DOI: 10.5281/zenodo.10903347
Vol. 2(1); 2024
Received 11 January 2024; Accepted 19 March 2024
Available online 31 March, 2024 2995-6587/© 2024

Journal of Interdisciplinary Insights
ISSN (Online) :2995-6587
Published by Global Insight Publishing Ltd,

Financial Contagion of Global Financial on selected Emerging Countries' Stock Market

An Ran[1], Xin Zhao[1*]

Abstract: Global financial crisis (GFC) only happened four times in the last 200 years, however, the profound and persistent negative influence of 2008 GFC spread to various countries due to the contagion effect. Therefore, this paper investigates the possible contagion effects from the US stock market to 15 selected emerging stock markets of 2008 (GFC)aims to give important implications to the policymakers, economists, investors and bankers. In order to capture further time-variation and dynamic linkages between stock markets, the multivariate DCC-GARCH model (Engle, 2002) was applied to the daily stock returns from 2000 through 2016. To compare and analysis the change of DCC, the sample is divided into sub-samples according to the crisis period. The main finding is that except China and Indonesia, there are statistically significant increases in dynamic conditional correlations between U.S equity market and selected emerging countries stock markets, during the crisis and after crisis period than pre-crisis period. That result evidenced that contagion effect of GFC, in addition herding phenomenon of the global financial crisis.

Key words: multivariate DCC-GARCH, emerging countries, contagion effect, financial crisis.

JEL Classification: G15, F31

I. Introduction

U.S. mortgage bubble burst 2007 and collapse of the U.S. housing market triggered 2008 U.S. subprime mortgage crisis and moreover a global financial crisis (GFC). The consequences of GFC was huge, profound and still linger. Almost the whole world stock markets had sharply fallen, interbank liquidity were hard up, many large financial institutions suffering for survival or finally collapsed or bought out, investor confidence dropped, and one after another countries economic dipped into recession. Lehman Brothers failed for bankruptcy, Indymac bank collapsed, Merrill Lynch was sold to Bank of America, and governments in many counties had to provide emergency funding as rescue packages just to bail out their financial institutions to prevent further huge financial catastrophe and loss. U.S federal also put the financial institutions, for instance Fannie Mae and Freddie Mac under the control of themselves to save it.

Global financial crisis (GFC) only happened four times in the last 200 years, but each time because the contagion effects, internationalization and integration of the financial market, that has affected multiple regions around the world regarding financial markets and real economics. The profound and persistent negative influence of 2008 financial crisis spread to various countries due to the globalization and interconnection of the world. Therefore, contagion effect became one of the essential and no ignorable factors that give important implications to the policymakers, economists, investors and bankers. Since the financial system and economic development are varying from

[1] GuangDong Medical University, Dongguan, China
* Corresponding Author

country to country, why and how they impacted by the GFC is meaningful to discuss and it also questioned the risk diversification.

The contagion can take place through the financial institutions collapse, stock market crashes and equity price rapidly dropped for most of the stock markets, exchange rate had high volatility (Kim, Kim and Lee, 2005), and liquidity problems on the credit market, a sudden stop of capital inflows, portfolio inflows, international market conducting and so on (Ghosh et al., 2009). The emerging financial market asset price return experienced the sharp decline after the first phase of the crisis and entry a higher volatility period (Min and Hwang 2012).

The contagion effects also spread to the real economic sectors, the emerging country growth were -1.9% and -3.2% that the fourth quarter 2008 and the first quarter of 2009 respectively. It was roughly 10% below 2007 value during the similar period (Blanchard, Faruqee and Das, 2010). The export demand for goods and services swift down sharply 35 percent from peak to trough from July 2008 to February 2009 (Keat, 2009)It seems that the emerging economics uncoupling and insulated from this crisis from beginning, since the financial integration degree is not high as the advanced economy, the policy makers can decrease the impact from the crisis by some regulations and independent policy. However 2008 global financial crisis is unprecedented and transmitted to also emerging economies in terms of financial market and real economy, which spread to the emerging economics rapidly after Lehman Brothers Bankrupted in 2008 (Dooley & Hutchison, 2009). We choose emerging economies also because they play more important role in the global financial and economic market. It is the main recover power for the world economy. Developing Asia was the only region has positive related strong growth (4.8% in 2009) after the financial crisis according to IMF estimates. In addition, they have many common characters like high profit with the high risk, the weak ability to transfer crisis risk and to defense risks, unsound financial system, and nontransparent market. The 15 emerging economies we will study are: Chile, China, Hungary, India, Indonesia, Israel, South Korea, Malaysia, Mexico, Peru, Poland, South Africa, Singapore, Thailand, and Turkey.

In this paper we will study whether there are empirical evidences to support contagion effect of global financial crisis or not? If it exists, when did it occur and stay short or long time. We study for a long time being from January 2000 to the July 2016. In order to investigate the time for crisis, we divided the time span to three periods: before crisis period from beginning of 2000 to the end of 2006, during crisis period that Jan. 2007 to Dec. 2009, and after crisis period from January 2010 until July 2016. Through compare the changing of dynamic conditional correlation which we get from the DCC-GARCH presented by Engle′ s (2002) to analysis the daily stock market returns for the selected emerging countries, to detect the contagion effect from U.S to the selected emerging countries.

Our study focuses on more emerging countries and takes a longer time period to investigate the impact of the crisis. In addition, from the different paths of the contagion we will classified selected emerging marekts to different developing and integration groups. We can further find the sources of the contagion and provide efficient policies to minimize the losses.

The article is organized as follow. After first section introduction is literature review about contagion effects. Section three is data and methodology. Section four we applied DCC-GARCH for selected emerging markets and U.S. estimate the parameters and dynamic conditional correlation for before-, during and after -crisis. In section six, we estimate the DCC for three phase of crisis to evidence the contagion effects. Last section is a conclusion.

II. **Literature review**

Financial crises contagion has been great concerned during the past two decades, especially in the nowadays globalization economy and finance environment, due to the contagious results play very import role for the investors and policymaker to optimal asset allocation and determine monetary and fiscal policy. There are 4 important issues we are concerned: 1) whether the contagion of financial crisis or sudden shocked between countries or markets exist or not. 2) Which contagion channels from one market transmission to another. 3) Whether 2008 financial crisis transmit from US to selected emerging countries stock market. 4) What the impact of 2008 financial crisis to the macroeconomics.

There are many evidences by applying difference methods identify contagion of financial crisis and sudden shocks on the emerging markets and developed counties. The essential idea is that evaluated and compares correlation coefficient between the source country of financial crisis and other impacted countries. If the correlation coefficient significant changed during the financial crisis then shows contagion during crisis, otherwise, just spillover or intergration.

King and Wadhwani (1990) supported the contagion effects in almost all stock markets after 1987 stock market crash. Calvo and Reinhart (1996), found Asian and Latin America emerging markets′ stock and equity price correlation increase significantly after 1994 Mexico crisis by investigating spillover effects. Baig and Goldfain (1999) analysis daily data by using 1995-1998 and confirmed the contagion between Asian five countries during crisis. Lin (2012) also found that during the crisis, contagion or spillover is exist between exchange rates and stock price.

However, there were heteroskedasticity problem for those studies. Forbes and Rigobon (2002) pointed out that those studies arbitrarily dividing the sample into two sub-periods and conclude there is no contagion only interdependence. However, this puzzle is resolving by the Chiang, Jeon and Li (2007) applied multivariate GARCH model and covered long span concluded supportive evidence of contagion during crisis.

Moreover, to avoid the heteroskedasticity bias, the dynamic conditional correlation is valid used by the researchers to study the contagion effect from financial crisis. GARCH model is one of the favorite and suitable models to apply.

Naoui et al (2010) did a comprehensive study2 about contagion reasons and identify three types as a simultaneously common shock, inter-countries trade and financial link. In addition, it pointed the pure contagion caused by panic movement. This study applied DCC - GARCH model and chooses 5 developed countries and 10 emerging countries by using August 2007 to February 2010 stock index daily data to classify the 10 emerging counties into 3 groups by the spillover effects correlation levels. The result shows that Brazil, Mexico and Argentina have 80% high conditional correlation with the American market during the crisis; India, Malaysia and Singapore are around 50%.

There are also many founds about the contagion of US financial crisis to the emerging eonomices. Kim, Kim, & Lee (2015) applied BEKK and multivariate GARCH models to indentify the transmission mechanism of global financial crisis to five emerging Asian countries by estimate dynamic conditional correlations of financial asset returns, they found that non-negligible financial contagion is exist from the U.S. to emerging Asian countries but just live a short time. At the same time, their study investigated that Libor-OIS spread, the sovereign CDS premium, and the amount of foreign order flows in the foreign exchange markets are the factors affect the dynamic conditional correlations significantly.

Specifically, Latin America equity markets as the emerging economics are very attractive to the investors due to the high growth rate. Hwang (2014) found that there were significant contagion from US financial crisis to four Latin America countries and handout effect instead short-lived, by analyzing unconditional correlation coefficient and DCC-GARCH model of dynamic conditional correlation using 2006-2010 daily data.

Certainly, there are also other methods to estimate the contagion effect of financial crisis to emerging market. Dooley and Hutchison (2009) apply VAR model to 14 emerging markets by focus on CDS spreads using data from 2007-2009 and identify the linkage and high volatility between US market to selected emerging markets. Dungey and Gajurel (2015) using a latent factor model found strong evidence of contagion from US equity markets to advanced and emerging economies.

