DYNAMIC INTER-LINKAGES AMONG EQUITY MARKETS IN SELECT EMERGING ECONOMIES

-An Econometric Study

Dr. Shalini Talwar*

Dr. Asha Prasuna**

ABSTRACT:

The paper studies dynamic linkages among the equity markets of Mexico, Indonesia, Nigeria and Turkey (MINT) with an objective to investigate the correlations and causation among these markets. The authors have tested the time series for stationarity by applying the Augmented Dickey Fuller test and Phillip Peron test. Thereafter, uni-directional and bi-directional causality was tested using Granger Causality test. Finally, VAR framework was applied to study the response of each market to shocks in other markets. On the basis of various empirical tests conducted, it was found that Mexican and Indonesian markets show a bi-directional causality. VAR statistics showed that all markets display contemporaneous correlation with them and account for 99% of their variance. The study is useful from the perspective of both, investors and policy makers.

1.0 INTRODUCTION:

Equity Markets have always attracted investors seeking high returns. With the gradual lowering of barriers to cross border investment, many opportunities have opened up for investing in markets providing potentially higher returns at lower risk. With the advent of opening up of economies with globalization and technological innovations, investors prefer to hold portfolio diversified not only across different asset classes but also across different countries. To hold assets issued by different countries, it is essential to understanding the inter-linkages and inter-relationships between various assets in different countries. The current paper attempts to analyze the inter-linkages between the equity markets of four emerging countries namely Mexico, Indonesia, Nigeria and Turkey with a view to understand whether the equity markets of these countries have sufficiently

Key words: Augmented Dickey Fuller test; correlation matrix; Granger Causality test; MINT; Phillip-Peron test; unit root; Vector Auto-regression. JEL: G15, C61, C87.

*KJ Somaiya Institute os Management Studies and Research, Vidyanagar, Vidyavihar(E), Mumbai - 400 077, Maharashtra, India, Email: shalini.t@somaiya.edu
**KJ Somaiya Institute os Management Studies and Research, Vidyanagar, Vidyavihar(E), Mumbai - 400 077, Maharashtra, India, Email: ashasivakumar@somaiya.edu

low correlations to enable international portfolio managers to include them in their portfolios. The current study also investigates whether the four markets have any correlation with the world markets, as represented by S&P 500. Further, the study applies Granger causality test to investigate the bivariate causality between each pair market under the study. The authors have also tested the four markets using Vector Auto-regression framework (VAR) to study multivariate causality and the transmission of shock from one market to another.

The four markets have been chosen on the basis of a grouping proposed by Terence James O'Neill who had coined the acronym BRIC for Brazil, Russia, India and China (it had later been changed to BRICS after South Africa joined in). The new grouping has been assigned the acronym 'MINT' and it has been ideated by O'Neill to represent economic, trade and investment alliance of the constituent countries. MINT stands for Mexico, Indonesia, Nigeria and Turkey, all four representing emerging economies that O'Neill has clubbed together on the basis of their potential to grow into the next economic powerhouses in the coming years.

Since the idea of MINT has been proposed by the same person who had brought BRICS into focus few years back, the authors feel that the new grouping should be given due thought and importance. The current study takes a look into these four economies to analyse their performance on some key macroeconomic variables during the past few years. This has been done primarily to understand the nature and potential of these four economies. The paper attempts to analyse the equity markets of the four countries as represented by their leading indices with an objective to investigate the correlations and causation among these markets.

The study of dynamic linkages among the equity markets of these four countries is important from the perspective of both, investors and policy makers. Investors and portfolio managers looking for newer avenues for international diversification would be interested in knowing whether equities from these four markets can be held together in a portfolio. The policy makers and regulators would be interested in understanding contagion risk i.e. the risk of transmission of shock from one market to another. In addition to the investors and policy-makers, the study is expected to be helpful in preparing automated trading that is getting popular known as algorithmic trading (Algo trading). As algos are prepared based on simple mathematics and statistics related to market and tested for a performance by using tools like pattern recognition, back testing, stress testing tools and simulations, the findings of the current study can provide useful inputs for their preparation and implementation to execute algo trading strategies.

To study correlation and causation among the four MINT markets, the authors have tested the closing price levels and lognormal returns of the key indices representing each of the above four markets for stationarity by applying the Augmented Dickey Fuller test and Phillip Peron test. The four indices, found to be stationary at first difference, were then used to generate correlation matrix to test the extent of co-movement between the variables under study. Thereafter, unidirectional and bidirectional causality was tested using the Granger Causality test to identify the influential markets. Finally, VAR framework was applied to the time series to understand the dynamic linkages among these markets from a multivariate perspective.

On the basis of various empirical tests conducted, the authors have found that Mexican and Indonesian markets show a bi-directional causuality , as confirmed by both, bi-variate Granger causality test and the multi-variate Block Exogenity Wald test. VAR framework, used to confirm the dynamic inter-relationship amongst the variables under the study, shows that no market (out of the four markets) can be called as an influential market. All markets display contemporaneous correlation with themselves. In all case, the response all each market to shocks in the changes in them fades out within two to three days. On the basis of these findings, it can be stated with relative confidence that these markets or their equities can be used to create international portfolios that satisfy the condition of low correlation and negligible co-movement between the markets.

The paper is arranged as follows: section 2 deals with the review of existing literature, section 3 deals with data description and methodology, and the results of empirical tests are described in section 4 followed by summary and concluding remarks in section 5.

2.0 LITERATURE REVIEW

The focus of literature review is on formulating an understanding of the macroeconomic scenario of the MINT economies. Such backdrop is essential to form a view whether the underlying economic fundamentals of these four countries justify the attention of fund managers, investors and regulators. Further, the authors have also reviewed the existing research papers related to the study of inter-linkages between equity markets across the world to serve as a basis for the current study.

