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Co-movement dynamics of US and Chinese stock market: evidence from COVID-19 crisis

Ge Song[a], Zhiqing Xia[a], Muhammad Farhan Basheer[b] and Syed Mehmood Ali Shah[c]

[a]School of Finance, Qilu University of Technology, Jinan, China; [b]Lahore Business School, The University of Lahore, Lahore, Pakistan; [c]Northeast Asian Research Centre, Jilin University, Changchun, China

ABSTRACT

This paper aims to examine the co-movement between the two economic powers, namely the USA and China. The authors are mainly interested in examining the dynamics of co-movements during, and in the pre-covid periods. Additionally, they have aimed to examine the volatility spillover between USA and China, during and in the pre-covid periods. In order to achieve the research-based objectives, advanced econometrics models have been applied to the data from July1, 2010, to April 30, 2021. The results show that the sample market is integrated in the long run. The results also indicate that the behaviour of the Chinese market is same as the US market, and offers negligible opportunities for investors for diversification during this time. The findings indicate that the Ganger Causality between the stock markets during crisis is significantly higher than the pre-crisis period. The results of EGARCH model confirm the presence of asymmetric volatility spillover effects between the US and Chinese markets, during the considered time periods. This study also examines the co-movement in China, grounded upon the robust approach that facilitates examining the dependence structure between the sample variables. The findings offer valuable understanding for investors who are looking for investment diversification opportunities worldwide.

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1. Introduction

The stock market (SM) is an integral part of any country's financial market, spurring its industrial and commercial growth, and ultimately developing its economy to significant levels (Su, Song, et al., 2021; Umar, Su, Rizvi, & Lobonț, 2021; Wang et al., 2021). Moreover, it fulfils the corporate sector's financial needs, and also opens up opportunities for investors to earn from stock trading(Umar, Su, Rizvi, & Shao, 2021; Umar et al., 2020). Also, the state of the economies is usually indicated by the SMs.

CONTACT Zhiqing Xia xiazhiqing@hotmail.com

Furthermore, globalisation has boosted cross-border trades and capital flows via the lifting of barriers, thus integrating deeply into the markets (Mobarek, 2013; Mobarek et al., 2016). In this regard, international SMs are experiencing stronger interconnections due to the concept of globalisation becoming more and more penetrative. The subprime crisis, and its side effects on the global SMs has revealed the interconnections within the financial markets and SMs, with interrelated impacts on individuals and institutional investment behaviours. Due to its prominent impact on the portfolio allocations and hedging strategies, the SM co-movement has become a critical financial issue in these times (Su, Sun, et al., 2021; Su et al., 2020; Umar, Rizvi, et al., 2021).

'SM integration' is an integral part of financial economics research that primarily entails various aspects of the SMs interrelationships (Costa et al., 2019). SM co-movements have redesigned the global investment markets, thus turning it into a prominent research subject. Following the ground breaking works of Grubel (1968), Levy and Sarnat (1970), and Solnik and Longin (2001), the SM co-movements have gained significant attention of researchers, with the introduction of numerous theoretical models attempting to elucidate the subject further. Yet, the subject remains a conundrum. In this regard, past studies have attempted to examine the SM co-movements, by specifically referring to well-known financial crises.

Recurring crises in the global financial markets have raised the level of interest in examining the correlation between financial markets, particularly during financial turmoil. Evidently, there is an increase in cross-market ties during crises situations, as a result of the proliferation of shocks from one nation to another, due to the integration of high financial and goods markets. Both the advanced and emerging markets eventually feel the brunt of the contagion effect. The direct impact includes the downfall of financial institutions, and as a result, the SM crashes which leads to significant credit crunches. In the past, numerous studies have examined the SM movements, focussing on the Mexican peso-devaluation (1994), the East Asian financial crisis (1997) and the global financial crisis (2009) amongst others, which are presented and elaborated upon in the literature review section (Aamir & Ali Shah, 2018; Costa et al., 2019). These inquiries consistently point towards the disordered local markets, as the preliminary source of the crises, leading to surplus market volatility and SM interconnections (Umar, Ji, et al., 2021; Umar, Mirza, et al., 2021). A majority of the past studies have also discovered high levels of interconnectedness among the developed markets, with very few prospects for diversification. Nevertheless, studies based on the emerging market are now increasingly in search for diversification prospects.