China attracted great attentions for researchers, due to the special government intervention and fix exchange rate system, it seems insulted from financial crisis with the minimum loss. It is also hard to find out the really impact in financial market, Kim, Kim, and Lee (2015) exclude China and Hongkong since the government has much inertial movement which unsuitable for the GARCH model. Fortunately, from the latest study Hou and Li (2016) the first time applied asymmetric VAR ADCC GARCH approach reveal the transmission from US to China future market by using data that covered from May 16, 2010 to July 31, 2013.

Instead of the contagion of financial crisis of the Chinese financial market new founding, most previous research focused on the spillover of the U.S 2008 financial crisis to the industrial and foreign trade sectors. Morrison (2009) found that China′ s economy growth, international trade volume and foreign direct investment and many other sectors have been hardly hit by the U.S. financial crisis. Shanghai Stock market lost nearly two-third value from December 31. 2007 to December 31, 2008. Approximately 20 million migrant workers lost jobs in 2008, industrial output increase rate drop 7% from 2008 to 2009.

Financial crisis spillover is not only to the financial market but also strongly impact on the real economics even caused the biggest recession after 1930s. Nikkinen, Saleem and Martikainen (2013) utilized multivariate GARCH model indicated that current US subprime crisis volatility spillover effects on BRIC financial market and industrial sector in the full sample and also during crisis, especially Russia and India were hardly hit of their equity market.

III. Data and methodology

3.1Data:The data were daily stock-price of indices from January 3, 2000 to 29 July 2016 the equity markets of 15 emerging markets and U.S. financial markets. We chose 2000 to 2016 due to the economic circle. The 2008 financial crisis lasted 18 months. From the economic cycle, the U.S. economy began a longer recovery after a short recession. The average duration of recession was 10 months, and the average duration of recovery and expansion was 63 months. For this reason, we selected 8 years for our analysis. Besides, in line with other studies about contagion of financial crisis, Baele et al. (2004), Cappiello et al. (2006), Chiang & Jeon and Li (2007), Syllignakis and Kouretas (2011), Harkmann(2014), and Kim & Kim and Lee(2015), stock market indices is a sensitive measure variable and can capture changes in market relatively quickly, therefore, we can use it to study contagion in financial market.

In this paper the data set consists of the national stock indices of Chile(1P), China (SSEC), Hungary (BUX), Indonesia (JKSE), Israel (TA-100), Malaysia (KLSE), Mexico (IPC), Peru (SPBLPGPT), Poland (WIG), Singapore (STI), South Africa (SPBLPGPT), South Korea (KS-11), Thailand (SETI) and Turkey (XU100) index, and US(S&P 500 index). All the national stock-price

indices are in local currency and based on daily closing prices in each national market. The data is extracted from DataStream International.

For the econometrics analysis, the daily asset returns are calculated as the first difference of the natural log of each stock-price index, multiplied 100. That is, $r_{i,t} = (\ln(p_{i,t})/\ln \quad (p_{i,t-1})) * 100$, where $p_{i,t}$ is the stock price level in country i at time t. Missing observations because of the holiday, bank off day and other reasons replaced with the last available trading day closing price on the market. The data base applied is 5 days a week to avoid bias created by too much replacement and generation of unnecessary data.

3.1.1 Unit root test:

We applied Dickey-Fuller (ADF) unit root test to examine the time- series asset return properties of stationary. The test result suggested that stock market asset return is stationary in level at the 1% significance level for these 15 emerging stock markets and U.S. as well. After confirm the stationary we can apply time-series analysis and DCC-GARCH for return data.

3.1.2 Timeline divide:

It is very important to consider the chronology to study financial crisis. To compare whether there is contagion effect or not, we take a longer timeline from 3rd January 2000 to 29th July 2016. According many previous studies like: Majid and Kassim (2016) study the date from 2006 to 2008 and made pre-crisis and during crisis two periods. Dooley and Hutchison (2009) divided timeline from February 2007 until March 2009 to three periods, pre and post-crisis by the Lehman Bankruptcy which called crisis point. It is getting more refinement in Min and Hwang (2012) study to divide crisis periods as first and second phases, and Cai, Tian and Hamori (2016) also applied this four phases type.

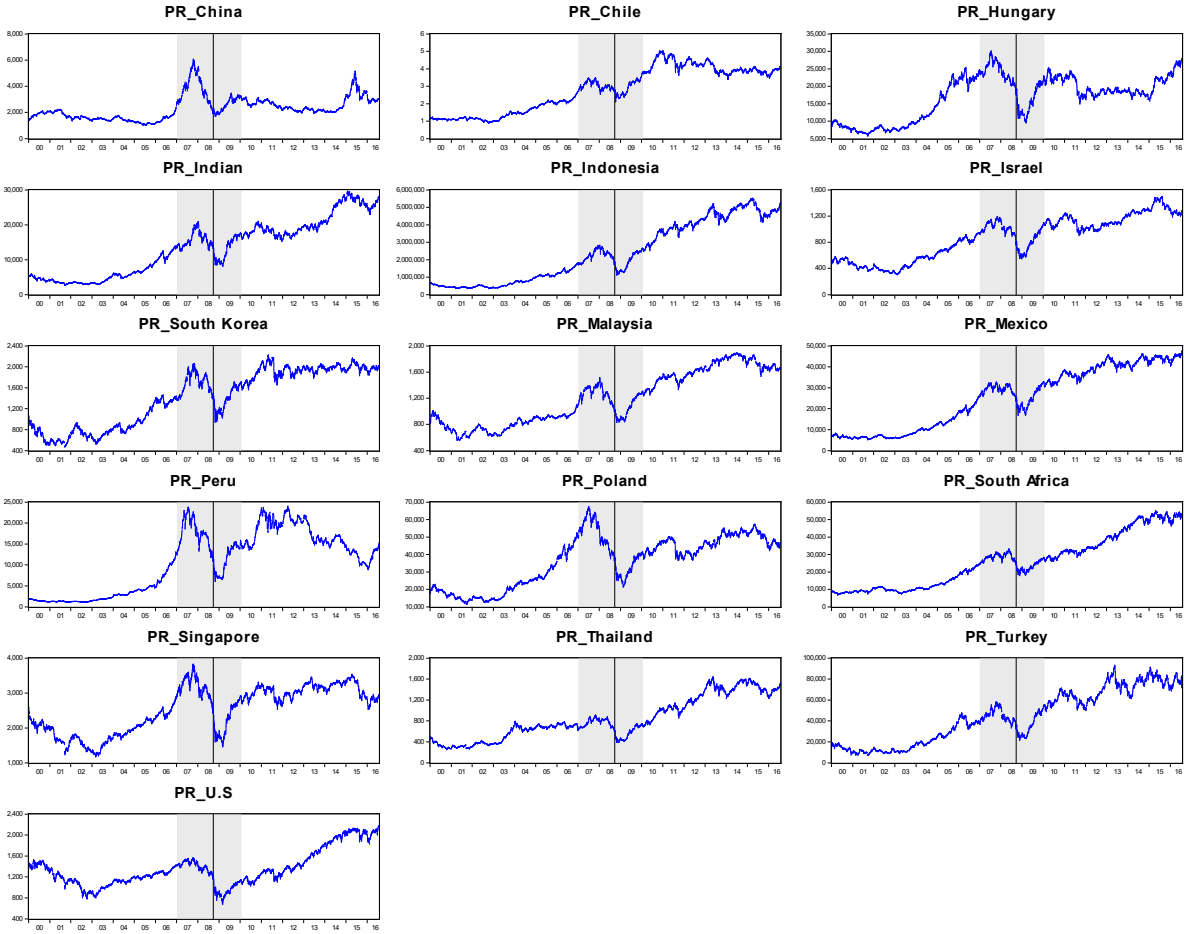


Figure 1: Stock price indices of 16 markets.

In our study since we want to real compare whether there is spillover effect or not then take a wide range timeline from January 2000 to July 2016 and divided to 3 different phase: Phase 1 is tranquil before crisis, spanning 3rd Jan. 2000 to 29th Dec.2006; second phase is crisis period: from 3rd Jan. 2007 to 31st Dec. 2009. Finally the last period is post crisis that is from 4th Jan 2010 to 29th July 2016. Specifically, we also take 15th Sep. 2008 that Lehman Brother′ s Bankruptcy as a important point to analyze contagion.

Figure 1 illustrates price stock for U.S and 15 emerging markets from 2000- 2016, there are some common characters. Before 2008 U.S. subprime crisis from 2000- 2006, most of the markets experienced a sharp downturn from 2000 to 2003, which some called "stock market crash" in stock markets involved U.S., Asia, Canada and Europe. In Nov. 2002 there was a lowest point for this Bear market. Then all stock market indices keep growing steadily with the increasing speeding, we can see it from the slope of the curve from 2003- 2006 that is getting steeper.

Second period, is the gray area in the graph, during crisis 2007- 2009 almost for all stock indices reached the peak during 2007, then from 2007 through 2009 they are a dramatic drop from the highest point to trough almost all in 2008. The difference from the top to bottom is huge and speed of the downturn is steeper. In the crisis period the volatility of stock indices was very high. It shows the degree and speed of fall down for the stock indices so fast and fierce. The trough point is around Sep. 2008 near the Lehman Brother′ s Company went bankrupt. All those markets experienced a rise after 2009 except China and Hungary market. Almost all markets follow the

similar path rising relative steadily and all of them impacted by the 2012 European Debt crisis more or less has a light decline but recover very soon, expect China. That is why many studies treat China separately because the government intervention plays very essential role in Chinese financial market.

