...	-0.0094449...	0.5052382...
	0.0256345...	0.0416617...	5.9676374...
	[-1.89750]	[-0.22671]	[0.08466]
VREU(-5)	0.0103392...	-0.1560627...	4.9564808...
	0.0256646...	0.0417107...	5.9746547...
	[0.40286]	[-3.74154]	[0.82958]
VREU(-6)	0.0021834...	0.2109257...	-3.9397649...
	0.0258155...	0.0419560...	6.0097908...
	[0.08458]	[5.02730]	[-0.65556]
VREU(-7)	0.0248854...	-0.0850851...	3.9278435...
	0.0260690...	0.0423680...	6.0688033...
	[0.95460]	[-2.00824]	[0.64722]
VREU(-8)	0.0034050...	0.0682653...	-3.2338702...
	0.0186323...	0.0302817...	4.3375608...
	[0.18275]	[2.25434]	[-0.74555]
VREC(-1)	-2.8518651...	7.8006758...	0.9150438...
	0.0001256...	0.0002042...	0.0292594...
	[-0.22690]	[0.38188]	[31.2735]
VREC(-2)	7.6302236...	8.6645590...	-0.0770140...
	0.0001722...	0.0002799...	0.0400992...
	[0.04430]	[0.30951]	[-1.92059]
VREC(-3)	-4.6274815...	-0.0003550...	0.1362406...
	0.0001678...	0.0002727...	0.0390698...
	[-0.27573]	[-1.30154]	[3.48711]
VREC(-4)	6.0038162...	6.7782969...	0.0083240...
	0.0001536...	0.0002496...	0.0357603...
	[0.39084]	[0.27151]	[0.23277]
VREC(-5)	-8.4539534...	0.0002109...	-0.5376922...
	0.0001536...	0.0002496...	0.0357636...
	[-0.55029]	[0.84491]	[-15.0346]
VREC(-6)	7.9741092...	-0.0001870...	0.3053090...
	0.0001678...	0.0002727...	0.0390689...
	[0.47515]	[-0.68567]	[7.81463]
VREC(-7)	-3.5227281...	0.0002828...	-0.0826814...
	0.0001720...	0.0002796...	0.0400587...
	[-0.20472]	[1.01152]	[-2.06401]
VREC(-8)	2.0277454...	-0.0002711...	0.2366648...
	0.0001253...	0.0002037...	0.0291884...
	[0.16173]	[-1.33059]	[8.10818]
C	0.0008218...	0.0011161...	0.0386856...
	0.0001788...	0.0002906...	0.0416394...
	[4.59465]	[3.83952]	[0.92906]

The USD/CNY exchange rate return exhibits significant volatility spillover effects on the U.S. export-oriented stock return index and China export-oriented stock return index across different sample periods, but these effects are unstable among all lag periods.

Moreover, the U.S. export-oriented stock return index has an unstable but significant impact on the USD/CNY exchange return rate in small proportion of the 8 lag periods, and a more pronounced volatility spillover effect on China export-oriented stock return index in later lag periods. However, during the crisis period, the impact of U.S. export-oriented stock return on China's decreases. The influence is weak and not significant.

Table 18. VAR Lag Exclusion Wald Test

(a) Full sample: August 12, 2015

	VSUC	VREU	VREC	Joint
Lag 1	1978.6713... [0.0000]	2701.5896... [0.0000]	2559.6356... [0.0000]	7234.3282... [0.0000]
Lag 2	9.3055711... [0.0255]	15.382158... [0.0015]	20.134704... [0.0002]	45.473131... [0.0000]
Lag 3	5.6690866... [0.1289]	6.7506594... [0.0803]	3.2125837... [0.3600]	15.846556... [0.0702]
Lag 4	8.2019234... [0.0420]	0.7066334... [0.8716]	0.5872319... [0.8993]	9.5917291... [0.3845]
Lag 5	36.999340... [0.0000]	44.277520... [0.0000]	291.40110... [0.0000]	374.32589... [0.0000]
Lag 6	88.871200... [0.0000]	66.621747... [0.0000]	179.11746... [0.0000]	333.36239... [0.0000]
Lag 7	9.3869075... [0.0246]	9.2235872... [0.0265]	31.017440... [0.0000]	50.297422... [0.0000]
Lag 8	38.563591... [0.0000]	8.1292891... [0.0434]	91.870927... [0.0000]	140.21451... [0.0000]
df	3	3	3	9

(b) Sample 2: August 12, 2015 - December 1, 2019

	VSUC	VREU	VREC	Joint
Lag 1	1235.1353... [0.0000]	1569.4428... [0.0000]	1486.9444... [0.0000]	4276.0923... [0.0000]
Lag 2	10.968882... [0.0119]	12.190436... [0.0068]	12.309362... [0.0064]	36.109034... [0.0000]
Lag 3	4.0696168... [0.2540]	1.5629705... [0.6678]	0.9964935... [0.8021]	6.5822798... [0.6805]
Lag 4	7.3090463... [0.0627]	5.5524208... [0.1355]	0.4948018... [0.9200]	13.498837... [0.1413]
Lag 5	29.134108... [0.0000]	34.597279... [0.0000]	144.44448... [0.0000]	210.65687... [0.0000]
Lag 6	38.027429... [0.0000]	42.551097... [0.0000]	107.95705... [0.0000]	187.34995... [0.0000]
Lag 7	14.212996... [0.0026]	3.5292029... [0.3170]	26.792982... [0.0000]	44.818982... [0.0000]
Lag 8	41.076425... [0.0000]	2.4649651... [0.4817]	49.215683... [0.0000]	93.499523... [0.0000]
df	3	3	3	9

(c) Sample 3: December 1, 2019 - December 31, 2022

	VSUC	VREU	VREC	Joint
Lag 1	738.34033... [0.0000]	1101.5178... [0.0000]	978.69083... [0.0000]	2818.7904... [0.0000]
Lag 2	1.0732413... [0.7835]	5.2385653... [0.1551]	7.0952892... [0.0689]	13.506313... [0.1410]
Lag 3	2.4050944... [0.4927]	7.1423022... [0.0675]	12.164085... [0.0068]	21.991473... [0.0089]
Lag 4	4.1442540... [0.2463]	0.8802880... [0.8302]	0.1133308... [0.9902]	5.0844502... [0.8269]
Lag 5	10.250727... [0.0166]	15.372116... [0.0015]	227.33886... [0.0000]	253.79817... [0.0000]
Lag 6	48.531167... [0.0000]	27.305976... [0.0000]	62.009659... [0.0000]	137.75661... [0.0000]
Lag 7	1.0006725... [0.8011]	7.3128114... [0.0626]	5.6479025... [0.1301]	14.138744... [0.1175]
Lag 8	9.6344126... [0.0219]	6.8566782... [0.0766]	66.199711... [0.0000]	83.215313... [0.0000]
df	3	3	3	9

From the Table presented, it is evident that across the three sample periods, the significance levels for lags 1, and lag 5 to lag 8 are consistently high. In contrast, the significance level for lag 2 to 4 is notably lower. It indicates that the inclusion of lags up to 5 to 8 significantly improves the explanatory power of the model for the variables examined.

