Scientific Annals of Economics and Business
69 (4), 2022, 615-629
DOI: 10.47743/saeb-2022-0026

Contagion Risk in Equity Markets During Financial Crises and COVID-19: A Comparison of Developed and Emerging Markets

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Abstract

This study compared the impact of the Global Financial Crisis (GFC) and the COVID-19 pandemic on financial market contagion between developed and emerging markets. A DCC-GARCH model was employed to test the contagion effects of developed and emerging markets using weekly returns for the S&P 500 (US), FTSE-100 (UK), ASX 200 (AUS), IBOVESPA (BRA), BSE SENSEX (IND) and BVM IPC (MEX). The results show that there was a persuasive case made for the integration of markets for efficient financial systems. A crisis occurring in one market holds significant repercussions for any of the connected markets. The findings show that the COVID-19 pandemic affected all the markets more severely than the GFC and contagion effects were more pronounced in emerging markets than in developed markets during the GFC and the pandemic. Consequently, policymakers in emerging markets should implement policies that reduce external vulnerabilities and improve their markets' stability to reduce the impact of contagion risk.

Keywords: contagion; financial crisis; COVID-19; DCC-GARCH model; internationalization.

JEL classification: G10; G15.

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1. INTRODUCTION

As the world becomes more globalized financial markets become more integrated. Globalization, which is the process of national economic systems becoming more interconnected, is strongly associated with a surge in technological developments (James, 2014). These developments have resulted in substantial enhancements in transportation, communication, and worldwide connection, thus making it easier for businesses and individual investors to conduct cross-border or cross-listing transactions (Elkins, 2018). Cross-listing involves the secondary listing of a firm's shares on foreign stock exchanges in addition to their primary domestic objectives (Garanina & Aray, 2021). The global integration of financial markets has impelled enterprises to cross-list their shares broadly, which exposes firms to opportunities and the chance to obtain affordable capital which engenders the integration of international equity markets (Baker *et al.*, 2002).

The integration of international equity markets advances capital acquisitions and portfolio diversification, however, it can also increase the likelihood of a financial crisis along with the risk of a crisis spreading across countries (Aderajo & Olaniran, 2021). This type of risk is termed contagion. Akhtaruzzaman *et al.* (2021), describe financial contagion as a large rise in cross-market linkages resulting from a shock to one or more nations. As such, the contagion effect transpires as a consequence of a financial crisis in one country extending into the financial structures of other countries.

Research showed that financial markets were adversely affected by the 2007-2008 GFC, which resulted from a collapse of the United States (US) subprime mortgage market (Mighri & Mansouri, 2013). During that crisis, not only did the value of the US stock market plummet but so did the stock markets in other countries. This indicated that stock market changes in the US exerted significant influences on other equity markets worldwide. Celık (2012) explained that these cross-national financial market co-movements arose because of financial market contagion or interdependence. In recent developments, the unprecedented occurrence of the 2020 COVID-19 pandemic has reignited interest in financial contagion. COVID-19 has triggered instability in stock markets, in the presence of rising inflation rates, thus investors have become pessimistic about the global economy and have liquidated some financial market holdings, which adversely impacted the global market (Jelilov *et al.*, 2020; Fu *et al.*, 2021). These dynamics reflected a form of contagion that requires scholarly analysis and professional policy inputs.

Further, both the GFC and Covid-19 propagated a sense of panic in investors, leading to stock market crashes regarded as the largest since the Great Depression (Strauss-Kahn, 2020). The GFC was considered as an issue in the US market, however it led to monumental damage in financial and banking sectors globally (Lustig & Mariscal, 2020). Similarly, COVID-19 was initially confined to China, however, given the major role of the Chinese economy in the global GDP, interferences in their markets imposed global spillovers prior to the spread of the virus itself (Lustig & Mariscal, 2020; Nguyen *et al.*, 2022).

Similar to how the emergence of COVID-19 and its subsequent quarantine requirements led to the deceleration of global supply chains which dampened consumer demand and resulted in a global concern of contagion, the oil price fluctuations caused by the GFC lead to a decline in demand, causing global market instability (Lustig & Mariscal, 2020; Pilloni *et al.*, 2022). Given the comparisons of the two crises, previous studies observed the effects of the COVID-19 pandemic to be more severe than that of the GFC (Li *et al.*, 2022; Verick *et al.*, 2022), while others found the contrary to be true (Brania & Gurgul, 2021; Nguyen *et al.*, 2022). While the GFC and COVID-19 differ in origin and the channels by which they are spread, a comparison of the impact two crises had on equity markets is certainly one of interest, which necessitates further investigation (Brania & Gurgul, 2021).