The country of Mexico represents the second largest economy in Latin America. The successive regimes in Mexico have pursued growth-oriented policies, placing it in a in a favorable position in terms of key macroeconomic indicators and financial stability. GDP Annual Growth Rate in Mexico as reported by the Instituto Nacional de Estadística y Geografía (INEGI) was at an average of 2.57 percent from 1994 until 2014. The service sector

[1]http://www.forbes.com/sites/chriswright/

accounts for 62 percent and the industry constitutes 18 percent of the total GDP. Mexico's GDP was 1260.91 billion USD in 2013, representing 2.03 percent of the world GDP. For the year 2014, the Mexican economy expanded by 2.1 percent 1.8% short of the 3.9 percent forecasted by its government at the start of 2014. Interest Rate in Mexico as reported by Banco de México averaged 5.65 percent for the period spanning 2005 through 2014 while the inflation rate in the country averaged 26.62 percent from 1974 until 2015. Mexico has been successful in bringing the inflation rate down to 3 percent in February of 2015 from an all time high of 179.73 percent reported in February of 1988. On the Foreign Exchange Reserves front, Mexico reached an all time high of 2937902650 MXN THO in January 2015, having averaged 322880992.22 MXN THO from 1960 until 2015. Mexico has been successful in attracting Foreign Direct Investment in the recent past. The infloe of FDI in averaged 2216161.99 USD Thousand from 1960 until 2014 and reached an all time high of 20994535.70 USD Thousand in the second quarter of 2013. Though all key indicators discussed above illustrate an encouraging economic growth picture, Economic Survey of OECD has found the per capita income in the country lower than expected and has stated that more reforms were required to make the growth story more plausible. Exhibit 1 shows the key macroeconomic indicators for Mexico for a period from 2007 through 2012.

"EXHIBIT 1 ABOUT HERE"

Rapidly advancing infrastructure, increasing middle class, declining poverty rates and large domestic consumer market are seen as the strengths of Mexican economy.

The second MINT country, Indonesia, is the largest economy in South East Asia, a region that has attracted the attention of the entire world during the past decade. The annual GDP growth rate of Indonesia as reported by the Statistics Indonesia, averaged 5.40 percent from 2000 to 2014, with an all time high of 7.16 percent in the fourth quarter of 2004. In Indonesia, industry accounts for 46.5 percent of total GDP and services constitute 38 percent of the total GDP. GDP in Indonesia was 868.35 billion USD in 2013 representing 1.40 percent of the world GDP. Though GDP in Indonesia expanded 5.01 percent in the fourth quarter of 2014 over the same quarter in 2013, yet, for the year 2014 as a whole, the GDP was recorded as 5.02 percent having expanded at its slowest pace in five years on account of a slowdown in privateand public spending and lower exports. Interest Rate in Indonesia as reported by the Bank Indonesia, averaged 7.71 percent for a period between 2005 to 2015, recording an all time high of 12.75 percent in December 2005 while inflation rate in the country averaged 11.52 Percent from 1997 to 2014.The inflation rate in Indonesia stood at 6.29 percent in February 2015, having touched a peak of 82.40 percent in September 1998. On the Foreign Exchange Reserves front, Indonesia reached an all time high of 124637.75 USD Million in August of 2011, having averaged 62077.02 USD Million from 2000 to 2015. FDI in Indonesia has risen at a high rate since 2010. On the whole, the inflow of FDI in Indonesia averaged 56085 Billion IDR from 2010 to 2014 and reached an all time high of 78700 Billion IDR in the fourth quarter of 2014. On the whole, though the forecast for GDP was revised in the downward direction from the April 2014 projection by Asian Development Outlook (ADO), yet the general outlook for the economy had improved on the back of reform agenda of the new government and the improved outlook for exports. Exhibit 2 displays the key macroeconomic indicators for Indonesia for a period from 2007 to 2012.

"EXHIBIT 2 ABOUT HERE"

The remarkably steady growth of Indonesia in the past few years has been attributed mainly to high domestic consumption and acceleration in exports of manufactured products and commodities.

The next MINT country Nigeria represents the largest economy in Africa with a GDP of 522.64 billion US dollars in 2013. This all-time high GDP of Nigeria represented 0.84 percent of the world GDP. The annual GDP growth rate of Nigeria, as reported by the Central Bank of Nigeria, averaged 6.13 percent from 2005 to 2014, with an all time high of 8.60 percent in the fourth quarter of 2010. For the full year 2014, Nigerian GDP increased to 6.22 percent and the statistical official forecast for 2015 stood at 5.54 percent.

Interest Rate in Nigeria as reported by the Central Bank of Nigeria, averaged 9.70 percent from 2007 to 2014, recording an all time high of 13 percent in November 2014 while the inflation rate in the country averaged 12.27 percent from 1996 until 2015. The inflation rate in Nigeria stood at 8.20 percent in January 2015 having touched a peak of 47.56 percent in January 1996.

On the Foreign Exchange Reserves front, Nigeria reached an all time high of 4166778.95 NGN Million in December 2014, having averaged 735237.22 NGN Million from 2000 to 2015.

FDI in Nigeria has been quite erratic and has shown a downtrend since January 2010.On the whole, the inflow of FDI in Nigeria averaged 212684.58 USD Thousand from 2007 until 2014 and reached an all time high 824311.38 USD Thousand in July 2007.

Exhibit 3 displays the key macroeconomic indicators for Nigeria for a period from 2007 to 2012.

"EXHIBIT 3 ABOUT HERE"

Nigeria faces downside risks as the future prospects of its economy depend strongly on the continued global economic recovery due to their high dependence on exports.

GDP in Turkey as reported by the World Bank Group, averaged 197.27 USD Billion from 1960 to 2013 and reached an all time high of 820.21 USD Billion in 2013. The economy of Turkey expanded by 2.1 percent year-on-year in the second quarter of 2014, having slowed down from a revised 4.7 percent expansion in the preceding period. Sharp reduction in investment and private consumption were the main causes behind a less than anticipated expansion. GDP in Turkey at 820.21 billion US dollars in 2013 represented 1.32 percent of the world GDP.

Interest Rate in Turkey as reported by the Central Bank of the Republic of Turkey, averaged 60.09 percent from 1990 to 2015 , reaching an all time high of 500 percent in March of 1994 while the inflation rate in the country averaged 36.87 percent from 1965 until 2015. The inflation rate in Turkey stood at 7.55 percent in February 2015 having touched a peak of 138.71 percent in May of 1980 .

On the Foreign Exchange Reserves front, Turkey reached an all time high of 150378.70 USD Million in July 2014, having averaged 44882.67 USD Million from 1981 to 2014.

FDI in Turkey in Turkey decreased to an amount of 12918 USD Million in 2013 from 13224 USD Million in 2012. It had averaged 12415.09 USD Million from 2003 until 2013 and an all time high of 22046 USD Million in 2007. The FDI has been relatively low as compared to 2007-08 levels. Exhibit 4 displays the key macroeconomic indicators for Turkey for a period from 2007 to 2012.

"EXHIBIT 4 ABOUT HERE"

Turkey's growth story during 2000s had been scripted by business sector dynamism, strong public finances and a sturdy banking sector. However, according to an OECD survey, the Turkish economy was still facing a threat of being slowed down by key macroeconomic parameters like high inflation, exchange rate volatility and low productivity, even though the external demand is strengthening.