Table 19. Granger Causality Test:

(a) Full sample: August 12, 2015 -December 31, 2022

Dependent Variable	Excluded Variable	Chi-sq	df
VSUC	VREU	42.65659949	8
VSUC	VREC	13.31907480	8
VREU	VSUC	46.43662746	8
VREU	VREC	6.174804649	8
VREC	VSUC	10.05375662	8

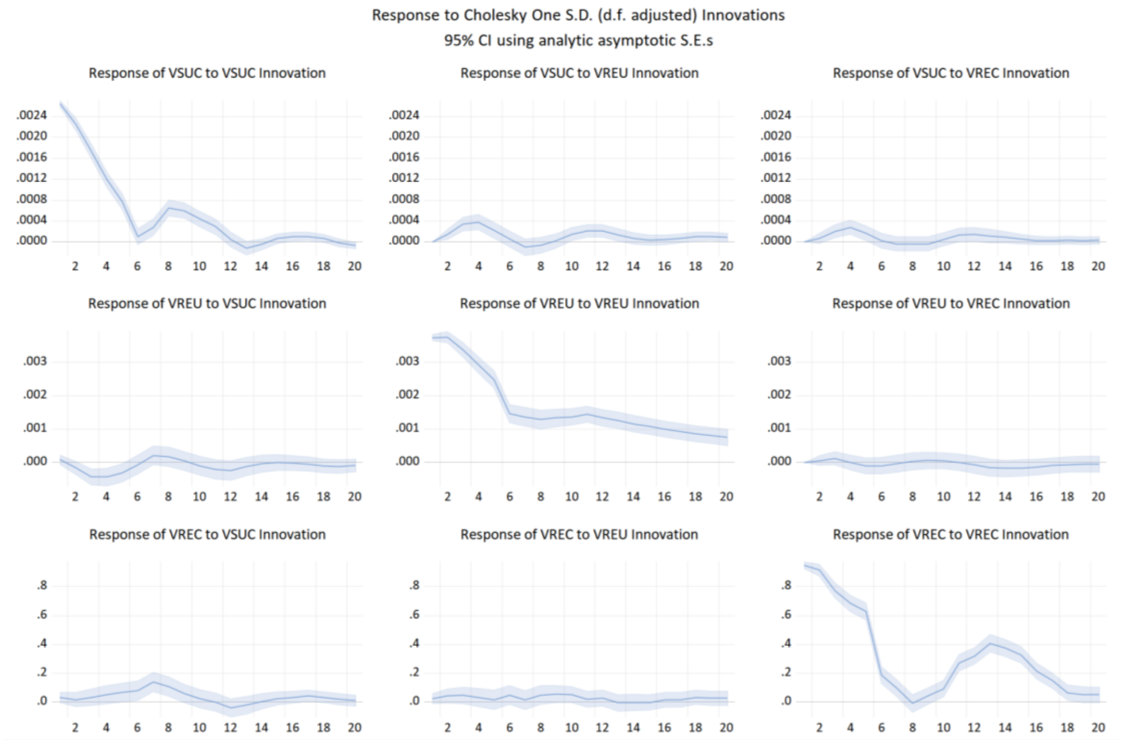
(b) Sample 2: August 12, 2015 - December 1, 2019

Dependent Variable	Excluded Variable	Chi-sq	df
VSUC	VREU	20.96434907	8
VSUC	VREC	15.50995260	8
VREU	VSUC	37.15579091	8
VREU	VREC	7.750090708	8
VREC	VSUC	14.33992634	8

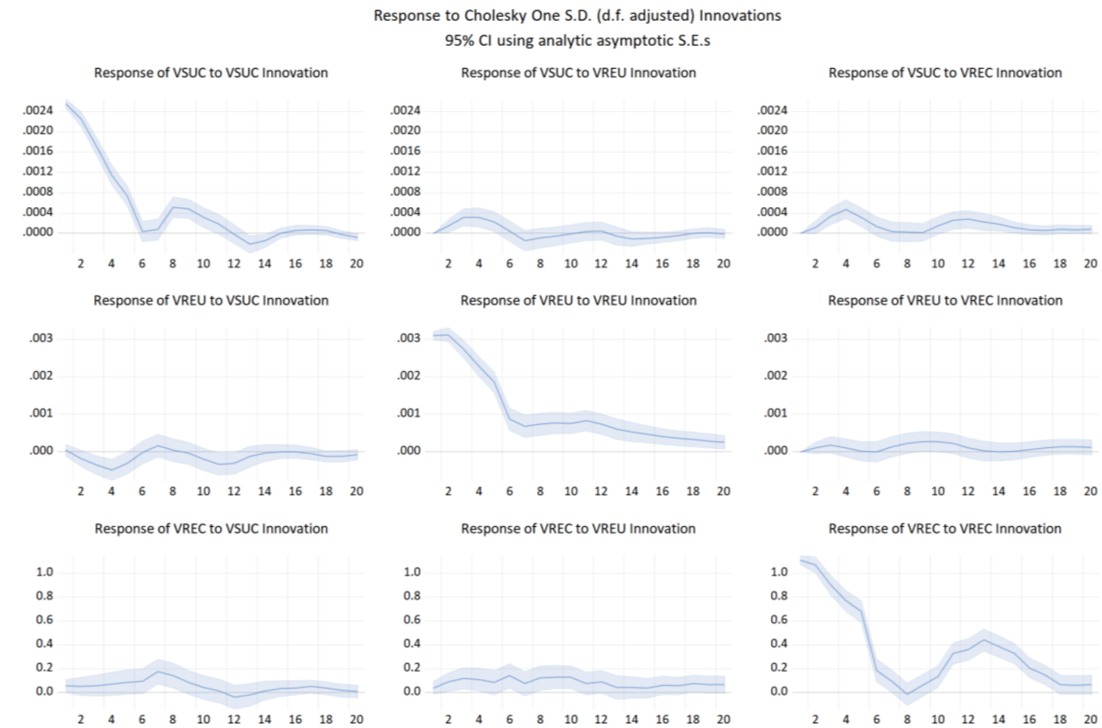
(c) Sample 3: December 1, 2019 - December 31, 2022

Dependent Variable	Excluded Variable	Chi-sq	df
VSUC	VREU	25.71965361	8
VSUC	VREC	1.055553037	8
VREU	VSUC	22.91584037	8
VREU	VREC	3.863023577	8
VREC	VSUC	12.37964684	8

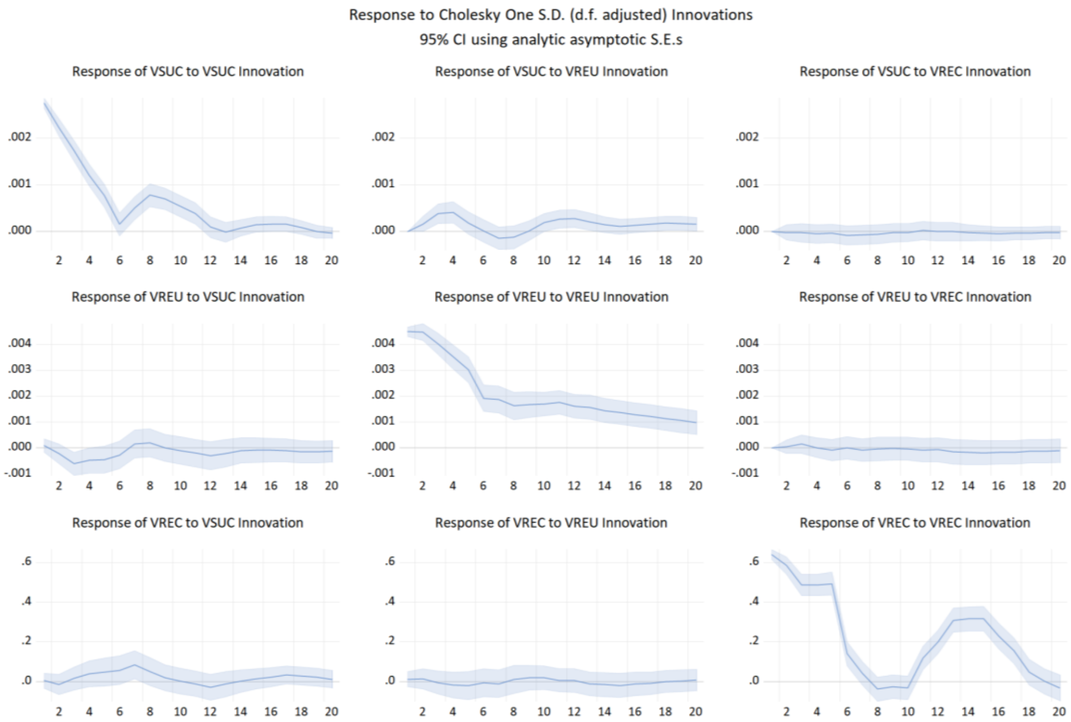
The Granger Causality Test results show that the exchange rate return volatility and the volatility of U.S. export-oriented stock index has a mutual predictive ability among all three periods. While different with previous Granger Causality Test results, this result shows that the volatility of U.S.' export-oriented stock index show a higher significant predictive ability on the volatility of China's export-oriented stock index.



(a) Full sample: August 12, 2015 - December 31, 2022



(b) Sample 2: August 12, 2015 - December 1, 2019



(c) Sample 3: December 1, 2019 - December 31, 2022

Figure 8. Impulse Response Result

As shown above, the volatility impulse result of international focused stock market and exchange market shows similar trend with Table 4, with a extended but moderate adjustment process.