The contagion impact of the GFC on developed and emerging markets is well documented in previous literature (Celık, 2012; Gaston *et al.*, 2020). However, research that compares the contagion effect of both the GFC and the COVID-19 pandemic on developed and emerging markets is underexplored. This research area therefore represents an essential contribution to existing literature which the present study seeks to fill. The outcome of this study has implications for investors and policymakers as it provides insight on the level of contagion in the different financial markets observed, which will contribute to the existing body of knowledge on the performance of these markets during periods of financial crisis.

The remainder of the study is organised as follows: Section 2 presents the literature review, Section 3 presents the data sources and methodology, Section 4 explains the estimation results, and Section 5 concludes.

2. LITERATURE REVIEW

Contagion, which refers to the prevalence of a high degree of correlation among financial markets is a widely studied subject matter in the finance literature (Forbes & Rigobon, 2002; Hansen, 2021). Research on the origin of co-movement within foreign equities markets may include a distinction between contagion and private trading instead of publicly available information. However, the utilisation of different market measures and sample sizes resulted in various conclusions across studies (Quoreshi *et al.*, 2019). Evidence suggested that changes in the market are linked to the flow of publicly available information (Ross, 1989; Hartzmark & Sussman, 2019). As such, fluctuations in the market may be largely linked to the flow of public information and not as a result of the effects of contagion. In contrast to this, Yildirim (2016) and King and Wadhwani (1990) proposed that contagion results from noise traders who cause security price fluctuations in various other markets.

Evidence by Forbes and Rigobon (2002) contrasts the attribution of contagion to financial markets' interdependence. Forbes and Rigobon (2002) analysed the effect of the crises in Mexico and Asia between 1994 and 1997 across 24 developed and developing markets. Their results suggested that contagion is not driven by market interconnectedness but by the flow of public information. Contrarily, other scholars (Caporale *et al.*, 2005; Chiang *et al.*, 2007) have found evidence that is consistent with the findings of King and Wadhwani (1990) regarding the spillover effect of contagion, as the effect of contagion was pronounced during the collapse of the Asian market in 1997.

Following the Asian market price instability of 1997, Saxena and Cerra (2000) examined whether the crisis in Indonesia was because of economic fundamentals, political unrest, environmental external factors or as a result of contagion from nearby countries. The analysis showed that all 4 of these causes under investigation occupied a pivotal role in the inducement of Indonesia's crisis. Additionally, the analysis showed that the pressure on exchange rates in certain South Asian countries could be used to project future pressures in exchange rates in Indonesia. Similarly, changes in security prices in Taiwan could be used to determine stock movements in Indonesia. This evidence supports the findings of Gkillas *et al.* (2019) and Chiang *et al.* (2007) on the effect of contagion on international equity markets.

In a related study, Connolly and Wang (2003) found that most observed correlations in the UK, US and Japanese equity markets, over the years 1985 to 1996, were not due to public information, particularly economic fundamentals. The evidence of Connolly and Wang (2003) was consistent with the market interconnectedness finding described as the cause of contagion by King and Wadhwani (1990). Similarly, Tai (2004) analysed the effects of contagion in Taiwan, Japan, Singapore and Hong Kong, by controlling for systemic risks and found the existence of strong contagion between these four Asian countries. Arasa and Mwaniki (2015) explain that co-movement within foreign capital markets offered an opportunity to raise corporate long-term financing needs through effective marketing strategies to attract the patronage of investors into long-term investments. Thus, free movement of foreign currency encourages an increased deployment of resources through the rise in the depth and liquidity of capital markets as well as the improvement of business planning and investment decision-making options (Howell, 2020). The market interconnectedness altogether led to the internationalization of capital markets. This resulted in lower capital cost since multinational investors are more able to diversify their non-systematic risks.

The internationalization of capital markets enables cross-listing which has strong strategic elements for investments. Practically, internationalization enables business managers to generate value for businesses and individual investors in both short and long-term business cycles. In the short-run, it reduces the capital costs while providing legitimacy to investors and potential stakeholders interested in the quality of firm corporate governance in the long-term (Siegel, 2009; Jones *et al.*, 2020). Scholars (Welch & Luostarinen, 1988; Melgarejo Duran & Stephen, 2020) explained that the process of internationalization of the capital market comprises several interconnected elements including market information, resources availability, strategies and the market environment. As a result, the process of internationalization of capital markets has increased international networking and international offerings of financial instruments. As such, capital market internationalization can result in efficient resource allocation, increased market liquidity, risk-sharing and greater portfolio diversification, and complete market integration which intensifies the risk of contagion.

It is expected that the rapid spread of information as a result of globalization, disturbances in one country will rapidly disperse into other economies, with adverse consequences for the international financial market (Ahlgren & Antell, 2010). Consequently, any crisis occurring in one market holds serious repercussions for connected markets because of financial linkages resulting from internationalization (Onyuma *et al.*, 2012). These dynamics make the analysis of the effect of cross-border financial market contagion essential for investors and corporate organisations who access financial market data for investments and policy development.