On the basis of the preceding discussion, it can be said that the MINT economies are showing some promise of a brighter future and have the potential to yield positive returns for fund managers and investors.

Study of inter-linkages among equity and other financial markets has attracted the attention of researchers since many decades. Financial literature has been enriched by many studies focusing on study of causality and cointegration among financial markets in both, advanced as well as emerging economies. Studies by Dungey, Fry and Martin, (2003); Wong, Penm, Terrell and Lim (2004) and Cheng and Glascock (2006) have studied inter-linkages between equity markets in different regions of the world. Roca (1999) used Granger causality test to study the linkages between the equity markets of Australia, U.S., U.K, Japan, Hong Kong, Singapore, Taiwan and Korea to find that Australian market was significantly caused by both, the U.S. and the U.K. markets. Gupta-Bhattacharya, Talwar and Sachdeva (2014) studied the integration amongst the select equity markets in South-east Asia. The study revealed that there were some cointegrating relationships amongst the six markets under study. Jorion and Schwartz (1996) and Cheung & Ho (1991) have revealed through their studies that inter-linkages between equity markets are usually strong in case of countries with strong economic ties.

Correlations are also important part of the studies related to inter-linkages between equity markets as low correlation between markets are essential for global portfolio diversification as seen in studies by Grubel and Fadner (1971) and Lessard (1973).

3.0 DATA DESCRIPTION AND METHODOLOGY

3.1 Data Description

The dollar-denominated daily closing prices of stock Indices of the four MINT countries; Mexico, Indonesia, Nigeria and Turkey have taken from the Bloomberg terminal for a period from January 2000 through November 2014 and used in the analysis. Dollar-denominated values of indices are used so that the four indices representing four different currencies are expressed in same monetary unit. The closing price of S&P 500 has been taken from Yahoo Finance for the corresponding period. These are also denominated in dollars. The details of indices with their brief description are exhibited in exhibit 5.

"EXHIBIT 5 ABOUT HERE"

Firstly, to investigate the nature of the five indices under study, their descriptive statistics have been generated. The authors have reported skewness, kurtosis, Jarque-Bera statistic and probability value for all stock market indices. The descriptive statistics are useful in providing elementary evidence about behavior changes in the time series under study and their respective distribution. Descriptive statistics of the five indices are displayed in exhibit 6.

"EXHIBIT 6 ABOUT HERE"

It can be seen in exhibit 6, that all stock market indices under study have negative skewness. Such stock markets offer investors frequent small gains but at the same time expose them to few extreme losses. Kurtosis values also reveal that all stock market indices follow Leptokurtic distribution, where large

fluctuations are more likely to occur within the fat tails. The Nigerian market, represented by All Share Index exhibits the highest kurtosis at 11.96, kurtosis indicating a higher probability of having extreme values in this market. The Mexican stock market, represented by Mexican Bolsa IPC Index has the lowest value of kurtosis in the group at 8.8.

Jarque-Bera statistic is used to test the null hypothesis that data is normally distributed. By using probability values of Jarque-Bera statistics, null hypothesis is rejected for all indices at 1% level of significance. The indices are not normally distributed and this shows inefficiency in the all four markets under study.

3.2 Methodology

The paper investigates the inter-linkages among the stock markets of the MINT countries by conducting various econometric tests on the dollar-denominated daily closing price level time series of their main indices described in exhibit 5. The stock prices represent financial time series and may suffer from the problem of non-stationarity or existence of unit root at levels. A stationary series tends to revert to its mean value and oscillates around it within a more or less constant range i.e. it has a finite variance.

Any significant statistical inference or accurate forecasting is possible only if the time series under study is stationary. If a non-stationary time series is regressed to other non-stationary time series, it may result into a spurious regression wherein a highly significant fit might be obtained even though the actual relationship between the two non-stationary variables may be non-existent. Therefore, before testing the time series for correlation and causation, it should be tested for stationarity.

Tests for stationarity begin with regressing the variable on time, with the residuals from such a regression forming a new variable that is stationary. The authors have used two formal tests of unit root namely, Augmented Dickey Duller (ADF) [Dickey, D. and Fuller, W. (1979, 1981)] test and Phillip Perron (PP) (1998) test. For both tests the null hypothesis of unit root against the alternative hypothesis of stationarity is tested. The decision rule used is to reject the null hypothesis if the value of probability is less than 0.05 for the test statistic thus computed.

The models that have been used to check the stationarity properties are as follows.

Model (1) : $Y_t = A(o) + A(1)\, Y_{t-1} + e_t$

		Test Statistics
Ho :	$A(o) = A(1) = 0$	f_1
	$A(1) = 0$	t_m

Model (2) $Y_t = A(o) + A(1)\, Y_{t-1} + A(2)_t + e_t$

		Test Statistics
Ho :	$A(o) = A(1) = A(2) = 0$	f_2
	$A(1) = A(2) = 0$	f_3
	$A(1) = 0$	t_t

$A(0) = 0$ => No constant/drift

$A(1) = 0$ => Presence of unit root $(1 - r) = A(1)$

$A(2) = 0$ => No trend

$r = \ln(P_t / P_t\text{-}1) * 100$

Where, r = return, P_t = Price of the day , P_t-1 = Price of the previous day The extent of integration among the MINT markets has been determined by examining if the changes in one market cause changes in another market i.e. can the value of one market be forecast using the past values of another market? The test used to assess such causality is called Granger Causality test. It is an econometric test proposed by Granger (1969, 1988) to infer cause and effect relationship between time series under the study. The test is based on a simple logic that the effect cannot lead the cause. Granger causality tests the null hypothesis of 'x does not granger cause y' and 'y does not granger cause x.' When the probability of the test statistic is below 0.05, one series is said to 'granger' cause another series.

When a series granger causes the other, it implies that the variable granger causing the other variable can be used to make a more accurate prediction of the other variable.

The authors have further studied the dynamic linkages among the MINT equity markets by conducting the Block Exogeneity Wald test and computing Impulse response function, that are the main summary statistics reported under Vector Autoregression (VAR) framework . Since VAR simulates the responses of a market to shocks in the other markets, time zone ordering becomes a very important consideration. Time zone ordering used for the VAR model in this paper is Indonesia, Turkey, Nigeria followed by Mexico.

In the simplest VAR model, known as standard VAR, all the variables are considered to be endogenous variables. In a compact manner, a VAR model for k variables may be represented as:

$$y_t = a_0 + A_1 y_{t-1} \ldots\ldots\ldots\ldots + A_p y_{t-p} + \varepsilon_t$$

Where yt = is a vector of all the k variables included in the VAR system, a0 is k×1 vector of intercepts, A1, A2,...,Ap are (k*k) matrix coefficients, Et is the k-dimensional vector of error terms and p is the optimal number of lag length.