4.3.2.3. Domestic Oriented Companies' Volatility Spillover

All data series were tested for stationarity using the Augmented Dickey-Fuller (ADF) test, and the results are provided in the Appendix 3 and 4.

Table 20. Vector Autoregrssion Analysis

(a) Full sample: August 12, 2015 - December 31, 2022

	VSUC	VRDU	VRDC
VSUC(-1)	0.8524901...	-0.0876384...	-0.1182177...
	0.0193051...	0.0419991...	0.0474310...
	[44.1587]	[-2.08667]	[-2.49241]
VSUC(-2)	-0.0683900...	0.0105300...	-0.0417450...
	0.0254631...	0.0553960...	0.0625606...
	[-2.68585]	[0.19009]	[-0.66727]
VSUC(-3)	-0.0373011...	0.0217057...	0.1381475...
	0.0251138...	0.0546363...	0.0617025...
	[-1.48528]	[0.39728]	[2.23893]
VSUC(-4)	-0.0021649...	0.0862964...	0.0833284...
	0.0249540...	0.0542886...	0.0613099...
	[-0.08676]	[1.58959]	[1.35914]
VSUC(-5)	-0.1527636...	-0.0201457...	0.0280365...
	0.0249161...	0.0542060...	0.0612166...
	[-6.13112]	[-0.37165]	[0.45799]
VSUC(-6)	0.2256654...	0.1779886...	-0.1311918...
	0.0250862...	0.0545761...	0.0616346...
	[8.99559]	[3.26129]	[-2.12854]
VSUC(-7)	0.0526308...	-0.2164779...	-0.0626476...
	0.0254520...	0.0553719...	0.0625333...
	[2.06784]	[-3.90952]	[-1.00183]
VSUC(-8)	-0.0985722...	0.0236309...	0.0287431...
	0.0193173...	0.0420257...	0.0474609...
	[-5.10279]	[0.56230]	[0.60562]
VRDU(-1)	0.0344524...	1.0966396...	-0.0098270...
	0.0089185...	0.0194027...	0.0219121...
	[3.86299]	[56.5197]	[-0.44847]
VRDU(-2)	-0.0343242...	-0.1989032...	-0.0031990...
	0.0131219...	0.0285473...	0.0322394...
	[-2.61579]	[-6.96748]	[-0.09923]
VRDU(-3)	0.0143493...	-0.0475921...	-0.0167648...
	0.0129540...	0.0281820...	0.0318269...
	[1.10771]	[-1.68874]	[-0.52675]
VRDU(-4)	-0.0244821...	0.1462911...	0.0108097...
	0.0126631...	0.0275491...	0.0311121...
	[-1.93334]	[5.31018]	[0.34744]
VRDU(-5)	0.0092521...	-0.3081827...	0.0308269...
	0.0126734...	0.0275715...	0.0311374...
	[0.73004]	[-11.1776]	[0.99003]
VRDU(-6)	0.0027595...	0.2985469...	0.0415901...
	0.0129683...	0.0282132...	0.0318621...
	[0.21279]	[10.5818]	[1.30531]
VRDU(-7)	0.0156784...	-0.1523348...	0.0815819...
	0.0131174...	0.0285375...	0.0322283...
	[1.19524]	[-5.33806]	[2.53137]
VRDU(-8)	-0.0134420...	0.0161063...	-0.1253646...
	0.0089044...	0.0193719...	0.0218773...
	[-1.50959]	[0.83142]	[-5.73033]
VRDC(-1)	0.0256257...	-0.0002913...	0.9146310...
	0.0078437...	0.0170644...	0.0192714...
	[3.26702]	[-0.01708]	[47.4604]
VRDC(-2)	0.0023882...	-0.0204912...	-0.0789178...
	0.0106549...	0.0231803...	0.0261782...
	[0.22414]	[-0.88400]	[-3.01463]
VRDC(-3)	0.0048135...	-0.0028358...	-0.0439221...
	0.0105852...	0.0230286...	0.0260070...
	[0.45474]	[-0.12314]	[-1.68886]
VRDC(-4)	-0.0288015...	0.0216321...	0.0322963...
	0.0104993...	0.0228417...	0.0257958...
	[-2.74318]	[0.94705]	[1.25200]
VRDC(-5)	-0.0147346...	0.0382139...	-0.1721345...
	0.0105122...	0.0228697...	0.0258275...
	[-1.40167]	[1.67094]	[-6.66476]
VRDC(-6)	0.0168995...	-0.0357619...	0.1647744...
	0.0105976...	0.0230557...	0.0260375...
	[1.59464]	[-1.55111]	[6.32833]
VRDC(-7)	-0.0032334...	0.0362339...	0.0136917...
	0.0106676...	0.0232079...	0.0262095...
	[-0.30311]	[1.56127]	[0.52240]
VRDC(-8)	0.0109253...	-0.0275142...	-0.0179762...
	0.0078560...	0.0170910...	0.0193015...
	[1.39070]	[-1.60986]	[-0.93134]
C	0.0007376...	0.0015701...	0.0036749...
	0.0001452...	0.0003159...	0.0003567...
	[5.07998]	[4.97034]	[10.3006]

(b) Sample 2: August 12, 2015 - December 1, 2019

	VSUC	VRDU	VRDC
VSUC(-1)	0.8903763...	-0.0767011...	-0.0745909...
	0.0253062...	0.0640187...	0.0666139...
	[35.1840]	[-1.19810]	[-1.11975]
VSUC(-2)	-0.1126003...	0.0391919...	-0.1207049...
	0.0339678...	0.0859304...	0.0894138...
	[-3.31491]	[0.45609]	[-1.34996]
VSUC(-3)	-0.0417219...	-0.0486699...	0.1829630...
	0.0337051...	0.0852658...	0.0887223...
	[-1.23785]	[-0.57080]	[2.06220]
VSUC(-4)	0.0151860...	0.1693398...	0.0602886...
	0.0334628...	0.0846528...	0.0880844...
	[0.45382]	[2.00040]	[0.68444]
VSUC(-5)	-0.1714418...	-0.1220832...	0.1015515...
	0.0333465...	0.0843588...	0.0877785...
	[-5.14121]	[-1.44719]	[1.15691]
VSUC(-6)	0.1978937...	0.2878129...	-0.2038261...
	0.0335193...	0.0847959...	0.0882333...
	[5.90386]	[3.39418]	[-2.31008]
VSUC(-7)	0.0977544...	-0.2968649...	-0.0957220...
	0.0338228...	0.0855637...	0.0890323...
	[2.89019]	[-3.46952]	[-1.07514]
VSUC(-8)	-0.1288383...	0.0183661...	0.1178784...
	0.0252205...	0.0638020...	0.0663884...
	[-5.10846]	[0.28786]	[1.77559]
VRDU(-1)	0.0277424...	1.1095301...	-0.0058947...
	0.0100951...	0.0255382...	0.0265734...
	[2.74811]	[43.4459]	[-0.22183]
VRDU(-2)	-0.0451142...	-0.2235069...	-0.0303469...
	0.0149169...	0.0377363...	0.0392660...
	[-3.02436]	[-5.92286]	[-0.77285]
VRDU(-3)	0.0357690...	-0.0509814...	0.0240312...
	0.0147249...	0.0372505...	0.0387606...
	[2.42915]	[-1.36861]	[0.61999]
VRDU(-4)	-0.0289428...	0.1820616...	0.0016521...
	0.0143343...	0.0362625...	0.0377325...
	[-2.01912]	[5.02065]	[0.04379]
VRDU(-5)	0.0045154...	-0.3498669...	0.0170661...
	0.0143530...	0.0363098...	0.0377817...
	[0.31460]	[-9.63560]	[0.45170]
VRDU(-6)	0.0110482...	0.3311468...	0.0563112...
	0.0147726...	0.0373711...	0.0388860...
	[0.74789]	[8.86103]	[1.44811]
VRDU(-7)	0.0126924...	-0.1833743...	0.0775760...
	0.0149685...	0.0378667...	0.0394017...
	[0.84795]	[-4.84263]	[1.96885]
VRDU(-8)	-0.0189927...	0.0114035...	-0.1269613...
	0.0101000...	0.0255506...	0.0265863...
	[-1.88047]	[0.44631]	[-4.77543]
VRDC(-1)	0.0219335...	-0.0049937...	0.9111011...
	0.0096177...	0.0243305...	0.0253168...
	[2.28053]	[-0.20525]	[35.9879]
VRDC(-2)	0.0038991...	-0.0139785...	-0.0704100...
	0.0130453...	0.0330015...	0.0343393...
	[0.29889]	[-0.42357]	[-2.05042]
VRDC(-3)	0.0099248...	-0.0021526...	-0.0265689...
	0.0129407...	0.0327369...	0.0340640...
	[0.76695]	[-0.06576]	[-0.77997]
VRDC(-4)	-0.0322425...	0.0154489...	0.0198328...
	0.0128094...	0.0324047...	0.0337183...
	[-2.51710]	[0.47675]	[0.58819]
VRDC(-5)	-0.0111588...	0.0597015...	-0.1828603...
	0.0128405...	0.0324835...	0.0338003...
	[-0.86903]	[1.83790]	[-5.41001]
VRDC(-6)	0.0087177...	-0.0327801...	0.1638802...
	0.0129634...	0.0327943...	0.0341237...
	[0.67249]	[-0.99957]	[4.80253]
VRDC(-7)	0.0060596...	0.0090237...	0.0317658...
	0.0130443...	0.0329990...	0.0343367...
	[0.46454]	[0.27345]	[0.92513]
VRDC(-8)	0.0101036...	-0.0094280...	-0.0357305...
	0.0096374...	0.0243803...	0.0253686...
	[1.04838]	[-0.38671]	[-1.40845]
C	0.0007948...	0.0016244...	0.0034219...
	0.0001718...	0.0004347...	0.0004523...
	[4.62548]	[3.73664]	[7.56471]