Further to the linkage between international equity markets integration and contagion, this study examined internationalization, contagion in financial markets and the channels in which contagion is transmitted in markets. Thus, this study extended the empirical evidence on the effect of contagion risk on international equity markets in the event of financial crises. The focus on the contagion between developed and emerging markets during the COVID-19 pandemic justified this study's unique contribution.

3. DATA AND METHODOLOGY

3.1 Data and sample selection

The study employed data of three developed stock market indices the S&P 500 (US), FTSE-100 (UK), ASX 200 (AUS), and three emerging market countries IBOVESPA (BRA), BSE SENSEX (IND) and BVM IPC (MEX) indices. These indices were selected primarily based on their equity market capitalization; however, regional representation and the availability of data were further considered as part of the sample selection, together with the interconnectivity of the indices and their experience with COVID-19 during similar periods. The dataset consisted of weekly index returns to avoid excessive noise and market microstructure biases that occur when using daily returns and secondly, to minimize the loss of information that results from employing low-frequency data (Kenourgios *et al.*, 2011; Syllignakis & Kouretas, 2011; Changqing *et al.*, 2015). The data was collected from Capital IQ for the period 05/07/2002 to 11/06/2021. The sample period comprises of two periods of stock market crashes namely, the GFC and the COVID-19 crises. As seen in Figure no. A1, severe fluctuations for the selected countries occur approximately in 2008 and 2020, representing the crisis period for the GFC and COVID-19 pandemic, as observed by Gunay and Can (2022). This study selected 12/31/2004 to 8/31/2007 as the pre-crisis GFC period, while the crisis period spans from 09/28/2007 to 12/25/2009, similar to the findings of Dominguez *et al.* (2012) and Nguyen *et al.* (2022). While there is uncertainty regarding the official date of the pandemic, COVID-19 was officially declared a global public health emergency by the World Health Organization (WHO) in January 2020, hence the pre-crisis and crisis period is defined as 04/06/2018 to 12/06/2019 and 01/03/2020 to 12/18/2020 respectively (Chang *et al.*, 2020).

3.2 Model specification: DCC-GARCH model

To test for financial contagion, this study employed the Dynamic Conditional Correlation Generalised Autoregressive Conditional Heteroskedasticity (DCC-GARCH) model of Engle (2002) to analyse the contagion among three developed markets and three emerging markets. This model is advantageous for this study as it enables one to test for dynamic conditional correlation (DCC) changes over time, which identifies changes in investor behaviour in response to different shocks or news and it also directly accounts for heteroscedasticity (Le & Tran, 2021). Consequently, the results from the analyses do not contain any volatility biases. This DCC is acceptable and is often used to test for contagion in emerging markets caused by herding behaviour during any crisis (Celık, 2012). This method is implemented in two stages. The first stage estimates the univariate GARCH model, and the second stage estimates the conditional correlation over time. The methodology used in this study is in accordance with Celık (2012) and Le and Tran (2021). The adopted DCC-GARCH model is defined in the following equations:

$$X_t = \mu_t + {H_t}^{0.5} E_t \quad (1)$$

$$H_t = D_t R_t D_t \quad (2)$$

$$R_t = \left(diagonal(Q_t)\right)^{-0.5} Q_t (diagonal(Q_t))^{-0.5} \quad (3)$$

$$D_t = diagonal({h_{11,t}}^{0.5}, {h_{22,t}}^{0.5}, \dots {h_{NN,t}}^{0.5}) \tag{4}$$

where, H_t denoted multivariate conditional variance, X_t is a past observations vector, μ_t is a conditional return vector, E_t is the standardised residuals vector, R_t symmetric dynamic correlation matrix, D_t conditional standard deviations of returns diagonal matrix, while ${h_{ii,t}}^{0.5}$ denote estimates from diagonal i obtained from the univariate GARCH model. The specifications of the DCC model are as follows:

$$Q_t = (1 - \Psi - \zeta)\underline{Q} + \zeta Q_{t-1} + \Psi \delta_{i,t-1}\delta_{i,t-1} \tag{5}$$

$$R_t = {Q_t}^{*-1} Q_t {Q_t}^{*-1} \tag{6}$$

where; $Q_t = [q_{ij,t}]$ represent dispersion matrix corresponding to the standardised residuals (δ_{it}) varying over time, $\underline{Q}$ is the unconditional correlations of the standardised residuals, ψ & ζ denote scalars that are greater than zero which satisfy the condition: $\psi<1-\zeta$, and ${Q_t}^* = {q_{ii,t}}^{0.5}$, the i^{th} diagonal observation to the power half of Q_t diagonal matrix. Thus, the conditional correlation for markets i and j paired at any point in time t is as follows:

