Unravelling the Interconnection of Stock Markets during Global Financial Crisis and Global Pandemic Crisis: The European and Asian Perspectives

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Abstract

Equity markets are seen as indicators of economic health because stock prices reflect the collective information and expectations of various market participants. Even though there have been several stressful events in the global stock markets since the beginning of the 21st century, the two glaring distortions are the Global Financial Crisis (GFC) of 2007-2009 and the COVID-19 pandemic (Global Pandemic Crisis - GPC). Diversifying portfolios internationally can provide a more efficient frontier for investors than investing domestically but increased financial integration among stock markets reduces the diversification benefits. During crises, the stock markets deviate from the long-run relationships and patterns. Thus, it is significant for the investors and portfolio managers to understand the interconnections among stock markets within the region and the extent of impact during crises. The European markets exhibited cointegration only during GFC, whereas the Asian stock markets had a co-movement during the GPC and GFC. The study offers insights for policymakers in crisis affected nations in formulating plans to boost stock market performance should.

Key Words: *Global Financial Crisis, Global Pandemic Crisis, Economic Integration, Stock Market Integration, Johansen Cointegration Method, Impulse Response Function*

JEL Codes: C32, F36, G01, G15, G14

Introduction

Equity markets are considered as the barometers of economies because stock prices incorporate the information on the market and the expectations of various market participants (Gunay & Can, 2022). Developments in the stock market have a direct relationship with economic growth since stock markets are vested to ensure easy capital flows across the economy (Choong et al., 2010). Even though there have been several stressful events in the global stock markets since the beginning of the 21st century, the two glaring distortions are the Global Financial Crisis (GFC) of 2007-2009 and the Covid-19 pandemic (Global Pandemic Crisis - GPC). In both crises, the stock market of major countries dropped by nearly a quarter.

Increase in the mobility of capital due to the international diversification of portfolios by investors is creating a more economically and financially integrated world, highlighting the significance of this study. Consequently, the stock markets will not exhibit independent price behaviour making it paramount to assess co-integration and co-movements of stock markets. Researchers have used different statistical tools to measure contagion and co-movements depending on the data under consideration and the definition of contagion. This paper focuses on the cointegration of stock market indices that is measured through the Johansen Cointegration technique. The Johansen method is applied for this study as the variables showed stationarity in the first differencing. This technique is followed by the Impulse response function and Variance Decomposition Analysis, which describe the trend of shocks or impulses in the stock market and the intensity of variation caused by the dependent variable with a shock on the independent variable.

Literature Review

The GFC had created the most severe decline in economic activity since the Great Depression of 1929-1939 (Johnstone, George, & Adrian, Wilkinson, 2019). In October 2007, the world equity market was at an all-time high with a market capitalization of $51 trillion. The subsequent months witnessed the greatest fall in stock values and by February 2009 the global equity market capitalization stood at $22 trillion (Bartram & Bodnar, 2009). The loss of equity holders was more than $29 trillion. The crisis originated in the US had impacted every country, sector, and industry across the globe.

The lockdowns imposed during the COVID-19 pandemic disrupted economic activities and impacted the world economy intensely. Even though COVID-19 is a health crisis, its effects on the contraction of demand and supply in labour and consumer markets turned it into a large-scale economic crisis (Goldstein et al.,

2021). An empirical investigation by Gunay and Can (2022) revealed that although the virus outbreak originated in China, the US stock market is the source of volatility spillovers and financial contagion during the pandemic. The fear of uncertainty experienced by investors has transmitted this effect from the US to various stock markets across the globe (Ji et al., 2022).

The GFC and GPC proved that heightened interdependence among the financial markets can potentially trigger systemic events. Financial crisis directly impacts the reduction in trade, Foreign Direct Investments and other capital flows (Morales & Andreosso-O'Callaghan, 2012). The spread of the crisis from one country to another thus depends on the extent of economic integration which includes trade and financial linkages. During crises, this high level of interaction and interlinkages between the countries' financial markets is the main source of volatility spillover effects. However, understanding how the effects of these crises have been transmitted to various stock markets will help predict future volatility spillovers.

Bavister and Squirrell (2000) defined contagion effect as an increase in market linkages after a shock/turmoil and thereby transmitting the shocks across countries. The shocks are transmitted through trade and finance links between countries. Morales & Andreosso-O'Callaghan, (2012) observed that GFC had not created a contagion effect in Asian Stock Markets while the American financial shock triggered volatility spillovers due to interlinkages in economies and their internal problems such as absence of proper regulation, information asymmetry and lack of transparency. A high level of co-movements has been observed among the developed European stock markets such as the UK, Germany, France and Austria since 1997 and therefore the GFC could only create a slight increase in the intensity of co-movements (Dajcman et al., 2012). An empirical study on the interdependence of BRIC nations and US by Aloui et al. (2011) revealed that Commodity-Price Dependent markets such as Brazil and Russia are more when compared to finished product export-oriented markets like India and China.

