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VOLATILITY SPILLOVER AND TIME VARYING CONDITIONAL CORRELATION BETWEEN STOCK AND BOND RETURNS: EVIDENCE FROM THE MINT ECONOMIES

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ABSTRACT

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One way to reduce investment risk is to diversify portfolio by investing in different asset classes or similar asset class in different market. It is paramount that volatility and correlation dynamics in financial market is assessed by investors in order to make informed decision and minimize risk. The aim of the thesis is to assess the stock-bond volatility spillover and correlation dynamics of emerging market such as the MINT economies. The research would contribute to existing studies on the volatility and correlation dynamics in the context of emerging markets such as MINT since most previous studies has been carried out on developed market with limited studies on emerging markets. This study is one of the few studies focusing directly on emerging markets and thus provides valuable insights into their functioning in terms of volatility and correlation dynamics. The general idea is to ascertain the volatility transmission, nature of conditional correlation and the existence of asymmetries in the conditional variance, covariance and correlation between both asset returns.

The analysis is approached using econometric models such as the BEKK GARCH, CCC GARCH, DCC GARCH and ADCC GARCH in modelling the phenomenon. The findings reveal that stock-bond return and volatility spillover exist among MINT economies albeit the volatility transmission is unidirectional. Also, evidence shows stock-bond conditional correlation is time varying and asymmetric effects exist among MINT economies whereby Mexico and Indonesian stock returns are more sensitive to negative shock than bond returns in full period while Nigerian and Turkish bond returns are more sensitive to negative shock than stock returns for both data period. The results provide insights for potential investors and portfolio managers on the potential benefits of investing in emerging market especially the MINT economies by portfolio diversification.

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CONTENTS

List of Tables

List of Figures

List of Abbreviations

ADC	Asymmetric Dynamic covariance
ADCC	Asymmetric Dynamic Conditional Correlation
ADF	Augmented Dickey-Fuller
ARCH	Autoregressive Conditional Heteroscedasticity
ARMA	Autoregressive Moving Average
ASEM	Alternative Securities Market
ASX	Australian Stock Exchange
BEKK	Baba, Engle, Kraft and Kroner
BIST	Borsa Istanbul
BRICS	Brazil, Russia, India, China and South Africa
CCC	Constant Conditional Correlation
CIVETS	Colombia, Indonesia, Vietnam, Egypt, Turkey and South Africa
DCC	Dynamic Conditional Correlation
DMO	Debt Management Office
EGARCH	Exponential Generalized Autoregressive Conditional Heteroscedastic
EMUSDGBI	Emerging Market US Dollars Government Bond Index
ETFs	Exchange Traded Funds
FMDQ	Financial Market Dealers Quotation
GARCH	Generalized Autoregressive Conditional Heteroscedastic
GDP	Gross Domestic Product
IDX	Indonesia Stock Exchange
IMKB	Istanbul Menkul Kiymetler Borsasi
ISA	Investment and Securities Act
JSX	Jakarta Stock Exchange
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LM	Lagrange Multiplier
MINT	Mexico, Indonesia, Nigeria and Turkey
NASQ	National Association of Securities Dealers
NSE	Nigerian Stock Exchange
RATS	Regression Analysis of Time Series
S&P	Standard & Poor's

SAP	Structural Adjustment Programme
SEC	Securities and Exchange Commission
SSX	Surabaya Stock Exchange
STCC	Smooth Transition Conditional Correlation
VAR	Vector Autoregressive
VBMFX	Vanguard Total Bond Market Index Fund
VECM	Vector Error Correction Model
VTSMX	Vanguard Total Stock Market Index Fund

1. INTRODUCTION

In 2011, Fidelity investment firm originally coined the acronym “MINT” which was popularised in 2013 by Jim O’Neill the former Goldman Sachs economist (Sophie, 2014) to identify four emerging markets comprising of Mexico, Indonesia, Nigeria and Turkey which are becoming important players in the international market. The MINT economies are expected to grow by 6% per year on average and are most likely to exhibit positive trend in growth until 2020 (Fransesco & Ardita 2015). With the slow growth of other emerging markets like the BRICS, the focus of international investors is now on MINT as the new leading emerging economies with good investment return potentials. According to Durotoye (2014, 99), the MINT economies are characterised by young and growing population, strategic geographical location in terms of being placed closer to larger markets, exporters of natural resources (Nigeria, Indonesia, and Mexico) and exporter of industrial product (Turkey) etc.

The portfolio selection theory of Markowitz (1952; 1959) opined that asset diversification can reduce risk taken by portfolio managers. There is a trade-off between asset returns and risk in most financial decision. The correlation and volatilities of asset are often the main components of risk. Cappiello, Engle and Sheppard (2003), revealed that portfolio diversification is typically achieved by adopting two strategies i.e. investing in different asset classes with negative or little correlation or investing in same asset classes in different markets through international diversification. While this assertion has strong empirical and theoretical justification, it is paramount that investors understand that correlation can be time varying.

There has been different finance literature over last two decades on the co-movement between stock returns and bond returns. According to Connolley et al. (2005), negative stock-bond correlations are likely to occur during stock market crashes. This phenomenon is called “flight to quality” which implies that turbulence in the stock market causes investors to transfer their investment from stock to bond or other non-risky assets. This shift in the correlation from positive to

negative during downturn in the stock market is an ideal scenario for investors due to decoupling benefits. The decoupling phenomenon was first documented by Gulko (2002), highlighting that during crashes in the stock market, the unconditional positive correlation between assets switches sign. Over the years, there have also been some divided opinions on the stock-bond co-movement. The works of Campbell & Ammer (1993) and Shiller & Beltratti (1992) assume that over time, the relationship between stock and bond prices remains constant. Other studies have shown that correlation between stock-bond returns depicts significant time-variation but dependent on the changes in the dynamics of financial market (Engle & Sheppard 2003; Connolly, Stivers & Sun 2005; Gulko 2002; Ilmanen 2003; Li 2004). Also, a number of studies have investigated the linkage between stock and bond market and concluded that volatility transmission exists between these markets (See Johansson 2010; Steeley 2006).

It is a well-known fact that assets from emerging markets have different characteristics to those of a developed market. According to Bekaert & Harvey (1997), some distinguishing characteristics of emerging markets (EMs) returns were outlined which include low correlation with returns from developed market, higher volatility, and higher sample average returns. In recent times, investors seeking to diversify their portfolio have tilted toward investing in EMs because of the potential of higher expected returns. Despite the potentials of expected return in EMs, not many studies have been carried out to test for volatility and correlation phenomenon especially for the MINT markets. Carlson, Kelly and Martins (1998) is among the very few studies to test for the relationship between stock-bond focusing on 11 EMs such as Argentina, Brazil, Indonesia, Venezuela, South Africa, Hong Kong, Malaysia, Philippines, Poland, Thailand and Mexico. Their studies revealed a great degree of co-movement compared to developed financial markets due to country risk in EMs.

There have been some approaches used to model correlation between stock and bonds in both developed and emerging markets. For example, a rolling regression method has been adopted in some studies (see Andersson et al. 2008, Wainscott 1990). During the last few years, different econometric models have been used to

model time series data. These models are able to describe the financial time series dynamics, and hence the application of the Autoregressive Conditional Heteroscedasticity (ARCH) model first introduced by Engle (1982) and other models within the ARCH family has become common in finance. To derive time varying correlation between stock and bonds, Generalised Autoregressive Conditional Heteroscedasticity (GARCH) type models were adopted; See DeGoeij and Marquering (2004), Engle and Kroner (1995) and Connolly et al. (2005). Also, linkage between different markets have been tested using the BEKK model of Engle & Kroner (1995), and Constant Conditional Correlation model (CCC) of Bollerslev (1990) have been adopted by Fang, Lim & Lin (2006), Padji & Lagesh (2010), Saleem (2011), Kim (2013) and Bichi, Dikko & Nagwai (2016). The CCC model fails to show the dynamic conditions of the market hence the introduction of the Dynamic Conditional Correlation (DCC) model as a new addition to the ARCH family models with the advantage of estimating large conditional variance matrices and avoiding complexities in computation (Engle 2002). On the other hand, asymmetries in conditional correlation, variance and covariance is not accounted for with the DCC model hence the introduction of the Asymmetric Dynamic Conditional Correlation (ADCC) model by Cappiello et al. (2006) to deal with the asymmetries.

This thesis examines the capital market of the MINT economies with emphasis on the stock and bond market. The time varying conditional correlation as well as the asymmetries between the stock and bond return are estimated. Also to ascertain whether volatility spillover between the markets exist, the study examines countries own return spillover (i.e. volatility spillover between stock and bond return within each country) rather than cross return spillover since there may be no economic integration between these countries. The findings and result of this study would offer a better understanding of the MINT markets which can as well be extended to other EMs as to the potentials in terms of portfolio diversification. The study and its finding can be beneficial to investors, researchers, portfolio managers by providing valuable information on the financial asset dynamic of emerging markets.

1.1 Aims and Objectives

Different studies have been done on correlation and volatility dynamics between stock and bond for different markets e.g. Australia, UK, US, Malaysia, Russia etc. but limited studies have been carried out on emerging markets such as MINT markets. The main aim of this study is to examine the relationship between the stock and bond returns in the MINT markets i.e. the correlation dynamics of stock and bonds. The level of time varying conditional correlation, as well as the asymmetric effects of asset returns is assessed. Also the volatility dynamics between stock and bond returns of the selected emerging markets is examined. The study is approached using a period of 15 years and weekly financial time series data from 2001 to 2015. Stocks and bonds are the two major asset classes traded in most financial markets and also a major portfolio component because of their returns and risk characteristics. From the viewpoint of investors, findings from this study would aid informed decision making in terms of portfolio management, asset allocation and risk management.