$$\rho_{ij,t} = \frac{(1-\psi-\zeta)\underline{q}_{ij} + \psi\delta_{i,t-1}\delta_{j,t-1} + \zeta q_{ij,t-1}}{[(1-\psi-\zeta)\underline{q}_{ii} + \psi{\delta^2}_{i,t} + \zeta q_{ij,t-1}]^{0.5}[(1-\psi-\zeta)\underline{q}_{jj} + \psi{\delta^2}_{j,t} + \zeta q_{ij,t-1}]^{0.5}} \tag{7}$$

where; q_{ij} is an observation from the i^{th} row and j^{th} column from Q_t. The log likelihood of parameters estimated are found by use of the Quasi-Maximum Likelihood Method (QMLE) by Bollerslev and Wooldridge (1992), which is given as:

$$L(\vartheta) = -0.5\sum_{t=1}^{T}[(nlog(2\pi) + log|D_t|^2 + E'_t {D^{-1}}_t {D^{-1}}_t E_t) + (log|R_t| + \delta'_t {R_t}^{-1}\delta_t - \delta'_t\delta_t)] \tag{8}$$

where n denotes the number of equations, T is the number of observations, while ϑ is the parameters vector. Following Celık (2012), this study uses the t-statistic test to investigate the consistency of the DCC coefficient between the foreign exchange markets during the crisis and pre-crisis period to evaluate the effect of contagion. The study tests the following null and alternative hypotheses:

$$H_0\colon {\mu_\rho}^{pre-crisis} = {\mu_\rho}^{crisis} \tag{9}$$

$$H_1\colon {\mu_\rho}^{pre-crisis} \neq {\mu_\rho}^{crisis} \tag{10}$$

where; ${\mu_\rho}^{pre-crisis}$ is the mean of the conditional correlation coefficient corresponding to the population during the pre-crisis period, while ${\mu_\rho}^{crisis}$ is the mean of the conditional correlation coefficient corresponding to the population during the crisis period. $n^{pre-crisis}$ and n^{crisis} denote pre-crisis and crisis periods respectively, while ${\sigma^2}_{pre-crisis}$ and ${\sigma^2}_{crisis}$ represent the variance corresponding to the respective populations, which are not equal and are both unknown. The study estimated the average of the DCC for pre-crisis and crisis periods, ${\underline{\rho}_{ij}}^{pre-crisis}$ and ${\underline{\rho}_{ij}}^{crisis}$ respectively. T-statistic and degrees of freedom are employed to test the null and alternative hypothesis as follows:

$$t = \frac{(\underline{\rho}_{ij}{}^{crisis} - \underline{\rho}_{ij}{}^{pre-crisis}) - (\mu_\rho{}^{crisis} - \mu_\rho{}^{pre-crisis})}{(\frac{S^2{}_{Crisis}}{n^{Crisis}})^{0.5} + \frac{S^2{}_{pre-crisis}}{n^{pre-crisis}}} \tag{11}$$

$$V = degrees\ of\ freedom = \frac{(\frac{S^2{}_{Crisis}}{n^{Crisis}} + \frac{S^2{}_{pre-crisis}}{n^{pre-crisis}})^2}{\frac{(\frac{S^2{}_{Crisis}}{n^{Crisis}})^2}{n^{Crisis}{}_{-1}} + \frac{(\frac{S^2{}_{pre-crisis}}{n^{pre-crisis}})^2}{n^{pre-crisis}{}_{-1}}} \tag{12}$$

where:

$$S^2{}_{Crisis} = \frac{1}{n^{Crisis} - 1} \sum_{t=1}^{n^{Crisis}} (\rho_{ij}{}^{crisis} - \overline{\rho}_{ij}{}^{crisis})^2 \tag{13}$$

Similarly:

$$S^2{}_{pre-crisis} = \frac{1}{n^{pre-crisis} - 1} \sum_{t=1}^{n^{pre-crisis}} (\rho_{ij}{}^{pre-crisis} - \overline{\rho}_{ij}{}^{pre-crisis})^2 \tag{14}$$

The rejection of the null hypothesis implies that the mean of the DCC coefficients is not the same in the pre-crisis and crisis period. Since contagion can be defined as a significant increase in linkages during unstable periods, an increase in the mean of the DCC coefficients between the two periods, suggests that there is a strengthening of links or transmission mechanisms of shocks between markets. Hence, empirical studies determine that the rejection of the null hypothesis provides strong evidence that a contagion effect is present (Forbes & Rigobon, 2002; Mighri & Mansouri, 2013; Hemche *et al.*, 2016; Le & Tran, 2021).