4.0 Results of Empirical Tests and Discussion

As explained above, all five time series were tested for stationarity using the Augmented Dickey Fuller test and Phillip-Perron test. The stock indices are found to follow an I (1) process i.e. non-stationary at levels but stationary at first difference. The time series plot of the closing levels and lognormal returns of the five markets are exhibited in exhibit 7 to 11 The plots of lognormal returns fluctuate around a constant mean, i.e. they are mean reverting. This shows that they follow a stationary process. A non-stationary series exhibits wild fluctuations as seen in the plots representing closing levels of the markets under consideration.

"EXHIBIT 7 ABOUT HERE"
"EXHIBIT 8 ABOUT HERE"
"EXHIBIT 9 ABOUT HERE"
"EXHIBIT 10 ABOUT HERE"
"EXHIBIT 11 ABOUT HERE"

The results of the ADF test are tabulated in exhibit 11 and the results of the Phillip-Perron test are tabulated in exhibit 12 for financial time series of the MINT countries and S&P500. The levels were tested with both, intercept only and trend & intercept. The test statistic was found to be statistically insignificant as the probability values were greater than 0.05 for all markets in both instances. Thus the null hypothesis that the series had unit root could not be rejected.

The series at first difference were also tested with both, intercept only and trend & intercept. The test statistic was found to be statistically significant as the probability values were less than 0.05 for all markets in both instances. Thus the null hypothesis that the series had unit root could be rejected. Hence, all the financial time series under study were found to be stationary at first difference.

Non-stationarity of all series at levels and stationarity at first difference can also be visually confirmed with the graphs illustrated in exhibits 7 through 11.

"EXHIBIT 12 ABOUT HERE"
"EXHIBIT 13 ABOUT HERE"

Exhibit 14 exhibits the correlations between the markets under study. A positive correlation exists between S&P500 and all four MINT indices but it is too low for the authors to conclude that the correlation between any of the pair of the MINT markets could be due to their correlation with S&P500. The correlation between MEXBO & JCI, MEXBO & XU100, NGSEI & XU100 and JCI & XU100 is positive but it is low enough to offer some short-run advantages of diversification. The negative correlation that NGSEI has with JCI & MEXBO offers more lucrative investment opportunities.

"EXHIBIT 14 ABOUT HERE"

The results of Granger Causality test are illustrated in exhibit 15. The test statistic and the related probability values of less than 0.05 indicate a bidirectional causality relationship between MEXBO & JCI stock indices. The low value of probability implies that the null hypothesis of 'MEXBO does not Granger Cause JCI' and 'JCI does not Granger Cause MEXBO' can be rejected.

For all other pairs of markets, the value of probability is high for the test statistic computed for the purpose. The high value of probability implies that the null hypothesis of each market not Granger causing another market cannot be rejected. Thus, there exists no causality from JCI to NGSEI or vice versa, from XU100 to JCI or vice versa, from MEXBO to NGSEI or vice versa, from XU100 to NGSEI and vice versa & from MEXBO to XU100 and vice versa. As explained in the preceding section, the causality indicates that the index that Granger causes another index can be used to make better prediction of the said index.

"EXHIBIT 15 ABOUT HERE"

Since no market could be identified as an influential market using the Granger Causality test, Vector Autogression framework was used by the authors to study the impact and transmission of shock from one market to another. As mentioned in the preceding section, time zone ordering for VAR may be listed as Indonesia, Turkey, Nigeria and Mexico. Exhibit 16 illustrates the results of various lag length criteria tested to determine the lag length to be used for the VAR model. It can be seen that four criteria have yielded the same result.

"EXHIBIT 16 ABOUT HERE"

Since FPE, AIC, SC and HQ indicate a lag length of 1, the same has been used to compute the VAR model.

Thus, the model computed is VAR (1) and it is specified as:

RETJCI = 0.113*RETJCI(-1) + 0.025*RETXU100(-1) + 0.001*RETNGSE(-1) + 0.040*RETMEXBO(-1) + 0.0003

RETXU100 = 0.014*RETJCI(-1) + 0.049*RETXU100(-1) + 0.018*RETNGSE(-1) + 0.042*RETMEXBO(-1) – 6.793e-05

RETNGSE = - 0.009*RETJCI(-1) - 0.012*RETXU100(-1) + 0.003*RETNGSE(-1) + 0.018*RETMEXBO(-1) + 0.0003

RETMEXBO = 0.045*RETJCI(-1) - 0.002*RETXU100(-1) - 0.011*RETNGSE(-1) + 0.119*RETMEXBO(-1) + 0.0003

Due to the problem of in built multicollinearity in the VAR model, instead of the model, certain summary statistics of VAR, namely block exogenity and impulse response function or variance decomposition are used for interpretation of VAR results. Before interpreting the summary statistics, the usefulness of VAR model needs to be evaluated. The VAR stability condition check reveals that no root lies outside the unit circle as shown in the exhibit 17. Thus, the VAR model computed in the current study satisfies the stability condition.

"EXHIBIT 17 ABOUT HERE"

The usefulness of estimated VAR model also depends on the possible presence of serial correlation in the residuals. Exhibit 18 displays VAR Residual Serial Correlation LM Test results. The computed LM statistic, which follows a Chi-square distribution, is statistically insignificant as p is more than 0.05. Thus, Null Hypothesis of no serial correlation at lag order h cannot be rejected. Thus the VAR model is stable and there is no serial correlation between the residual.

"EXHIBIT 18 ABOUT HERE"

The result of Block Exogeneity Wald Test illustrated in exhibit 19 shows that causality runs from XU100 and MEXBO to JCI. This can be seen from the value of probability below 0.05, because of which, the null hypothesis of XU100 and MEXBO not causing JCI can be rejected. XU100, NGSE and MEXBO also jointly cause JCI as deduced from the p value of 0.01. XU100 is not caused by JCI, NGSE and MEXBO individually or jointly as the test-statistic is statistically insignificant ($p>0.05$). NGSE is also not caused by JCI, XU100 and MEXBO individually or jointly as the test-statistic is statistically insignificant ($p>0.05$). MEXBO is caused by JCI as the p value is 0.0040.

Thus, there exists bidirectional causality between RETJCI and RETMEXBO. There is no causality between any other pair of markets. Same results had been obtained by using the bivariate Granger Causality test illustrated in exhibit 15.