According to Solnik (1974), diversifying portfolios internationally can provide a more efficient frontier for investors than investing domestically but increased financial integration among stock markets reduces the diversification benefits (Aloui et al., 2011). The GFC had been transmitted to almost all economies and resulted in a sharp decline in global stock market values, while GPC created a different but more severe contagion effect in emerging stock markets (Nguyen et al., 2022). For the past three decades emerging markets have given risk diversification and better returns for investors (MSCI, 2019). However, the high interdependence of stock markets poses a risk to international investors. Hence, a

better understanding of the transmission of shocks during financial turmoil periods is crucial to maintain an efficient international portfolio.

US stock markets had created contagion effects in both Advanced and Emerging Asian Markets during GFC and the transmission of shock is more among developed countries when compared to emerging markets (Gunay & Can, 2022). During GPC the Asian stock markets were more affected by the contagion from Chinese and Japanese stock markets (Nguyen et al., 2022). An assessment of the long-run relationships of emerging Asian markets with developed stock markets of Japan and the US found that Asian stock markets exhibited strong ties with US stock market rather than with the neighbouring country Japan (Batareddy et al., 2012). Despite long range dependence is observed among the stock markets of the five ASEAN countries from 2002 to 2020 no cointegration with the Chinese stock exchange except for Indonesia, was visible. On the contrary, the five ASEAN countries showed strong cointegration with US stock market (Caporale et al., 2022). Assessment of the co-movement of Asian stock markets during pre-and post – GPC using the Johansen co-integration test revealed that co-integration value was reduced during the pandemic and regained its original level in the following year (Verma, 2023).

The co-movements created by financial crises were not uniform among stock markets in European countries (Dajcman et al., 2012) and emerging stock markets (Aloui et al., 2011). In European and East Asian stock markets, the covariance and volatility were relatively high and stable until the second half of 2008. At the same time, a sharp decline in regional correlation was observed in the third quarter in both Europe and East Asia followed by a sharp increase (Johansson, 2011). It was also observed that Europe was more affected by the spread of the crisis because of regional co-movements. The stock markets in European countries were more correlated during GFC when compared to Asian countries (Lee & Nobi, 2018;(Alexandridis & Hasan, 2020).

Similarities in stock market movements were observed during GFC and GPC in six Central and Eastern European countries namely Bulgaria, Austria, Czech Republic, Hungary, Romania, Poland and Germany by Vlădoi and Merling (2022) and they found that during crises or distress periods, these countries' stock markets exhibit stronger cointegration and an increase in correlation with respect to volatility of stock market indices. In the initial stages of GFC, developed countries were more impacted and the spillover effects were reflected in emerging economies as a second-round effect. On the other hand, GPC affected both developing and emerging nations simultaneously (Pedisic, 2022).

From the above review of literature, it can be inferred that during crises, the stock markets deviate from the long-run relationships and patterns. Thus, it is significant for the investors and portfolio managers to understand the interconnections among stock markets within the region and the extent of spillover effects. Empirical analysis of various markets of countries and their co-movements will help identify whether a country is vulnerable to contagion during crises. This will benefit the regulators and authorities of vulnerable countries to initiate policy intervention to mitigate risk. However, only a few empirical studies analysed cointegration of Asian and European stock markets during GFC and GPC. Asian Region is mostly constituted of emerging economies while in Europe most of the countries have developed economies. Therefore, a comparison of these two regions would offer insights into the impact of crises on developed as well as emerging economies. Hence, the paper aims to (i) assess the co-movement of stock indices in Asian and European regions during GFC and GPC (ii) identify the co-integration among inter regions of Asia and Europe in the GFC and GPC (iii) recognise the trend of impact by GFC and GPC on the stock indices of Asian and European countries in region basis (iv) evaluate the dynamic response of Asian and European stock indices on GFC and GPC.

The rest of the paper is outlined as follows, section 3 discusses the data and methods, section 4 presents analysis and findings, and Section 5 focuses on the conclusion.