4. RESULTS AND DISCUSSION

Table no. 1 illustrates the descriptive statistics of weekly returns for the S&P 500 (US), FTSE-100 (UK), ASX 200 (AUS), IBOVESPA (BRA), BSE SENSEX (IND) and BVM IPC (MEX). The table shows that the mean values for all market indices are greater in the pre-crisis than the crisis period for both the GFC and COVID-19 pandemic. Moreover, the mean values are mostly positive in the pre-crisis periods (except for MEX) and the mean values are mostly negative in the crisis periods (except for BRA, IND, and MEX in the GFC and MEX in the COVID-19 crisis). Regarding normality, the null hypothesis of the market index return having a normal distribution is rejected at the 5% level for all indices. This is concurred by the kurtosis values of the market return indices, where majority are above three, indicating a leptokurtic distribution. IND and MEX have a kurtosis value below 3 in the crisis period, whilst BRA recorded a kurtosis below three during the pre-crisis period indicating a platykurtic distribution for these markets during those periods. The standard deviation, a measure of stock market risk, is observed to be greater in the crisis periods than in the pre-crisis period for all markets. This simultaneous increase in volatility across all markets during the same period indicates the possible presence of shared financial disturbances (contagion).

Table no. 1 – Descriptive statistics of stock market indices weekly returns

			US	UK	AUS	BRA	IND	MEX
GFC	Pre-crisis period	Mean	0.0014	0.0019	0.0031	0.0053	0.0060	0.0062
		Median	0.0017	0.0028	0.0046	0.0085	0.0096	0.0076
		Maximum	0.0348	0.0436	0.0710	0.0875	0.0682	0.0634
		Minimum	-0.0502	-0.0578	-0.054	-0.083	-0.1161	-0.0901
		Std. Dev.	0.0146	0.0146	0.0164	0.0329	0.0277	0.0261
		Skewness	-0.549	-0.549	-0.546	-0.582	-0.8617	-0.9381
		Kurtosis	3.787	3.787	6.224	3.291	5.050	4.574
		J.-Bera	10.650***	18.997***	67.59***	8.394***	41.84***	34.993***
	Crisis period	Mean	-0.0026	-0.0012	-0.0024	0.0013	0.0004	0.0005
		Median	0.0002	-0.0009	-0.0013	0.0049	0.0094	-0.0007
		Maximum	0.1136	0.1258	0.0911	0.1684	0.1317	0.1858
		Minimum	-0.2008	-0.2363	-0.1702	-0.223	-0.1738	-0.1793
		Std. Dev.	0.0406	0.0412	0.0360	0.0530	0.0511	0.0475
		Skewness	-0.728	-1.322	-0.8717	-0.547	-0.3192	0.0555
		Kurtosis	7.451	11.840	6.012	6.394	3.623	6.299
		J.-Bera	107.81***	418.57***	59.55***	62.496***	43.66***	53.56***
COVID-19 Pandemic Crisis	Pre-crisis period	Mean	0.0020	0.0003	0.0017	0.0030	0.0023	-0.0011
		Median	0.0048	0.0021	0.0034	0.0064	0.0041	-0.0021
		Maximum	0.0473	0.0305	0.0350	0.0519	0.0486	0.0670
		Minimum	-0.073	-0.045	-0.048	-0.062	-0.052	-0.045
		Std. Dev.	0.0192	0.0147	0.0157	0.0256	0.0167	0.0186
		Skewness	-0.910	-0.463	-0.794	-0.579	-0.286	0.5156
		Kurtosis	5.239	3.184	4.269	2.8012	4.152	3.973
		J.-Bera	30.531***	17.983***	15.14***	21.904***	6.0648**	7.3689**
	Crisis period	Mean	-0.0061	-0.0031	-0.0004	0.0002	-0.0084	-0.0096
		Median	-0.0021	-0.0029	0.0037	0.0052	-0.0083	-0.0044
		Maximum	0.1142	0.0759	0.0612	0.1108	0.1216	0.0753
		Minimum	-0.162	-0.186	-0.140	-0.209	-0.131	-0.105
		Std. Dev.	0.0678	0.0431	0.0382	0.0562	0.0619	0.0471
		Skewness	-0.5218	-1.555	-1.694	-1.353	-0.823	-0.335
		Kurtosis	3.264	8.512	6.856	6.628	2.794	2.654
		J.-Bera	37.279***	85.110***	56.03***	43.564***	12.69***	7.4916**

Notes: Global financial crisis; Pre-crisis period from 31/12/2004 to 31/08/2007 and crisis period from 28/09/2007 to 25/12/2009. COVID-19 pandemic crisis; Pre-crisis period from 06/04/2018 to 06/12/2019 and crisis period from 03/01/2020 to 18/12/2020. ***, ** and * indicate the significance level at 1%, 5% and 10% respectively.

Source: authors estimations

Table no. 2 shows the results of the DCC-GARCH model between the crisis country (US) and the remaining 5 countries (UK, AUS, BRA, IND and MEX). The results indicate that the unconditional correlation and DCC increased in the crisis periods for the global financial crisis and the COVID-19 pandemic. In terms of the GFC, the unconditional correlation increased by 15.87%, 14.97%, 13.38%, 41.18%, and 13.86%, while the DCC coefficient increased by 11.80%, 3.73%, 9.32%, 37.18% and 8.54% for the UK, AUS, BRA, IND and MEX respectively.