"EXHIBIT 19 ABOUT HERE"

The impulse response function has been generated by following a time zone based VAR ordering as mentioned in the preceding section. Thus the Cholesky Ordering is: RETJCI RETXU100 RETNGSE RETMEXBO. Exhibit 20 displays the individual graphs of impulse response of one market on the other. The first row displays the changes in RETJCI in response to shocks in the changes in it and in RETXU100, RETNGSE and RETMEXBO. Column one of the exhibit displays changes in RETJCI, RETXU100, RETNGSE and RETMEXBO in response to shocks in the changes in RETJCI.

In graph one of the first row, it can be seen that JCI has contemporaneous correlation with itself, which makes sense. It implies that RETJCI changes immediately in response to shocks in the changes in itself. Further, the impact of the shock dies down by the third day, as seen by the flat line beyond 3. The response of RETJCI to the shocks in other three begins at zero, showing no contemporaneous correlation. This is logical because, in the Cholesky Ordering RETJCI precedes the other three. There is a small change in RETJCI in response to shock in the change in RETXU100. The response seems to last up to the third day. The response of RETJCI to shocks in the changes in RETMEXBO is also almost same as its response to RETXU100. The flat line in graph 3 in first row indicates that RETJCI does not respond at all to shocks in the changes in RETNGSE.

Similarly, row 2 displays the changes in RETXU100 in response to the shocks in the changes in the other three markets. As in the case of RETJCI, RETXU100 also shows contemporaneous correlation with itself only. Further, the impact of the shock dies down by the third day, as seen by the flat line beyond 3.It shows no response to RETJCI and RETNGSE. Further, its response to shocks in RETMEXBO is negligible.

Row 3 displays the changes in RETNGSE in response to the shocks in the changes in the other three markets. As in the case of RETJCI and RETXU100, RETNGSE also shows contemporaneous correlation with itself only. Further, the impact of the shock dies down by the second day, as seen by the flat line beyond 2. Its response to RETJCI, RETXU100 and RETMEXBO is of a very low magnitude. In fact its response to RETXU100 begins below zero.

Row 4 displays the changes in RETMEXBO in response to the shocks in the changes in the other three markets. As in the case of RETJCI, RETXU100 and RETNGSE, RETMEXBO also shows contemporaneous correlation with itself only. Further, the impact of the shock dies down by the third day, as seen by the flat line beyond 3. Its response to RETJCI is of a very low magnitude and it is negligible in the case of RETXU100 and RETNGSE.

The responses depicted in the impulse response graphs confirm that there is no clear leading market among the four markets under study. Impulse graph shows that Indonesian market transmits shock to only Mexican market, that too of low magnitude, which disappears in a two to three days.

Turkish market transmits shock to Indonesian market, but again of low magnitude, which fades off in a two to three days. It causes the Nigerian market to respond in reverse direction, confirming the negative correlation and has no impact on the Mexican market.

Nigerian market does not transmit shock to any market.

Shocks in Mexican market impact the changes in Indonesian

market at a low magnitude for 2 to 3 days. It has an impact of lower magnitude on the other two markets, which fades off in 2-3 days.

"EXHIBIT 20 ABOUT HERE"

5.0. Summary and Concluding Remarks

In this paper, the authors have analyzed the correlations, causality and dynamic linkages among the stock markets of Mexico, Indonesia, Nigeria and Turkey using the dollar denominated daily closing price data during the period from January 2000 to November 2014. Bidirectional causality was found between Indonesian and Mexican markets, indicating precedence, information content and usefulness for making better predictions. This implies that the two markets are inter-linked to some extent. This inter-linkage may be attributed to the greater integration in the economies of the two countries. This can be confirmed historically by tracing the transmission of shock of ASIAN currency crisis directly from South-east Asia to the Latin American countries.

Positive, but low correlations amongst the pairs of indices indicate some opportunities for diversification in the short run. Further, low correlation of each index with S&P500 and beta values, obtained by regressing each index to S&P 500, shows that any correlation between the markets under the study cannot be attributed to their individual linkage with world market, as represented by S&P500.

Impulse response function, reported as a summary statistics for interpretation of VAR showed that none of the market acted as a lead for influential market for the other three markets. Each market showed a contemporaneous correlation with shocks in the changes in itself, and for all markets the impacted of shock appeared to die down within two to three days. Response of the Indonesian market to Mexican market of some magnitude and vice versa, confirms the existence of bi-directional causality between the two. The response of each market to the shocks in the changes in other markets has already been discussed in detail in the preceding section.

Further, the markets under study are not completely isolated from each other, as exhibited by the results of the decomposition of variance forecast, which showed that no variance is completely accounted by its own innovation. However, at the 10-day horizon, the percentage of forecast error for all markets under study accounted for their own innovation to the extent of 99%. This confirms that the movement in each market under study is impacted to a very low extent and a short duration by all other markets under consideration. The influence of the markets on each other was found to be confined to below 1%.

It needs to be clarified here that change in ordering of variables in VAR system can substantially alter the outcome of the tests. It has been discussed in the preceding sections that the outcome of VAR framework is dependent on the sequence of the indices. The authors have chosen the sequence for the current study on the basis of time zones as it is considered to be the best way of sequencing of time series related to financial markets.

The findings of the study can prove to be extremely useful in policy making for protecting the markets against the risk of transmission of shock, country asset allocation, making effective hedging & portfolio diversification decisions and generating the code for algotrading related to the markets under the study.

6.0. References

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[5] *Variance decomposition was com puted but not reported as there is a norm to report either impulse response function or variance decomposition as summary statistics to interpret the results of VAR.*

EXIHIBITS

Exhibit 1: Key Macroeconomic Indicators for Mexico (2007-2012)

	2007	2008	2009	2010	2011	2012
GDP growth (annual %)	3.15	1.40	-4.70	5.11	4.04	3.98
Current account balance (BoP, current US$)	-14267765239	-19561518936	-7850633825	-3284766643	-12261773418	-14642175872
Foreign direct investment, net (BoP, current US$)	-23371263010	-26711019270	-7133676990	-7582462230	-11168375700	7782338910
Total reserves (% of total external debt)	43.78	46.10	49.99	49.49	52.10	47.08
Inflation, consumer prices (annual %)	3.97	5.13	5.30	4.16	3.41	4.11
Official exchange rate (LCU per US$, period average)	10.93	11.13	13.51	12.64	12.42	13.17

Source: Compiled by the authors (Data source: databank.worldbank.org)

Exhibit 2: Key Macroeconomic Indicators for Indonesia (2007-2012)