1.2 Research Questions

1. Is there volatility spillover between the stock market and bond market in each of the MINT economies?
2. What kind of conditional correlation is present between stock and bond returns of MINT economies?
3. Is there asymmetric effect in the conditional correlation between stock and bond returns in each country?
4. Is there a potential benefit among the MINT economies to be exploited for portfolio diversification?

The listed research question above would be answered using MGARCH models. The GARCH BEKK model would be adopted to assess the volatility dynamics between the asset classes. The Constant Conditional Correlation (CCC), Dynamic Conditional Correlation (DCC) and Asymmetric Dynamic Conditional Correlation (ADCC) is adopted to test whether the correlation between the asset classes have

constant or time varying correlation and also to test for asymmetric effect among assets in the MINT economies.

1.3 Motivation and Contribution to Existing Literature

The work of Markowitz (1952; 1959) is the bedrock of the investment portfolio optimization where the aim is to minimize portfolio variance and maximize expected return. It has been suggested that in times of shocks in the market, portfolio managers tend to favour asset diversification by moving from stock to bond known as “flight to quality” in order to minimize risk (Hartmann et al. 2004). The correlation and co-movement between stock and bond is of immense importance in portfolio optimization. Investing in different asset classes with low or negative correlation is essential for portfolio diversification which is empirically and theoretically justified. It is of great interest for portfolio managers and investors to understand the nature of stock-bond return linkage as it has implication for risk management, diversification and asset allocation. Over the years, stock-bond return correlation has received attention in academic literature. Studies on developed markets have revealed that time varying correlation exists between stock and bond returns (see Ilmanen 2003; Gulko 2002; Connolly et al. 2004; Engle & Sheppard 2001; Li 2004). The emerging markets exhibit a higher degree of co-movement between stock and bond returns than in developed market because country risk in emerging market makes returns in domestic bonds more equity like (Kelly, Carlson & Martins 1998). Also research carried out on developed markets has shown some inconsistent results like stock and bond prices tend to move toward the same direction (Puja Padhi & M. A Lagesh 2010; Ilmanen 2003) and on the other hand, according to Basky (1989), stock and bond tend to move in the opposite direction.

This study contributes to existing literature in that it seeks to implement Multivariate GARCH models such as BEKK, Constant Conditional Correlation (CCC), Dynamic Conditional Correlation (DCC) and Asymmetric Dynamic Constant Conditional Correlation (ADCC) to test for volatility transmission and time varying conditional correlation between stock and bond return in MINT economies.

There have been limited studies on stock-bond correlation and volatility spillover with main focus on the MINT markets regardless of the diversification opportunities and potentials as an emerging market as previous studies have focused more on developed market. This study seeks to fill in the research gap and focus on emerging markets such as MINT. This gap has further motivated me to carry out this study in the context of MINT market in order to explore and understand the behavioural pattern between stock and bond in emerging market.

1.4 Scope and Limitation of the Study

Financial liberalization and globalization has made it possible for investors to be able to have access to different markets especially emerging markets. This has enabled investors to create portfolio with variety of asset classes from different markets. In strategic asset allocation, equity and bonds are two asset classes broadly defined. A shrewd investor is consistently searching for the optimum way to improve the performance of his portfolio through risk reduction and increased returns. Therefore, predicting correlation between stock and bond returns plays a vital role in the process of portfolio diversification and asset allocation. The focus of this study is to examine the volatility and correlation dynamics between stock and bond returns in each of the MINT economies in order to ascertain if the phenomenon exists in these markets. It is necessary for investors to determine the risk level of the MINT market in order to better manage risk and determine whether opportunities in risk diversification exist. The result from the study should give a clear idea of the risk potentials of the individual market economies which would be beneficial to portfolio managers since it takes into account data for the last 15 years.

There are some limitations to the study encountered which includes the fact that only traditional asset classes were examined thereby disregarding more asset classes that may have high market returns and diversification potentials e.g. commodities, foreign currencies, real estate etc. On the other hand, access to complete financial data for some countries was a problem. Data is supposed to start from January 2001 but available stock market data for the Nigerian market

started from June 2002 and bond data for the Indonesian market started from June 2004. This could be due to the fact that some of the markets among the MINT economies are newly developed hence the lack of sufficient financial data. The different starting point for the Nigerian stock market and Indonesian Bond market data has no significant influence on the result since the idea is to separately analyse the individual market economies. The study only used weekly data in the analysis although it would have been interesting to find out if high frequency data gives similar results. Also, the Nigerian bond data depict constant value between the periods of 2007 to 2011, which may raise the question of data reliability as well its implication on the result. Although, the data for the study is split into two periods i.e. full period and post-crisis period in order to ascertain if the result is consistent for both periods and to overcome any issues relating to reliability of the research findings. The post-crisis period starts from 2011 to 2015 thereby bypassing the problematic data and also providing most recent results after the financial crisis.

1.5 Structure of the Study

This research work has been structured and organized in seven chapters which include the following: Chapter one provides a general introduction and aim to the study as well as research questions, contribution to existing literature, motivation of the study, limitation and scope of the study. Chapter two provides an overview of the various capital markets under study as well as the historical development of each country. Chapter three discusses previous work done in regards to volatility transmission and time varying conditional correlation. It expatiates more on various findings from previous studies on the behavioural patterns between the stock and bond market in both developed and developing market.

Methodology and the various models used in the study are presented in chapter four. Chapter five presents financial time series data for the study by describing the characteristics of the data with regards to descriptive statistics and preliminary test in order to ascertain whether the data can be used for the study. Chapter six discusses the empirical findings of the study and seeks to answer the research

questions. Finally, chapter seven provides a comprehensive conclusion of the study on the basis of the findings while outlining the implication for investors and portfolio managers, and also proffer some recommendation for further research.

2. ECONOMIC HISTORY AND CAPITAL MARKET DEVELOPMENT OF THE MINT ECONOMIES

2.1 Mexico

Mexico is the third largest country in Latin America after Argentina and Brazil, and situated in the southern part of North America. The country is open to foreign direct investment (FDI) in most of its economic sectors and a major beneficiary of FDI among emerging economies. Its economic history is similar to most developing nations in Latin America. During the 20th century, it faced macroeconomic problems as a result of international price fluctuation. In the 1940's, it was apparent that an industrialization policy was needed in order to limit primary goods dependency. Taking into account the protectionist policies that was common across Latin America, import substitution industrialization was considered by the government as a suitable strategy to lead the country to economic development. The economic performance was good during the 1960's and partly in the 1970's where on average, the GDP annual growth rate was 7%, inflation was below 5% and there was an improvement in the living standard of the populace. However, they began to experience decreasing GDP growth rate in the 1980's due to increase in inflation of about 30% from 4.7% in the 1970's (Dussel 2000). The need to establish a different economic model as well as liberalize the economy was evident which led to economic reforms by the government.

The Mexican economy has gone through the process of economic reforms since the mid 1980's by shifting away from the previous model of inward oriented development. The reforms were aimed at limiting state's involvement in the economy both directly and indirectly. In 1982, economic liberalization process began due to the fall in petroleum prices and increase in international interest rates which highlighted the vulnerability in the Mexican economy. The economic reforms sought to transform the private sector into the spine of economic growth by making it operate competitively in the global market without subsidies. The reforms process included components such as attracting foreign investment, privatising public enterprises, opening domestic market to international trade,

deregulating the economy, liberalizing financial market and the signing of the North American Free Trade (NAFTA). By late 1980's, there had been a transformation of the economy from a nearly closed one to an economy open to foreign involvement in investment and trade (Mattar, Moreno-Brid & Peres 2002).

In the early 1990's, it was expected that the economy would enter a different phase of strong and sustained growth. There was optimism in the private sector; that privatization would improve investment prospect and encourage flow of FDI. However, these expectations were not fulfilled when the devaluation of the currency in 1995 led to the country's recession. In the first half of the 1990's, short term capital inflow was dynamic. In 1993, portfolio investment was almost $29 billion which was seven times the level of foreign direct investment. However, the currency crisis led to decrease in portfolio investment accounting for a negative flow of investment (Mattar, Moreno-Brid & Peres 2002).

As Castellanos & Martinez (2005) highlighted, despite the difficult condition in the global market, the Mexican financial market recovered due to the stabilization reforms implemented. Fiscal and monetary discipline enabled the government to reduce its foreign debt dependency and issue longer maturity fixed coupon bonds. At the same time, there was a willingness by investors to acquire peso denominated debt due to expected interest rate decline which would imply greater benefits. The major reform was from the pension fund system i.e. from pay-as-you-go to a fully funded one. The new system allowed for long term savings instruments to be in significant demand contributing to the development of the debt market. The pension funds, in addition to mutual funds and insurance market increased debt market participation thereby creating a stable demand for fixed income securities.

Securities trading began in Mexico in the 1850's when American and European businessmen openly traded mining shares in the streets of Mexico City. In 1894, the National Exchange of Mexico (i.e. Bolsa Nacional de Mexico) was established and a year later, merged with a group of organised investors. The merger between the two entities gave rise to the Mexican stock Exchange (Bolsa de Mexico).