3.1.3 Descriptive statistics of data: price and return

Table 1 represents the summary of descriptive statistics of the daily stock-index return in the 16 economies. Specifically, the mean, standard deviation, skewness, kurtosis, Jarque-Bera were reported. Except Peru market has negative mean of return, other economies all have positive return. Panel A is the entire period from 3 Jan. 2000 to 29 July 2016. Panel B, C and D is before-(3rd Jan. 2000-29th Dec. 2006), during- (3rd Jan. 2007- 31st Dec. 2009) and after crisis (4th Jan. 2010 – 29th July 2016), respectively.

There are some common results for four Panels. The skewness, Kurtosis and also Jarque-Bera shows that asset return is not normal distributed. The skewness are negatively skewew for most of the economies (except Chile) shows that most of the return have big and long tail in the left side which means more extreme value appeared. Kurtosis tells that the returns are leptokurtic, and steep with sharp peak. All those suggested that for those markets are easily influenced by the big shock of other markets either good or bad shocks. In addition, Jarque-Bera value is significantly in 1% for all selected countries, which reveals that the asset returns are non-normality of high frequency financial time series. Therefore, we will use Student′ s-t distribution instead of normal distribution to the DCC-GARCH Model.

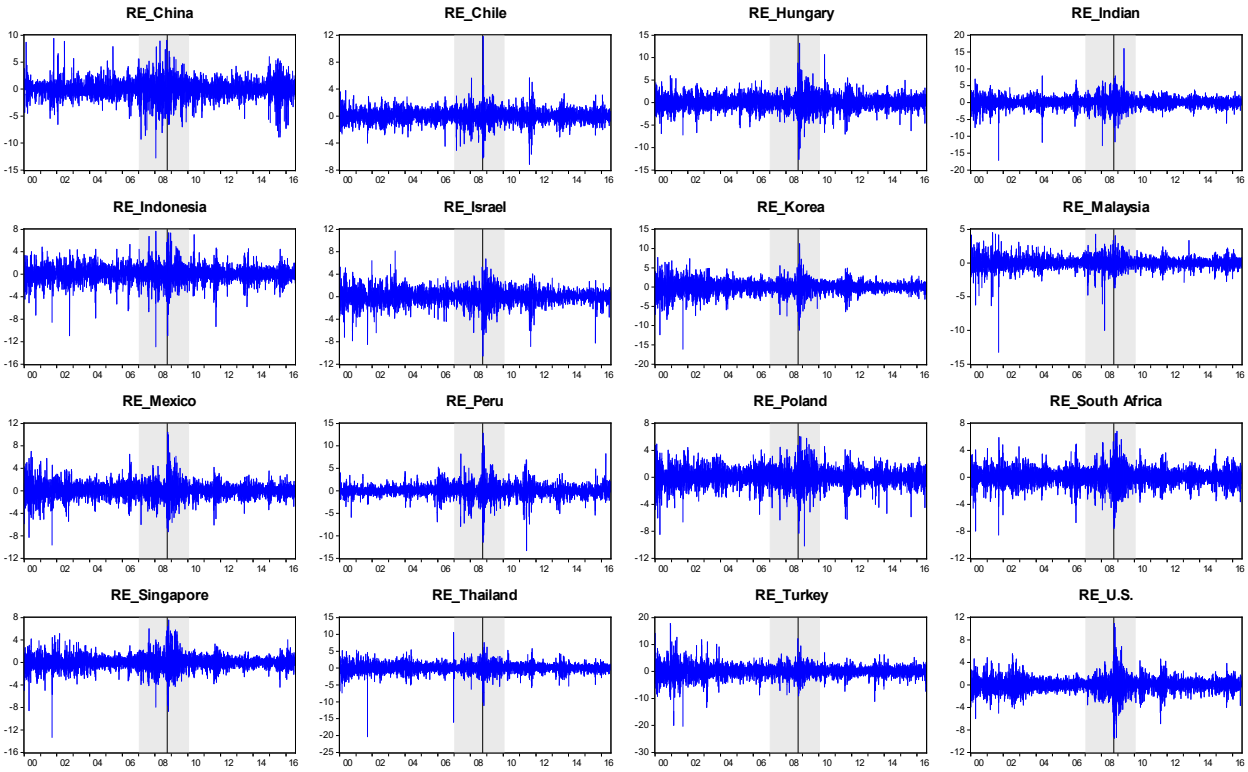
Compare the mean of stock return before-, during- and after crisis, except Malaysia, South Korea, Malaysia and Turkey, all other emerging markets and US were lower during crisis than before, which shows the return dropped during crisis period, and that could be seen in the figure 1. According to the comparison of mean of return before and during crisis, the most influenced countries in our studies are Peru, Poland, Hungary, Mexico and South Africa, which sharply dropped 9.84%, 8.16%, 7.97%, 4.92% and 4.69%, respectively. Conversely, Malaysia (-0.42%), Singapore (0.73%) and South Korea (-0.22%) did not follow the same path but had very limited change before-, during- and after crisis. （Note: The number in the brackets is the mean of stock return before crisis minus during crisis value.

Meanwhile, most of the selected countries stock return could not recover to the same level as before crisis even we took the longer time period until July 2016, except Malaysia, Thailand, and US. That tell us this time global financial crisis has extensive, profound and long persistent impact to the whole financial markets. The stock return of South Korea and Malaysia, post crisis are lower than crisis period, it is a normal phenomenon also for most of the emerging market. The market responds are little bit lag but persistent for a while. However, some emerging market recovered very fast following U.S (7.21%) market after financial crisis, like Poland (3.93%), Hungary (3.67%), South Africa (2.52%), and Thailand (3.38%). However, the return of China, Chile, Israel and South Korea stay in a lower level after crisis, especially China which has negative return. (Note: The numbers in brackets are difference of mean after crisis and during crisis.)

It is not worth to compare of asset return among different economies due to the market characters are different (Syllignakis and Kouretas (2011)). In addition, except Turkey all other selected countries follow the same path of the standard deviations that are much higher during crisis than before crisis which followed by after crisis. Regarding to Turkey the standard deviation is higher before crisis than the crisis period.

To visualize the asset return for all markets, we plot asset return figure, it shows that a clustering of larger return volatility during 2007-2009 crisis period than before and after crisis. This character is suitable for GARCH model.

Figure 2: Daily Stock Return of Emerging markets and U.S. 1/03/2000 – 7/29/2016



Panel A. Entire period 1/03/2000-7/29/2016																
	RECHA	RECHE	REHG	REIND	REINSIA	REIS	REKO	REMA	REME	REPE	REPO	RESA	RESG	RETH	RETR	REUS
Mean	0.0187	0.0308	0.0274	0.0396	0.0490	0.0221	0.0162	0.0164	0.0452	0.0508	0.0213	0.0436	0.0023	0.0276	0.0384	0.0096
Std. Dev	1.6296	0.9813	1.5526	1.5491	1.3872	1.2212	1.5760	0.8511	1.3269	1.4004	1.2914	1.2346	1.1931	1.3818	2.2176	1.2571
Skew.	-0.3866	0.0366	-0.1050	-0.5806	-0.8296	-0.6769	-0.7207	-1.6101	-0.0072	-0.3833	-0.4652	-0.2676	-0.5724	-1.4015	-0.1854	-0.1910
Kurtosis	8.4288	11.9916	9.1639	14.2048	11.2535	10.7248	10.9535	26.3634	8.5981	14.2956	7.0622	7.0215	11.7537	22.9688	11.8902	10.9981
Jarque-Bera	5224.56	14048.57	6609.11	22048.13	12314.31	10686.4300	11352.07	96643.24	5445.16	22270.92	3017.4980	2859.71	13541.7	70648.66	13756.22	11140.16
Obs.	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170
Panel B. Before Crisis 1/03/2000 - 12/29/2006																
Mean	0.0382	0.0490	0.0589	0.0535	0.0558	0.0345	0.0189	0.0156	0.0749	0.1110	0.0555	0.0608	0.0064	0.0196	0.0537	-0.0015
Std. Dev	1.3368	0.8662	1.4116	1.5800	1.3513	1.2706	1.8472	0.9309	1.4164	1.0133	1.2791	1.1839	1.1683	1.5104	2.7506	1.1294
Skew.	0.6648	-0.0214	-0.1454	-1.2797	-0.8199	-0.2737	-0.7205	-1.8663	-0.1618	-0.0432	-0.3082	-0.4505	-1.0992	-1.9534	-0.1437	0.1035
Kurtosis	8.7994	4.5314	4.8236	14.6853	8.5413	8.8302	8.9463	30.8900	6.9137	7.6889	5.7224	7.7628	15.4572	30.7003	10.3768	5.6252
Jarque-Bera	2594.62	172.02	249.93	10487.89	2447.59	2513.22	2743.68	58031.45	1130.31	1611.92	571.0478	1722.03	11727.74	57355.86	3994.42	508.25
Obs.	1759	1759	1759	1759	1759	1759	1759	1759	1759	1759	1759	1759	1759	1759	1759	1759
Panel C. Crisis Period 1/03/2007 12/31/2009																
Mean	0.0268	0.0377	-0.0208	0.0313	0.0449	0.0186	0.0211	0.0198	0.0257	0.0126	-0.0306	0.0139	-0.0010	0.0102	0.0397	-0.0318
Std. Dev.	2.3815	1.3779	2.1734	2.2650	1.9051	1.5868	1.891578	1.1110	1.7967	2.2092	1.7413	1.7401	1.7854	1.6842	2.1705	1.8868
Skew.	-0.5104	0.2425	-0.0097	-0.8162	-0.7685	-0.6075	-1.3501	0.2378	-0.2156	-0.4248	-0.1631	-0.7765	-0.0580	-0.1703		