	2007	2008	2009	2010	2011	2012
GDP growth (annual %)	6.35	6.01	4.63	6.22	6.49	6.26
Current account balance (BoP, current US$)	10492590000	125583310.5	10628491686	5144284990	1685068003	-24073887520
Foreign direct investment, net (BoP, current US$)	-2253330000	-3418723399	-2628247483	-11106333135	-11528394762	-14309235970
Total reserves (% of total external debt)	38.51	32.70	36.86	48.04	48.98	44.25
Inflation, consumer prices (annual %)	6.41	9.78	4.81	5.13	5.36	4.28
Official exchange rate (LCU per US$, period average)	9141.00	9698.96	10389.94	9090.43	8770.43	9386.63

Source: Compiled by the authors (Data source: databank.worldbank.org)

Exhibit 3: Key Macroeconomic Indicators for Nigeria (2007-2012)

GDP growth (annual %)	6.83	6.27	6.93	7.84	4.89	4.28
Current account balance (BoP, current US$)	27643445782	29154225208	13867630391	14459202642	12554056121	20352840955
Foreign direct investment, net (BoP, current US$)	-5167441548	-7145016212	-7029701168	-5133465521	-8025110602	-5564172195
Total reserves (% of total external debt)	1343.76	1293.45	664.59	493.53	402.54	471.87
Inflation, consumer prices (annual %)	5.38	11.58	11.54	13.72	10.84	12.22
Official exchange rate (LCU per US$, period average)	125.81	118.55	148.90	150.30	154.74	157.50

Source: Compiled by the authors (Data source: databank.worldbank.org)

Exhibit 4: Key Macroeconomic Indicators for Turkey (2007-2012)

GDP growth (annual %)	4.67	0.66	-4.83	9.16	8.77	2.13
Current account balance (BoP, current US$)	-37781000000	-40438000000	-12168000000	-45447000000	-75092000000	-48507000000
Foreign direct investment, net (BoP, current US$)	-19941000000	-17211000000	-7110000000	-7572000000	-13698000000	-8944000000
Total reserves (% of total external debt)	29.60	25.49	27.03	28.73	28.79	35.31
Inflation, consumer prices (annual %)	8.76	10.44	6.25	8.57	6.47	8.89
Official exchange rate (LCU per US$, period average)	1.30	1.30	1.55	1.50	1.67	1.80

Source: Compiled by the authors (Data source: databank.worldbank.org)

[5]*Variance decomposition was com puted but not reported as there is a norm to report either impulse response function or variance decomposition as summary statistics to interpret the results of VAR.*

Exhibit 5: Description of Stock Market Indices

Name of Country	Name of Index	Description of Index
Mexico	Mexican Stock Exchange Mexican Bolsa IPC Index(MEXBO)	The Mexican IPC index (Indice de Precios y Cotizaciones) is a capitalization weighted index of the leading stocks traded on the Mexican Stock Exchange. The index was developed with a base level of .78 as of October 30, 1978.*
Indonesia	Jakarta Stock Exchange Composite Index(JCI)	The Jakarta Stock Price Index is a modified capitalization-weighted index of all stocks listed on the regular board of the Indonesia Stock Exchange. The index was developed with a base index value of 100 as of August 10, 1982. Please look at CDR JA for exchange trading days.*
Nigeria	Nigerian Stock Exchange All Share Index (NGSEI)	The Nigerian Stock Exchange All Share Index was formulated in January 1984 with a base value of 100. Only ordinary shares are included in the computation of the index. The index is value-relative and is computed daily.*
Turkey	Borsa Istanbul 100 Index(XU100)	The Borsa Istanbul 100 Index is a capitalization-weighted index composed of National Market companies except investment trusts. The constituents of the BIST National 100 Index are selected on the basis of pre-determined criteria directed for the companies to be included in the indices. The base date is January 1986 and base value is 1 for the TL based price*
USA	S&P 500	Standard and Poor's 500 Index is a capitalization-weighted index of 500 stocks. The index is designed to measure performance of the broad domestic economy through changes in the aggregate market value of 500 stocks representing all major industries. The index was developed with a base level of 10 for th e 1941-43 base period*

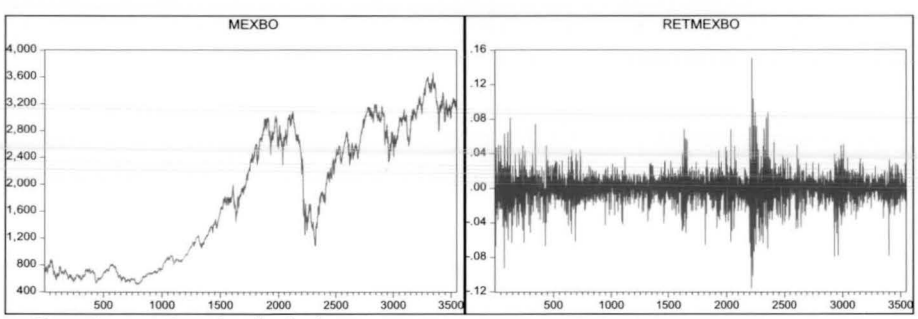
*http://www.bloomberg.com/
Source: Based on authors' data collection

Exhibit 6: Descriptive Statistics of Stock Market Indices

	RETUSINDEX	RETMEXBO	RETJCI	RETXU100	RETNGSE
Mean	6.14E-05	0.000390	0.000433	-7.49E-06	0.000354
Median	0.000550	0.001388	0.001454	0.000856	0.000229
Maximum	0.109572	0.151214	0.128918	0.200216	0.119186
Minimum	-0.094695	-0.115317	-0.163976	-0.263406	-0.110946
Std. Dev.	0.013131	0.017256	0.018393	0.029300	0.015566
Skewness	-0.175506	-0.110389	-0.657291	-0.284605	-0.151364
Kurtosis	10.70376	8.803537	10.55839	9.982604	11.96437
Jarque-Bera	8776.955	4977.955	8686.372	7243.503	11873.31
Probability	0.000000	0.000000	0.000000	0.000000	0.000000

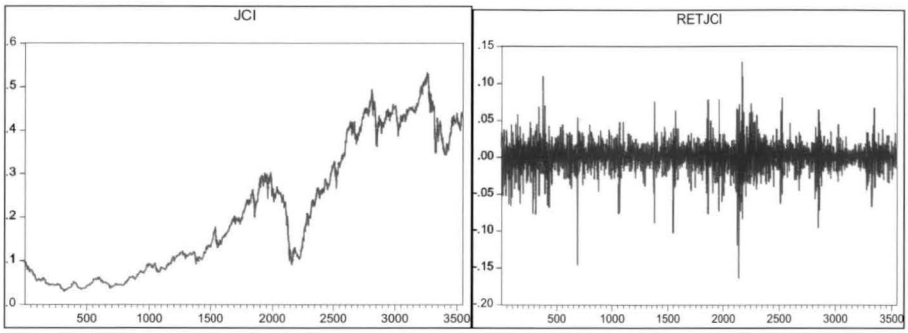
Source: Based on authors' calculations

Exhibit 7: The time series plot of the closing levels and lognormal returns of MEXBO