Data and Methods

The scope of the study is the European Union and the Asian Zone. The European zone comprises of 28 nations and the Asian zone consists of 48 nations. The period considered for the study is divided into two crisis periods-- Global Financial Crisis (GFC) and Global Pandemic Crisis (GPC). The time period observed for GFC is from 3rd of December 2007 to 30th of June 2009. Similarly, the duration of GPC is identified as 15th of March 2020 to 15th of June 2020. Nations that could provide data relating to stock indices for the above-mentioned periods were taken into consideration for the purpose of the analysis. After scrutiny seven nations from European league and 12 from Asian zone are finalised for the study. The selected European nations are Austria, Belgium, France, German, Ireland, Netherland and Spain. The 12 Asian countries shortlisted for the study are India, Hong Kong, Indonesia, Kazakhstan, Korea, Kualalumpur, the Philippines, China, Singapore, Taiwan, Thailand and Tokyo. The stock indices of selected nations were gathered and organised from Yahoo Finance. The stock indices of European nations mentioned in the order of list of nations as described above are as follows: Austrian

trade index, BFX-BEL 20, FTSE France, GDAXI, ISEQ, AEX-Index, Dow Jones Spain Index. The stock indices from the side of Asia are BSE, HANG SENG Index, JKSE, KTLE.VI, KOSPI COMPOSITE Index, FTSE Bursa Malaysia, PSEi Index, SSE Composite, STI Index, TSEC, SET Index and Nikkei 225.

It is crucial to verify the stationarity of the series—which is defined as having a constant mean, constant variance, and constant auto-covariances for each given lag—because the current study deals with time series data on various selected indices. The ADF test has been used to determine whether the series is stationary or whether there is a unit root in time series data on particular indices. Adjusted R^2 has been used to select which ADF test specification is optimal. This estimate of the Durbin-Watson (d) statistic was made to identify the existence of an autocorrelation issue.

The Johansen Cointegration test has been used to look at the cointegration between the chosen indices. After establishing the cointegration of stock indices based on intra and inter region wise through running the variables under lag order selection, it becomes essential to understand the transmission of impulses or shock and explanation of its variances on each of the stock indices. This is performed through impulse response function and variance decomposition analysis, respectively.

The impulse response function displays the trend of the shock or impulses through standard deviation. The IRF graph shows two red dotted lines and blue dotted line. The blue dotted line must be inside both the red dotted lines. The red dotted lines show the standard error confidence bands and their confidence intervals are computed through +/- 2 SE. The X axis and Y axis represent periods and percentage variation respectively. The impact of a one-time shock to one of the innovations on the present and future values of the endogenous variables is tracked by an impulse response function (Lada & Wojcik, 2007).

The variance decomposition is a crucial instrument for analyzing data. Measuring the percentage of a dependent variable's variation that each independent variable account for is helpful. The VAR model is fitted, and then the variance decomposition is produced. As a function of its own lagged values and independent variables, the VAR model describes the variation in the dependent variable by estimating parameters in an equation system. The amount of variation in the dependent variable, attributed to each of its covariates, can be ascertained by estimating and contrasting these parameters. Effectiveness of this method in finding important variables in regression analysis or forecasting has been established. As a result, variance decomposition offers a useful method for calculating the relative influence of various independent variables on dependent variables. It also aids in

finding connections between two or more time series that might not be immediately clear from visual inspection on its own (Lada & Wojcik, 2007). The next section of the research paper deals with the Analysis.

Results and Analysis

This phase of the research paper is divided into three sub-sections. The first sub section reveals the result of the stationarity in the variables among both the Asian and European regions during GFC and GPC. The second sub section throws light on the individual cointegration results for Asian and European regions and a inter region cointegration during both the period of crisis. The third sub section deals with transmission of shocks among the selected indices within the region and inter region through impulse response function and variance decomposition analysis.

Table 1: ADF Unit root test results in I(0) and I(1) during Global Financial Crisis

Index	Country	I(0) Prob.	I(1) Prob.	Remarks
ATI	Austria	0.67008	0.00	Stationarity in *I*(1)
BFX	Belgium	0.65520	0.00	Stationarity in *I*(1)
FTSE-FRANCE	France	0.47815	0.00	Stationarity in *I*(1)
GDAXI	German	0.48466	0.00	Stationarity in *I*(1)
ISEQ	Ireland	0.57887	0.00	Stationarity in *I*(1)
AEX	Netherlands	0.69573	0.00	Stationarity in *I*(1)
DJSI	Spain	0.32791	0.00	Stationarity in *I*(1)
SSE	China	0.30511	0.00	Stationarity in *I*(1)
HANG SENG	Hong Kong	0.33586	0.00	Stationarity in *I*(1)
BSE	India	0.43432	0.00	Stationarity in *I*(1)
JKSE	Indonesia	0.64985	0.00	Stationarity in *I*(1)
KTLE	Kazakhstan	0.85574	0.00	Stationarity in *I*(1)
KOSPI	Korea	0.32462	0.00	Stationarity in *I*(1)
FTSE BURSA	Kualalumpur	0.38320	0.00	Stationarity in *I*(1)
PSEi	Philippine	0.24515	0.00	Stationarity in *I*(1)
STI	Singapore	0.38058	0.00	Stationarity in *I*(1)
TSEC	Taiwan	0.67460	0.00	Stationarity in *I*(1)
SET	Thailand	0.73334	0.00	Stationarity in *I*(1)
NIKKEI 225	Tokyo	0.45339	0.00	Stationarity in *I*(1)