(c) Sample 3: December 1, 2019 - December 31, 2022

	VSUC	VRDU	VRDC
VSUC(-1)	0.8023864... 0.0301376... [26.6241]	-0.1138363... 0.0494600... [-2.30158]	-0.1714107... 0.0676650... [-2.53322]
VSUC(-2)	-0.0139026... 0.0388791... [-0.35759]	-0.0153986... 0.0638060... [-0.24134]	0.0578079... 0.0872914... [0.66224]
VSUC(-3)	-0.0268393... 0.0381040... [-0.70437]	0.0820465... 0.0625340... [1.31203]	0.0986740... 0.0855512... [1.15339]
VSUC(-4)	-0.0219874... 0.0379153... [-0.57991]	0.0298797... 0.0622243... [0.48019]	0.0941624... 0.0851275... [1.10613]
VSUC(-5)	-0.1318672... 0.0379376... [-3.47589]	0.0585436... 0.0622610... [0.94029]	-0.0561929... 0.0851777... [-0.65971]
VSUC(-6)	0.2566862... 0.0381825... [6.72260]	0.0522031... 0.0626629... [0.83308]	-0.0309251... 0.0857275... [-0.36074]
VSUC(-7)	0.0012956... 0.0389537... [0.03326]	-0.1296130... 0.0639285... [-2.02747]	-0.0285590... 0.0874590... [-0.32654]
VSUC(-8)	-0.0723385... 0.0302584... [-2.39069]	0.0331997... 0.0496583... [0.66856]	-0.0846163... 0.0679363... [-1.24552]
VRDU(-1)	0.0519440... 0.0183758... [2.82676]	1.0484185... 0.0301573... [34.7650]	-0.0094440... 0.0412574... [-0.22891]
VRDU(-2)	-0.0051473... 0.0264422... [-0.19467]	-0.1452245... 0.0433954... [-3.34654]	0.0593548... 0.0593681... [0.99978]
VRDU(-3)	-0.0423585... 0.0261906... [-1.61732]	-0.0260179... 0.0429825... [-0.60531]	-0.1181232... 0.0588032... [-2.00879]
VRDU(-4)	-0.0188813... 0.0259629... [-0.72724]	0.0506811... 0.0426089... [1.18945]	0.0190512... 0.0582921... [0.32682]
VRDU(-5)	0.0237214... 0.0259582... [0.91383]	-0.2077922... 0.0426010... [-4.87763]	0.0804928... 0.0582814... [1.38111]
VRDU(-6)	-0.0148770... 0.0262925... [-0.56583]	0.2277896... 0.0431496... [5.27906]	-0.0023804... 0.0590319... [-0.04033]
VRDU(-7)	0.0164499... 0.0265187... [0.62031]	-0.0688110... 0.0435209... [-1.58110]	0.0808974... 0.0595398... [1.35871]
VRDU(-8)	0.0018011... 0.0184457... [0.09764]	0.0236713... 0.0302720... [0.78195]	-0.1125691... 0.0414144... [-2.71811]
VRDC(-1)	0.0324913... 0.0133636... [2.43133]	0.0063441... 0.0219315... [0.28927]	0.9183410... 0.0300040... [30.6072]
VRDC(-2)	0.0005978... 0.0181985... [0.03285]	-0.0226670... 0.0298663... [-0.75895]	-0.0869650... 0.0408593... [-2.12840]
VRDC(-3)	-0.0053419... 0.0181107... [-0.29496]	-0.0106558... 0.0297222... [-0.35852]	-0.0797960... 0.0406622... [-1.96241]
VRDC(-4)	-0.0213186... 0.0180085... [-1.18381]	0.0442638... 0.0295544... [1.49770]	0.0519717... 0.0404327... [1.28539]
VRDC(-5)	-0.0167657... 0.0180243... [-0.93017]	-0.0033107... 0.0295804... [-0.11192]	-0.1484087... 0.0404682... [-3.66729]
VRDC(-6)	0.0262475... 0.0180691... [1.45261]	-0.0420403... 0.0296540... [-1.41769]	0.1593595... 0.0405689... [3.92812]
VRDC(-7)	-0.0164296... 0.0181869... [-0.90338]	0.0835399... 0.0298473... [2.79891]	-0.0133474... 0.0408333... [-0.32688]
VRDC(-8)	0.0115934... 0.0133441... [0.86880]	-0.0562047... 0.0218995... [-2.56648]	0.0089833... 0.0299602... [0.29984]
C	0.0006451... 0.0002673... [2.41325]	0.0012433... 0.0004387... [2.83410]	0.0041704... 0.0006001... [6.94851]

Shown as above, the USD/CNY exchange rate return exhibits an significant influence on China's domestic-oriented stock return index across all three sample periods, though this effect is unstable.

Similarly, the USD/CNY exchange rate return also significantly affects U.S. domestic-oriented stock return index, but this impact is unstable across the periods analyzed. Furthermore, U.S. domestic-oriented stock return index shows significant influence on the exchange market in the earlier lagged periods across all three sample periods. While the effect of U.S. domestic-oriented stock return index on China's becomes more pronounced in the later lags. On the respect of China's domestic-oriented stock return index, China's domestic-oriented stock return index has a weak impact on the exchange market in the earlier periods, while it exhibits a relatively weak influence on the U.S. stock return in the later lagged periods.

Table 21. VAR Lag Exclusion Wald Test

(a) Full sample: August 12, 2015

	VSUC	VRDU	VRDC	Joint
Lag 1	2008.1009... [0.0000]	3198.5210... [0.0000]	2255.9719... [0.0000]	7449.4516... [0.0000]
Lag 2	14.640286... [0.0022]	49.790082... [0.0000]	9.6302808... [0.0220]	71.886498... [0.0000]
Lag 3	3.5119167... [0.3192]	2.9832574... [0.3942]	8.0218816... [0.0456]	14.861996... [0.0948]
Lag 4	11.526271... [0.0092]	32.674060... [0.0000]	3.6528421... [0.3015]	49.408506... [0.0000]
Lag 5	40.016063... [0.0000]	127.68106... [0.0000]	45.362737... [0.0000]	215.65304... [0.0000]
Lag 6	84.013108... [0.0000]	126.48703... [0.0000]	46.367576... [0.0000]	254.34514... [0.0000]
Lag 7	5.9133159... [0.1159]	46.852706... [0.0000]	7.6236112... [0.0545]	62.962294... [0.0000]
Lag 8	30.700911... [0.0000]	3.5142401... [0.3189]	34.205265... [0.0000]	69.328147... [0.0000]
df	3	3	3	9