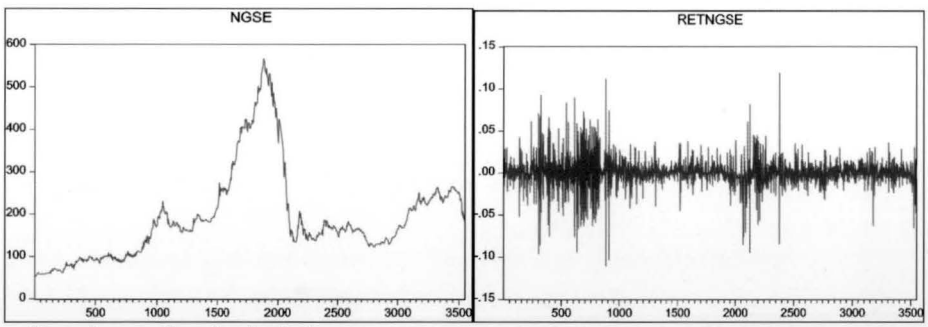
Source: Based on authors' calculations

Exhibit 8: The time series plot of the closing levels and lognormal returns of JCI



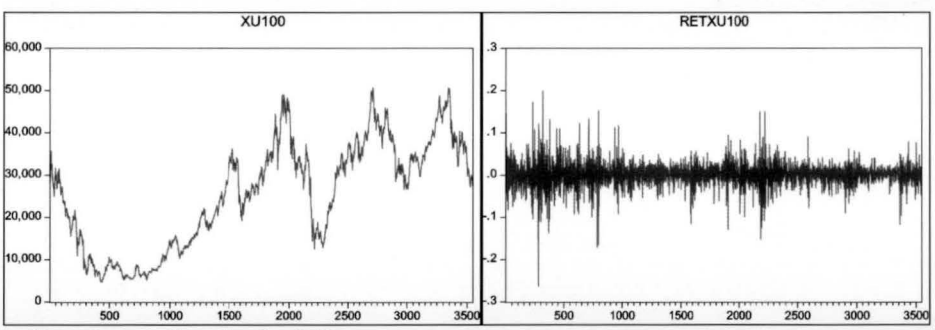
Source: Based on authors' calculations

Exhibit 9: The time series plot of the closing levels and lognormal returns of NGSE



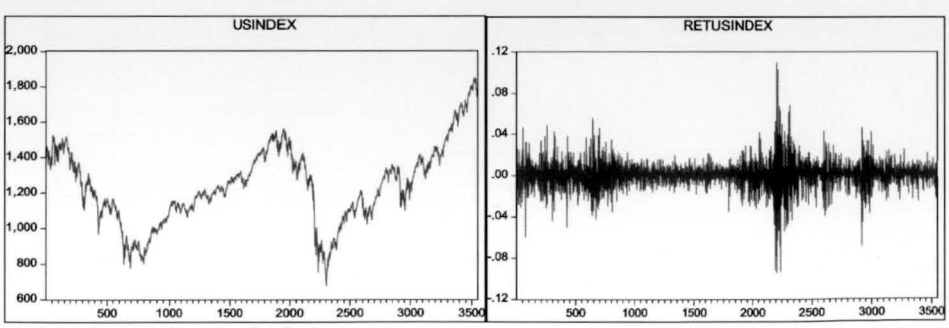
Source: Based on authors' calculations

Exhibit 10: The time series plot of the closing levels and lognormal returns of XU100



Source: Based on authors' calculations

Exhibit 11: The time series plot of the closing levels and lognormal returns of S&P500 (USIndex)



Source: Based on authors' calculations

Exhibit 12: Results of Augmented Dickey-Fuller Unit Root Test for MINT Stock Market Indices and S&P500 (January, 2000- November 2014)

Augmented Dickey Fuller Test Statistic								
	At Level with Intercept	Probability *	At Level with Intercept & Trend	Probability*	At First Difference with Intercept	Probability*	At First Difference with Intercept & Trend	Probability *
MEXBO	-1.017521	0.7491	-2.763047	0.2113	-54.57774	0.0001	-54.57774	0.0001
JCI	-0.370838	0.9117	-2.857165	0.1769	-55.38123	0.0001	-55.38244	0.0000
NGSEI	-1.481944	0.5429	-1.187383	0.9120	-31.92464	0.0000	-31.94133	0.0000
XU100	-1.582585	0.4914	-2.714243	0.2307	-58.20621	0.0001	-58.20075	0.0000
S&P500	-0.934991	0.7776	-1.596949	0.7944	-46.20030	0.0001	-46.23919	0.0000

*MacKinnon (1996) one-sided p-values
*Exogenous: Constant
*Lag Length: 1 (based on SIC, maxlag=29)
Source: Based on authors' calculations

Exhibit 13: Results of Phillips Perron Unit Root Test for MINT Stock Market Indices and S&P500 (January, 2000- November 2014)

*MacKinnon (1996) one-sided p-values

Phillips-Perron Test								
	At Level with Intercept	Probability*	At Level with Intercept & Trend	Probability *	At First Difference with Intercept	Probability*	At First Difference with Intercept & Trend	Probability *
MEXBO	-0.935327	0.7774	-2.561896	0.2981	-54.38473	0.0001	-54.37659	0.0000
JCI	-0.310108	0.9211	-2.774519	0.2069	-55.26082	0.0001	-55.26098	0.0000
NGSEI	-1.460929	0.5535	-1.142455	0.9203	-44.58654	0.0001	-44.58822	0.0000
XU100	-1.627980	0.4681	-2.775526	0.2065	-58.22375	0.0001	-58.21771	0.0000
S&P500	-0.961305	0.7688	-1.666159	0.7661	-65.10904	0.0001	-65.23754	0.0000

*Exogenous: Constant
*Bandwidth: 13 (Newey-West automatic) using Bartlett kernel
Source: Based on authors' calculations

Exhibit 14: Correlation Matrix for Daily Stock Returns for MINT Stock Market Indices and S&P500 (January, 2000- November 2014)

	RETUSINDEX	RETMEXBO	RETJCi	RETXU100	RETNGSE
RETUSINDEX	1				
RETMEXBO	0.0148	1			
RETJCI	0.0472	0.0240	1		
RETXU100	0.0021	0.0131	0.0133	1	
RETNGSE	0.0335	-0.0097	0.0209	-0.0348	1