Source: Output obtained through data derived from Yahoo Finance

This test ensures stationarity of the variables used in the study. The unit root test adopted for checking stationarity is Augmented Dickey Fuller (ADF) Test and

found that none of the stock indices of the nations that come under European and Asian region shows stationarity under level category. As the nature of the data gives an attribute of time series it is very much essential that the variables should possess stationarity. This paves way for checking the stationarity of same variables through the first difference. When the variables are undergone through first difference, then the results are symbolised as I(0).The results of I(1) is exhibited through Table 1.

Table 2: ADF unit root test results in I(0) and I(1) during Global Pandemic Crisis

Index	Country	I(0) Prob.	I(1) Prob.	Remarks
ATI	Austria	0.188529	0.00	Stationarity in *I*(1)
BFX	Belgium	0.2204215	0.00	Stationarity in *I*(1)
FTSE-FRANCE	France	0.287183	0.00	Stationarity in *I*(1)
GDAXI	German	0.4791061	0.00	Stationarity in *I*(1)
ISEQ	Ireland	0.6033204	0.00	Stationarity in *I*(1)
AEX	Netherlands	0.210261	0.00	Stationarity in *I*(1)
DJSI	Spain	0.14519	0.00	Stationarity in *I*(1)
SSE	China	0.4226603	0.00	Stationarity in *I*(1)
HANG SENG	Hong Kong	0.3108883	0.00	Stationarity in *I*(1)
BSE	India	0.7035163	0.00	Stationarity in *I*(1)
JKSE	Indonesia	0.7067136	0.00	Stationarity in *I*(1)
KTLE	Kazakhstan	0.0981638	0.00	Stationarity in *I*(1)
KOSPI	Korea	0.4618721	0.00	Stationarity in *I*(1)
FTSE BURSA	Kualalumpur	0.817871	0.00	Stationarity in *I*(1)
PSEi	Philippine	0.6787128	0.00	Stationarity in *I*(1)
STI	Singapore	0.2976089	0.00	Stationarity in *I*(1)
TSEC	Taiwan	0.5853626	0.00	Stationarity in *I*(1)
SET	Thailand	0.3004328	0.00	Stationarity in *I*(1)
NIKKEI 225	Tokyo	0.4540442	0.00	Stationarity in *I*(1)

Source: Level and First Difference computed from the data sourced through Yahoo Finance

When the variables were put onto first differencing, all of them showed stationarity. This was inferred through the p-value or probability value which is lesser than 0.05. When the probability values are lesser than 0.05, we accept that variables are stationary. Hence, we accept alternate hypothesis. This has cleared the path for selecting suitable methodology for establishing cointegration. If the variables are proved stationary within level category rather than first differencing then it is symbolised as I(0).Contemporarily if the variables showed stationarity with a mix of I(0) and I(1) then the suitable methodology for establishing a relationship is

ARDL (Auto Regressive Distributed Lag). Similarly, if ALL the variables showed stationarity with first differencing I(1) as in the case of present research, then we will establish cointegration between the variables through the Johansen Cointegration technique. The data relating to the two regions based on the Global Financial Crisis has proved that their cointegration would be revealed through the Johansen Cointegration method. The next attempt is to find out the status of variables during the Global Pandemic Crisis.

The above results show the acceptance of alternate hypothesis in first differencing for both the regions during Global Pandemic Crisis. This has brought clarity in establishing the relation or cointegration within the regions of Europe and Asia during GPC.

As the stationarity of the variables in GPC are similar to that of GFC for both the regions, hence the same Johansen Cointegration technique will be implemented. The first sub-section does not end here because it is essential to find out the cointegration from the inter regional aspect. This makes it important to run the stationarity test in the context of inter region. The inter region comprises of Asian countries on one side and the Europe on the other end. In the inter-regional wise computation, average of stock indices from the Asian region represents the Asian Zone index. Similarly, the computation of mean of stock indices from the European region indicates the European Zone Index. The European Zone Index and Asian Zone Index are used for establishing the cointegration on inter region basis and the results are presented in table 3 and 4.