(b) Sample 2: August 12, 2015 - December 1, 2019

	VSUC	VRDU	VRDC	Joint
Lag 1	1267.6038... [0.0000]	1889.8385... [0.0000]	1296.3340... [0.0000]	4446.3689... [0.0000]
Lag 2	20.511164... [0.0001]	35.633970... [0.0000]	6.8823548... [0.0757]	60.975123... [0.0000]
Lag 3	8.0195768... [0.0456]	2.2555261... [0.5211]	5.2476907... [0.1545]	16.048900... [0.0659]
Lag 4	10.821700... [0.0127]	30.061960... [0.0000]	0.8284959... [0.8426]	42.702080... [0.0000]
Lag 5	27.349618... [0.0000]	97.835741... [0.0000]	30.612777... [0.0000]	157.20283... [0.0000]
Lag 6	35.976274... [0.0000]	90.205165... [0.0000]	30.714847... [0.0000]	155.57342... [0.0000]
Lag 7	9.3461361... [0.0250]	35.212602... [0.0000]	6.0151647... [0.1109]	52.425203... [0.0000]
Lag 8	30.602822... [0.0000]	0.4150423... [0.9371]	28.052077... [0.0000]	59.593934... [0.0000]
df	3	3	3	9

(c) Sample 3: December 1, 2019 - December 31, 2022

	VSUC	VRDU	VRDC	Joint
Lag 1	739.95875... [0.0000]	1210.5936... [0.0000]	945.25901... [0.0000]	2890.7208... [0.0000]
Lag 2	0.1792920... [0.9809]	12.180262... [0.0068]	5.9926442... [0.1120]	18.436261... [0.0304]
Lag 3	3.4366660... [0.3291]	2.1020845... [0.5515]	9.0076762... [0.0292]	14.478002... [0.1063]
Lag 4	2.3723431... [0.4988]	4.0432075... [0.2568]	3.0883542... [0.3782]	9.8413780... [0.3635]
Lag 5	13.386459... [0.0039]	24.140713... [0.0000]	15.596076... [0.0014]	55.219550... [0.0000]
Lag 6	47.329072... [0.0000]	31.293433... [0.0000]	15.556830... [0.0014]	94.674596... [0.0000]
Lag 7	1.1825043... [0.7572]	14.908586... [0.0019]	1.9748943... [0.5776]	19.065067... [0.0246]
Lag 8	6.4693070... [0.0909]	7.6498067... [0.0538]	9.9131600... [0.0193]	25.234797... [0.0027]
df	3	3	3	9

From the Table presented, it is evident that across the three sample periods, the significance levels for lags 1, and lag 5, 6, 8 are consistently high. In contrast, the significance level for lag 2 to 4 is notably lower. It indicates that the inclusion of lags up to 5, 6 and 8 significantly improves the explanatory power of the model for the variables examined.

Table 22. Granger Causality Test:

(a) Full sample: August 12, 2015 - December 31, 2022

Dependent Variable	Excluded Variable	Chi-sq	df
VSUC	VRDU	25.65474608	8
VSUC	VRDC	51.82864205	8
VRDU	VSUC	45.68327673	8
VRDU	VRDC	15.91217312	8
VRDC	VSUC	41.065761	8

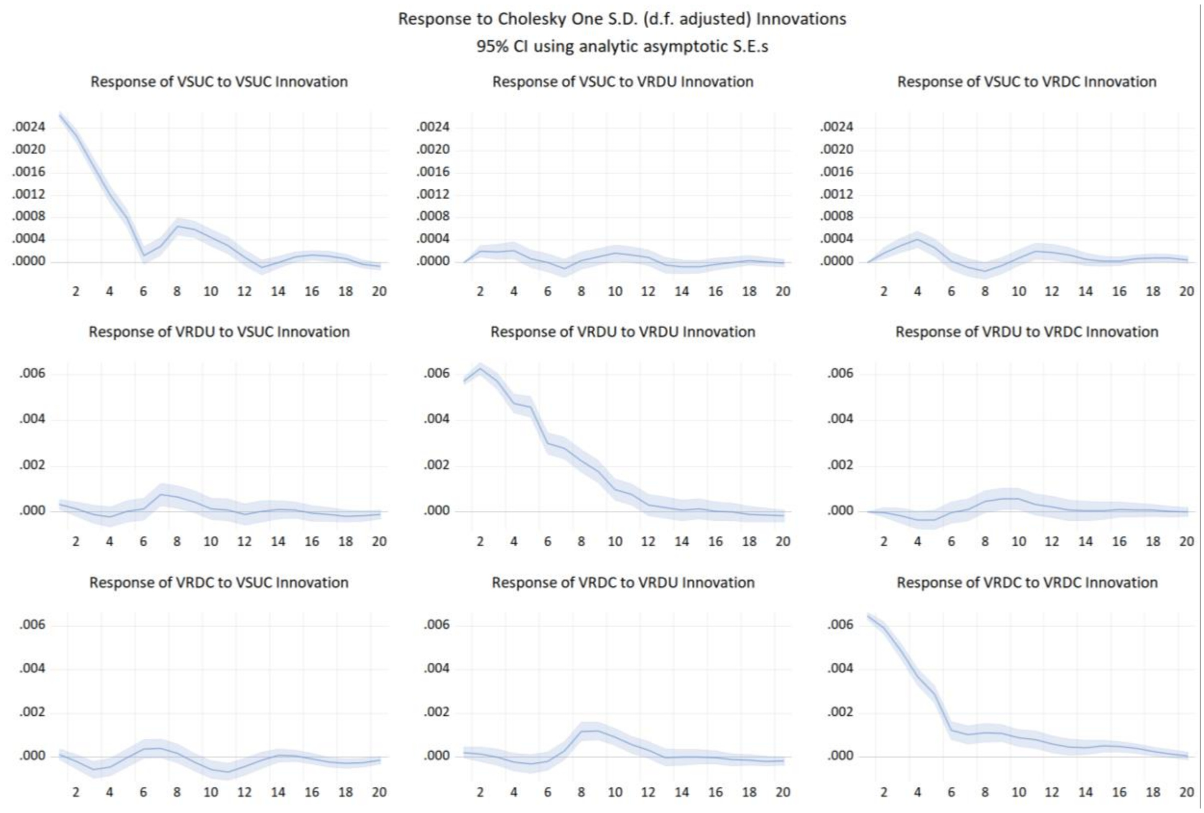
(b) Sample 2: August 12, 2015 - December 1, 2019

Dependent Variable	Excluded Variable	Chi-sq	df
VSUC	VRDU	22.27938381	8
VSUC	VRDC	33.55159019	8
VRDU	VSUC	31.42872795	8
VRDU	VRDC	10.52930128	8
VRDC	VSUC	27.3370672	8

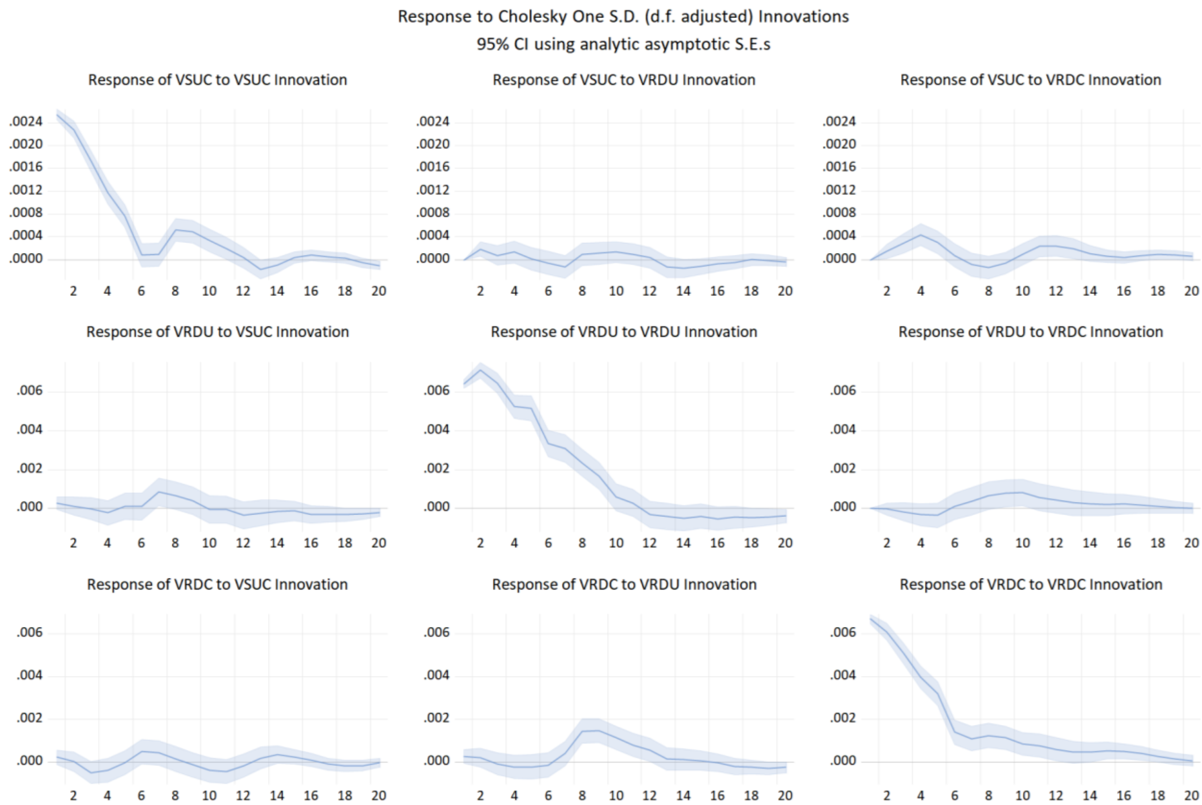
(c) Sample 3: December 1, 2019 - December 31, 2022