Various theoretical explanations have come out of the growing body of knowledge, on the subject justifying the SM linkages. These include the theories based on SM movement, and SM interdependence, which has primarily been drawn from the one price (LOP) law and the Modern Portfolio Theory (MPT). The main purpose of the theories is to underline portfolio diversifications in the global markets (Caferra & Vidal-Tomás, 2021; Williamson, 2021). The expectation theory suggests that the investors' analogous expectations are genuine indicators of their investments. The discussion then steers towards the capital asset pricing theory, arbitrage pricing theory,

information spill over effects, efficient market theory, and the behavioural finance theory. The principles on which the asset pricing theory, and the arbitrage pricing theory are based, suggest that international markets are inter-connected and the same price is borne by every commodity in the international markets. It has been assumed by the SM efficiency theory that the inter-connections between the international markets have been built by the flow of stock price information. Moreover, it has also been suggested by the behavioural finance theory that the priorities of the investors depend upon the subjective factors, which create herding effects while inter-linking these markets. Other than that, information spill over effect is similar to the SM efficiency theory, which assumes the SM information to be the main contributing factor to SM correlation. Additionally, it also holds the assumption that the stock information spill over among the different countries and regions of different time zones tend to contribute towards the correlation between the stock information and the international SMs. In addition to this, the SM co-movement measures are deemed to be the benchmark for analysing the benefits of portfolio diversification for investors, and also the derived benefits for the real economy from the standpoint of economic growth and global market connectedness.

In specific terms, China is significantly linked to other countries via trade. Therefore, this study focuses on the SMs of China's key trade partners. Remarkably, China's main trade partners entail both the developed and emerging nations, with low co-movements amongst them; hence, investors can very well benefit from such portfolios. In this context, 'SM co-movement' is a term that refers to an area in financial economics research that encompasses various interrelation aspects in SMs. Financial market co-movements are also known as 'correlations', 'synchronizations' or 'integrations'. The SM integration entails market unification and friction reduction as well. It is noteworthy that globalisation has led to a boost in cross-border trade and capital flows by lifting the existing barriers and integrating markets. Yet, the modern portfolio theory states that there are lesser integrated markets for investors, so as to achieve optimal risk-adjusted returns. Hence, from the standpoint of investors, the prospects for portfolio diversification are reduced, with effective market integration.

How the SMs respond to a crisis situation is the main focal point for the scholars to study, particularly since the COVID-19 outbreak (Baker et al., 2020; Narayan et al., 2020; Rizvi, Mirza, et al., 2020; Rizvi, Yarovaya, et al., 2020; Sun et al., 2021). All the studies in this regard agree at a point that due to the emergence of this pandemic, prices have, and continue to fluctuate vigorously, and there is an immense downfall in the stock prices. Nonetheless, it has been observed to best of the knowledge available, that no study has thus far tested the actual point in time when the novel COVID-19 virus started to bring about drastic changes in the performance of the SM, presuming that there has been no earlier knowledge about the break location(Mirza, Hasnaoui, et al., 2020). Moreover, the aspect of price fluctuations was the main area of concern to address for the prior studies, but none of them have been able to address the stock co-movement and volatility spillover between the two economic superpower, which is assumed as a crucial aspect of literature that is based on finance in the current times.