Table 3: ADF unit root test results for Average Indices of European and Asian regions during GFC

Average Indices	I(0) Prob.	I(1) Prob.	Remarks
AESI_GFC	0.45988	0.00	Stationarity in I(1)
AASI_GFC	0.38866	0.00	Stationarity in I(1)

Source: Stationarity computed through data sourced from yahoo finance

AESI represents Average European Stock Indices and AASI refers to Average Asian Stock Indices. The variables, i.e. average stock indices belonging to both the regions showed non-stationary under level category. This is inferred through p-values, as they are greater than 0.05. This makes the variables to run on first differencing and its results are depicted in Table 3. The probability value lesser than 0.05 indicates that data is stationary for the average indices of both the regions

during GFC under first differencing. The stationarity test during GPC is also exhibited in Table 4.

Table 4: ADF unit root test results for Average Indices in I(0) and I(1) during Global Pandemic Crisis

Average Indices	I(0) Prob.	I(1) Prob.	Remarks
AESI_GPC	0.390088	0.00	Stationarity in *I*(1)
AASI_GPC	0.824344	0.00	Stationarity in *I*(1)

Source: Stationary results computed through data sourced from yahoo finance

This states that the average indices of both the regions showed stationarity in the first differencing during GPC. This further helps to conclude the first sub section that in all the three scenarios i.e. for the Asian region, for the European region and for the inter region the variables were stationary under first differencing. This further helps in identifying and resorting to the Johansen technique for establishing cointegration within the regions and inter regions. This puts an end to the first sub section and the second sub section begins with the lag order selection. The lag order selection is done prior to the variables put for establishing cointegration. The lag order selection is done in the order of European Region, Asian Region and Inter Region during GFC and GPC.

The lag order results for each of the contexts mentioned above are presented in the following tables.

Table 5: Lag selection for the European region during GFC

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-16927.985	NA	8.21E+30	91.04831	91.12205	91.07759
1	-13574.32323	6563.08	1.58E+23	73.28131	73.87125	73.51559
2	-13418.23594	299.5869	8.88E+22	72.70557*	73.81171*	73.14485
3	-13299.68405	223.0815	6.11E+22	72.33163	73.95397	72.97591*
4	-13229.44471	129.5274	5.46E+22	72.21744	74.35598	73.06672
5	-13178.03451	92.87004	5.40E+22	72.20449	74.85922	73.25875
6	-13121.74807	99.56042*	5.21e+22*	72.16531	75.33625	73.42458
7	-13084.31643	64.80101	5.57E+22	72.22751	75.91464	73.69177
8	-13045.19227	66.25865	5.90E+22	72.2806	76.48393	73.94986

*** indicates lag order selected by the criterion**

The lag selected for the European region during GFC is 2, as majority of the criterions i.e. AIC and SC support the same lag at two.

Table 6: Lag selection for European region during GPC

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2635.525252	NA	4.27E+25	78.88135	79.11169	78.9725
1	-2318.116483	559.0184	1.43e+22*	70.86915	72.71188*	71.59832*
2	-2281.789334	56.38841	2.18E+22	71.24744	74.70256	72.61464
3	-2251.102941	41.22053	4.26E+22	71.79412	76.86162	73.79934
4	-2187.887975	71.70653*	3.58E+22	71.36979	78.04968	74.01304
5	-2126.168975	57.1131	3.86E+22	70.99012	79.2824	74.27139
6	-2072.293837	38.59711	7.35E+22	70.84459*	80.74926	74.76389

* indicates lag order selected by the criterion

The lag selected for European region during GPC is 1, as majority of the criterions i.e. FPE, SC and HQ supports the same lag at one.

Table 7: Lag selection for Asian region during GFC

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-17307.34623	NA	1.13E+50	149.3047	149.483	149.3766
1	-13834.47463	6556.542	3.89e+37*	120.6075*	122.9252*	121.5422*
2	-13723.4527	198.1167	5.22E+37	120.8918	125.3488	122.6893
3	-13601.27381	205.3869	6.44E+37	121.0799	127.6763	123.7402
4	-13462.20345	219.3955	7.03E+37	121.1224	129.8581	124.6455
5	-13351.89454	162.6105	1.01E+38	121.4129	132.2879	125.7987
6	-13216.73849	185.257	1.22E+38	121.4891	134.5035	126.7377
7	-13068.70444	187.5949*	1.39E+38	121.4543	136.6081	127.5657
8	-12952.78276	134.9088	2.22E+38	121.6964	138.9895	128.6705

* indicates lag order selected by the criterion

The lag selected for Asian region during GFC is 1, as majority of the criterions i.e. FPE, AIC, SC and HQ supports the same lag at one.

Table 8: Lag selection for Asian region during GPC

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-5517.7	NA	3.21E+44	136.5358	136.8906	136.6782
1	-4858.58	1106.674	9.95e+38*	123.8168	128.4283*	125.6670*
2	-4707.42	209.0074*	1.03E+39	123.6401*	132.5084	127.1982

* indicates lag order selected by the criterion

The lag selected for Asian region during GPC is 1, as majority of the criterions i.e. FPE, SC and HQ support the same lag at one.