Trading started in October 1895 on the floor of Bolsa de Mexico (Bhattacharya et al. 1999). In early 1986, eight private and three public issuers were already listing in the exchange among which were the bank of Mexico, the internacional Hipotecario, and the Bank of London. The commercial and industrial development coupled with the frequent emergence of firms led to the formation of the Stock Exchange of Guadalajara and Monterrey in the 1950's. In 1975, the securities market law came into force and the name of the stock exchange changed from Bolsa de Mexico to Bolsa Mexicana de Valores (BMV) and also incorporated the Monterrey and Guadalajara stock exchange (BMV 2016). Between the first exchange market and the current BMV, a sequence of institution in Mexico provided facilities for the constant evolution of trading. Over the years, trading in the market has been interrupted for short periods like the internal monetary turbulence after the First World War (Bhattacharya et al. 1999).

The Mexican bond market is the most developed and the second largest in Latin America as well as one of the most important among emerging economies. It has been included in the group of world government indices as a result of its full market access and investment grade credit quality for foreign investors. Since president Nieto's came into power in December 2012, the bond market has gone through a series of reforms (Xie 2015). In recent report from May 2016, the IMF noted that the implementation of reforms could increase annual growth over the medium term. In expectation of fiscal flexibility and increased growth potentials in the medium term, credit rating agencies such as Standard & Poor, and Moody have given Mexico a rating of BBB+ in August 2016 and A3 in March 2016 (IMF 2016).

Since the mid 1990's, the local bond market in Mexico had witnessed rapid development particularly in government bonds. After the currency crisis in 1994, the debt management strategy of transferring financing to domestic debt from external debt was adopted by the government as well as developing a liquid domestic yield curve and debt maturity extension. In 2001, the central bank (Banco de Mexico) adopted an inflation targeting regime with a target of 3% and variability band of +/- 1%. Inflation has gone down to 3% from more than 10% as

of February 2015 and for the past five years, inflation averaged 3.85%. The pension reform is another policy initiative that has influenced the growth of the bond market. The Mexican pension system was transformed in 1997 to a compulsory contribution plan from a defined benefit system fully funded by individual account and managed by private administrators. As at February 2015, pension funds in Mexico held about 104 billion USD in domestic debt market securities and are a prime domestic investor in local bonds (Xie 2015).

2.2 Indonesia

Indonesia is situated in Southeast Asia and the fourth most populous nation in the world as well as the most populous among MINT economies. The country has significant growth potentials, low public debt, young demographics, stable political system, large domestic market, and blessed with natural resources. The Indonesian economy has gone through different phases in its history. According to Gray (2002), from independence until 1965 there was increased reliance on fiscal stimulus which was financed by money creation. The policy mix caused rise in inflation, economic stagnation, and a collapse in confidence. In 1965, inflation peaked and accompanied by high unemployment and food shortage. From the period 1965 to 1986, Indonesia witnessed a change in the economic situation through the introduction of economic reforms in 1965. The government of President Soeharto implemented economic policies like the introduction of multi-year plan in order to guide economic development. Revenues from oil allowed government to play a role in driving growth in the economy while maintaining relatively conservative monetary and fiscal policies. The Indonesian government began liberalization program in early 1967 by implementing its investment law. In the subsequent years following the liberalization, the country experienced a 7.3% economic growth rate over the period 1970-1996 (Khaliq & Noy 2007). As a result of the economic growth, real annual income of an average person in 1996 was nearly four times higher than it was during the 1970's (Gallup, Radelet & Warner 1998). The economic growth reflected in the reduction of poverty compared to anywhere in the world at that time.

According to Radelet (1999), four pillars provided the base for the rapid growth in the Indonesian economy. Firstly, in the 1970's, the country relied on its rich base of natural resources which includes gold, oil & gas, rubber, copper, palm oil and tin. Revenues from the export of the resources help finance provision of different infrastructures. Secondly, output from agriculture grew steadily as there was rapid increase in the production of rice as a result of the green revolution technologies. The government supported agriculture with investment in agricultural infrastructure, and irrigation. Thirdly, the government also promoted the export of labour intensive manufactured goods after the fall in oil prices in the mid 1980's with goods such as furniture, textile, toys, footwear etc. Foreign investment barriers were broken (although not completely) in many sectors during the late 1980's and early 1990's. Finally, prudent macroeconomics policies were adopted that kept inflation low, reasonable level of current account deficit, budget in balance, and export competitiveness. This helped the economy steer through the decline in oil prices and kept the balance in the macro economy. Between 1990 and 1996, the average capital inflow received in the country was about 4% of GDP.

But during 1997 to 1998, Indonesia experienced economic crisis which lead to outflow of net private capital. The country was hit hard in 1998 due to the East Asian financial crisis with a 13% contracting GDP as well as extreme currency depreciation. The worst hit sectors were transport, finance, construction, hotel and restaurants (Khaliq & Noy 2007). The instability in the economy led to investor's panic which resulted in capital outflows and thus weakened the economy (Cole and Slade, 1996). In order to improve the investment climate, an agreement was signed with the International Monetary Fund (IMF) for assistance in combating the economic difficulties with currency depreciation, fragile banking system, and increasing inflation. Reforms to free foreign investors from some bureaucratic red tape and cumbersome documentary requirement were adopted in addition to allowing foreign investors acquire local firms and ensuring original owner have small stake in the firm. In 2007, Yudhoyono's government issued a new investment law with the intention of making the economy an attractive place for foreign investments. In implementing the new law, a one-stop-shop system was

launched by the government in 2010 to allow investors process business licence more quickly, and mitigate bureaucratic red tape. In order to facilitate this system, the National Single Window for Investment (NSWI) was established as an electronic system for investments that enables investors utilize the online system in applying for licensing and non-licensing services (Fitriandi, Kakinaka & Kotani 2014).

According to OECD (2015), the Indonesian economy has performed reasonably well over the years following the Asian crisis as a result of solid policy reforms and shrewd macroeconomic framework which continues to bear dividend. Although, in recent years, there has been a moderate growth which is reflected by the slow investment growth and weak international demand due to infrastructural bottlenecks, regulatory uncertainties and lower commodity prices. Since 2012, a great deal of turbulence has been encountered by the Indonesian economy. GDP growth declined below 6% in 2013 since the global financial crisis and through 2014, the growth continued to soften. The country has outperformed other Association of Southeast Asian Nations (ASEAN) countries in terms of economic growth despite the slowdown which can be attributed to sound macroeconomic policies such as fiscal prudence and inflation targeting. In 2014, there was a growth in the economy by 5% as export accelerated due to low exchange rate.

Despite the drop in global oil prices, unstable global financial market, capital outflows from the country, the economy performed reasonably well in 2015. At the end of 2015, headline inflation declined to 3.4% on account of lower fuel and food prices, dissipating effect of the increase in fuel price in late 2014. Also, relative to the US dollars, the rupiah depreciated by 10% while bond yield increased by 100 basis points which is relatively modest in both cases compared to other EM's (IMF 2015).

The existence of the Indonesia capital market can be traced back to 1912 when the stock exchange was established by the Dutch colonial government. The capital market started with the launch of the trading floor of the stock exchange in Batavia (current day Jakarta). It was the fourth established exchange in Asia after

Bombay (1830), Hong Kong (1871) and Tokyo (1878). At the beginning, eighteen financial institutions were members of the Batavia stock exchange. The traded stock and bonds were that of Dutch companies and/or Indonesian plantations, government bonds (municipalities and provinces), securities certificate of American firms issued by the Dutch administrative office and bonds of other companies from Holland (ADB 2012).

But due to lack of interest from investors, the market stagnated and was closed in 1956. The real development of the Indonesia capital market started in 1977 when the newly established Capital Market Operation Board (BAPEPAM) by the ministry of finance re-opened the Jakarta stock exchange. In the 1980's, reforms were introduced by the government in order to create a conducive climate and increase investors interest. The Paket Kebijaksanaan Desember (PAKDES) 1 package of 1987 which became effective in December the same year relaxed market regulation, and licensing. This package limits government roles in the stock exchange, introduced over-the-counter (OTC) trade, allowed share values to be determined based on market forces, and allowed foreign participation in the stock exchange. Also, certain procedures for issuing securities were simplified including the licensing of institutions (securities traders, brokers, securities administration bureau and guarantors) and application for sight draft share issues (Rosul 2002).

The government introduced a second reform in December 1988 focusing on non-bank financial institutions and the capital market with the PAKDES 2 reform package. The new reform gave way for issuance of more brokerage licence and partial listing of well-established firms was also authorized. The measure for this reform package encompasses the establishing of a stock exchange in major cities outside Jakarta such as the Surabaya Stock Exchange, the Indonesian Parallel Exchange (i.e. OTC market), and development of finance firms. In 1989, MOF decree 1055 was issued which allowed foreign investors to purchase shares in new issue of up to 49% and hold outstanding shares of up to 49% excluding bank shares (Than & Thein 2000). In December 1990, the PAKDES 3 package was introduced with the aim of reforming the institutional structure of the capital market. The package gave way for the privatisation of the Jakarta stock exchange when

the government relinquished control thereby making it a private limited company. Also, capitalisation requirements for securities firms including underwriters, issuers and brokers were changed (James & Karoglou 2009).