Source: Based on authors' calculations

Exhibit 15: Results of Pair-wise Granger Causality between MINT Stock Market Indices (January, 2000- November 2014)

Null Hypothesis	F-Statistic	Probability	Interpretation
MEXBO does not Granger Cause JCI	4.06566	0.0172	MEXBO Granger causes JCI at 1% significance level. This causality is bidirectional.
JCI does not Granger Cause MEXBO	4.37137	0.0127	JCI Granger causes MEXBO at 1% significance level. This causality is bidirectional.
NGSEI does not Granger Cause JCI	0.04394	0.9570	
JCI does not Granger Cause NGSEI	2.60077	0.0744	
XU100 does not Granger Cause JCI	2.69844	0.0674	
JCI does not Granger Cause XU100	0.51726	0.5962	
NGSEI does not Granger Cause MEXBO	0.20393	0.8155	
MEXBO does not Granger Cause NGSEI	0.95628	0.3844	
XU100 does not Granger Cause NGSEI	1.10514	0.3313	
NGSEI does not Granger Cause XU100	0.15272	0.8584	
XU100 does not Granger Cause MEXBO	0.61441	0.5410	
MEXBO does not Granger Cause XU100	1.38785	0.2497	

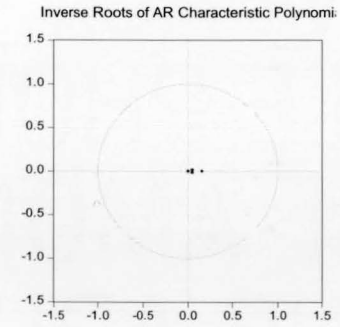
Source: Based on authors' calculations

Exhibit 16: Lag length criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	35675.24	NA	2.05e-14	-20.16464	-20.15766	-20.16215
1	35742.24	133.7977	2.00e-14*	-20.19346*	-20.15858*	-20.18102*
2	35754.27	23.99877	2.00e-14	-20.19122	-20.12842	-20.16882
3	35760.41	12.23949	2.01e-14	-20.18565	-20.09494	-20.15329
4	35768.44	15.98469	2.02e-14	-20.18114	-20.06253	-20.13883
5	35784.02	30.97355	2.02e-14	-20.1809	-20.03438	-20.12864
6	35799.76	31.25575	2.02e-14	-20.18076	-20.00633	-20.11854
7	35810.96	22.22521	2.03e-14	-20.17805	-19.97571	-20.10587
8	35837.87	53.31456*	2.01e-14	-20.18421	-19.95396	-20.10208

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
Included observations: 3538
Endogenous variables: RETJCI RETXU100 RETNGSE RETMEXBO
Exogenous variables: C
Source: Based on authors' calculations

Exhibit 17: VAR Stability Condition Check



Source: Based on authors' calculations

Exhibit 18: Autocorrelation LM test

Lags	LM-Stat	Prob
1	27.80693	0.1333
2	22.76297	0.1202
3	13.86098	0.6091
4	15.67938	0.4756
5	30.96118	0.0136
6	31.93157	0.0102

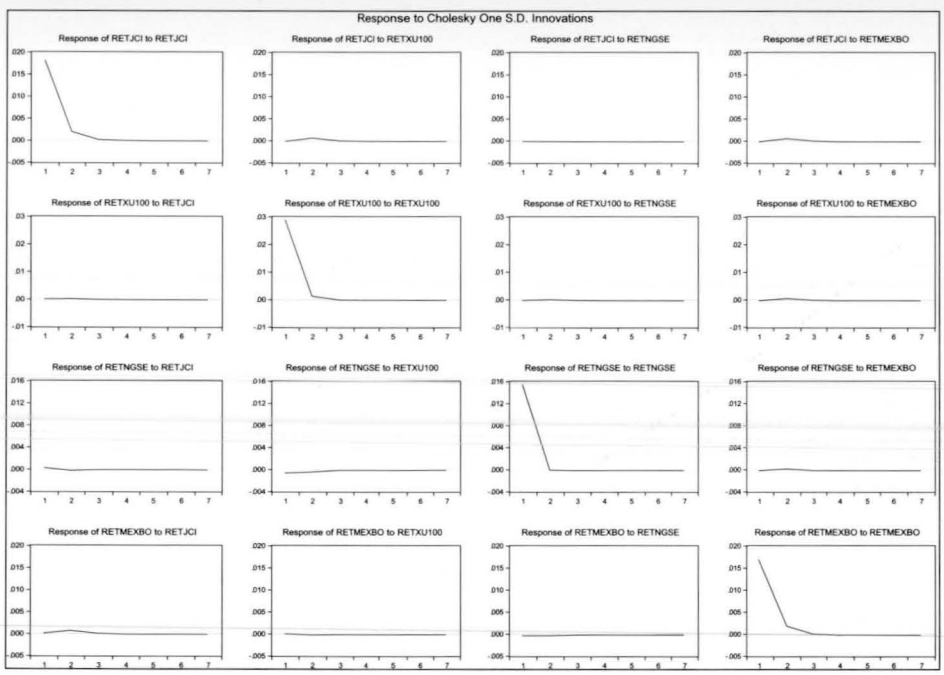
*Probs from chi-square with 16 df.
Source: Based on authors' calculations

Exhibit 19: Result of Block Exogeneity Wald Test

Dependent variable: RETJCI			
Excluded	Chi-sq	df	Prob.
RETXU100	5.886365	1	0.0153
RETNGSE	0.002735	1	0.9583
RETMEXBO	5.298595	1	0.0213
All	11.32791	3	0.0101
Dependent variable: RETXU100			
Excluded	Chi-sq	df	Prob.
RETJCI	0.271079	1	0.6026
RETNGSE	0.308826	1	0.5784
RETMEXBO	2.234139	1	0.1350
All	2.850471	3	0.4153
Dependent variable: RETNGSE			
Excluded	Chi-sq	df	Prob.
RETJCI	0.380860	1	0.5371
RETXU100	1.812114	1	0.1783
RETMEXBO	1.402290	1	0.2363
All	3.544282	3	0.3151
Dependent variable: RETMEXBO			
Excluded	Chi-sq	df	Prob.
RETJCI	8.286562	1	0.0040
RETXU100	0.061390	1	0.8043
RETNGSE	0.326096	1	0.5680
All	8.582063	3	0.0354

Source: Based on authors' calculations

EXHIBIT 20: Impulse Response Function of MINT Market at Time Zone VAR Ordering



*Cholesky Ordering: RETJCI RETXU100 RETNGSE RETMEXBO
Source: Based on authors' calculations