Table 9: Lag selection for Inter region during GFC

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-5939.5	NA	1.98E+11	31.68815	31.70909	31.69646
1	-4583.6	2690.24	1.46E+08	24.47765	24.54048	24.5026
2	-4544.3	77.4225	1.21E+08	24.28974	24.39445	24.33131
3	-4516	55.64824	1.07E+08	24.15985	24.30646*	24.21805*
4	-4510.4	10.90166*	1.06e+08*	24.1514	24.33989	24.22623
5	-4508.7	3.265269	1.07E+08	24.16376	24.39414	24.25522
6	-4508.3	0.821248	1.09E+08	24.18283	24.45509	24.29092
7	-4507.2	2.069121	1.11E+08	24.19841	24.51257	24.32313
8	-4503.7	6.696466	1.11E+08	24.20104	24.55708	24.34239

* indicates lag order selected by the criterion

The lag selected for Inter region during GFC is 3, as majority of the criterions i.e. SC and HQ support the same lag at three.

Table 10: Lag selection for Inter region during GPC

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-918.8109113	NA	2.97E+09	27.48689	27.5527	27.51293
1	-789.8715173	246.3320*	71251358*	23.75736*	23.95479*	23.83548*
2	-788.0457164	3.379094	76062206	23.82226	24.15132	23.95247
3	-785.194121	5.107335	78791636	23.85654	24.31722	24.03883
4	-780.1396104	8.751093	76482773	23.82506	24.41737	24.05944
5	-776.7342642	5.692519	78065407	23.84281	24.56674	24.12927
6	-773.761845	4.791362	80817134	23.87349	24.72904	24.21203

* indicates lag order selected by the criterion

The lag selected for Inter region during GPC is 1, as majority of the criterions i.e. FPE, AIC, SC and HQ support the same lag at one. The lag selection of all the three contexts were made and now cointegration is to be established for the three contexts. The method used for establishing cointegration is said to be Johansen Cointegration.

The results of Johansen cointegration are reported in the order of European region, Asian region and inter regional wise during the GFC and GPC. The Johansen Cointegration uses Trace test statistic and Maximum Eigen value statistic. Both are essential for establishing and interpreting cointegration vectors among the variables.

Similarly, the other method for finding out cointegration is to compare the values of Trace statistic and Critical value. If the Trace statistic is greater than the Critical value then till that CE or Cointegrating equation there is said to be cointegration. Contemporarily the p-value or probability value will be less than 0.05 till that CEs or cointegrating equations. The results of cointegrating equations are exhibited for each of the contexts.

Table 11: Results of Cointegration for European Region during GFC

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.154196088	179.0356845	125.6154331	0.00
At most 1 *	0.122432002	115.063012	95.75366142	0.001239
At most 2	0.066606868	65.17349255	69.81888745	0.110991
At most 3	0.044838226	38.84268956	47.85612716	0.266584
At most 4	0.029474627	21.3186093	29.79707334	0.33807
At most 5	0.021538938	9.890035363	15.49471288	0.289282
At most 6	0.0041074	1.572257976	3.841465501	0.209878
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.154196088	63.97267246	46.23141975	0.00028
At most 1 *	0.122432002	49.88951944	40.07757358	0.002916
At most 2	0.066606868	26.330803	33.87686662	0.300941
At most 3	0.044838226	17.52408026	27.58433779	0.535143
At most 4	0.029474627	11.42857393	21.1316163	0.604526
At most 5	0.021538938	8.317777388	14.26460015	0.347323
At most 6	0.0041074	1.572257976	3.841465501	0.209878
Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				

At a significance level of 5%, the Trace statistic shows the existence of one cointegrating equation. There is only one linear combination among the chosen seven indices, according to this cointegrating equation. Also, the Maximum eigenvalue statistic demonstrates the existence of one cointegrating equation that validates the Trace Test at the 5% level. As a result, these two tests validate a cointegrating relationship between the chosen seven indices of European region, which compels these indices to have a relationship in the event of Global Financial Crisis.