Therefore, in this study, two developed nations have been selected, i.e., China, and USA, and the analysis mainly concentrates on their daily stock price data from the years 2010 to 2021. The selected timeframe entails three crises' periods, namely the COVID-19 crisis that spread in the year 2019, and was still ongoing at the time of this study (Mirza, Naqvi, et al., 2020). As the second largest economy in the world, China and the world leading economies are widely open to the global economy, which in turn pose substantial dynamic effects on the Chinese and US SM. This fact has driven the current study to empirically examine the correlation between the frequency and time with the developed and emerging SMs. Additionally, this study has aimed to focus primarily on the spillover effects of the internal and external shocks, such as the COVID-19 and the SM index movements in the developed and emerging SMs. Evidently, in this regard, investors have thus far tended to prefer high volatility stocks during normal periods and low volatility stocks during times of crisis Younis et al., 2020)]. This study has therefore endeavoured to somewhat address the literature gap, and offer empirical proof based on the SM integration among the US and Chinese markets. This study has also combined the US SM with China, in an attempt to come up with interesting findings for investors (Su, Cai, et al., 2021). The research findings can facilitate investors in boosting their risk management, optimising capitalisation structure and hedging choices. This study also facilitates policymakers in increasing the Asian-European market integration with China, while preventing the risk of contagion (Kartal et al., 2021). In the financial context, we have discovered that the developed and emerging markets' co-movement strength could affect the VaR levels of the countries' portfolios. These findings can potentially improve and offer possible implications for the portfolio managers of the developed and emerging markets that are requested to contemplate upon the co-movement via the dimensions of frequency and time, in their portfolio design. As for the policymakers, the study outcomes can facilitate them in gauging the co-movement of equity, in identifying the macroeconomic performance of the Chinese market with that of USA.

The rest of the paper is organised into four more sections. Section 2 is dedicated to outlining the emerging literature, while section 3 deliberates upon the methodological framework. Furthermore, section 4 highlights the study's outcomes, and finally, section 5 wraps up the study by presenting the conclusion of the findings.

2. Literature review

As the Coronavirus disease 2019 (COVID-19) broke out in a sudden manner, it has brought an environment of uncertainty in economic matters (Baker et al., 2020; Su, Huang, et al., 2021; Yarovaya et al., 2020), which lead to an unstable economy in 2020 across the globe. The Chinese government has put all of its efforts into formulating health-related strategies to avoid the spread of COVID-19, including the imposition of lockdowns and stay-at-home orders, which have shown adverse impacts on the Chinese economy. All of the transport facilities were suspended in the city of Wuhan, and a complete lockdown was imposed on January 23, 2019, on the Lunar New year celebration, a most celebrated event for China. Moreover, the schooling routine in China came to a halt, and no one was allowed to travel and manage public

gatherings by the central government. There was no celebration among Chinese citizens for the Chinese New Year in 2020. Due to the spread of coronavirus and the imposition of strict lockdowns, China's economy suffered adversely, and a decline in economic activities was already predicted. As the economic condition was suffering, the SM also had considerably unfavourable impacts. Referring to the studies of (Baker et al., 2020) indicate that US SM showed frequent big swings and was prone to volatility. While various studies have been showing the adverse impacts of this pandemic on the economy (Yin et al., 2021)and economic strategies (Huang et al., 2020), which have been designed to tackle COVID-19 in China, yet the issues relevant to SM from the perspective of COVID-19 are ambiguous. Thus, the present study is intended to examine the impacts of COVID-19 and particularly the influences of pandemic lockdowns and curfews on both firm and industry level stocks in SM of China.

The US economy has been experiencing extraordinary disturbance due to the novel Corona Virus (COVID-19), and the US SM is showing unprecedented downfall. Generally, to preserve US SM from devastation, a market-wide circuit breaker is employed in March 2020 in a sequential manner. As the stock prices started plunging, various investors faced huge losses. The global environment started to encompass the crisis fear, and its influences on the economy across the globe started expanding. On March 17, 2020 in China Daily, it has been reported that; 'Coronavirus: US stocks see worst fall since 1987' as the US experienced a historical downfall regarding its economy, the global economies showed the same decline. The conditions of US SM had been representing the intensity of the downfall global markets were facing. Thus, the present study is intended to examine the relationship between the COVID-19 circumstances and the performance of U.S. SMs encompassing price volatility and return predictability, which would guide the investors about decision making in fluctuating times (Youssef et al., 2021). Prior evidence shows that risks are caused to emerge through increasing crisis, yet it creates investment opportunities: In worst situations, there is an increase in stock return predictability and price volatility (Nonejad, 2020).

Throughout the Lunar year 2020, Chinese SM faced extraordinary instability. Since the beginning of the Chinese Year, Wuhan was in lockdown mode by the Central government of Chinato stop the spread of Coronavirus. Additionally, it was decided to provide holidays regarding Lunar New Year till February 02, 2020. Even though it was a good economic indicator that the stock market would be operational gain from February 3, 2020 (Huang et al., 2020), yet much risk was there in re-opening of the SM, and then it was observed that there was an immense downfall of the SM on the Chinese New Year. That is why this Lunar New Year became a highlighted event window for the SM downfall due to this deadly pandemic, and thus, the policymakers and research scholars found it more interesting to understand the results produced by crucial reactions of Chinese SM. Due to this reason, the Lunar New Year holiday is viewed as the event window to investigate the lockdown-related reactions of SMs. Generally, the reactions are viewed from both of the levels; firm and industry.