As a result of the three PAKDES packages of the late 1980's, the Indonesia capital market has made significant strides. Another turning point in the development of the capital market is the enactment of law No.8 of 1995 which made self-regulation, full disclosure and supervision the three basic principles of the market. With the enactment and other regulations, the capital market moved to a phase of rapid development propelled by strong investor interest. According to Rosul (2005), certain factors contributed to a climate favourable to portfolio investment in Indonesia which includes investment policies that are consistent with global economic development, domestic market potentials, diverse natural resources, relatively low labour cost, strategic location etc.

In 1995, an automated electronic transaction system was introduced by the Jakarta Stock Exchange in order to support trade infrastructure. Also, the establishment of the Indonesian Clearing and Guarantee Corporation and Indonesian Central Securities Depository in 1996 and 1997 respectively was part of the stock exchange enhancing the position of the Surabaya Stock Exchange (SSX) and the Jakarta Stock Exchange (JSX) as a self-regulating organization. In 1995, the merger of the Indonesia Parallel Exchange and the Surabaya Stock Exchange was witnessed. In 2000 and 2002 respectively, a breakthrough in the capital market in terms of the implementation of trading without clearance and remote trading. In 2007, the SSX and JSX merged and became the Indonesia Stock Exchange (IDX). Then in 2009, a new trade system was launched by IDX called JATS-NextG which was an improvement of the earlier generation with the capability of handling different products transaction from a sole platform (Indonesia Stock Exchange 2015).

2.3 Nigeria

Nigeria became a sovereign state in October 1960 after the British gave her its independence. It is a country that is economically, politically and population wise, one of the biggest in the African continent. It became the biggest African economy following the rebasing of its GDP in 2013. Following its independence, the country has gone through various political challenges such as military coup, civil war, regime changes etc. According to PWC (2015), the country is blessed with various natural resources like coal, iron ore, lead, bauxite, zinc, crude oil etc.

Over the years, the government has implemented various reforms and policies in an attempt to improve growth in the economy. It implemented the indigenization decrees of 1972 and 1977 in order to limit foreign participation in the economy. This led to considerable transfer of foreigner's investments to the government. The motivation for doing this was to limit the large profit repatriation by foreigners but it eventually led to a serious hindrance to economic growth. The acquired investments by the government from foreigners were mismanaged (Edo & Ikelegbe 2014). During the period, the government received enormous revenue from oil export due to the oil boom. In addition to oil revenue, Nigeria accumulated foreign debt offshore due to her creditworthiness in order to carry out some ambitious projects. Excessive borrowing coupled with oil wealth created an impetus for enormous spending that was unproductive. The inefficiency of the Nigerian government hampered on the development and growth of the economy which led to economic stagnation for long periods. The government were under immense pressure to undertake economic reforms in order to encourage growth and development.

The government attempted to put in place sets of stabilization measure in order to overcome the economic stagnation. The Economic Stabilization Act of 1982 was enacted but it was counterproductive and ineffective to the extent that the country recorded negative GDP growth rate and capacity utilization in industry drastically decreased. In 1985, more stringent monetary, fiscal and exchange control measures were designed to overcome the degenerating economic situation (Edo

& Ikelegbe 2014). The new measure helped to restore some control but the macroeconomic imbalance remained in the economy. The only option to prevent total economic collapse was to institute a fundamental economic reform. The Structural Adjustment Programme (SAP) which came into effect in 1986 was a major reform aimed at resolving the structural and prevailing macro-economic imbalance in the country (Addeusi, Sulaiman & Azeez 2013).

There were mixed impact of SAP on the economy. The gains include significant boost in government revenue, impressive growth rate, increase in agricultural exports, international creditworthiness, and improved external payments. However, the implementation of SAP was not very successful in tackling the fundamental economic problems which include sharp depreciation of the local currency, galloping inflation, increased unemployment, near paralysis of the real sector, deteriorating living standard of the populace, among others (Obadan & Edo 2008). Other reform policies were implemented after the SAP between 1990 and 2003 like, the Rolling Plan which on a continuous basis took into cognisance improved data analysis, and new information into the planning machinery. This was replaced by the National Economic Empowerment and Development Strategy (NEEDS) in 2004 which focused on re-orientating values, employment generation, wealth creation, and poverty reduction (Ibietan & Ekhosuehi 2013).

The Nigerian economy which has been characterised by poor economic performance due to mismanagement and inadequate plan implementations has had an upturn in the last decade following the return of democratic system of government. Recent macroeconomic indicators look good given the tight monetary control and recent policies of fiscal consolidation. Over the last decade, the country has witnessed economic stability which has been growing with an average growth rate of 7% per year, also real GDP have increased by 6% due to strong performance in the service and agriculture sector. The oil sector has been in decline due to drop in oil price albeit at a slow rate compared to previous year (World Bank 2016). In spite of previous economic setback in the country, the macroeconomic fundamental shows that it can still remain Africa’s largest economy.

Although the Nigerian capital market compared to other market in the developed economies is small, it is one of the major markets in Sub-Saharan Africa and in recent years, has made some significant strides. According to Ewah et al. (2009), the main aim of creating the Nigerian capital market is to provide sufficient liquidity to investors, to mobilize savings from different economic units for development and growth, provide different source of funds for government and also create a thriving private sector. The capital market development started in the 1950s when the government set up the Barback committee through the ministry of industry to advice on means and ways of establishing a stock market.

In an attempt to improve growth, the federal government embarked on capital market development. Based on the committee's report, the Lagos Stock Exchange was established in 1960 and commenced operations in 1961 with the enactment of the Lagos Stock Exchange Act the same year. In 1977, the name was changed to the Nigerian Stock Exchange (NSE) following the proposal of the Government Financial System Review Committee (Bassey 2009). The NSE is licensed and regulated by the Investment and Securities Act (ISA) and the Securities and Exchange Commission (SEC) respectively.

In 1961, trading activities in the market began with two federal government development stock i.e. three domestic equities and one preference share. The government through its policies and legislation has influenced the growth of the capital market. Also, the Income Tax Management Act 1961 was enacted by the government which required both the provident and pension funds to invest a significant proportion of their funds in government stock. The Trustee Investment Act of 1962 required trustees to invest in quoted industrial securities and government stock, and insurers to invest a specified proportion of their risk premium in government securities (Tanko 2004). The market grew gradually and by 1966, the quoted securities were about nineteen. There were criticisms with regards to the NSE not responding to the needs of indigenous investors who desired to raise capital which led to the introduction of the Second-Tier Securities Market in 1985 to provide a platform for the listing of small and medium scale

companies (See Englama, Nnanna & Odko 2004). The introduction of SAP in 1986 put lots of pressure on the capital market as a result of the high interest rates in the money market at that time, which led private companies to patronise the capital market in order to raise equity capital (Babalola & Adegbite 1999). The liberalization and privatization of the financial sector has led to the growth of the stock market and made the importance of capital market known to companies and investors. As at July 2016, the total market capitalization was USD 61.07bn which is an increase from 2015 by 1.57%. The total number of listed companies on the NSE is 180 which include 168 equities listed on the main board, 3 on the premium board and 9 on the Alternative Securities Market (ASEM). Also, the Exchange Traded Funds has 7 listed companies (NSE 2016).

As depicted in figure 1 below, there is a low level of sophistication and diversity of financial products in the Nigerian capital market. Available asset classes for trade are mostly limited to equities and recently to ETFs and bonds, even with recent commencement of two new over-the-counter exchanges such as the National Association of Securities Dealers (NASQ) and Financial Market Dealers Quotation (FMDQ). As at 2013, over 70% of activities for private sector in the capital market are concentrated more in the equities segment. Although, there is lack of more sophisticated financial products such as commodity derivative, forward, future and other variant limits market ability to diversify investment and also hinder desired economic function like transactional efficiency (SEC 2013).

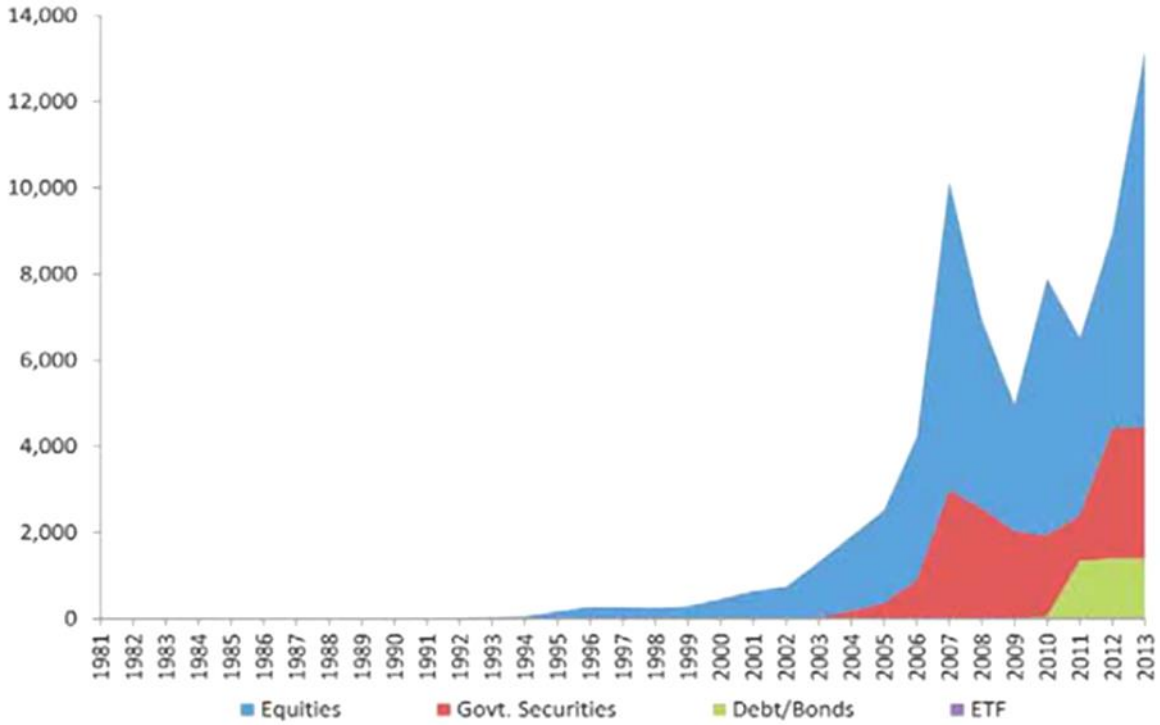

Figure 1: Growth of the Nigerian capital market from 1980-2013 (N'bn) (Source: Central Bank of Nigeria)