Dependent Variable	Excluded Variable	Chi-sq	df
VSUC	VRDU	19.59037413	8
VSUC	VRDC	20.08790412	8
VRDU	VSUC	23.28751888	8
VRDU	VRDC	13.38399748	8
VRDC	VSUC	22.04713028	8

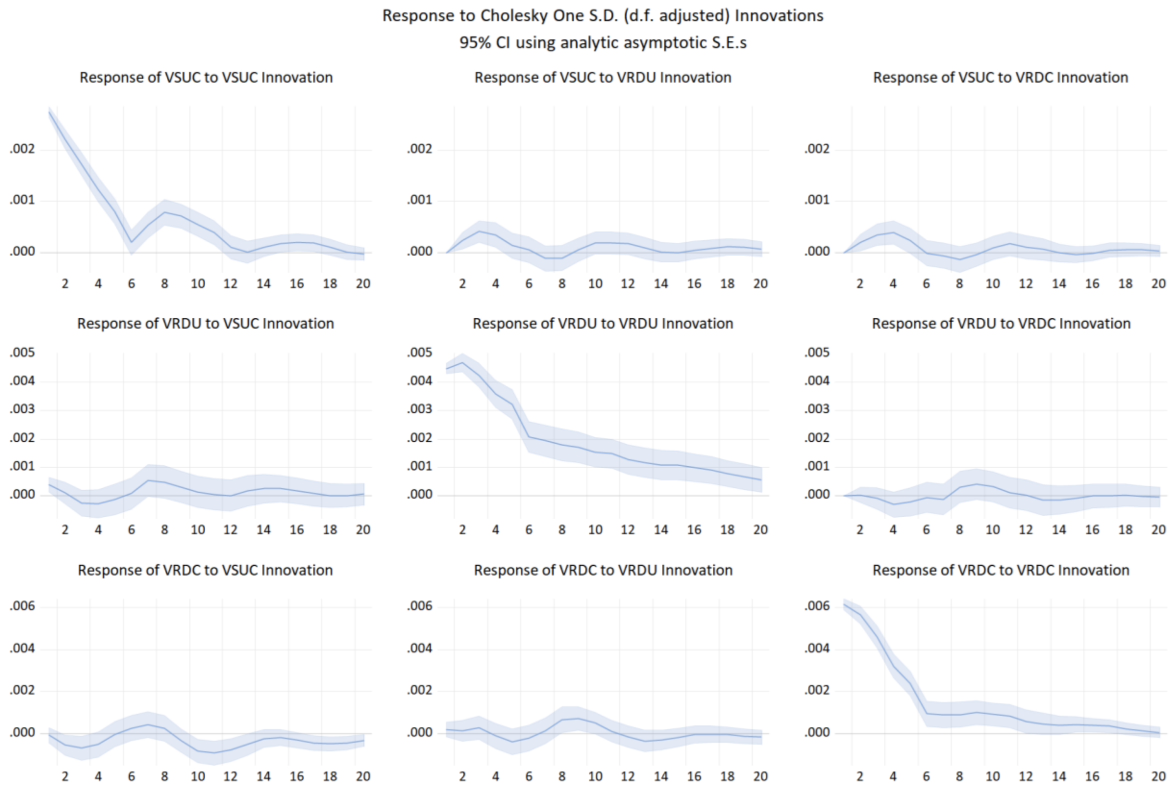
Table 22 indicates that the three markets' volatility returns all have mutual significant predictive ability among all three periods.



(a) Full sample: August 12, 2015 - December 31, 2022



(b) Sample 2: August 12, 2015 - December 1, 2019



(c) Sample 3: December 1, 2019 - December 31, 2022

Figure 9. Impulse Response Result

As shown above, the impluse result of domestic focused stock return show similar trends with the previous volatility studies. It is interesting to find that the Chinese domestic focused stock index show much weaker volatility under an innovation than the export oriented market stock return.

5. RESULT DISCUSSION

This research finding reveals that China's SSE50 stock return, export-oriented stock return index and domestic-oriented stock return index; U.S. SPX 500, export-oriented companies and domestic-oriented companies' stock return, and the USD/CNY exchange rate return exhibit significant lag effects. Specifically, past values of these variables have a notable influence on their future volatility, indicating the persistence of market trends and the importance of historical data for forecasting future returns.

Furthermore, the analysis of mean spillover effects among the China's SSE50 and U.S. SPX 500 stock return, export-oriented stock return index and domestic-oriented stock return index; as well as the USD/CNY exchange rate return indicate that the U.S. stock market has a significant mean spillover effect and predictive power on exchange rates among all periods, while the USD/CNY exchange rate return fails to show any mean spillover effect on the U.S. stock returns. During periods of economic crises, the spillover effects and mutual predictive capabilities between the Chinese stock market and the USD/CNY exchange rate return become pronounced, while no significant relationship showed in stable periods. This suggests that during the pandemic crises, interactions among financial variables become more evident due to increased market uncertainty and pressure. This result is consistent with previous spillover effect studies and heightens significance during crises underscores the market's robust response to economic shocks and policy changes.

In terms of volatility spillover effects, the the USD/CNY exchange rate return exhibits significant volatility spillovers to the U.S. stock market across three sample periods for both cross-industry indexes and the S&P 500, indicating a strong and stable spillover effect between the exchange rate and U.S. stocks. While the exchange rate return's volatility spillovers to Chinese stocks are unstable, with significant effects observed only during crisis periods for the SSE50, and significant but unstable effects for cross-industry indexes.

The S&P 500 exhibits volatility spillovers to the exchange return, with stronger effects during the pandemic, and stable spillovers to the SSE50. The U.S. export-oriented and import-oriented stock return index also have a relatively stable impact on the exchange market; as well as significant impacts the Chinese' cross-industry stock indexes, but this effect is significant only in later lags.

China's stock return indexes generally have an impact on the exchange rate return in earlier lags, indicating that the volatility spillover is transmitted quickly but is not sustained. Moreover, the effect of the SSE on the USD/CNY exchange rate return is stronger during the pandemic. For its impact on U.S. stocks, only the S&P 500 and the domestic-oriented indexes in U.S. have been significant impacted.

In summary, the U.S. stock market show a strong and stable bidirectional volatility spillovers with the USD/CNY exchange rate returns. While U.S. stock market seems to have a stronger volatility spillover on China's during later lag period, indicating it may suggest that U.S. market shocks have a delayed but persistent impact on Chinese stock market volatility. This could imply that fluctuations or changes in the U.S. market are transmitted to China over time. Moreover, China's stock market could have a significant spillover on U.S. stock market most of the time, while the exported-oriented China's stock return index fails to show a significant spillover on the U.S. exported-oriented companies stock market. In addition, only among the volatility spillovers between the SSE 50 stock return, SPX 500 stock return and the USD/CNY exchange rate return shows a higher significance level during crisis period, the cross-industry sectors' volatility spillover effects do not become stronger during the Covid-19 periods.

On the hand of the causality test between the market return volatility, most of the markets show a bidirectional predictive ability to other markets, except the exported-oriented stock markets in China, it shows insignificant causal relationship with other markets in most of the periods.