The outbreak of the Corona Virus (COVID-19) was unpredictable, having extraordinary uncertain impacts on the economy across the world (Baker et al., 2020).

Economic conditions during the COVID-19 period have been a major topic of various studies. Such as, Hassan et al. (2021) addressed how individual corporations faced the immediate COVID-19 shock. Similarly, Jordà et al. (2020) studied the long-run economic influences. Additionally, Baker et al. (2020) investigated that during the COVID-19 era, there have been certain variations in the consumption behaviours of the households, and Ludvigson et al. (2020) show that level of employment and activities in the labour market have been adversely affected during this pandemic. Moreover, it has also been considered that different countries have different strategies and policies to tackle the effects of this pandemic leading to in-depth discussions. In the study of Krueger et al. (2020), the effectiveness of government and its involvement has been focussed on, monetary policy was studied by Caballero and Caballero & Simsek (2020), and economic out-turns due to the lockdowns were the main point to focus for Mazur et al. (2021). Huang et al. (2020) specifically focussed the Chinese economy and recorded various financial and economic strategies which have been formulated to stop the economic devastation. The study of Baker et al. (2020), with respect to pandemic effects on SM, claims that the US is suffering from the historical impacts of SM volatility and, consequently, is at the highest point of devastation. Evidence provided by Ru et al. (2020) discuss that those economies which have not experienced SARS did not respond to COVID-19 in a serious manner. This study is concerned with the contribution to the literature by examining the Chinese SM response to COVID-19, specifically, from the perspective of lockdowns.

Most studies on financial downturns had focussed on the crises that occurred in the 1980s and 1990s. Recently, however, research attention is increasingly being directed at the US subprime mortgage crisis. The emerging markets have not been thoroughly examined. Meanwhile, price co-movements in SMs in various contexts have been broadly scrutinised. The concept of price co-movement had been classified into two, namely spatial price co-movement and across-industry market (Urom et al., 2021). Meanwhile, market cointegration is defined based on the perspectives of asset pricing or statistics (Younis et al., 2020). Asset pricing market cointegration is where investors gain the same risk-adjusted expected returns using the same financial instrument and a different national market (Hoq, 2020). Statistical market integration is where the national market stock prices tend to move together long-term due to factors like arbitraging or financial regulation changes. Additionally, the benefits of global portfolio diversification would be reduced due to increased co-movements and integration between US and Chinese SM exchanges.

Studies on SM relationships are multidimensional in terms of methodology, scope, and SM selection. Fareed et al. (2020)employed the coherence wavelet approach to determine the relationships between the Gulf Cooperation Council (GCC) SM returns. The finding revealed that the reviewed markets are strongly dependent on each other, particularly when the 2007 recession occurred (Graham & Nikkinen, 2011). Global and regional co-movement of the MENA SMs. Journal of Economics and Business, 65, 86-100.also employed the coherence wavelet approach in studying the local and global co-movement trends in the MENA region's SM. The finding demonstrated variations in the markets' co-movements in terms of frequency and time, with significant coherence during the 2007 recession. Higher dependencies were detected in the frequencydomain, specifically in the lower frequency regions. Also

employing the coherence wavelet approach, Shahzad et al. (2017) studied the interrelations among 13 Asia-Pacific region SMs against the US and European SMs and found that the former showed significant co-movement variations during times of recession; higher medium-scale coherence was found to exist during the sub-prime recession period than the low-scale coherence during the European debt crisis.