According to Oji (2015), on the Nigerian bond market, the federal government bonds are the most common types traded. The Debt Management Office (DMO) which issues government bonds regulates the activities in the bond market. The Central Bank of Nigeria acts as registrar and issuing house for the bonds. There are no separate body that trades bond in Nigeria hence all government bonds are listed and traded on the NSE. The various laws and legislation have contributed to the development and growth of the Nigerian bond market such as the Securities and Investment Act of 1999, and the DMO Act of 2003. Also, the pension reforms have influenced the development of bond market in Nigeria. As depicted in figure 2 below, there are a total of 64 bonds listed in the NSE comprising of FGN bond, corporate bond, supranational bond and state/municipal bond.

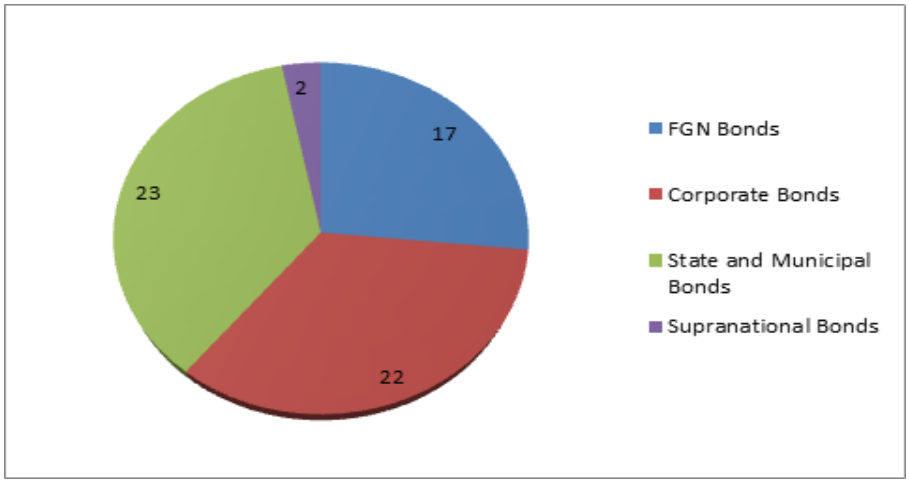

Figure 2: Number of listed bonds in the NSE (Source: Nigerian Stock Exchange)

2.4 Turkey

Turkey is the 17th biggest economy in the world and the 6th biggest economy in Europe with a per capita income which exceeds 10,500 dollars (World Bank 2016). The country has shifted from its huge reliance on industrial and agricultural sector to a more diversified economy and serves as a link between the Middle East, Europe, Eurasia, and North Africa. Its main asset includes a large domestic market, young dynamic population, and strategic location combined with good infrastructural facilities as well as improved public services. Over the last decades, it has experienced substantial success as well as problems specifically with the failed coup in July 2016 against the incumbent government by the military.

Over the past three decades, the economy has gone through significant changes where it has transformed into a market oriented free enterprise system from a state oriented system. There has been a limited role of the public sector in the country, removed exchange control and capital transfer, liberalized foreign trade and foreign investment support since the introduction of reforms in the 1980's. The economic liberalization embarked in the 1980's made good progress towards removing subsidies, price control, interest ceiling, encouraging foreign direct investments, expanding the private sector, freeing foreign trade, and relaxing capital control. As a result, FDI and foreign trade significantly increased although from low levels (European Commission 2009). Boom-and-bust cycle in addition to

devaluation of the Lira and balance of payment crises hampered growth performance.

After the 1980's, the growth of the Turkish economy was low and erratic relative to the period from 1961 to 1979. The average growth rate between 1961 and 1979 was 5.2% whereas this decreased to 4.2% in the succeeding period. Since the 1980's, Turkey has experienced different crisis with the first to hit the country in 1994. A budget deficit that was unsustainable with high inflation and interest rates led the economy to a sudden financial reversal thereby causing a collapse of the Lira (Comet & Colak 2014). Export oriented industrialization approach was adopted and import substitution industrialization approach was abandoned in the 1980's in an effort to integrate with world economies. Thus, market intervention by the state was limited by the economic market mechanism.

In the 1990's, the Turkish Lira became convertible and also the country witnessed capital movement liberalization. Between 1991 and 1994, public deficit in the economy grew and interest rates skyrocketed. In an attempt to overcome these situations, a stabilization program was introduced in April 1994 which was not completely adequate in its stabilization effects. Although the economy experienced an initial period of recovery, then the economy was struck by the Asian crisis in 1997 (Isler 2004). In the face of enormous high debt level and public deficits in the country, the implemented policies were no longer sustainable. By the end of 1999, inflation reached 70% in the country, the economy had contracted by 6.1%, budget deficit enormously increased with total debt outstanding amounting to 60% of GDP (Yurdakul 2014). In mid-August 1999, the country was hit by an earthquake which also increased the economic predicament and later followed by the boom-bust cycle culmination in 2001 which triggered sets of reforms.

According to the European Commission (2009), the economy recovered from the 2001 crisis due to strong external anchor such as the IMF programmes, clear medium term roadmap, bold domestic reforms and the possibility of EU accession. Macroeconomic stability was achieved by means of strong monetary and fiscal policy and enhanced by structural reforms in the area of privatisation and

enterprise restructuring, reforms in the banking sector, and trade liberalisation. This led to an increase in domestic and foreign investments, sectoral transformation and increasing labour productivity in the economy. Between the periods 2002-2007, the Turkish economy accelerated where on average the GDP increased by 6.8% annually which more than doubles that posted during the 1990's. The 2001 economic crisis in Turkey represents the turning point of the economy, not because it was the severest but because of the structural changes implemented during that period with the exception of the 2008 global financial crisis. Accordingly, the GDP from 2002 to 2013 increased from 233 to 820 billion dollars and its total trade increased from 114 to 476 billion dollars within the same period (Kutlay 2015).

The origin of the Turkish security market can be traced back to the second half of the nineteenth century to the establishment of the first securities market during the period of Ottoman Empire in 1866 under the name Dersaadet Tahvilat Borsasi (Istanbul Bond Exchange). Following the establishment of the Turkish republic, the law Nr 1447 guiding "Securities and Foreign Exchange" launched in 1929 provided a platform for an organised stock exchange under a new name "Istanbul Securities and Foreign Exchange Bourse". The stock exchange grew within a short period and contributed significantly to firm financing all over the country. However, the crisis in 1929 and the Second World War had a negative effect on the capital market and the general business environment. The subsequent years which saw a period of rapid industrial growth had also recorded increased number of firms that offered their stock to the general public (CMB 2013). In the 1960's, in order to meet the need for conversion of semi-compulsory liberty bonds and compulsory savings bonds into cash, the second hand market was formed which was later withdrawn from the market in the 1980's (Kartal 2013). In the early 1980's, the securities market went through series of developments in terms of setting up institutional and legal framework appropriate for sound capital movements. In 1981, the capital market law Nr. 2499 was implemented as well as the launching of the decree establishing the fundamental principle concerning operation and foundation of the securities exchange in October 1983. The regulation regarding the operation and foundation of the securities exchanges was revealed in the

official Gazette in 1984. The Istanbul stock exchange was officially established in 1985 following the introduction of relevant regulations and began operation on January 1986 (CMB 2013). Based on recent regulations, like the Capital Market Law Nr 6362 published on 6th December 2012 in the official Gazette, the stock exchange was rebranded as “Borsa Istanbul” following the merger of Istanbul Gold Exchange and Istanbul Menkul Kiymetler Borsasi (IMKB) and restructured as a joint stock company which is subject to private law. In 2013, in line with the law, the traded contract on the Turkish Derivatives Exchange was transferred to Borsa Istanbul (BIST). The Turkish Derivative Exchange ultimately ceased to exist in April 2014 as a legal entity hence the sole platform for financial trading in Turkey is Borsa Istanbul. The financial instrument and asset classes traded in the market include stocks, government bonds, money market instruments (repo and reverse repo), exchange traded funds (ETFs), corporate bonds, derivative instruments, lease certificates, foreign securities and precious metals (Borsa Istanbul 2015).