			0.0828									0.0892				
Kurtosis	5.3830	11.9811	8.7153	8.6826	9.9970	8.166714	8.9800	13.75026	7.0786	8.3476	5.9013	4.9682	5.8203	8.8977	5.8336	9.0737
Jarque-Bera	211.70	2548.19	1029.79	1017.20	1626.10	915.3145	1172.958	3870.047	531.13	906.67	287.89	123.03	253.8986	1171.64	253.35	1165.69
Obs.	756	756	756	756	756	756	756	756	756	756	756	756	756	756	756	756
Panel D: Post Crisis 1/3/2007 12/31/2016																
Mean	-0.0058	0.0084	0.0159	0.0286	0.0436	0.0436	0.0105	0.0109	0.0226	0.0043	0.0087	0.0390	-0.0006	0.0441	0.0215	0.0403
Std. Dev	1.4846	0.8729	1.3414	1.0262	1.1192	1.1192	0.9452	1.0003	0.9113	1.2718	1.0383	0.9846	0.8259	1.0452	1.4842	1.0003
Skew.	-0.8476	-0.2970	0.0024	-0.1340	-0.6106	-0.6106	-1.3389	-0.4471	-0.3045	-0.6133	-0.6599	-0.2101	-0.2875	-0.3529	-0.5857	-0.4377
Kurtosis	8.3793	9.6299	7.7647	4.5363	9.3881	9.3881	15.0581	7.3084	5.8822	14.8604	7.1488	4.4319	5.3532	6.9783	7.1480	7.0149
Jarque-Bera	2193.62	3055.47	1565.55	167.71	2916.90	2916.90	10520.89	1335.17	598.41	9804.09	1307.08	153.56	404.65	1125.77	1281.12	1164.44
Obs.	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655

Note: p −value of Jarque-Bera for all countries are statistically significant in 1% level.

3.1.4 Unconditional correlation

The pair-wise correlation is widely applied to show the basic relation between variables even though our data has heteroskedasticity problem. Unconditional correlation follows the same path of the entire shape before-, during- and after crisis. In terms of the entire data from Jan. 2000 to July 2016, U.S has significant correlation with all studies emerging market, and the range from 0.0520 (China) to 0.6816 (Mexico). All correlation coefficients are statistically significant in 1%. There are some countries like China, Indonesia, and Malaysia keep lower correlation which less than 0.1, in each period compare to other emerging countries. The related higher correlation group which average correlation is more than 0.4 include Chile, Hungary, Mexico, Peru, Poland and South Africa.

The table 2 illustrates that the correlation between U.S. to all selected emerging markets in this paper increased significantly during the crisis period than before crisis, also most of them significant in 1% level. However, for China, Indonesia and Malaysia are not statistically significant correlated

with U.S market before crisis. These three countries financial markets are not integration or open as others, the government intervention play an important role. In addition, even though there are heteroskedasticity problem, that is the correlation will increase by time, still we notice that for many emerging markets, the correlation during crisis is bigger than that after crisis periods, or at least does not have much difference which implied that during crisis correlation between U.S. and all selected emerging countries increased a lot except Chinese financial market.

17 Table 2: Pair-Wise unconditional correlations of stock return

Pearson correlation					increase%	increase%	Spearman correlation			
	REUS-entire	REUS-before	REUS-crisis	REUS-after	Crisis/before	after/before	REUS-entire	REUS-before	REUS-crisis	REUS-after
RECHA	0.052***	-0.0098	0.0443	0.1309***	5.41	14.07	0.0367	-0.0035	0.0317	0.0829***
RECHE	0.4889***	0.4035***	0.5679***	0.4898***	16.44	8.63	0.4148***	0.3737***	0.5058***	0.4122***
REHG	0.3468***	0.2283***	0.4115***	0.409***	18.32	18.07	0.2743***	0.1876***	0.3513***	0.3333***
REIND	0.2242***	0.0909***	0.3255***	0.2858***	23.46	19.49	0.1611***	0.059**	0.2480***	0.2441***
REINSIA	0.1027***	0.0177	0.1448***	0.1655***	12.71	14.78	0.0764***	0.0189	0.1345***	0.1092***
REIS	0.2401***	0.1906***	0.2253***	0.3498***	3.47	15.92	0.2149***	0.1644***	0.2164***	0.2797***
REKO	0.1723***	0.1254***	0.2251***	0.2159***	9.97	9.05	0.1502***	0.1240***	0.1817***	0.1658***
REMA	0.0804***	0.0138	0.1291***	0.1333***	11.53	11.95	0.0761***	0.0146	0.1274***	0.1211***
REME	0.6816***	0.6052***	0.7855***	0.6823***	18.03	7.71	0.6191***	0.5781***	0.7171***	0.6185***
REPE	0.3757***	0.2004***	0.4530***	0.4423**	25.26	24.19	0.3191***	0.2145***	0.3785***	0.4061***
REPO	0.3459***	0.1955***	0.4104***	0.4808***	21.49	28.53	0.3001***	0.1955***	0.3653***	0.3958***
RESA	0.3619***	0.2644***	0.3874***	0.4663***	12.3	20.19	0.3155***	0.2515***	0.3302***	0.3873***
RESG	0.2485***	0.1836***	0.2783***	0.3075***	9.47	12.39	0.1970***	0.1585***	0.2101***	0.2434***
RETH	0.1714***	0.0718***	0.2771***	0.2077***	20.53	13.59	0.1388***	0.0620***	0.2191***	0.1887***
RETR	0.2256***	0.1036***	0.3915***	0.3447***	28.79	24.11	0.2053***	0.0787***	0.3497***	0.3024***

18 Note: The *** and ** indicate statistical significance at the level 1% and 5% level, respectively.

From the unconditional correlation, we could see that these 15 EMs behaviors influenced by U.S financial market and changed by time in response to the ongoing shocks. There are strong correlations between U.S financial markets to the emerging markets. The correlation increase dramatically during crisis than before, also after the crisis still the spillover persistent. To dealing with heteroskedasticity problem better and also capture the time-varying characteristics, we can apply multivariate GARCH model and use dynamic conditional correlation to investigate the spillover effect and correlation from U.S financial market to other 15 emerging markets. In addition, EMs is getting much more correlated with each other during the crisis period than before.

Due to the asset return is not normal distributed, after the unconditional correlation test we also applied Spearman correlation. These two unconditional correlation tests have similar result. (not showing in the paper)

3.2Methodology

Mean equation: $y_t = \gamma_0 + \gamma_1 y_{t-1} + \gamma_2 y_{t-1}^{U.S.} + \varepsilon_t$

variance equation: $h_{i,t} = \omega + \alpha_i \varepsilon_{i.t-1}^2 + \beta_i h_{i,t-1}, i = 1, \ldots, 10$

DCC equation: $q_{ij,t} = \bar{\rho}_{ij}(1 - a - b) + b\rho_{ij,t-1} + a\eta_{i,t-1}\eta_{j,t-1}$

$$\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t}}\sqrt{q_{jj,t}}}, where\ i, j = 1,2, \ldots, 10, and\ i \neq j$$

Consider y_t is the asset returns serious for t=1, …, 10.

In this paper we will apply DCC-MGARCH model proposed by Engle (2002) to employ the stock price returns of different emerging markets and U.S. market return and to find the possible contagion or spillover effect by investigate changing of dynamic conditional correlations. We could get dynamic conditional correlation which enable us to analyze the dynamic correlation behavior between asset returns in order to reveal how they response to financial shocks.

There are many advantages to apply multivariate DCC-GARCH model. First, DCC-GARCH could handle heteroskedasticity problem. Although unadjusted Pearson correlation widely used to study the correlation between variables, for time series data, it suffering heteroskedasticity bias problem that is correlation between countries will increase simultaneously with the higher volatility during the crisis period. DCC-GARCH could addresses heteroskedasticity problem by standardizing residuals, which data series' residuals divided by the GARCH conditional standard deviation in correlation calculation.

Second, the multivariate GARCH model is parsimonious, it can estimate up to 45 pair-wise correlation coefficient series in a single representation without adding too many parameters. In our study, the aim is to find spillover effect from U.S to selected emerging market, therefore, we apply DCC-GARCH (1,1) focus on the separately pair. The parameters of model will be different but should meet the model requirement.

Third, the DCC-GARCH could include additional exogenous variables in the mean and variance equations to measure the common factors impaction and to investigate the transmission channel of volatility in the crisis. (need to continus)

The estimation steps as follow.

Estimation of mean equation

Mean equation:$r_t = \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 r_{t-1}^{U.S.} + \varepsilon_t$, (1)

Where $r_t$is the asset returns series, $r_{t-1}$is the AR(1) of asset return, which is for the autocorrelation of returns, , $r_{t-1}^{U.S.}$is the one-day lagged U.S. stock return, which have been often used to account for a global factor (Dungey et al. 2003). From the investor aspect, they will do investment depend on the previous returns, in addition U.S. financial market play an important role of emerging markets (Chiang, Jeon and Li, 2007), that is why the mean equation we put AR(1) and Lagged U.S return as explanatory variables.

The asset return and residual of the mean equation are not normal distribution, therefore, Gaussian GARCH model unable to explain the leptokurtosis exhibited in this study. We will apply Student's t-distribution suggested by Bollerslev (1987) instead of normal distribution. The distribution of the error term will takes the form as below according to Bollerslev (1987).

where ν is the degree of freedom of the t-distribution. We expect is significant during the analysis.

Estimation of the variance equation

Variance equation: $h_{ii,t} = \omega + \alpha_i \varepsilon_{i.t-1}^2 + \beta_i h_{ii,t-1}, i = 1, ..., 10$ (2)

Where $\varepsilon_{i.t-1}^2$ is the ARCH term, and $h_{ii,t-1}$ is the GARCH term that is dynamics of volatility. $\alpha_i, \beta_i and\ \omega$ are the parameters to be estimate. The parameter β_i measures the persistence conditional volatility. The bigger the value the longer persist.