On the respect of the impulse response analysis, it reveals that reactions of each market to innovations from other markets are relatively moderate. Mean spillover effects generally stabilize within 4-5 years, while the response to volatility spillover effects persists longer but remains at a moderate level. This suggests that although markets react to shocks, the magnitude of these reactions typically diminishes over time. This moderate response could be attributed to market adjustment mechanisms, where initial volatility adjustments lead to stabilization as the market absorbs and processes new information.

Interestingly, export-oriented markets in China exhibit a higher impulse response to innovations compared to domestic-oriented markets. This indicates that export-oriented markets are more sensitive to external shocks and innovations. The increased volatility may be due to their exposure to global economic conditions, trade policies, and international market fluctuations, which amplify their reaction to market innovations.

However, when comparing domestic-oriented and export-oriented stock return indices, this analysis exhibits that the mean spillover effects and the predictive power of domestic-oriented indices in China and the U.S. do not significantly differ from those of export-oriented indices. This finding aligns with Lin (31), indicating although the exported-oriented stock markets is more sensitive to the international shocks, the relationship between stock markets and exchange rates is primarily driven by stock market dynamics rather than trade flows.

6. CONTRIBUTION AND CONCLUSION

In conclusion, our analysis provides a comprehensive understanding of the intricate interactions between the Chinese and U.S. stock markets and the exchange rate markets. The findings reveal significant lag effects in stock returns, highlighting the importance of historical data in forecasting future market movements. In addition, the observed mean spillover effects emphasize the substantial predictive power of the U.S. stock market on exchange rates, while although China's stock markets only show a significant relationship with the exchange markets in crisis period, suggesting that financial market interactions become more pronounced under heightened uncertainty, which is aligns with the previous studies' result. While the exchange

rate fails to show predictive ability to other markets, this mean spillover result could provide some supportive evidence to the stock-oriented model. Furthermore, the comparison between domestic-oriented and export-oriented stock return indices provides insights into the primary drivers of market interactions. The results suggest that stock market dynamics, rather than trade-related factors, play a crucial role in shaping the relationship between stock markets and exchange rate returns.

This study also underscores the strong volatility spillover causal relationship among these markets, indicating a high degree of interconnectedness and mutual influence. The exchange market also shows a significant predictive ability to China and U.S. stock returns, consequently, the volatility result may more in favour of the assumption that there are mutual interactions between these markets. Furthermore, it is evident that during crisis period, the relationship between SSE 50, SPX 500 and the USD/CNY become more significant. However, same as the mean spillover effects, China's stock market seems to have a less significant relationship with other markets. The weaker relationship may could be attributed to several factors. Firstly, the U.S. market benefits from greater maturity and liquidity, resulting in more pronounced inter-market linkages. Additionally, China's relatively strict capital account controls limit the free flow of international capital, which diminishes the spillover effects between its stock and exchange rate markets. Furthermore, China's more active market regulation and intervention may also contribute to the observed instability and weaker connections between its financial markets and exchange rate.

The impulse response analysis further illustrates that while the three markets react to other markets' innovations, these reactions tend to moderate over time, reflecting market adjustment mechanisms. While notably, the heightened sensitivity of China's export-oriented markets to external shocks points to their increased vulnerability to global economic conditions.

The findings in this study offer several important policy implications. Firstly, the analysis highlights the significant role of the U.S. stock market in influencing exchange rate return, with stronger mean spillover effects observed particularly during economic crises. This underscores the need for policymakers to monitor U.S. stock market trends closely, as they can have substantial ripple effects on global exchange rates and financial stability. For policymakers, the results highlight the need for targeted financial regulation, particularly during periods of economic crises. For investors, the study's insights into the volatility spillover effects emphasize the importance of considering global market interactions when making investment decisions. Diversifying portfolios and staying informed about both U.S. and Chinese market developments can mitigate risks and enhance investment strategies. Additionally, investors are encouraged to utilize historical data effectively for forecasting. Understanding lagged effects and historical market responses can provide valuable insights for making informed investment decisions. Future research could extend this analysis by exploring the impact of recent global economic changes, such as the post-pandemic recovery phase, on these market dynamics.

APPENDIX:

7. DESCRIPTION STATISTIC - MEAN SPILLOVER EFFECT

7.1. Domestic Focused Industry: Mean Spillover Effect

(a) Full sample: August 12, 2015 - December 31, 2022

index	CH_local	US_local	Exchange_Rate
count	2699	2699	2699
mean	0.001178735	0.000568846	0.000306312
std	0.019702865	0.014940376	0.00737917
min	-0.123989852	-0.251433123	-0.0302
25%	-0.004747715	-0.002825741	-0.00265
50%	0	0	0.000515385
75%	0.005527267	0.004751473	0.00375
max	0.130220401	0.299617102	0.0303

(b) Sample 2: August 12, 2015 - December 1, 2019

index	CH_local	US_local	Exchange_Rate
count	1573	1573	1573
mean	0.001546003	0.000527063	0.000494269
std	0.019524538	0.014732737	0.007030346
min	-0.123989852	-0.251433123	-0.0295
25%	-0.00448239	-0.002706441	-0.00224
50%	0	0	0.0006
75%	0.004725494	0.004396138	0.003925
max	0.111071392	0.299617102	0.0303

(c) Sample 3: December 1, 2019 - December 31, 2022

index	CH_local	US_local	Exchange_Rate
count	1126	1126	1126
mean	0.000665669	0.000627216	4.37404E-05
std	0.019946696	0.015232097	0.007836178
min	-0.090389588	-0.1513094	-0.0302
25%	-0.005438412	-0.003137391	-0.003475
50%	0	0	0.00015
75%	0.006390115	0.00544872	0.003385
max	0.130220401	0.112323869	0.0302

7.2. International Focused Industry: Mean Spillover Effect

(a) Full sample: August 12, 2015 - December 31, 2022

index	CH_inter	US_inter	Exchange_Rate
count	2699	2699	2699
mean	0.282233325	0.00044946	0.000306312
std	1.967729652	0.011568285	0.00737917
min	-0.941849168	-0.135636033	-0.0302
25%	-0.007340312	-0.001413344	-0.00265
50%	0	0	0.000515385
75%	0.008516281	0.003807252	0.00375
max	16.90332087	0.10651981	0.0303

(b) Sample 2: August 12, 2015 - December 1, 2019

index	CH_inter	US_inter	Exchange_Rate
count	1574	1574	1574
mean	0.383396165	0.000510446	0.000494654
std	2.325278037	0.008929791	0.007028127
min	-0.941849168	-0.086809305	-0.0295
25%	-0.005411974	-0.000814002	-0.00224
50%	0	0	0.00065
75%	0.008397226	0.003186734	0.0039125
max	16.47360684	0.099314476	0.0303

(c) Sample 3: December 1, 2019 - December 31, 2022

index	CH_inter	US_inter	Exchange_Rate
count	1126	1126	1126
mean	0.140575431	0.000366239	4.37404E-05
std	1.300543119	0.014472017	0.007836178
min	-0.941747934	-0.135636033	-0.0302
25%	-0.009272794	-0.002980639	-0.003475
50%	0	0	0.00015
75%	0.008718693	0.005253662	0.003385
max	16.90332087	0.10651981	0.0302

8. ADF TEST - MEAN SPILLOVER EFFECT

8.1. Domestic Focused Industry: Mean Spillover Effect

(a) Full sample: August 12, 2015 - December 31, 2022

Column	CH_local	US_local	Exchange_Rate
ADF Statistic	-52.5657409	-11.21347929	-21.89648388
p-value	0	2.09737E-20	0
Critical Value (1%)	-3.432776068	-3.432793291	-3.43277787
Critical Value (5%)	-2.862611859	-2.862619465	-2.862612654
Critical Value (10%)	-2.567340586	-2.567344636	-2.56734101

(b) Sample 2: August 12, 2015 - December 1, 2019

Column	CH_local	US_local	Exchange_Rate
ADF Statistic	-22.02871485	-26.83923256	-19.29004029
p-value	0	0	0
Critical Value (1%)	-3.434524653	-3.43452199	-3.43451933
Critical Value (5%)	-2.863383859	-2.863382683	-2.863381509
Critical Value (10%)	-2.567751638	-2.567751012	-2.567750387

(c) Sample 3: December 1, 2019 - December 31, 2022

Column	CH_local	US_local	Exchange_Rate
ADF Statistic	-33.95149111	-6.881833643	-10.63899664
p-value	0	1.42691E-09	4.98611E-19
Critical Value (1%)	-3.43617603	-3.436276349	-3.436202099
Critical Value (5%)	-2.864112529	-2.864156782	-2.864124029
Critical Value (10%)	-2.568139686	-2.568163255	-2.568145811