BIST equity market comprises of the main market, Stars market, Emerging Companies Market (ECM), equity market for qualified investors, collective and structured products market, and watchlist market where stocks from different sectors, ETF, pre-emptive rights, and the certificates and warrants are traded. In 2015, the Turkish stock market was ranked fourth among the World Federation of Exchanges members with a 212% turnover velocity clearly indicating substantial liquidity. Over the last decade, the share of foreign investors in the stock market free-float market capitalization has gradually increased and sustained its historical level in 2015. The evidence that foreign investors possess 62.36% of free float market capitalization shows that investors have trust in the country and the capital market. In terms of traded value, the stock exchange was ranked 7th among World Federation of Exchange members in 2015 and the debt securities market is among the most advanced in the world. The government debt securities, private sector bonds, asset backed securities, commercial paper, lease certificate, asset covered bonds, structured debt instrument, treasury bills and bank bills are traded on the debt securities market (Borsa Istanbul 2015). Based on 2015 figures, the overall value traded on BIST markets is TRY 11.90 trillion with a 33% annual increase while the debt securities market account for 86.3% of the traded value

(see Figure 3 below). The total numbers of listed companies are 416, BIST market capitalization/ GDP is 26% and the daily traded value of the market is TRY 47.3 billion (BIST 2015)[1].

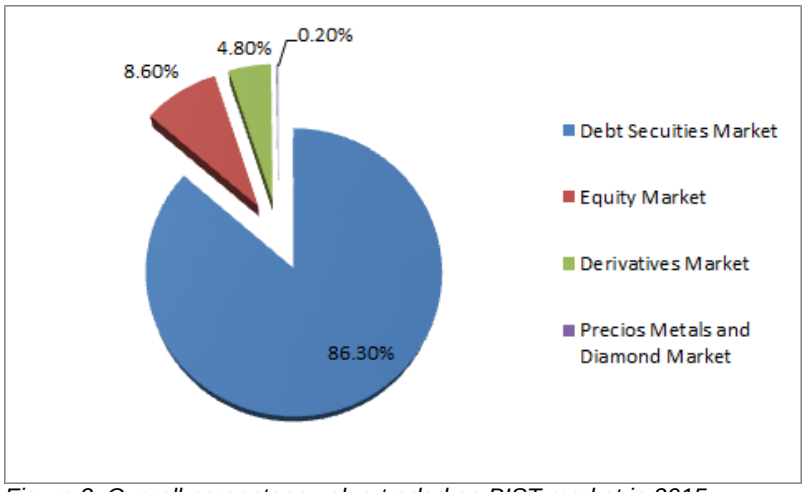

Figure 3: Overall percentage value traded on BIST market in 2015

[1] The charts indicating securities traded are done only for the Nigerian and Turkish markets due to limited access to information for the Mexican and Indonesian markets.

3. LITERATURE REVIEW

3.1 Volatility Spillover between Stock and Bond

Volatility spillover effect between related markets like the stock and bond markets occurs when transmission of information between these individual markets are neither immediate nor complete. For instance, consider the effect in the prices of stock on the announcement of macroeconomic news that creates unanticipated decline in prices of bonds. This may evolve into a corresponding fall in prices of stock if it signals that company's future cash flows will be lower due to the expectation that higher interest rate would hinder growth in the economy. In such situation, transmission from bond market flows into the stock market. Another instance is when declining stock prices are related to rising discount rate and increased market uncertainty for all assets which includes bonds whose prices drop in response. In such case, the transmission emanates from the stock market into the bond market (Dean et al. 2010). Having a clear knowledge of the nature of these types of spillover is vital for various purposes including asset allocation, portfolio management, capital market regulation, and risk management.

Stock and bond are the two most fundamental asset classes traded in most financial markets and ascertaining the volatility and correlation dynamics are important in risk management and asset allocation. Since the 1970's, stock and bond relationship have attracted interest among scholars and researchers. The motivation behind this interest is quite obvious. The idea of profiting by forecasting price trends of stock according to that of bonds and alternatively to evaluate the existence of volatility transmission between stock and bond market (Zhang et al. 2013).

Different mechanisms are suggested by Dean et al. (2010) in explaining the existence of volatility transmission between different markets like the stock and bond market. The following mechanisms were used which includes asset substitution, hedging financial demands, news decomposition, financial contagion, asymmetric price adjustment, and news specificity. Asset substitution regards both

assets i.e. stock and bonds as competing asset. Disclosures of information influence the perceived appeal of these assets to prospective investors. News favouring bonds over stock influence prospective investors to purchase bonds and sell stocks while the reverse is the case when news favours stock. Therefore, hypothesis related to asset substitution suggests that positive return shocks in a particular market will impact negatively in another market. For example, returns from bond market should drop following positive news being released in the stock market. Hedging financial demand arise when changes in price in certain market motivates hedgers to alter their position in another market in order to maintain their target hedge ratio (Dean et al. 2010). A financial trading model that describes the linkage was provided by Fleming et al. (1998) which suggested that high price in stock prompts hedgers to sell stock for bonds and vice versa. For example, an increase in the price of stock motivates an active hedger to move funds from bonds to stocks. In such scenario, the demand for bonds drops even during lack of information flow. Just like the asset substitution hypothesis, the hedging financial demand hypothesis predicts that positive news in the bond market will reduce prices of stock and vice versa.

News decomposition is the splitting of news into two distinct components comprising of news concerning future cash flow and news concerning discount rate. As suggested by Campbell and Vuolteenaho (2004), differentiating between these two news types is essential for the fact they possess distinctive valuation impacts. They further suggested that stock prices suddenly appreciate with good news about future cash flows and depreciate when there is increase in the discount rates. However, instantaneous rise in discount rate also suggests higher future returns. Therefore, an unanticipated shock as a result of revision in rate of discount expectations is partially reversed by future returns. As a result, investors strongly respond more to news concerning future cash flows than news related discount rates. If return shock in bond market conveys news concerning future cash flows, then the hypothesis related to news decomposition predicts that news about cash flow in bond returns will transmit into the stock returns with similar sign. However, if news about bond market is mainly associated to discount rates, the hypothesis related to news decomposition suggests that bonds returns will

transmit into stock returns in the opposite direction although with less strength than in the instance of news on cash flow (Dean et al. 2010).

Asymmetric price adjustment arises when news is impounded at different rate into market prices depending on the return shock sign (Damodaran 1993). This can be as a result of asymmetric transaction costs. The asymmetric partial adjustment model was estimated by Koutmos (1999) which shows market prices impound negative news faster than positive news. However, the hypothesis related to asymmetric price adjustment suggests that negative news transmit between stock and bond market faster than positive news. Financial contagion relates to the return shocks propagation over different financial markets in the absence of news announcement, or as an overreaction to news disclosure. As suggested by King and Wadhwani (1990), this phenomenon arises during a partially revealing equilibrium where prices in a particular market respond not only to price changes but also to fundamental information in other markets. Also, Ito and Lin (1994), opined that contagion is a situation where prices in a particular market are affected by changes in prices in other market beyond which can be justified by economic fundamentals. The hypothesis related to financial contagion predicts that negative news in either market is conveyed to other markets irrespective of economic fundamentals.

News specificity relates to the perception that news transmitted by changes in the price of bonds and stocks differs with regards to the level to which they supply information of a certain nature about the different classes of assets. Changes in price of government bonds transmit news about overall economic situations and broad shift in firm's profitability. A change in price of stock reflects revisions to firm's valuations emerging from both individual and aggregate fundamental factors. If news emanating from the bond market is basically informative about general economic situations, this should affect both bond and stock in similar direction. However, if information emanating from the stock market is dominated by news specific to stock, then stock shock is more probable to have a substitution effect as they indicate changes in the relative attractiveness in the investment of stock compared to bond. The hypothesis related to news specificity predicts that

bond returns shocks transmit into stock returns with similar sign whereas stock return shocks transmit into bond returns with the opposite sign (Dean et al. 2010). Having considered the various ways in which return spillovers arise, it is important to note that each of these approaches also likely leads to return volatility spillovers given that large return spillover of both positive and negative sign will increase volatility in the market (Ross 1989).

3.1.1 Previous Studies on Volatility Spillover

Various studies have been carried out to assess the volatility transmission between stock and bond market while adopting different econometric models. This research work focuses on Autoregressive Conditional Heteroscedasticity model (ARCH) family models and as such, previous studies using similar model is examined. Dean et al. (2010) examined the asymmetry in return and volatility spillover between Australian stock and bond market. The period investigated in the research was from 1st June 1992 to the 20th November 2006 and excluded days when either of the market was closed. In order to explore interdependence of both markets, the analysis was approached using a bivariate GARCH model with asymmetric effects and spillover. The data comprises of daily returns from the ASX all ordinaries index and the all lives government bond index. Based on their findings, the stock-bond volatility transmission dynamics are highly asymmetric. In regards to return volatility, negative news derived from bond market transmit over into lower stock returns while positive news from stock market leads to lower rates of bond. Spillover from bond market which flows into the stock market volatility at different rates is dependent on the respective signs of the return shocks in the bond and stock market. Conversely, conditions in the stock market do not seem to affect bond market volatility.

Bichi, Dikko and Nagwai (2016), examined volatility transmission in intra-national markets of frontier economies such as the Nigerian stock and bond market by using MGARCH models. They adopted the BEKK GARCH model and DCC GARCH model in modelling volatility transmission between both markets. The period investigated in the research was from 6th August 2010 to 3rd December

2015 and data comprises of weekly returns of Nigeria Stock Exchange, all share index and federal government bond. Based on their findings, a bi-directional volatility shock spillover was discovered between both markets. Also, the performance analysis done shows that the most ideal model for the equity and bond markets of frontier economies is the Dynamic Conditional Correlation (DCC) model. Steeley (2006) examined volatility transmission between the UK equity and bond market using a GARCH framework. The model includes asymmetries, volatility spillover and a time varying correlation structure. The time varying correlation adopted a non-parametric structure which allows the correlation between market shocks to evolve over sample period. The period investigated was from June 1984 to June 2004 and data comprises of daily closing observation of FT100 share index, FTLG representing long term bonds and FTSG representing short term bond. Based on the findings, it was discovered that correlation between long term bond yield shock and short term yield shock during the sample period was relatively stable. While the correlation between the equity market and each of the bond market reversed sign. Also, evidence shows that past bond market volatility influence both markets.