Estimation of multivariate conditional variance matrix

$H_t = {D_t}^{1/2} R_t {D_t}^{1/2}$ (3)

$R_t = diag(Q_t)^{-1/2} Q_t diag(Q_t)^{-1/2} Q_t$ (4)

$Q_t = (1 - \lambda_1 - \lambda_2) R_t + \lambda_1 \tilde{\varepsilon}_{t-1} \tilde{\varepsilon}'_{t-1} + \lambda_2 Q_{t-1}$ (5)

Where H_t is an N × N positive definite matrix, which is the conditional variance matrix of r_t by volatilities $h_{i,t}$.

D_t is a N × N diagonal matrix of the conditional variance of the residual returns.

In which each $\sigma_{i,t}^2$ evolves according to the univariate GARCH model of the form

Rt is N × N time-varying matrix of conditional quasicorrelations,

$$R_t = \begin{bmatrix} 1 & \rho_{12,t} & \cdots & \rho_{1m,t} \\ \rho_{12,t} & 1 & \ldots & \rho_{2m,t} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{1m,t} & \rho_{2m,t} & \cdots & 1 \end{bmatrix}$$

$\tilde{\varepsilon}_t$is an m×1 vector of standardized residuals, ${D_t}^{-1/2} \varepsilon_t$; and λ_1 and λ_2 are nonnegative and satisfy the $0 \leq \lambda_1 + \lambda_2 < 1$ parameters that govern the dynamics of conditional quasicorrelations.

The DCC-GARCH model proposed by Engle (2002) followed two-steps estimation of conditional variance matrix Ht. The first step is get the standard variance $\sigma_{i,t}^2$ from the univariate GARCH model. The second step is transfer the standard variance obtained from the first step to conational correlation by $\tilde{\varepsilon}_{i,t} = \varepsilon_{i,t} / \sqrt{\sigma_{i,t}^2}$.

The dynamic conditional correlation (DCC) calculates conditional covariance matrix based on variance equation. We calculate the conditional correlation in the bivariate case:

$$\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t}q_{jj,t}}}, i, j = 1,2, \ldots, n, and\ i \neq j$$

$$\rho_{12,t} = \frac{q_{12,t}}{\sqrt{q_{11,t}q_{22,t}}}$$

$$= \frac{(1-\lambda_1-\lambda_2)\bar{q}_{12,t} + \lambda_1\tilde{\varepsilon}_{1,t-1}\tilde{\varepsilon}_{2,t-1} + \lambda_2 q_{12,t-1}}{\sqrt{(1-\lambda_1-\lambda_2)\bar{q}_{11} + \lambda_1\tilde{\varepsilon}^2_{1,t-1} + \lambda_2 q_{11,t-1}}\sqrt{(1-\lambda_1-\lambda_2)\bar{q}_{22} + \lambda_1\tilde{\varepsilon}^2_{2,t-1} + \lambda_2 q_{22,t-1}}}$$

Where ρ_{ij} is the unconditional correlation of $\tilde{\varepsilon}_{i,t}$ and $\tilde{\varepsilon}_{j,t}$.

The parameter λ_1 show the volatility of the shock, specifically showing the immediate and short time impact of the volatility on the DCCS. λ_2 indicate the persistence of the shock.

The DCC-model can be estimate by using a –two stage approach to maximize the log-likelihood function (Engle 2002). The log-likelihood was written as the sum of volatility part and a correlation part.

$$L_{(\theta,\phi)} = \left[-\frac{1}{2}\sum_{t=1}^{T}(nlog(2\pi) + log|D_t|^2 + \varepsilon'_t D_t^{-2}\varepsilon_t\right] + \left[-\frac{1}{2}\sum_{t=1}^{T}(log|R_t| + \tilde{\varepsilon}'_t R_t^{-1}\tilde{\varepsilon}_t - \tilde{\varepsilon}'_t\tilde{\varepsilon}_t\right]$$

Empirical result of DCC- GARCH

107 Table 3: Empirical analysis results of the DCC-MGARCH models.

Country	return equation			variance equation					
	$r_t = \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 r_{t-1}^{U.S.} + \varepsilon_t$			$h_{i,t} = \omega + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1}, i = 1, \ldots, n$					
	γ_0	γ_1	γ_2	ω	α_i	β_i	Persis.	Quasicorr.	v
china	0.313*	0.0007	0.1096***	0.0284***	0.0589***	0.9274***	0.9863	0.0433**	6.0046***
	0.018	0.0148	0.0162	0.0069	0.0078	0.0092		0.0202	0.4032
Chile	0.0615***	0.1444***	0.0511***	0.0308***	0.1064***	0.8559***	0.9623	0.4378***	9.5273***
	0.0113	0.0154	0.0121	0.0055	0.0133	0.0055		0.042	0.8733
Hungary	0.0436**	-0.0477***	0.2364***	-0.6968	0.1317***	1.1913***	1.323	0.2838***	4.4711***
	0.0216	0.017	0.0219	0.5729	0.03	0.2751		0.0205	0.2491
India	0.0867***	0.0184	0.2292***	0.0326***	0.0873***	0.8964***	0.9837	0.2163***	7.8323***
	0.0164	0.0154	0.0164	0.0071	0.0101	0.0112		0.0477	0.604
Indonesia	0.0923***	0.0391**	0.2905***	0.0647***	0.1256***	0.8353***	0.9609	0.1027***	6.3552***
	0.0149	0.0154	0.0155	0.0155	0.018	0.0238		0.0171	0.4252
Israel	0.0414***	-0.0681***	0.1956***	0.0055***	0.0346***	0.9594***	0.994	0.2241***	4.7572***
	0.0122	0.0133	0.0141	0.0019	0.0054	0.0061		0.0448	0.2798
South Korea	0.0478***	-0.0689***	0.4346***	0.0103***	0.0774***	0.9191***	0.9965	0.2144***	8.4416***
	0.0145	0.0143	0.0165	0.003	0.0095	0.0093		0.0376	0.7045
Malaysia	0.0245***	0.0965***	0.1935***	0.0086***	0.0886***	0.8956***	0.9842	0.1913***	5.7983***
	0.008	0.0145	0.0086	0.0021	0.0124	0.0137		0.0419	0.3605
Mexico	0.0806***	0.0383**	0.0444**	0.0137***	0.0610***	0.9293***	0.9903	0.6598***	8.0770***
	0.014	0.0151	0.0176	0.0031	0.0061	0.0068		0.0411	0.6599
Peru	0.0606***	0.1585***	0.0813***	0.0470***	0.1466***	0.8237***	0.9703	0.3187***	7.2374***
	0.0133	0.0154	0.0127	0.0091	0.0165	0.019		0.0679	0.5445

Poland	0.0466***	-0.0299**	0.2283***	0.0142***	0.0521***	0.9383***	0.9904	0.3719***	7.7727***
	0.0148	0.0148	0.0165	0.0037	0.0064	0.0074		0.0803	0.6103
SA	0.0799***	-0.0782***	0.3097***	0.0172***	0.0737***	0.9139***	0.9876	0.3841***	9.4072***
	0.0138	0.0148	0.0157	0.0043	0.0084	0.0096		0.0579	0.844
Singapore	0.0265**	-0.0618***	0.3465***	0.0085***	0.0775***	0.9161***	0.9936	0.2534***	8.1741***
	0.0114	0.0144	0.0135	0.0022	0.0094	0.0095		0.0537	0.6589
Thailand	0.0774***	-0.0037	0.2376***	0.0390***	0.1066***	0.8712***	0.9778	0.2409***	6.7233***
	0.0147	0.0153	0.015	0.0078	0.0115	0.0129		0.0618	0.4711
Turkey	0.1002***	-0.0343**	0.2589***	0.0436***	0.0628***	0.9263***	0.9891	0.2756***	7.0639***
	0.0235	0.0152	0.0245	0.0116	0.0089	0.0101		0.0616	0.5065

Note: v is the degree of freedom of t-distribution. The standard errors are in the parentheses. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels.

Table 3 shows the analysis result from DCC-GARCH model. First for the mean equation, that is return equation in the table 3, the constant term is statistically significant for each selected EMs, except China in 10% and Hungary in 5% significant level, all others are significant in 1%. The AR(1) term in the mean equation γ_1 is not significant for China, India and Thailand, but higher positive significant for Chile, Malaysia, and Peru in 1% and Indonesia and Mexico in 5% significant level, respectively. In addition, it is negatively significant for Israel, Hungry, South Africa Poland, Singapore and Turkey.

Moreover, the impact from U.S. previous return γ_2 in the mean equation are highly positive statistically significant for all selected emerging market returns. and for Hungry, India, Indonesia, South Africa, Thailand and Turkey impact level are more than 20% which in a large magnitude. Those result evidenced that U.S. stock market has strong influence to the selected emerging markets. This result is consistent with Cai,Tian and Hamori (2016) that U.S. stock market plays influence role on emerging East Asian c stock and also Kim and Kim (2011) .

The coefficients of variance equation for all selected emerging markets α_i and β_i are highly statistically significant in 1% level, revealing a dynamic substantial time-varying co-movement of the volatilities between U.S. stock market and selected emerging markets. Moreover, this result indicates that ARCH term and GARCH term lagged conditional volatility are both significant in the variance equation, justifying the appropriateness for GARCH (1, 1) specification.