Table 12: Results of Cointegration for European Region during GPC

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.400806547	123.4734407	125.6154331	0.067072488
At most 1	0.312465639	87.10931578	95.75366142	0.169506912
At most 2	0.306032051	60.50962936	69.81888745	0.220035381
At most 3	0.207193096	34.57123466	47.85612716	0.470844208
At most 4	0.110344716	18.08676793	29.79707334	0.55964479
At most 5	0.103128009	9.78536187	15.49471288	0.297609549
At most 6	0.028563974	2.057570296	3.841465501	0.151450178
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.400806547	36.36412493	46.23141975	0.37648587
At most 1	0.312465639	26.59968642	40.07757358	0.661071926
At most 2	0.306032051	25.9383947	33.87686662	0.324525908
At most 3	0.207193096	16.48446673	27.58433779	0.624377944
At most 4	0.110344716	8.301406059	21.1316163	0.884343093
At most 5	0.103128009	7.727791574	14.26460015	0.407047865
At most 6	0.028563974	2.057570296	3.841465501	0.151450178
Max-eigenvalue test indicates no cointegration at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				

The null hypothesis (H_0: No cointegration) cannot be rejected in trace statistics or maximum eigenvalue statistics, as can be seen in Table 12. This indicates that, in the context of a pandemic, there is no co-integration among the chosen seven indices. Further, generally there is no correlation between the seven European markets that were not significantly impacted by the pandemic situation.

Table 13: Results of Cointegration for Asian Region during GFC

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.309116864	424.7328441	334.9837112	0.00
At most 1 *	0.207216084	307.5111285	285.142508	0.004154122
At most 2	0.142071147	233.9022752	239.2354149	0.084739803
At most 3	0.124042445	185.3270642	197.3708726	0.167768766
At most 4	0.10402584	143.3443314	159.5296978	0.268134554
At most 5	0.102188819	108.5238767	125.6154331	0.339199085
At most 6	0.083957462	74.35270347	95.75366142	0.567462239
At most 7	0.055376072	46.55418835	69.81888745	0.777513714
At most 8	0.036217397	28.49520848	47.85612716	0.791776562
At most 9	0.024677683	16.80122893	29.79707334	0.654685765
At most 10	0.023450917	8.88026088	15.49471288	0.376567985
At most 11	0.004274016	1.357766735	3.841465501	0.243924074

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.309116864	117.2217156	76.57842994	0.00
At most 1 *	0.207216084	73.60885324	70.53513439	0.025336889
At most 2	0.142071147	48.57521107	64.50471706	0.640070301
At most 3	0.124042445	41.98273278	58.43353809	0.705324201
At most 4	0.10402584	34.8204547	52.36260958	0.803905014
At most 5	0.102188819	34.17117321	46.23141975	0.513672589
At most 6	0.083957462	27.79851512	40.07757358	0.576200386
At most 7	0.055376072	18.05897987	33.87686662	0.874659373
At most 8	0.036217397	11.69397955	27.58433779	0.944290842
At most 9	0.024677683	7.92096805	21.1316163	0.908456794
At most 10	0.023450917	7.522494145	14.26460015	0.429312539
At most 11	0.004274016	1.357766735	3.841465501	0.243924074

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Two cointegrating equation at a 5% significance level is also shown by the Trace statistic in Table 13, indicating that there are two linear combinations among the chosen 12 indices in the Asian region. There is two cointegrating variables, as indicated by the maximum eigenvalue statistic, similar to the equation that validates the Trace Test at a 5% level. Consequently, it is also confirmed that there is a cointegrating relationship between the chosen 12 indices during the Global Financial Crisis period.

Table 14: Results of Cointegration for Asian Region during GPC

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.673858013	443.7606128	334.9837112	0.00
At most 1 *	0.592285679	353.0063944	285.142508	0.00
At most 2 *	0.585263027	280.3341224	239.2354149	0.000158578
At most 3 *	0.520484372	209.0451508	197.3708726	0.011507577
At most 4	0.366150069	149.5118687	159.5296978	0.15382483
At most 5	0.295545527	112.5804813	125.6154331	0.235671729
At most 6	0.273356776	84.20362387	95.75366142	0.238332251
At most 7	0.248442513	58.33873032	69.81888745	0.289901066
At most 8	0.171300315	35.20451669	47.85612716	0.437212343
At most 9	0.135745027	19.98482315	29.79707334	0.423877824
At most 10	0.078202033	8.167939995	15.49471288	0.447620381
At most 11	0.019222409	1.572174487	3.841465501	0.209890553
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
No. of CE(s)	Eigenvalue	Max-Eigen Statistic	Critical Value	Prob.**
None *	0.673858013	90.75421848	76.57842994	0.001630344
At most 1 *	0.592285679	72.67227196	70.53513439	0.031353762
At most 2 *	0.585263027	71.28897158	64.50471706	0.009927404
At most 3 *	0.520484372	59.53328216	58.43353809	0.03876788
At most 4	0.366150069	36.93138737	52.36260958	0.686161441
At most 5	0.295545527	28.37685742	46.23141975	0.862691647
At most 6	0.273356776	25.86489355	40.07757358	0.711485913
At most 7	0.248442513	23.13421363	33.87686662	0.520220254
At most 8	0.171300315	15.21969354	27.58433779	0.730651769
At most 9	0.135745027	11.81688315	21.1316163	0.565841678
At most 10	0.078202033	6.595765508	14.26460015	0.538002394
At most 11	0.019222409	1.572174487	3.841465501	0.209890553

Trace test & Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

It can be seen from Table 14 that trace statistics reject the null hypothesis (H0: No cointegration). Similarly, the maximum eigenvalue also shows that the null hypothesis (H0) is not rejected. This indicates that during the pandemic, there was cointegration among the chosen twelve indices, reflecting potential association between the 12 markets in the Asian region.