Further research concentrated on the multi-horizon shape ratio by employing the wavelet model to measure the efficacy of the mutual fund. The finding showed that a decrease in wavelet variance increases scale. Additionally, none of the studied funds were found to be extensively ranged. Implications-wise, the findings urge horizontal diversity in assets distribution (Lai &Tseng, 2010). Kim et al. (2011) used the wavelet approach to examine the multi-period shape ratio of government bonds and stocks. The results demonstrated a decrease in wavelet variance on the wavelet scale and increased retention time for both asset classes. Save for several scales, there was higher output for the risk-adjusted stocks than the bonds, thus underlining the need for horizontal diversity in assets distribution. Trimech et al. (2009) analyzed the impacts of the 2007-08 sub-prime crises, focussing on the change in SM correlation. It was found that the correlational strength is determined by numerous factors such as market conditions and local characteristics. Mylonidis and Kollias (2010) studied the correlation between the SM and futures market by employing the wavelet correlation method and found substantial investment scale variation. Additionally, J. Yang et al. (2003) also studied the correlation between stock returns and inflation using another wavelet correlation approach and found that there is a positive correlation at the extreme timescale and a negative correlation at the moderate scale.

The review of the literature demonstrated that market integration has its pros and cons. It unifies investors in the market but reduces the benefits of diversifying. Many authors underlined its positive effects on economic growth and general welfare as a result of greater household savings allocation. However, poor allocation of capital inflows resulting from the integration may lead to financial instability and stunted growth. Additionally, there is also an increased risk of contagion. Increasing SM integration has also been found to decrease the benefits of portfolio diversification for investors, particularly in the aftermath of the GFC. International SM integration is driven by several factors. Mutual trade between countries has been indicated as the most significant factor in several studies (W. Yang & Zhao, 2021). However, Gupta and Guidi, (2012) contradicted the notion by stating that bilateral trade is insignificant in driving SM integration. With growing international trade relations, numerous research attempts are again underway to empirically examine the long-term SM relations between trading partner nations, albeit limited to only several countries.

Paramati et al. (2016) also studied the SM relationship between Australia and its trading partners. In determining the impact of trade intensity, the authors had categorised the Australian trade partners as major, medium, and minor and subsequently studied the impact of each category individually. The findings showed that trade intensity poses no long-term impacts on SM relationships and that the Australian SMs have higher integration with developed countries. Additionally, the integration between Australia and its trading partners increased during the global financial crisis and was most prominent during the GFC instead of before and after the said period.

Vo and Tran (2020) studied the trade and financial integration in the US to ASEAN countries. Bidirectional causality was identified mostly in the studied markets. The findings showed that trade and SMs have mutual impacts. Dhanaraj et al. (2013) observed that macroeconomic integration in the recently industrialised Asian countries does not lead to SM integration and that increased bilateral trade intensity does not increase SM integration. The forecast error variance decomposition (FEVD) was estimated using the vector autoregressive (VAR) model, while the macroeconomic variables were regressed on the FEVD using the time series regression. Based on their study on the SM prices of 15 countries over 28 years, Vithessonthi & Kumarasinghe (2016) established that a country's financial growth facilitates SM integration, while its bilateral trade integration is insignificant to the SM integration other countries.

3. Data and methodology

3.1. Data

The dates used in the current study are covering the period from 01/07/2010 to 30/04/2021. To achieve the study's unique objectives, the data is split into two periods, namely the pre-covid and during covid. The closing prices of stock indices of China and the USA are collected from yahoofinance.com. To capture detailed mode information, the daily continuous compounding returns are used in the current study (Habiba et al., 2020; Li & Giles, 2015). The S&P 500 index equity market of the USA and China are considered.

3.2. Methodology

The study used descriptive statistics to analyse the general characteristic and normality of the data set used. To investigate the correlation between the SMs, the study has employed the correlation test. The Augmented Dickey-Fuller (ADF) 1979 test and the Phillips–Perron (PP) test 1988 are used to trace the stationarity of datasets.

The current study is carried out to examine the long-run dynamic relationship andthe short-term association between sample SMs. To analyse the long-term relationship between Chinese and US SM, we have employed the (Johansen & Juselius, 2009) test. The trace test and maximum eigenvalue tests are the two components of Johansen cointegration. The metaethical models of trace test and maximum eigenvalue are shown in Tables 1 and 2, respectively.

$$\tau trace = -T \sum LN(1 - \tau_1) \ldots\ldots\ldots \quad (1)$$

$$\tau max = -TLN(1 - \tau_{t+1}) \ldots\ldots\ldots \quad (2)$$

the $\tau trace$ and τmax in Equations (1) and (2) are representing the trace statistics and maximum

Eigenvalue statistic, respectively, while the observations are represented by the T.The cointegrating vector $r + 1$, which is an alternative hypothesis and contradiction

Table 1. Summary statistics.