The parameter β_i represents the persistence of the DCC process (Harkmann (2014, for GARCH the desired requirement for β_i is range between 0 to 1, that means the closer to 1, the longer of effect will last. Regarding to requirement of β_i , except Hungary is greater than 1, all other selected emerging market is suit in the range and with a related higher level which between 0.8237 (Peru) and 0.9594 (Israel). That result shows the impact persistent in a longer time.

In addition, in our study we run DCC-GARCH model for each pair, namely, a selected emerging market and U.S, the model conditional variance averages around close to 1, which exhibited that the conditional correlations high persistence. The estimated parameter persistence in the table, which is the sum of constant term α_i and conditional variance β_i are less than 1 but very close to 1, which also illustrates that the GARCH (1,1) model fits the data very well, except Hungary (Persistent=1.323), and shows that the volatility in the GARCH models displayed high persistence additionally, that consistence with the result of Syllignakis and Kouretas (2011).

This DCC-MGARCH also could get the estimated conditional quasicorrelation between the volatilities of the two stock markets, the value of quasicorrelation for U.S and selected EMs are high and positive, except China and Indian, which indicates that high volatility in the emerging market is associated with high volatility in the U.S stock market. China is a very special case, the government intervention play an essential role in the financial market.

The last column at the table is the degree of freedom (v) of the Student′ s t-distribution, for all selected emerging markets the estimator v are all significant at 1% level, indicating that the error term has a heavier tail than the normal distribution and it is more suitable for this analysis.

To conclude from the DCC-GARCH estimator result, the stock market volatilities of selected emerging markets are associated with U.S. stock market and impact with a highly persistence and

statistically significant level. The DCC-GARCH is suitable for our analysis with exception of China market.

3.3 Dynamic Conditional Correlation (DCC) analysis

One of the important superiority of multivariate DCC-GARCH model is that we can obtain dynamic conditional correlation for all possible pair-wise (max 45 pairs) for the index returns of the markets and estimate it with particular study purposes. In this paper, we could applied this model to investigate the spillover effect of 2008 U.S. financial crisis to selected emerging markets. Figure X illustrative dynamic conditional correlations (DCCs) during the entire periods, namely January 2000 to July 2016, for each selected EMs against U.S stock market and table 4 represents the descriptive statistics result for four different panels by time spanning.

It can be seen that the selected EMs do not follow identical pattern. Firstly, China and Indonesia exhibited the similar pattern; there is no significant increase or jump before, during or after financial crisis according the mean value. It seems no contagion and stay related stable during the whole period. These two financial markets are much more independent from the U.S. financial market, the range of the DCCs for China and Indonesia are in very low level, which from -0.0181 to 0.2626 and from 0.037 to 0.3283 respectively, in addition with the very low standard deviation 0.0290 and 0.0097, respectively (table 4). This implied that there was no spillover effect of global financial crisis to China and Indonesia and their government intervention play essential role in the financial market.

Especially for China, the DCC values in a very low level less than 0.1 for most of time with the exception of beginning of crisis time, namely 28th Feb.2007 – 1st May, 2007. That is why, many studies, for instant Kim& Kim and Lee (2015) treated China as a special case. Actually for China stock market, on 28th Feb. 2007, the DCC increased suddenly to the highest level 0.2626, however it immediately back to the lower level at beginning of May and even change the direction to negative against U.S. stock market. It is more interesting that regarding to Indonesia, the max value of DCC 0.3283 was in 18th Sep. 2001 near stock market crash that happened in 2002, but did not showing any significantly changing during 2008 global financial crisis, the range is 0.0887 to 0.1971with 0.0097 very low volatility which even lower than China.

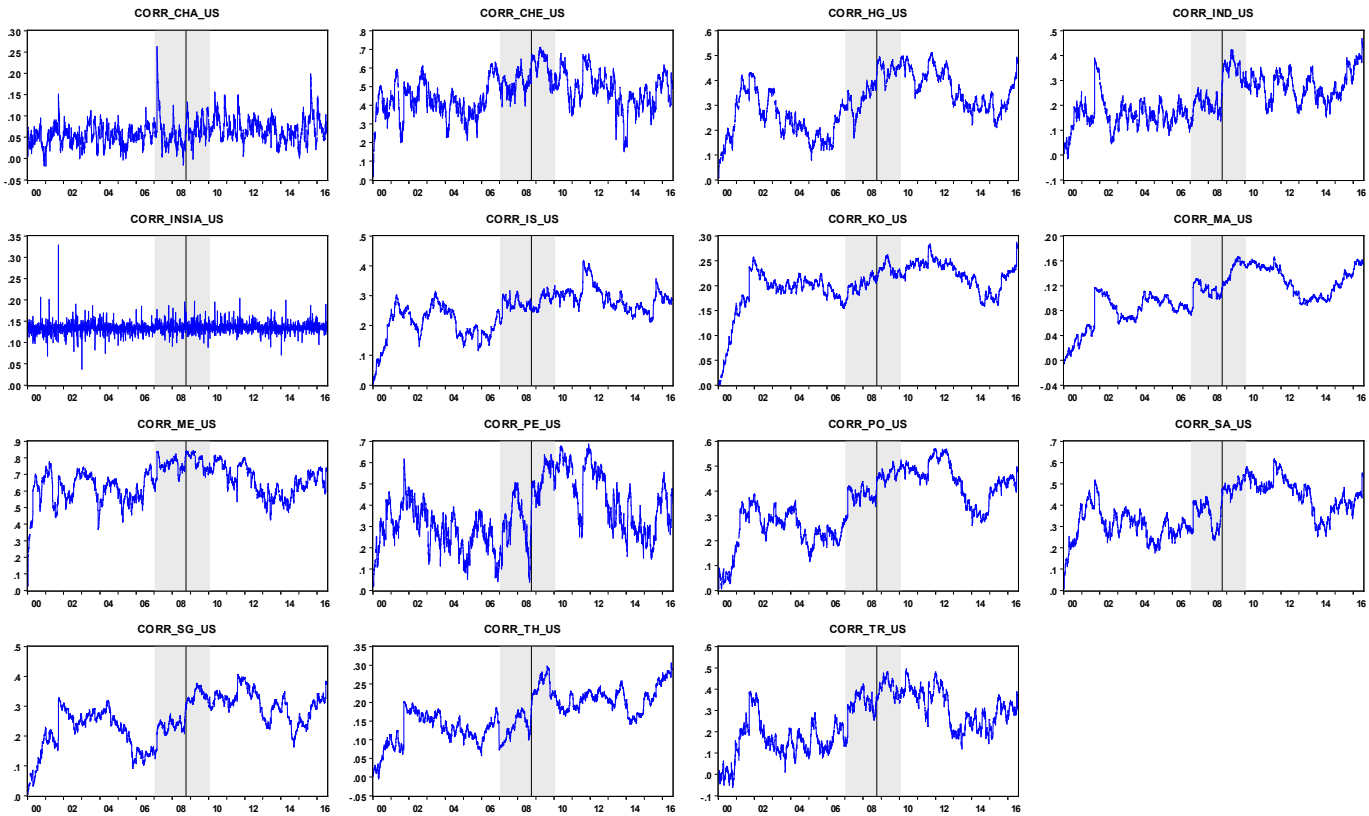
Secondly, for other selected emerging markets, namely, Chile, Hungary, Indian, Israel, Korea, Malaysia, Singapore, Thailand and Turkey, which follow the similar pattern related to the responds of 2008 financial crisis. Generally speaking, the common characteristic of the depicted pair-wise correlations in the figure 3 is the location of peak, trend, moreover the shapes of the DCCs in three periods consistent. Before global financial crisis the first peak appeared during Sep.-Oct. 2001 until beginning of 2002, they experienced a sharp DCC increase because of 2002 stock market crash. All those market shows the contagion from U.S. financial market. At the end of 2004, it became normal level. The contagion did not persistent long period. Except the first dramatic increasing resulted from 2002 stock market crash, DCCS in the first period from 2000- 2006 are relative steady and lower compare to the crisis period.

Moreover, the second peak and dramatic jump with an upward trend is the global financial crisis period from 2007 to 2009. The peak reached after Sep. 15 2008 either at the end of the 2008 or during 2009. The shade area in the figure 3 could exhibited that, DCCs for those EMs has a strong and highly increase during the crisis period. It started to increase from the end of 2006 with a strong upward increasing trend that showing by the slope of the graph and reach the peak around end of 2011 or beginning of 2012, then stay for a while. However, almost all of them could not go down to the similar lower level as before crisis. That confirmed the spillover effect persistent for long which also consistence with table 3 DCC-GARCH results.

In addition, the third peak reached after global financial crisis period was around Aug. 2011 that euro-zone sovereign debt crisis escalated in April 23, 2010 after Greece searching financial support. It was also related to the 2008 financial crisis that caused the Euro-Zone financial market problems. Therefore, the influence and spillover effect of 2008 financial crisis was profound and huge. After the highest value the DCCs decreased but could not back to the same lower range as before.

In figure 3, the vertical line represents the date of Sep. 15, 2008 which the Lehman Brother′ s announcement bankrupt. It is clear that from that day there is a significant jump of the DCCs for Chile, Hungary, Indian, Korea, Malaysia, Mexico, Peru, Poland, South Africa, Singapore, Thailand and Turkey. Our result confirmed the finding of Cai & Tian, and Hamori (2016) which refined crisis to two different phases by Sep.15 2008 and found the DCCs of second phase of crisis is higher than the first phase of crisis from end of 2006 to the crisis date. It implied high contagion of financial crisis with this co-movement.

Figure 3: Dynamic Conditional Correlations between selected emerging countries and U.S. stock return.