By employing the BEKK GARCH model and the decomposition approach of the MGARCH (1, 1) model, Fang, Lim and Lin (2006) investigated market wide volatility transmission between stock market and bond markets of the U.S and Japan. The set of stock indices used were Dow Jones Industrial and Nikkei 225 Stock Average while the government bond indices were sourced from JP Morgan. The sample period was between January 1988 and February 2004 in order to avoid distortion that may occur in the result due to the market crash of October 1987. Analysis was done based on domestic cross-market influences and international cross-market influences and their findings shows there exist unidirectional volatility transmission between domestic cross markets i.e. stock market tend to influence the bond market but not vice versa. On the other hand, the U.S stock market exerts strong influence on the stock market of Japan but no influence on the bond index. Also, the Japanese government bonds have an influence in the stock market in variance of the U.S but not much volatility persistence from the Japanese stock market to the U.S bond market. There was

also no causal effect in variance from the bond market of Japan to the U.S bond market. Evidence from international cross-market influence is mixed with strong linkages in the stock markets but not the case in the bond markets.

Kim (2013), explored the volatility transmission effect on the Islam financial market with reference to the Malaysian stock and bond market. The study was approached using two daily indices such as the Sharia index and 5 years Sukuk GII Yield over two periods between January 2007 to January 2009 and January 2009 to December 2011 i.e. during and after the global financial crisis. Data was analyzed using the VECM-bivariate GARCH and VAR models. Their finding shows that no evidence of returns spillover between the stock and the bond market. By employing the VAR-GARCH-BEKK models, unidirectional volatility spillover was found between the bond and stock market during the crisis period implying that volatility in the bond market increase volatility in the stock market but not vice versa. On the other hand, price discovery role and volatility spillover between stock and bond market after the crisis period was examined. It was discovered that the bond market contributes more than the stock market in price discovery. Also, after the financial crisis, no spillover effect was found between the bond and stock market.
This study is approached using 15 years weekly frequency data and VAR-GARCH BEKK model to ascertain if there is consistency or contradiction to previous empirical findings especially for emerging markets.

3.2 Time Varying Conditional Correlation

3.2.1 Stock and Bond Correlation

Over the year's different studies have provided contradictory result on the behavioral pattern between stock and bond returns. Gulko (2002) suggested that stock and bond are correlated positively due to its exposure to common macroeconomic conditions like inflation rate, interest rate, economic growth etc. Campbell and Ammer (1993), discussed factors behind stock and bond return correlation. They opined that expected long term increase in inflation tends to drive

bond market down and equity market up. This makes returns on bond and equity negatively co-vary, offsetting the positive covariance advancing from the expected excess return effects and real rate of interest. When the prospects of the economy are good, investors tend to purchase equity irrespective of whether the coupon rate for bonds is high. Empirical evidence by Kwan 1996, Gulko 2002, and Li 2002 provides some evidence on the negative correlation between two assets returns. This arise when the equity market is experiencing a crash or in a down period. When the equity market falls, investors are more likely to be risk averse and bonds tend to be more attractive thereby prompting investors to move funds from the equity market to the bond market, a phenomenon known as “flight-to-quality” or “flight-to-safety” (See Baur & Lucey 2009; Hartmann et al. 2001). On the other hand, when equity market experience sustained increase in equity price, investors becomes less risk averse and are motivated to take advantage of the high returns, a phenomenon known as “flight-from-quality”. Due to these two phenomena, the correlation between stock and bond returns is negative (See also Gulko 2002; Connolly et al. 2005; Baur & Lucey 2006).

Some studies have examined the stock-bond correlation dynamics and discovered factors influencing its behavioural patterns. Li (2002), investigated the stock-bond returns correlation by studying the G7 countries where he discovered major trends in the correlation between stock and bonds which in the past 49 years follows a similar reverting pattern. He also adopted the asset pricing model in order to show that stock and bond yields correlation can be influenced by macroeconomic variables. By adopting three successively practical interpretations of the dynamics of asset return, he studied the relation amongst macroeconomic variables and stock-bond correlation. The findings reveal that major trends in the correlation of stock and bonds are due to uncertainty about inflation estimation. The un-estimated inflation and real interest rate are to some extent significant. Also, links between inflation risk and stock-bond correlation was discovered. Ilmanen (2003) opined that correlation between stock and bond is likely to be negative in period of high stock market volatility and low inflation. Yang, Zhou and Wang (2009) investigated the correlation between stock and bonds in the US and UK markets for over a 150 years period adopting the smooth transition conditional correlation

model (STCC) and discovered that higher correlations between stock and bond likely follow higher inflation rates (to a minimal extent) and higher short rates. Pastor and Stanbaugh (2003) identified liquidity as a determinant to changes in correlation between US stock and bonds. Using the dynamic factor model, Baele et al. (2010) considered different macroeconomic factors coupled with liquidity proxies and discovered that stock-bond correlation is more dependent on liquidity factor in the US market. Although majority of previous studies was carried out on developed market, and very few studies on emerging and frontier market, this study helps to ascertain if some of these empirical findings holds on emerging market.

3.2.2 Constant and Time Varying Conditional Correlation

The stock-bond correlation dynamic has been studied over the years and it is believed that over time it is subject to fluctuations, with the implication that such changes affect portfolio risk. Different studies have contradictory opinions regarding the stock-bond co-movement i.e. whether the conditional correlation is constant or time varying. Early studies of Shiller and Beltratti (1992) assume implicitly time invariance in the stock-bond correlation by the use of the present value model. Discount rates are based on the interest rates in the market which are the sum of the constant risk premium and the future short rate. Their model indicates the existence of time invariance and positive correlation between stock and bond. However, the authors discussed that the empirical correlation is underestimated by the model reason being that the real stock price overreact to long term interest rates changes. Campbell and Ammer (1993) used similar model to decompose the variance and covariance of 10 years monthly US equity and bond returns into several discount rates and real cash flow components. Their model indicates the existence of time invariance. Kaplanis (1988), carried out a study on ten market between the periods 1967 to 1982 and found constant correlation. Also similar result was provided by Ratner (1992), as study was carried out on a group of seven markets between the periods 1973 to 1988 and found the existence of constant correlation.

On the other hand, more studies on developed markets have shown the stock-bond correlation exhibits time variation (See Siegel 1998; Gulko 2002; Ilmanen 2003; Cappiello, Engle & Sheppard 2003; Jones & Wilson 2004; Connolly, Stivers & Sun 2004; Li 2004). Whereas, Scruggs and Glabadanidis (2003) dismiss models that imposes a constant correlation restriction on the covariance matrix between equity and bond returns. Also, Campbell (1987) indicates that state dependent time varying correlation between equity and bond returns exist. He associates the covariance matrix of a portfolio consisting equities, treasury bonds, treasury bills to the state of interest rate term structure. The Capital Asset Pricing Model was used and the asset returns are associated to a fixed portfolio weight of equities, bonds and bills whose expected returns are in proportion to their conditional variances. Capiello, Engle and Sheppard (2003) indicate that investors should be aware of stock-bond return correlation exhibit time variation. They used the Asymmetric GARCH model to determine the conditional correlation. The Asymmetric GARCH model assumes that negative and positive past shocks impact on correlation differently. Longin & Solnik (1995), carried out a study on the G7 countries using MGARGH (1,1) and Ljung-Box method to ascertain whether constant conditional correlation exist in cross country asset returns and discovered both constant and time varying correlation with France and Canada exhibiting constant conditional correlation while the hypothesis of constant correlation was rejected in the other countries. Coaker (2006) carried a study on the correlation and its implications on decisions for asset allocation by estimating the simple rolling correlation of fifteen different classes of asset against the S&P 500 in 1, 5 and 10 year time series rolling correlation between the periods 1970 to 2004 using a monthly return data. He discovered that the correlation S&P 500 with investment grade government bonds is time varying but also provides diversification benefits.

Efforts have been made by researcher to ascertain economic drivers that bring about time varying correlation between stock and bonds returns. Andersson et al. (2008) gave reference to news or macroeconomic factors such as economic growth or business cycle. Connolly, Stivers & Sun (2007), gave priority to stock market uncertainty. Kim et al. (2006) conducted an analysis on the European market and discovered that stock market uncertainty decrease asset returns

correlation. More so, similar findings were discovered by Connolly et al. (2007) using daily returns data in the US and some developed market. On the other hand, Ilmanen (2003) discovered that period of economic expansion causes an increase in correlation while in period of economic contraction, correlation decreases. These findings are contrary to that of Jensen & Mercer (2003) where they opined that during economic contraction, conditional correlation increases but remain low and during economic expansion, conditional correlation decreases.