Table 15: Results of Cointegration on Inter region during GFC

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.044454267	20.71667792	15.49471288	0.007441
At most 1	0.009146678	3.482542383	3.841465501	0.062015
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.044454267	17.23413553	14.26460015	0.016473
At most 1	0.009146678	3.482542383	3.841465501	0.062015

Trace test & Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 15 demonstrates how the trace statistics disprove the null hypothesis, that there is cointegration. Likewise, the maximum eigenvalue indicates that there is rejection of the null hypothesis (H_0). This suggests that there is cointegration among the inter region indices between Europe and Asia during the Global Financial Crisis. This demonstrates that the markets in the European and Asian regions are generally associated.

Table 16: Results of Cointegration on Inter region during GPC

Unrestricted Cointegration Rank Test (Trace)				
No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	Prob.**
None	0.104071149	9.059904549	15.49471288	0.359867084
At most 1	0.017554112	1.25741091	3.841465501	0.262140863
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
No. of CE(s)	Eigenvalue	Max-Eigen Statistic	Critical Value	Prob.**
None	0.104071149	7.802493639	14.26460015	0.399127984
At most 1	0.017554112	1.25741091	3.841465501	0.262140863

Trace test & Max-eigenvalue test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

The trace statistics accepts the null hypothesis which holds that there is no cointegration, as illustrated in Table 16. Similarly, the null hypothesis (H_0) is accepted according to the maximum eigenvalue. This shows that during the Global Pandemic Crisis, there was no cointegration among the interregional indices between Europe and Asia. This reflects that there is no general association between the markets in the European and Asian regions during the pandemic.

Discussion

It is also substantiated that the Asian markets usually have the tendency to show stronger cointegration during the post crisis period than before the crisis period (Yang, Kolari, & Min, 2002). Hussain and Saeed (2016) stated that the cointegration among the Asian markets show more cointegration during the financial crisis due to the effects of contagion. Contemporarily, the study showed cointegration in European market during the GFC. This was appended by the contribution of Dajcman et al. (2012) in which it was stated that the cointegration among the European market got strengthened during GFC. When interregional markets were explored it was found that there was cointegration between European and Asian markets during the GFC and no cointegration was found during the pandemic. This finding has completely negated the findings of Pedisic (2022) who revealed that GFC could establish cointegration only in the developed economies and pandemic showed cointegration between the stock markets of emerging and developed economies. This study concludes with the revelation that the spill over impact on European market by the Asian market is about 91%, whereas a shock in European market is able to explain only 1% of variation in Asian market. This finding corroborates the findings of Guru & Yadav (2023) during the GFC but the spill over identified for Asia is 67% and for Europe it is 80%. The study's findings would have important ramifications for how policymakers in crisis affected nations should formulate plans to boost stock market performance. The outcomes would also help investors to undestand the connections that certain Asian markets share with European Markets. The cointegration level between the various stock markets on other continents may be investigated in the future; the stock markets of the Asian and European regions (Johnstone, George, & Adrian, Wilkinson, 2019) have been the sole focus of this study.

Conclusion

Global stock markets are anticipated to be interconnected and sensitive if the nations share a common economic, political, or social status. Any change to the top stock exchange in one of these nations could have an impact on the stock exchanges of other nations that are connected (Das & Gupta, 2022). However, this anticipation was negated in the present study for European market during the GPC. Because during pandemic the European market did not show any cointegration. This was true because during the pandemic each nation in European region suffered casualties and fatalities different to one another. The stock movements or indices of each nation depended on the number of people affected by the corona virus (Celik,

Nergiz, & Akdag, 2022). The stock indices showed cointegration with the number of people infected with the virus. This is one of the reasons that the present study showed no signs of cointegration among European nations during the GPC. The statistics showed that all the nations coming under the European region were different in terms of the number of people that were affected by the virus (Statista, 2023). This would make the indices of respective nations different from others and ultimately lead to non-cointegration whereas the Asian stock markets had a co-movement during the GPC and they also showed cointegration during the Global Financial Crisis. This has proved to be true as it is believed that the Asian stock markets are strongly associated and it always show cointegration during the pre, post, during and normal periods of any crisis (Verma, 2023).

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