The third phase of our study for selected emerging market is from 2010 to 2016 long period. One of the common character of the DCCs for all selected EMs, expect China and Indonesia, they rise again due to the sovereign debt crisis. It start at the end of 2010 and reached the peak end of 2011 or first season of 2012 then went down in the middle of 2013. However, the average level of DCCs did not return back to the same lower level as before crisis but stay in a high level. It indicated that the sovereign debt crisis also has spillover effect to other emerging countries.

Regarding to the DCCs instead of pattern, we could classify these 15 selected emerging markets into 4 different groups. China (0.0620), Indonesia (0.1347), Malaysia (0.1054) and Thailand (0.1683) is group one with a low less than 0.2 mean of DCCs. Second group is middle value of

DCCs that mean value between 0.2 and 0.3, those also follow the same pattern and showing contagion, which include Indian (0.2265), Israel (0.2508), Korea (0.2032), Singapore (0.2575) and Turkey (0.2532). The third group is DCCs between 0.3-0.4 which including Hungary (0.3139), Peru (0.3633), Poland (0.3493) and South Africa (0.3798). Then the high DCCs group with a related high DCCs more than 0.4 that include Chile (0.4680) and Mexico (0.6559), which implied highly contagion of financial crisis. (Note: The number in the brackets are the mean of DCCs for entire periods from Jan. 2000 to July 2016.)

With the exception of China and Indonesia, all other selected emerging countries show volatility of the DCCs by the similar pattern. During the crisis period the DCCs increased dramatically and with a high value compare to the before period. That is evidence that there were spillover effects from global financial crisis to the emerging countries which we selected. Among them Mexico shows the highest level of dynamic correlation, range from 0.0252 to 0.8454 and with an average high DCC 0.6559 over the whole sample. Malaysia exhibited the lowest DCC level (range from -0.0054 to 0.1668) in this similar pattern group with a 0.1054 mean of the whole sample. However, the jumping degree during crisis period is obvious big and significantly.

From the table 4 we also make calculation for the DCCs difference among three periods. TheΔM: crisi-before represents that the percentage difference of DCCs mean value between crisis period and before crisis. The results indicated that for all selected EMs, the DCCs increased during the crisis period than before crisis period. The most increase counties of the DCCs is Turkey with a 20.55% high level increasing of DCC during crisis and before crisis period. Poland and Mexico also belong to the high changing DCCs group, with increasing 17.91% and 15.81%. This result indicated that these three countries impacted a lot by global financial crisis compare to other selected countries.

The DCCs of Chile (13.66%), Hungary (13.06%), Peru (11.66%), South Africa (10.38%), and Indian (10.16%) also raised significantly that more than 10% during the crisis period than before. It provided evidence that the spillover effect of global crisis to these emerging countries. In addition, the DCCs of Israel (7.39%), Singapore (6.66%), Thailand (5.69%) and Malaysia (5.01) and Korea (3.47%) also increased in a certain level during crisis period than before. However, Indonesia and China showed very slight change and almost stay the same as the difference only 0.15% and 1.17% rose.

Moreover, the ΔM: after-crisis (it means the difference of the mean value between the after crisis period and during crisis period) results exhibited that after 2008 global financial crisis the average DCCs of selected emerging financial market against US had slight changing than crisis period. Indonesia (-0.03%), Malaysia (0.29%), Hungary (0.51%), China (0.58%) and Korea (0.87%) are in the smallest changing group. Moreover, most of the selected emerging countries, namely, Thailand, Singapore, Poland, Peru, Israel, and Indian the changing of DCCs in a related lower level either positively or negatively. The correlations between U.S. and emerging countries after crisis just changed very low level, which consistent with the DCC-GRACH result for the persistence. The 2008 global financial crisis had profound a persistence spillover effect to the emerging countries.

It is worth to mention that Mexico, Chile, and Turkey, dynamic conditional correlation′ s mean value decreased in a significant level. From the previous analysis we see that these countries are very sensitive to the U.S financial market. During the crisis the DCCs increased in a dramatic range but after that, they drop down obviously. South Africa is also in a high sensitive level but increase 4.35% after crisis.

The last term of difference ΔM: after-before is difference of the DDCs mean values after crisis minus crisis for each EMs. The result is confirmed our DCC-MGARCH model analysis result, that the spillover effect were not disappeared very fast but keep a persistence and last longer and even getting bigger. The result is similar like before, China and Indonesia as previous study did not impact by U.S. market. There is no spillover effect on these two countries. However, the correlation after crisis and before crisis changed in a high level more than 10% for those emerging countries: Poland (20.41%), Turkey (15.35%), South Africa (14.73%), Peru (14.24%), Hungary (12.54%) and Indian (11.9%). Most of them are not Asian emerging countries, and they have higher financial integration level and more related and depend on the change of American financial markets.

Regarding to DCCs difference between after and before crisis, Singapore, Thailand, Mexico, Malaysia, Korea, and Chile changed in a moderate level less than 10%. Those countries are most Asian emerging countries.

All those variation of DCCs significant increased during and after crisis period than before that evidenced the spillover effect of the U.S. financial crisis from American stock market to those selected emerging markets., namely, Chile, Hungry, India, Mexico, Israel, Korea, Malaysia, Poland, Peru, South Africa, Singapore, Thailand and Turkey. However, it seems that only weak impact or no impact to Indonesia and China financial market. This result is consistent with many other studies about contagion of financial crisis, Syllignakis and Kouretas (2011), Harkmann (2014), Cai&Tian, and Hamori (2016). The impact kept persistence and the DCCs level after crisis did not turn back as previous lower level.

Moreover, there are some studies for instance, Chiang et al. (2007), Hirshleifer and Teoh (2003) distinguish the contagion and herding of financial crisis. According to their definition, if the responds of the other markets simultaneous with a high correlation to the financial shocks then there are herding phenomenon. Regarding to that, in our study, there are herding among the selected emerging markets except China and Indonesia. They all had significant increase of dynamic conditional correlation during the financial crisis period 2007-2009 and kept in the higher level and increased dramatically during the sovereign debt crisis in the similar time that could be thought at simultaneously.

Table 4: descriptive statistics of DCCs

Panel A. Entire 1/03/2000-7/29/2016

	China_US	Chile_US	Hungary_US	Indian_US	Indonesia_US	Isreal_US	Korea_US	Malaysia_US	Mexico_US	Peru-US	Poland_US	South Africa_US	Singapore_US	Thailand_US	Turkey_US
Mean	0.0620	0.4680	0.3139	0.2265	0.1347	0.2508	0.2032	0.1054	0.6559	0.3633	0.3493	0.3798	0.2575	0.1683	0.2532
Std. Dev.	0.0290	0.1054	0.1031	0.0859	0.0097	0.0641	0.0442	0.0364	0.1025	0.1422	0.1246	0.1045	0.0760	0.0598	0.1212
Skew.	1.0820	-0.2782	-0.1746	0.1459	2.1819	-0.7441	-1.9981	-0.5597	-0.7243	0.2192	-0.4525	-0.0958	-0.6484	-0.2267	-0.2308
Kurt.	6.8839	3.1826	2.2541	2.5051	52.1368	4.1997	8.7779	3.1222	4.4217	2.3162	2.6503	2.3938	3.1521	2.6783	2.2988
JB	3433.76	59.57	117.82	57.33	422713.20	634.75	8573.07	220.22	715.67	114.61	163.48	70.21	296.10	53.69	122.40
Obs.	4169	4169	4169	4169	4169	4169	4169	4169	4169	4169	4169	4169	4169	4169	4169

Panel B. Before-Crisis 1/03/2000 12/31/2007

DCCs	China_US	Chile_US	Hungary_US	Indian_US	Indonesia_US	Isreal_US	Korea_US	Malaysia_US	Mexico_US	Peru-US	Poland_US	South Africa_US	Singapore_US	Thailand_US	Turkey_US
Mean	0.0530	0.4204	0.2404	0.1608	0.1339	0.2009	0.1798	0.0753	0.6071	0.2856	0.2358	0.3025	0.2071	0.1234	0.1550
Std. Dev.	0.0224	0.0956	0.0887	0.0625	0.0109	0.0595	0.0521	0.0292	0.0973	0.1009	0.0863	0.0766	0.0720	0.0443	0.0922
Skew.	0.0953	-0.1534	0.2929	0.7307	2.9089	-0.6957	-1.8013	-0.8478	-1.2602	-0.0225	-0.7254	-0.0243	-0.5475	-0.5764	0.1820