8.2. International Focused Industry: Mean Spillover effect

(a) Full sample: August 12, 2015 - December 31, 2022

Column	CH_inter	US_inter	Exchange_Rate
ADF Statistic	-4.587751136	-12.1215132	-21.89648388
p-value	0.000136054	1.82073E-22	0
Critical Value (1%)	-3.432801535	-3.432793291	-3.43277787
Critical Value (5%)	-2.862623105	-2.862619465	-2.862612654
Critical Value (10%)	-2.567346574	-2.567344636	-2.56734101

(b) Sample 2: August 12, 2015 - December 1, 2019

Column	CH_inter	US_inter	Exchange_Rate
ADF Statistic	-4.04269631	-15.70089715	-19.2961082
p-value	0.001202724	1.39655E-28	0
Critical Value (1%)	-3.434573182	-3.434532664	-3.434516673
Critical Value (5%)	-2.863405278	-2.863387395	-2.863380337
Critical Value (10%)	-2.567763044	-2.567753521	-2.567749763

(c) Sample 3: December 1, 2019 - December 31, 2022

Column	CH_inter	US_inter	Exchange_Rate
ADF Statistic	-4.430736624	-7.40974745	-10.63899664
p-value	0.000261781	7.18618E-11	4.98611E-19
Critical Value (1%)	-3.436244298	-3.436276349	-3.436202099
Critical Value (5%)	-2.864142644	-2.864156782	-2.864124029
Critical Value (10%)	-2.568155725	-2.568163255	-2.568145811

9. DESCRIPTIVE STATISTIC-VOLATILITY SPILLOVER EFFECT

9.1. Domestic Focused Industry: Mean Spillover Effect

(a) Full sample: August 12, 2015 - December 31, 2022

index	CH_local	US_local	Exchange_Rate
count	2697	2697	2697
mean	0.019805306	0.01435179	0.008229023
std	0.001446061	0.001526345	0.001055599
min	0.002456157	0.000166049	4.19509E-16
25%	0.019713144	0.013607821	0.007791039
50%	0.020021144	0.014594053	0.00790582
75%	0.020425943	0.015394632	0.008042837
max	0.024534262	0.016561997	0.01232896

(b) Sample 2: August 12, 2015 - December 1, 2019

index	CH_local	US_local	Exchange_Rate
count	1573	1573	1573
mean	0.02008731	0.015040383	0.007784401
std	0.000367979	0.000798163	0.000159505
min	0.019505192	0.013821319	0.007377803
25%	0.019747649	0.014275088	0.007704917
50%	0.019997247	0.015032562	0.00782051
75%	0.020426716	0.015656646	0.007908398
max	0.020906003	0.016561997	0.008015012

(c) Sample 3: December 1, 2019 - December 31, 2022

index	CH_local	US_local	Exchange_Rate
count	1125	1125	1125
mean	0.019398029	0.013376539	0.008836646
std	0.002176801	0.001804407	0.001487765
min	0.002456157	0.000166049	-0.007585714
25%	0.018524642	0.012682973	0.00796465
50%	0.020083919	0.012989572	0.008165566
75%	0.02041978	0.01488033	0.009792716
max	0.024534262	0.01581034	0.01232896

9.2. International Focused Industry: Mean Spillover Effect

(a) Full sample: August 12, 2015 - December 31, 2022

index	CH_inter	US_inter	Exchange_Rate
count	2697	2697	2697
mean	1.49212721	0.012554676	0.008229023
std	0.66418249	0.001067758	0.001055599
min	0.002605459	0.001708331	4.19509E-16
25%	1.115972476	0.011659752	0.007791039
50%	1.500663968	0.01268855	0.00790582
75%	2.051350572	0.013237314	0.008042837
max	2.320403106	0.014918481	0.01232896

(b) Sample 2: August 12, 2015 - December 1, 2019

index	CH_inter	US_inter	Exchange_Rate
count	1574	1574	1574
mean	1.924762123	0.012757149	0.007780155
std	0.323081704	0.000841804	0.000231976
min	0.005754273	0.002736508	0.0011
25%	1.780477097	0.012002974	0.007703814
50%	2.015679224	0.012953818	0.007820508
75%	2.159135711	0.01335621	0.007908313
max	2.320403106	0.014465148	0.008015012

(c) Sample 3: December 1, 2019 - December 31, 2022

index	CH_inter	US_inter	Exchange_Rate
count	1124	1124	1124
mean	0.884961973	0.012262407	0.008851257
std	0.532432878	0.001298983	0.001405364
min	0.002605459	0.001708331	4.19509E-16
25%	0.560941475	0.011459398	0.007964854
50%	0.93984208	0.012227132	0.008166394
75%	1.377235796	0.013049744	0.009793905
max	1.560348637	0.014918481	0.01232896

10. ADF TEST - VOLATILITY SPILLOVER EFFECT

10.1. International Focused Industry: Volatility Spillover effect

(a) Full sample: August 12, 2015 - December 31, 2022

	CH_inter	US_inter	Exchange_Rate
ADF Statistic	-7.673849603	-8.300725346	-4.636208745
p-value	1.56769E-11	4.02524E-13	0.00011071
Lags Used	23	28	27
Number of Observations Used	2673	2668	2669
Critical Value (1%)	-3.432798781	-3.432803374	-3.432802454
Critical Value (5%)	-2.862621889	-2.862623918	-2.862623511
Critical Value (10%)	-2.567345926	-2.567347006	-2.56734679

(b) Sample 2: August 12, 2015 - December 1, 2019

	CH_inter	US_inter	Exchange_Rate
ADF Statistic	-4.15392523	-7.181700091	-5.566065428
p-value	0.000787758	2.63959E-10	1.50381E-06
Lags Used	0	0	0
Number of Observations Used	1573	1573	1573
Critical Value (1%)	-3.43451402	-3.43451402	-3.43451402
Critical Value (5%)	-2.863379166	-2.863379166	-2.863379166
Critical Value (10%)	-2.567749139	-2.567749139	-2.567749139

(c) Sample 3: December 1, 2019 - December 31, 2022

	CH_inter	US_inter	Exchange_Rate
ADF Statistic	-4.71252234	-4.751021639	-5.733036066
p-value	7.97109E-05	6.74172E-05	6.53333E-07
Lags Used	13	20	22
Number of Observations Used	1110	1103	1101
Critical Value (1%)	-3.436254943	-3.436292506	-3.436303326
Critical Value (5%)	-2.86414734	-2.864163909	-2.864168682
Critical Value (10%)	-2.568158226	-2.56816705	-2.568169592

10.2. Domestic Focused Industry: Volatility Spillover Effect

(a) Full sample: August 12, 2015 - December 31, 2022

	CH_local	US_local	Exchange_Rate
ADF Statistic	-0.842716635	2.723996341	-4.636208745
p-value	0.806251338	0.999087908	0.00011071
Lags Used	28	28	27
Number of Observations Used	2668	2668	2669
Critical Value (1%)	-3.432803374	-3.432803374	-3.432802454
Critical Value (5%)	-2.862623918	-2.862623918	-2.862623511
Critical Value (10%)	-2.567347006	-2.567347006	-2.56734679

(b) Sample 2: August 12, 2015 - December 1, 2019

	CH_local	US_local	Exchange_Rate
ADF Statistic	-7.779152162	-9.270456584	-5.566065428
p-value	8.50899E-12	1.33118E-15	1.50381E-06
Lags Used	7	5	23
Number of Observations Used	1565	1567	1549
Critical Value (1%)	-3.434535341	-3.43452999	-3.434578644
Critical Value (5%)	-2.863388576	-2.863386215	-2.863407689
Critical Value (10%)	-2.56775415	-2.567752893	-2.567764328

(c) Sample 3: December 1, 2019 - December 31, 2022

	CH_local	US_local	Exchange_Rate
ADF Statistic	-4.867561435	-4.980398762	-6.220521507
p-value	4.03156E-05	2.42633E-05	5.23704E-08
Lags Used	22	20	22
Number of Observations Used	1102	1104	1102
Critical Value (1%)	-3.436297911	-3.43628711	-3.436297911
Critical Value (5%)	-2.864166293	-2.864161529	-2.864166293
Critical Value (10%)	-2.56816832	-2.568165783	-2.56816832

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