Period	Mean	Median	Max	Min	SD	Skewness	Kurtosis	Jarque–Bera
USA								
Pre-Covid	0.001	0.050	5.732	−5.143	1.198	0.147	5.548	561.24***
During-Covid	0.082	0.052	3.782	−9.587	2.377	−0.089	7.361	371.79***
China								
Pre-Covid	0.076	0.153	9.231	−10.372	1.420	0.684	8.127	2181.28***
During-Covid	0.003	0.078	5.990	−12.346	2.743	−0.363	9.873	872.64***

Note: The sample period is from 01/07/2010 to 31/04/2021.
***Denotes significant at 1%.
Source: Author Estimation.

Table 2. Correlation matrix.

Period	USA	China
Pre-Covid period		
USA	1.0000	0.0431
China	0.0431	1.0000
During-Covid		
USA	1.0000	0.4698
China	0.4698	1.0000

Source: Author Estimation.

of the null hypothesis assuming r s cointegrating vector, is evaluated by trace test. the parameters represent the estimated eigenvalue of the specific rots τ_{t+1}

One of the objectives is to examine the short-term association between SMs in China and the USA. The study has employed the pairwise Granger Causality to achieve the objective. It helps us to identify the interdependence between two financial markets in the shortterm.

Prior to using the extended EGARCH model, the following prerequisite of the model was checked, i.e., there should be a presence of the ARCH effect in datasets. In the interest of simplicity, there heteroskedasticity and autocorrelation problem must be present in datasets. Following Habiba et al. (2020), the ARCHLM test is employed to measure the above assumption. For the generation of volatility residuals of stock indices, authors have used the GARCH (1, 1) model separately on each dataset. Additionally, the EGARCH model captures the shocks originating from the USA to China and China to the USA.

$$R_t = \beta_0 + \beta_1 + \alpha_{Rt-1(stockindices)} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\ln(h_t) = \emptyset_0 + \emptyset_1 \left[\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right] + \partial \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \emptyset_2 h_{t-1} + \gamma_{volatalityresiduals} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where R_t is representing the return and the effect of own lagged re return are measured through β_0 and β_1 Moreover, the return from spillovers from the USA to China and China to the USA are measured with α. $\ln(h_t)$ represents the conditional variance $\emptyset_0$ and $\emptyset_1$ measures the intercepts and captures of volatility and $\emptyset_2$ is volatility function. $\gamma_{volatalityresiduals}$ Captures the spillover and finally ∂ is used to tarc the asymmetric effect.

Table 3. Unit root tests.

Period	ADF test	PP test	ARCH effect
USA			
Pre-Covid	−48.1631***	−48.3821***	62.6571***
During-Covid	−22.6531***	−29.3871***	135.6521***
China			
Pre-Covid	−42.8137***	−49.6217***	54.01324***
During-Covid	−30.8342***	−33.6473***	125.8462***

***Denotes significant at 1%.
Source: Author Estimation.

4. Results and discussion

The USA and China summary statistics are shown in Table 1 below for the two sub-periods.The SM return of China is higher than the USA, where both SM returns of both countries are negative during the Covid-19 crisis. One interesting observation is that the standard deviation during the covid-19 period is higher than the post-crisis period. The skewness of both China and the USA during the crisis period is negative. The values of coefficients of kurtosis are positive in all cases.

The correlation matrix is used to examine the relationship between the two sample markets, and the results are reported in Table 2. The correlation matrix also helps explore the extent of linkage between the two markets during and pre-crisis periods. Overall, the results show that the values of correlation coefficients are higher during crisis periods, which indicate a perfectly linear relationship between the two markets during a crisis is accompanied by a perfectly consistent change in the other

Once the correlation between the sample markets is established, the next step determines the stationarity of datasets. ADF test and PP test are used to examine the stationarity of datasets. The results of the sub-periods are shown in Table 3 below. Table 3 demonstrates the findings that show that the datasets are immobile at pre- and during crisis levels. It has been shown by the analysis of the results that, in the data series, there is a significant presence of the ARCH effect, and in the data set, it is indicating the existence of heteroscedasticity and autocorrelation. Regarding this situation, the EGARCH model can be applied.