The results show that the GFC influenced both developed and emerging markets. India (37.18%) appears to be the most affected by the contagion effects of the US. According to Jaiswal and Dubey (2022), this was a result of foreign portfolio investors withdrawing their positions from the Indian stock market which led to a financial collapse in India, which is also supported by Ali and Afzal (2012), who also found India to be significantly impacted by the global financial crisis. On the other end, AUS (3.73%) seems to be affected by the GFC the least, which can be attributed to Australia's adequately effective regulatory systems, as supported by the work of Wettenhall (2011). Furthermore, the author found that more advanced markets suffered more than AUS. This is evident in this study too, as the UK (11.8%), known to have a more advanced economy than AUS, was found to have been impacted more than AUS by the GFC. Regarding the COVID-19 pandemic, the unconditional correlation increased by 36.32%, 80.62%, 249.79%, 134.23%, and 75.77% for the UK, AUS, BRA, IND, and MEX respectively. Further, the DCC coefficient increased by 19.97%, 79.90%, 228.70%, 98.42%, and 64.92% for the UK, AUS, BRA, IND, and MEX respectively.

Similarly, the COVID-19 was found to have influenced both developed and emerging markets. Brazil (228.70%) and India (98.42%) were the most affected by the contagion effects of the US. These findings are in line with Malik *et al.* (2022), who analysed the contagion effects of the COVID-19 pandemic on BRICS. They found significant contagion effects between the US market and BRICS countries, India and Brazil. This can be attributed to the emergence of COVID-19, where US stock indices plummeted by more than 10%, which triggered negative investor sentiment regarding the state of the global economy, hence investors liquidated their market positions, affecting stock markets globally (Fu *et al.*, 2021; Malik *et al.*, 2022). According to Akhtaruzzaman *et al.* (2021), herd behaviour spread vastly, which suppressed the growth of markets and economies globally. However, the UK (19.97%) was considerably less affected by the pandemic compared to the other markets in this study. Developed countries are expected to have better control of the pandemic due to their stable markets (Le & Tran, 2021).

On average, the contagion effects were higher for emerging markets than developed markets for both the GFC and COVID-19 crisis. This can be attributed to the instability of emerging markets, consequently, financial contagion can have widespread damaging consequences in these markets (Celık, 2012). These results are similar to Patel and Sarkar (1998), who analysed financial crisis in developed and emerging countries. Their study indicated that prices fall rapidly and steeply in emerging markets. Further, they found that the correlation between the US and emerging markets is higher during market declines.

The results of the DCC-GARCH analysis can be used to compare the contagion effects of the GFC and the COVID-19 crisis to determine which crisis had a larger impact. The GFC had an 11.80%, 3.73%, 9.32%, 37.18% and 8.54% on the UK, AUS, BRA, IND and MEX respectively. Whereas the COVID-19 pandemic crisis had a 19.97%, 79.90%, 228.70%, 98.42% and 64.92% on the UK, AUS, BRA, IND and MEX respectively. It is evident from DCC coefficients that the COVID-19 pandemic crisis had a bigger impact on both developed and emerging markets than the global financial crisis.

The 2007-2008 GFC crisis originated from the US stock market and was considered one of the largest global crises to occur since the 1930 recession (Ali & Afzal, 2012). It originated from the decline of the subprime mortgage market in the US. This crisis was spread to a global scale because of excessive risk taking by US banks. Mighri and Mansouri (2013) found that the GFC uncovered flaws in numerous financial institutions and systems worldwide. This is evident by the contagion effects of the crisis on the markets analysed in this study. However, except for India (37.18%), the largest DCC coefficient is 11.8% for the UK. The UK, AUS, BRA and MEX managed to isolate their economies and stock market from major contagion effects from the US to an extent. This could be credited to the tight control of the banking industry and the capital markets in these countries (Le & Tran, 2021).

The COVID-19 pandemic crisis is arguably the most significant crisis the world has experienced since World War II. The pandemic is significantly different and more harmful than the GFC in terms of its impact on the economic, social, and political aspects. The World

Health Organization (2020) declared COVID-19 to be an unprecedented socio-economic crisis beyond it already being a health crisis. This further motivates the severity of this crisis. The economic growth of most countries was slow during the pandemic's peak as due to strict lock down regulations which adversely impacted on production (Le & Tran, 2021). Apart from the UK (19.97%),-the epidemic prevention and control programs of the other countries (AUS, BRA, IND and MEX) appear to be weak. Based on these reasons it can be seen why the COVID-19 pandemic was more severe than global financial crisis, particularly for the countries in this sample. The results in Table no. 2 thus, support the contagion hypothesis. The results of the contagion effect test are presented in Table no. 3.