Kurt.	3.3682	3.3857	2.3068	5.4585	70.1210	3.3511	5.9153	2.8677	6.1689	2.9648	2.9767	3.6950	2.4655	2.9192	3.2257
JB	12.59	17.80	60.34	599.21	332487.4	150.86	1573.25	211.86	1200.89	(0.24)	154.23	35.55	108.75	97.83	13.44
Obs.	1758	1758	1758	1758	1758	1758	1758	1758	1758	1758	1758	1758	1758	1758	1758
Panel C. Crisis Period 1/03/2007 12/31/2009															
crisis	China_US	Chile_US	Hungary_US	Indian_US	Indonesia_US	Isreal_US	Korea_US	Malaysia_US	Mexico_US	Peru-US	Poland_US	South Africa_US	Singapore_US	Thailand_US	Turkey_US
Mean	0.0647	0.5570	0.3710	0.2624	0.1354	0.2749	0.2144	0.1254	0.7652	0.4022	0.4149	0.4063	0.2737	0.1803	0.3605
Std. Dev.	0.0376	0.0762	0.0762	0.0801	0.0097	0.0246	0.0215	0.0221	0.0492	0.1448	0.0525	0.0840	0.0600	0.0633	0.0686
Skew.	1.5755	0.1635	-0.3743	0.2322	1.0459	-0.4084	0.0016	0.1155	-0.6695	-0.3705	-0.3508	-0.4117	-0.0639	0.1404	-1.0629
Kurt.	7.7114	2.1285	2.3280	1.7665	11.8305	3.2176	2.7032	2.4989	3.3797	2.2819	2.6299	2.0565	2.1523	1.7607	4.8171
JB	1011.99	27.29	31.88	54.72	2594.10	22.51	(2.77)	9.59	61.01	33.54	19.82	49.39	23.15	50.86	246.35
Obs.	756	756	756	756	756	756	756	756	756	756	756	756	756	756	756
ΔM: crisi-before	1.1671	13.6551	13.0571	10.158	0.1524	7.3901	3.4678	5.0088	15.808	11.656	17.908	10.377	6.6614	5.6874	20.5523
Panel D. After Crisis 1/03/2010 7/29/2016															

after	China_US	Chile_US	Hungary_US	Indian_US	Indonesia_US	Isreal_US	Korea_US	Malaysia_US	Mexico_US	Peru-US	Poland_US	South Africa_US	Singapore_US	Thailand_US	Turkey_US
Mean	0.0705	0.4779	0.3658	0.2798	0.1351	0.2927	0.2231	0.1283	0.6579	0.4280	0.4399	0.4498	0.3036	0.2106	0.3085
Std. Dev.	0.0278	0.0975	0.0763	0.0591	0.0082	0.0407	0.0283	0.0234	0.0855	0.1389	0.0779	0.0804	0.0494	0.0332	0.0851
Skew.	0.7846	-0.5645	0.1223	0.2927	1.2672	0.7374	-0.5341	-0.1758	-0.1608	-0.0056	-0.4445	-0.3521	-0.3361	0.2798	0.0212
Kurt.	4.5052	3.7685	1.8515	2.6808	17.6934	3.6997	2.6991	1.5288	2.1471	1.7729	2.3514	2.5470	2.7239	2.7589	1.9658
JB	326.02	128.62	95.08	30.65	15330.87	183.76	84.94	157.78	57.30	103.85	83.51	48.35	36.41	25.60	73.87
Obs.	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655
ΔM after-crisis	0.5805	-7.9113	-0.5132	1.7429	-0.0289	1.7824	0.8665	0.2922	-10.73	2.5863	2.5049	4.3532	2.9858	3.0348	-5.2003
ΔM after-before	1.7476	5.7438	12.5439	11.901	0.1235	9.1725	4.3343	5.301	5.0788	14.242	20.413	14.73	9.6472	8.7222	15.352

299

IV. **Conclusion**

In this paper, we applied unconditional correlation and Engle′ s (2002) multivariate DCC-MGARCH model to investigate 2008 the global financial crisis contagion effects from U.S financial market to 15 selected emerging countries financial markets, namely, China, Chile, Hungary, Indian, Indonesia, Israel, Korea, Malaysia, Mexico, Peru, Poland, South Africa, Singapore, Thailand and Turkey, by employing return of daily stock-price indices during Jan. 2000 to July 2016 which divided to three different periods, which are before-, during-, and after crisis.

Through estimating of dynamic conditional correlation during periods of financial turmoil among selected emerging financial markets and American financial market we concluded that there are substantial evidences of significant variation and co-movement of the dynamic conditional correlations before, during and after financial crisis with the exception of China and Indonesia, and also confirmed the contagion from U.S financial market to the selected emerging markets by evidenced the existence of increased correlation patterns.

Our empirical results can be concluded as follows. First, there is no contagion effect to China and Indonesia financial market from the U.S financial crisis. The unconditional or dynamic conditional correlation either not statistically significant or have very slight increasing related to crisis. Second, for other thirteen selected emerging countries had very similar pattern of the dynamic conditional correlation, which confirmed the contagion, co-movement of U.S financial crisis. The DCCs had sharp increasing during the crisis period than before turmoil, which shows the spillover effect of the U.S financial market to selected emerging markets. In addition, there is persistence impact which evidenced that the DCCs stay a higher level for a while and keep in the relative higher level than before crisis, also evidenced the herding phenomenon after crisis.

Among those EMs, Mexico is the most impacted market with a highest mean value of dynamic conditional correlation, and Thailand is the lowest one that influenced by U.S. Between them, Child, Peru and South Africa had higher value of DCCs and big difference of DCCs during crisis and before crisis, which indicated that they were impacted strongly by financial crisis. Hungary, India and Turkey also influenced by the crisis significantly but with a little bit lower mean of DCCs, range from 0.2-0.3.

There are meaningful implications for investors and governments′ financial institutions to make investment, to manage portfolio and risk assessment. To recognize the dynamic correlation between international financial markets could provide valuable information for the international investors. In addition, our findings imply that the financial markets of emerging countries are sensitive and vulnerable to external shocks that are useful implications for the policy makers. Try to identify the contagion channels and realize the signs for potential crisis will help them to stabilize the financial mechanism and system.

References:

[1].Apostolakis, G. (2016). Spreading crisis: Evidence of financial stress spillovers in the Asian financial markets. International Review of Economics and Finance, 43, 542-551. doi:10.1016/j.iref.2016.02.002
[2].Blanchard, O. J., Das, M., & Faruqee, H. (2010a). The Initial Impact of the Crisis on Emerging Market Countries. Brookings Papers on Economic Activity, 263-307. doi:http://www.brookings.edu/about/projects/bpea/past-editions
[3].Blanchard, O. J., Das, M., & Faruqee, H. (2010b). The Initial Impact of the Crisis on Emerging Market Countries. Brookings Papers on Economic Activity(1), 263-323.
[4].Dooley, M., & Hutchison, M. (2009). Transmission of the U.S. subprime crisis to emerging markets: Evidence on the decoupling–recoupling hypothesis. Journal of International Money and Finance, 28, 1331-1349. doi:10.1016/j.jimonfin.2009.08.004
[5].Dungey, M., & Gajurel, D. (2014). Equity market contagion during the global financial crisis: Evidence from the world's eight largest economies. Economic Systems, 38, 161-177. doi:10.1016/j.ecosys.2013.10.003
[6].Engle, R. (2002). Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models. Journal of Business & Economic Statistics, 20(3), 339-350.
[7].Hou, Y., & Li, S. (2016). Information transmission between U.S. and China index futures markets: An asymmetric DCC GARCH approach. Economic Modelling, 52(Part B), 884-897. doi:10.1016/j.econmod.2015.10.025
[8].Hwang, J.-K. (2014). Spillover Effects of the 2008 Financial Crisis in Latin America Stock Markets. International Advances in Economic Research, 20(3), 311-324. doi:http://link.springer.com/journal/volumesAndIssues/11294
[9].Jussi Nikkinen, K. S., Minna Martikainen. (October 2013). Transmission of The Subprime Crisis: Evidence From Industrial And Financial Sectors of BRIC Countries. The Journal of Applied Business Research, 29(5), 1460-1478.
[10].kamel naoui, n. (2010). A Dynamic Conditional Correlation Analysis of Financial Contagion: The Case of the Subprime Credit Crisis. International Journal of Economics and Finance(3).
[11].Kavli, H., & Kotze, K. (2014). Spillovers in Exchange Rates and the Effects of Global Shocks on Emerging Market Currencies. South African Journal of Economics, 82(2), 209-238. doi:http://onlinelibrary.wiley.com/journal/10.1111/%28ISSN%291813-6982/issues
[12].Kim, B. H., Kim, H., & Lee, B. S. (2015). Spillover effects of the U.S. financial crisis on financial markets in emerging Asian countries. International Review of Economics and Finance, 39, 192-210. doi:10.1016/j.iref.2015.04.005
[13].King, M. A., & Wadhwani, S. (1990). Transmission of Volatility between Stock Markets. Review of Financial Studies, 3(1), 5-33.
[14].Lin, C.-H. (2012). The comovement between exchange rates and stock prices in the Asian emerging markets. International Review of Economics and Finance, 22, 161-172. doi:10.1016/j.iref.2011.09.006
[15].Liow, K. H. (2015). Conditional Volatility Spillover Effects across Emerging Financial Markets. Asia-Pacific Journal of Financial Studies, 44(2), 215-245. doi:http://onlinelibrary.wiley.com/journal/10.1111/%28ISSN%292041-6156/issues
[16].Ma, P., Li, D., & Li, S. (2016). Efficiency and cross-correlation in equity market during global financial crisis: Evidence from China. Physica A: Statistical Mechanics and its Applications, 444, 163-176. doi:10.1016/j.physa.2015.10.019
[17].Majid, M. S. A., & Kassim, S. H. (2009). Impact of the 2007 US financial crisis on the emerging equity markets. International Journal of Emerging Markets, 4(4), 341.
[18].Moriyama, K. (January 2010). The spillover effects of the global crisis on economic activity in MENA emerging market countries –An anlysis Using the Financial Stree Index. IMF.
[19].Mourrison, W. M. (2009). China and the Global Financial Crisis: Implications for the United States. Paper presented at the Congressional Research Service.

[20].Sugimoto, K., Matsuki, T., & Yoshida, Y. (2014). The global financial crisis: An analysis of the spillover effects on African stock markets. Emerging Markets Review, 21, 201-233. doi:10.1016/j.ememar.2014.09.004

[21].Sui, L., & Sun, L. (2016). Spillover effects between exchange rates and stock prices: Evidence from BRICS around the recent global financial crisis. Research in International Business and Finance, 36, 459-471. doi:10.1016/j.ribaf.2015.10.011

[22].Yang, T., & Lim, J. J. (2004). Crisis, Contagion, and East Asian Stock Markets. Review of Pacific Basin Financial Markets & Policies, 7(1), 119-151.