The results of the Johansen–Juselius cointegration among the sample countries for both subperiods are reported (see Table 4). A explained earlier, the test is used to examine the long-run relationship between the two markets, and for this purpose, two subtests of Johansen–Juselius cointegration, namely trace-test and maximum-eigenvalue test, are used. The Johansen–Juselius cointegration test is based on the two hypotheses, namely the null hypothesis and alternative hypothesis, where earlier assumes that there is no cointegration between the sample markets and later assumes that the market conditions between the two markets are the same and integrated. The results have supported the alternate hypothesis that the sample market is integrated in the longrun and rejects the null hypothesis. The results indicate that the behaviour of the Chinese market is the same as the US market and offers no or minimum opportunity for investors for diversification in the time of crisis.

As explained earlier, the Granger Causality is used to examine the short-term relationship between the two as in our sample (see Table 5). The null hypothesis of Granger Causality hypothesis that there is no Granger Causality between the SMs in

Table 4. Cointegration between the USA and China.

Period	Eigenvalue	Trace statistics	0.5 critical value	Max-Eigen statistics	0.5 critical value	Prob.
Pre-Covid						
None*	0.2231	1012.461	51.6231	405.0264	27.58434	0.000
At most 1*	0.1932	820.652	37.3421	356.0068	21.13162	0.000
At most 2*	0.1721	621.4621	19.2371	306.7558	14.26460	0.000
At most 3*	0.1571	571.2310	8.9821	264.5378	3.841466	0.000
During Covid						
None*	0.2062	1332.327	47.8561	321.1271	34.23790	0.000
At most 1*	0.1837	927.3004	29.7970	287.2011	29.32801	0.000
At most 2*	0.1605	571.2936	15.4947	256.3611	23.43091	0.000
At most 3*	0.1400	264.5378	3.8414	213.2310	15.78231	0.000

*Denotes significant at 10%.
Source: Author Estimation.

Table 5. Granger causality between the USA and China.

Null hypothesis	Pre-Covid period	During-Covid period
USA-China	3.8231***	13.6521***
China-USA	6.7821***	19.2351***

***Denotes significant at 1%.
Source: Author Estimation.

Table 6. EGARCH model (pre-crisis period).

Pre-Covid period					
Mean equation			Variance equation		
Coefficients	USA	China	Coefficients	USA	China
β_0	0.0002(0.0001)	0.0009(0.0003)	$\emptyset_0$	−0.3982***(0.0126)	−2.0361***(0.2251)
β_1	−0.0732***(0.0342)	0.0532***(0.0220)	$\emptyset_1$	1.0432***(0.0172)	0.4351***(0.0361)
α_{USA}	–	0.0470**(0.172)	∂	−0.0892***(0.0281)	−0.1762***(0.0271)
α_{China}	0.0372***(0.128)	–	$\emptyset_3$	0.3720*** (0.0034)	1.2315***(0.2781)
			γ_{USA}	–	0.6532***(0.0910)
			γ_{China}	1.3261***(1.2371)	–

***Denotes significant at 1%.
**Denotes significant at 5%.
Source: Author Estimation.

our sample, while the alternative hypothesis assumes that there is Granger Causality between the SMs in our sample. The findings indicate that the ganger causality between the SMs during a crisis is significantly higher than in the pre-crisis period. These findings, which have been examined, are observed to be consistent with Pearson correlation test results. Bidirectional causal links are observed with the help of findings between Indian and US markets. With the help of these findings, we suggest that the investors are more likely to get advantages from investing for the short-term in portfolio diversification in the correlated markets.

To estimate the volatility transformation from USA To China and the linkage of returns the study has applied the EGARCH model. The findings of EGARCH model are shown in Tables 6 and 7 for the pre- and during crisis periods respectively.

The results are shown in Tables 6 and 7 offer some interesting insights, such as the spillovers of sample markets own market returns are significant in all two periods. It revealed the fact that all the sampled returns are affected by their past returns.

Table 7. EGARCH model (during-crisis period).