Table no. 2 – Unconditional correlation and DCC

		Unconditional correlation			Dynamic conditional correlation		
US		**Pre-crisis**	**Crisis**	**% Change**	**Pre-crisis**	**Crisis**	**% Change**
Global Financial Crisis	UK	0.756	0.876	15.87%	0.729	0.815	11.80%
	AUS	0.568	0.671	14.97%	0.590	0.612	3.73%
	BRA	0.710	0.805	13.38%	0.708	0.774	9.32%
	IND	0.408	0.576	41.18%	0.390	0.535	37.18%
	MEX	0.743	0.846	13.86%	0.738	0.801	8.54%
US							
COVID-19 Pandemic Crisis	UK	0.614	0.837	36.32%	0.591	0.709	19.97%
	AUS	0.454	0.820	80.62%	0.418	0.752	79.90%
	BRA	0.237	0.829	249.79%	0.230	0.756	228.70%
	IND	0.333	0.780	134.23%	0.317	0.629	98.42%
	MEX	0.454	0.798	75.77%	0.419	0.691	64.92%

Note: Global financial crisis; Pre-crisis period from 31/12/2004 to 31/08/2007 and crisis period from 28/09/2007 to 25/12/2009. COVID-19 pandemic crisis; Pre-crisis period from 06/04/2018 to 06/12/2019 and crisis period from 03/01/2020 to 18/12/2020.

Source: authors' estimations

Table no. 3 – Contagion effect test

US	**Countries**	**Period**	**Mean**	**Variance**	**T-statistic** $H_0: \mu_p^{pre-crisis} = \mu_p^{crisis}$
GFC	UK	Pre-crisis	0.729	0.0135	5.1758***
		During Crisis	0.815	0.0212	
	AUS	Pre-crisis	0.590	0.0074	4.5256***
		During Crisis	0.612	0.0183	
	BRA	Pre-crisis	0.708	0.0019	7.0297***
		During Crisis	0.774	0.0088	
	IND	Pre-crisis	0.390	0.0090	8.8627***
		During Crisis	0.535	0.0240	
	MEX	Pre-crisis	0.738	0.0001	7.3018***
		During Crisis	0.801	0.0087	
US					
COVID-19 Pandemic Crisis	UK	Pre-crisis	0.591	0.0003	8.5059***
		During Crisis	0.709	0.0576	
	AUS	Pre-crisis	0.418	0.0109	29.7758***
		During Crisis	0.752	0.0001	
	BRA	Pre-crisis	0.230	0.0216	33.4405***
		During Crisis	0.756	0.0001	
	IND	Pre-crisis	0.317	0.0236	11.4942***
		During Crisis	0.629	0.0239	

US	**Countries**	**Period**	**Mean**	**Variance**	**T-statistic** $\boldsymbol{H_0}$: $\mu_p^{pre-crisis} = \mu_p^{crisis}$
	MEX	Pre-crisis During Crisis	0.419 0.691	0.0188 0.0001	18.5245***

Notes: Global financial crisis; Pre-crisis period from 31/12/2004 to 31/08/2007 and crisis period from 28/09/2007 to 25/12/2009. COVID-19 pandemic crisis; Pre-crisis period from 06/04/2018 to 06/12/2019 and crisis period from 03/01/2020 to 18/12/2020. ***, ** and * indicate the significance level at 1%, 5% and 10% respectively.

Source: authors' estimations

Table no. 3 reports the results of the contagion effect test (t-test). This test is conducted to confirm the existence of contagion, a t-test is used to determine if the dynamic conditional correlation coefficients differ in the pre-crisis period and crisis period. The null hypothesis that the mean of DCC coefficients is the same in the pre-crisis and crisis period is rejected for all countries, in both the GFC and COVID-19 pandemic. This indicates the presence of contagion effects from the US market to the other five markets (UK, AUS, BRA, IND and MEX). Therefore, the US stock market crashes caused by the global financial crisis and COVID-19 pandemic, spread to both developing markets (UK and AUS) and emerging markets (BRA, IND and MEX).

5. CONCLUSION AND RECOMMENDATIONS

This study compared the effect of contagion on international equity markets between developed and emerging markets during periods of financial crises. The analysis shows that, while there is a persuasive case made for the integration of markets for efficient financial systems, a crisis occurring in one market holds significant repercussions for any of the connected markets. Specifically, when firms seek capital financing through equity cross-listing, multiple foreign exchanges become linked, ensuing internationalization. However, equity cross-listing amplifies contagion risk, as any market crash induces a domino effect and affects all linked investors and firms internationally.

The results further indicate that contagion effects are more pronounced in emerging markets than developed markets for the global financial crisis and the COVID-19 pandemic, as a result of the instability in emerging economies compared to developed markets (Celık, 2012; Le & Tran, 2021). However, all the markets were affected more severely by the pandemic than the global financial crisis. This can be explained by the unexpected advent of the pandemic, which made it difficult for businesses and investors to implement contingency strategies. This situation allowed for the easy spread of the crisis across international borders, thereby causing significant risk-aversion and stock redemption patterns among investors.

Based on our findings it is recommended that policymakers in emerging countries should implement policies that reduce the channels of contagion and improve the instability of their markets. Additionally, emerging markets should consider the dynamics of the US market in the formulation of their economic policies, as it is the single largest market in the world and its activities impact significantly on emerging markets. Moreover, policymakers and market regulators should ensure adequate flow of market information across all segments of market participants, as information asymmetry increases the risk of contagion on financial markets. Future studies can examine the presence of contagion in other asset markets (such as foreign exchange markets, asset markets and sovereign bond markets).

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APPENDIX

Stock market indices weekly returns

Figure A1 is a graphical representation of the weekly returns for the S&P 500 (US), FTSE-100 (UK), ASX 200 (AUS), IBOVESPA (BRA), BSE SENSEX (IND) and BVM IPC (MEX). The highest spikes for all countries notably occur roughly in 2008 and 2020, the crisis period for the GFC and COVID-19 pandemic.

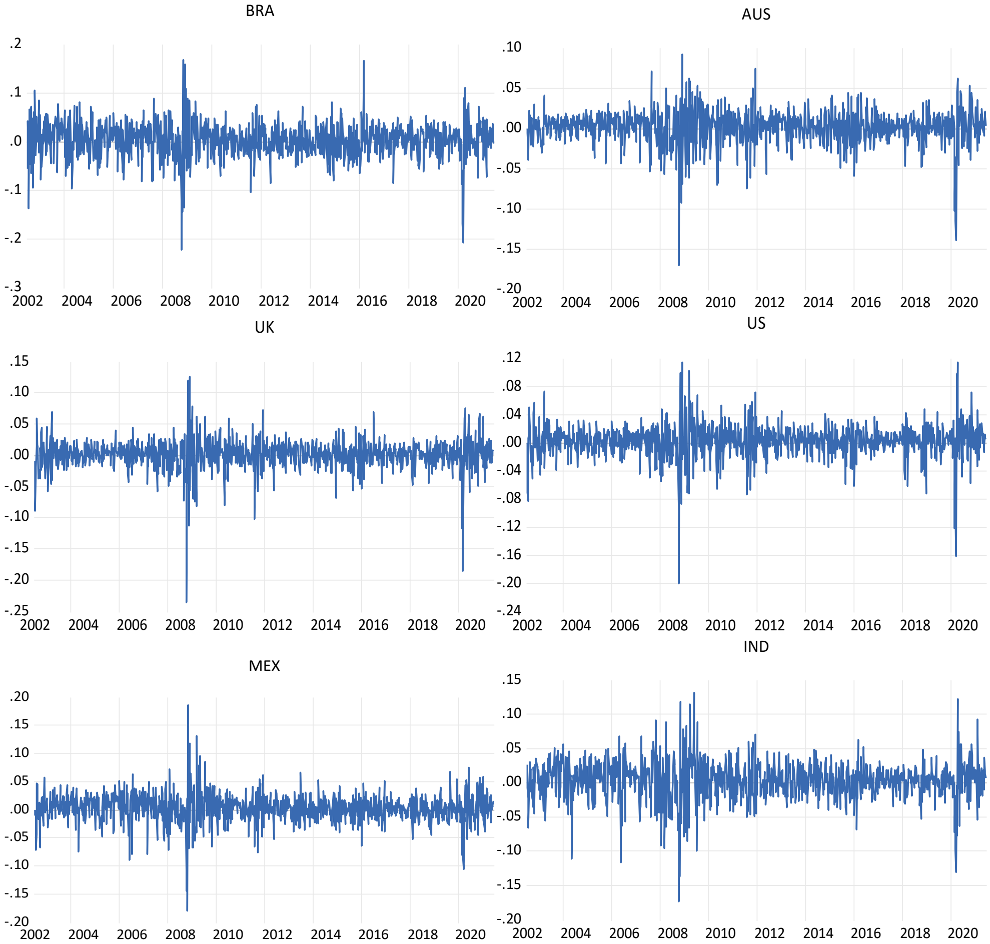

Figure A1 – Stock market indices weekly returns

To cite this article: Muzindutsi, P.F., Sheodin, A., Moodley, K., Naidoo, M., Ramjiyavan, P., Moonsamy, R., Pillay, T.A., Dube, F. (2022). Contagion Risk in Equity Markets During Financial Crises and COVID-19: A Comparison of Developed and Emerging Markets. *Scientific Annals of Economics and Business*, 69(4), 615-629. https://doi.org/10.47743/saeb-2022-0026