During-Covid period					
Mean equation			Variance equation		
Coefficients	USA	China	Coefficients	USA	China
β_0	0.0002(0.0001)	0.0009(0.0003)	$\emptyset_0$	−0.3982***(0.0126)	−2.0361***(0.2251)
β_1	−0.0732***(0.0342)	0.0532***(0.0220)	$\emptyset_1$	1.0432***(0.0172)	0.4351***(0.0361)
α_{USA}	–	0.0470**(0.172)	∂	−0.0892***(0.0281)	−0.1762***(0.0271)
α_{China}	0.0372***(0.128)	–	$\emptyset_3$	0.3720*** (0.0034)	1.2315***(0.2781)
			γ_{USA}	–	0.6532***(0.0910)
			γ_{China}	1.3261***(1.2371)	–

***Denotes significant at 1%.
**Denotes significant at 5%.
Source: Author Estimation.

Meanwhile, there is a significant spillover from China to the USA and from the USA to China.

5. Conclusion and policy suggestions

The study is carried out to explore and explain the short t-term and long-run integration between the USA and China from the period covering from 2010 to 2021, comprising of two sub-period, namely the pre-covid crisis (2010–2019) and during a crisis (2019–2021). To examine the long-run association between the US and Chinese markets during and pre-crisis, the Johansen and Juselius (2009) cointegration is used, and for the short-run association, the Granger Causality test is applied (Habiba et al., 2020). The ADF test and PP test of unit root tests are used to determine the stationarity of the datasets.

The study results indicate that the Chinese and US markets are integrated in the long run in all periods, i.e., pre-crisis and post-crisis. However, integration is stronger during the crisis period, and both markets have bidirectional causal relationships. The results of the EGARCH model have confirmed the presence of asymmetric volatility spillover effects between US and Chinese markets during and pre-crisis periods. However, interestingly the spillover effect during the crisis period is higher than the pre-crisis period. Meanwhile, the two markets also share a bidirectional spillover which is statistically significant, indicating that both the markets are highly correlated. The findings are in line with the results of Johansen and Juselius (2009) long-run integration test.

The Johansen and Juselius cointegration test, Granger Causality test, and bivariate EGARCH model. The results show that the sample market is integrated in the long run, supporting the alternative hypothesis, and the null hypothesis is not supported. It has been observed through the results that the Chinese and US markets offer the same behaviours, and there is no significant diversification opportunity for the investors in the prevailing situation of crisis. After analysing the results, we know that there is a higher granger casualty during the period of Covid compared to the pre-Covid period. Pearson correlation test results are consistent with these findings. It has been made sure from examining the results of the EGARCH model that there is an existence of asymmetric volatility spillover impacts during and pre-covid periods between

Chinese and US markets. The present study is intended to investigate the co-movement within China, making a robust approach as a base that would help assist the observance of dependence of the variables of the existing sample. These results prove crucial for the investors for their investment behaviours regarding diversification opportunities in this time of crisis. Being the second-largest economic power, China is vulnerable for the globe regarding its economic activities, through which the Chinese stock market is prone to various considerable market changes.

The present study has several valuable practical implications for various stakeholders, including for investors and policymakers in the government. A deeper insight into the integration between financial markets is mainly instrumental information. Moreover, by taking stock of all these facts, international investors and fund managers can increase the scope of diversification opportunities and help diminish the probability of risk in their activities. Investors can potentially benefit by devoting their investments to non-correlated markets. The findings of this study also have significant value for stakeholders, especially policymakers, within the Chinese market. In particular, for economic policymakers who might design and implement policies more effectively and efficiently.

When interpreting the results of this study, certain limitations within the research design must be taken into consideration and when designing and conducting further research in this area of study. The primary focus for the author in this paper has been cointegration and volatility spillover effects between the Chinese and the USA financial market to assess the effects of the global financial crisis. Future researchers can examine the transmission channels that assisted the crisis spread across the local, regional economies to expand the concept.Moreover, the present study would be providing the drive for future conduction of research in the domain of cointegration and volatility spillovers. In the future, SM's study would remain linked with the same region through this course of study. The Chinese SM spillover effects can also be focussed on improved insight into this study area and practice.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Muhammad Farhan Basheer http://orcid.org/0000-0001-8622-9866

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