3.2.3 Asymmetric Effects on Stock and Bond Market

According to Cappiello et al. (2006), asymmetric volatility can be economically explained by different models such as time-varying risk premia (i.e. volatility feedback) and leverage effect. Black (1976) first noted the asymmetric volatility effect which refers to the tendency that positive and negative news in returns have different effect on conditional volatility in equity market. Empirical evidence suggests that accurate predictions of volatility can be derived when asymmetric response to shock is allowed (Bekaert & Wu 2000). Different literature has over the years examined the second moment dynamics of different assets returns. Often, the second moment of stocks exhibit asymmetric volatility whereby an increase in volatility is caused after negative shock than after a positive shock of similar magnitude. Previous studies have accounted for asymmetric volatility effects in conditional covariance (for example, Booth, Martikainen & Tse 1997; Scruggs 1998, & Christiansen 2000). Econometric models have been developed to capture asymmetric volatility. For example, univariate models have been introduced by several studies to capture asymmetric effect (e.g. Nelson 1991; Glosten, Jagannathan & Runkle 1993; Engle & Ng 1993). On the other hand, bivariate EGARCH model with asymmetries in stock returns betas were estimated for various sectors (Braun, Nelson & Sunier 1995).

One of the most prominent studies on time varying covariance modelling is the research work carried out by Kroner and Ng (1998). They proposed an asymmetric extension of the MGARCH model by introducing the Asymmetric Dynamic covariance (ADC) model. Data on large and small firm was used to compare four

different MGARCH models. Cross-asymmetric volatilities were not taken into cognisance in their approach. Bekaert & Wu (2000) used a general empirical framework to examine asymmetric volatility in the Japanese stock market based on a MGARCH-in-mean model. They attempt to differentiate between the two major asymmetry explanations and concluded that time varying risk premia (volatility feedback) was the main cause of the asymmetry. Also, concluded that the significant source of asymmetric volatility is the leverage effect. De Goeji & Marquering (2009) developed a multivariate model taking into account asymmetric volatility and level effects in order to forecast the conditional volatility of U.S equity and 10 years Treasury bond returns. Daily excess returns were used on both the stock and bond market and found evidence of asymmetric effects in the variance and covariance of both stock and bond returns. Also, significant cross-asymmetric effect was found in the conditional covariance.

3.2.4 Previous Studies on Conditional Correlation

Different studies have been carried out on the time varying correlation between stock returns and bond returns. For example, Saleem (2011) examined the time varying conditional correlation for the Russian stock and bond market using daily return data (for a five days period). The period investigated in the research was from July 1994 to December 2007 and analysed using the Multivariate GARCH models such as the CCC, DCC, and ADCC. The empirical finding suggests that constant conditional correlation is not supported, conditional correlation is time varying and highly dynamic between the stock and bond market. Also, both markets show positive asymmetries in the conditional correlation, variances and covariance. Padji and Lagesh (2010) examined the correlation dynamics between the Indian stock and bond market returns. The period investigated was from January 2003 to March 2010 and daily return data for BSE SENSEX index and CCIL bond index was used in the analysis. They used Multivariate GARCH models such as the CCC and DCC in the investigation of correlation dynamics. The empirical findings suggest that constant conditional correlation cannot be accounted for while on the other hand, there is evidence showing that the conditional correlation between stock and bond returns is time varying. While

examining the correlation between stock and bond returns, macroeconomic fundamentals were not taken into cognisance in the analysis.

Jammazi et al. (2015) examined the time varying dependence between stock and bond returns for 16 developed markets which were classified into four categories. They include markets in periphery of the euro area, core markets of the euro area, non-euro zone members, and markets not part of the European countries. The period investigated was from January 1993 to April 2013 and a weekly frequency data was preferred. A number of stock indices as well as 10-years benchmark bond index of each country were utilized. They used a time varying DCC GARCH copula method in analysing these markets. The empirical result reveals that in most countries, over time there was significant variability in the dependence structure between stock-bond returns. They also found a positive comovement in the 1990's between stock and bonds returns for all countries. However, since the early 2000, negative correlation was discovered between stock and bond markets. It was discovered that as a result of the Eurozone sovereign debt crisis in late 2009, a shift in the dependence pattern was witnessed in the markets in periphery of the euro area such as Spain, Greece, Ireland, Portugal and Belgium. This implies that international investors moved funds from these markets to markets with good economic outlook and better fundamentals.

Cappiello et al. (2006) examined the asymmetric dynamics in the correlation of global stock and bond returns. They proposed an asymmetric generalised dynamic conditional correlation model (AGDCC) which was used in the analysis. The model allows for smoothing parameters and specific news impact as well as allows for asymmetries in conditional variance for a broad cross section of government bonds and national equity returns. The data used for the study consists of government bond indices for 13 countries in Europe and FTSE All-World Indices for 21 countries in European, America and Australasia region. The sample period for the study was from January 8, 1987 to February 7, 2002 with a weekly returns data frequency. The empirical findings reveal widespread evidence of asymmetry in conditional volatility of equity returns while little was discovered for bond returns. However, asymmetry in the conditional correlation was exhibited in both asset

classes, although stronger response is seen in equity than bonds to joint negative news. The study also discovered that during financial turmoil periods, equity market volatilities exhibit significant linkages.

Chiang and Li (2009) examined the correlation dynamics between stock and bond returns in the US market. By employing both dynamic correlation coefficient models (i.e. the Asymmetric Dynamic Conditional Correlation (ADCC), the BEKK-GARCH model) and rolling correlation models for a sample period ranging from 1996 to 2008. The data comprises of the Vanguard Total Stock Market Index Fund (VTSMX) and the Vanguard Total Bond Market Index Fund (VBMFX). The findings reveal an average negative correlation between stock and bond although very close to zero. Also, the stock-bond correlation coefficient is time varying and depends on macroeconomic fundamentals. Chiang, Li and Yang (2015) examined the dynamic correlations between stock and bond returns and financial market uncertainty for six advanced markets. They adopted the Asymmetric Dynamic Conditional Correlation (ADCC) model in the analysis. Empirical findings suggest that correlation between stock and bond vary over time and reveal smooth transitional changes. Stock market uncertainty is negatively correlated with stock-bond correlations as measured by the implied volatility of the S&P 500 index and the conditional variance. However, bond market uncertainty is positively related with stock-bond relations as measured by bond returns conditional variance. Different research on the volatility and correlation dynamics especially on developed market have yielded different results as examined in this chapter employing econometric models such as the ARCH family models. The findings from previous studies highlighted in this chapter would give an indication of expected findings for this study as well as indicate whether our research findings are consistent with previous research findings. The following chapter examines these ARCH family models employed in this research study in order to provide an insight on these models.

4. METHODOLOGY

One assumption of the classical linear regression model is that of homoscedasticity i.e. variance of the error term is constant. But if the variance is not constant but assumed constant, it implies that the estimated standard error could be imprecise. In the context of financial time series, it is unlikely that over time the variance of the error term is constant, hence the need for a model that does not assume constant variance but highlight how the variance of the error is evolving. Also, one feature of financial time series is volatility clustering which provides another reason for the implementation of ARCH models. This phenomenon can be parameterised with the use of ARCH models (Brooks 2008, 386). Capital market has been an important part of any economy, playing major roles as source of capital as well as information dissemination. The phenomenon of volatility clustering may be present in financial asset return from capital markets hence different empirical models mostly ARCH family models have been used to study capital market. Time series models are able to describe the financial time series dynamics, and hence the application of the Autoregressive Conditional Heteroscedastic (ARCH) model first introduced by Engle (1982) and other models within the ARCH family has become common in finance. The ARCH model laid the foundation for other volatility models as it was the model first used to model the conditional heteroscedasticity in volatility. The model is intuitive and simple but usually requires many parameters to adequately describe volatility process. The model was extended by Bollerslav (1986) to the Generalised ARCH in order to overcome some of the limitations of the ARCH model e.g. violation of non-negativity constraint. One of the features of most financial data is that they usually experience volatility clustering and to capture this clustering, ARCH model has been popularly used.

4.1 ARCH Model

In the context of financial time series, it is highly unlikely that over time the variance of the error is constant which explains why it is necessary to consider a model that does not follow the assumption of constant variance and which

explains the evolution of the variance of the error, hence the introduction of the Autoregressive Conditional Heteroscedasticity (ARCH) model by Engle (1982). Also, volatility pooling or clustering is another feature of most financial time series data which prompt the adoption of the ARCH class of models. Volatility pooling or clustering phenomenon describe that there is high probability of big change following big changes in prices of assets as well as small changes following small changes i.e. the tendency of the current level of volatility to be correlated positively with its level during preceding periods (Brooks 2008, 386). From the expressed ARCH equation (1) below, y_t is the conditional mean and σ_t^2 is the conditional variance of the error terms i.e. the variance based on previous information and derived by using the weighted moving average of squared error term. While $x_{1t}, \dots, x_{4t}$ represent the values of exogenous and endogenous explanatory variables at time t. The weight $\propto_1$ for the squares of previous error terms u_{t-1}^2 is estimated from the data in order to provide the best fit.

$$y_t = \beta_1 + \beta_2 x_{2t} + \beta_3 x_{3t} + \beta_4 x_{4t} + u_t \quad (1)$$

$$u_t = v_t \sigma_t \quad v_t \sim N(0,1)$$

$$\sigma_t^2 = \propto_0 + \propto_1 u_{t-1}^2$$

The ARCH order represents the numbers of lags taken into cognisance in the estimation of the conditional variance. It needs to be of higher order in order to be useful as a result of volatility lingering phenomenon in the financial market. Further analysis of the ARCH model is not necessary in this research paper since it only represent the foundation at which the other time series econometric models are based upon.

4.2 GARCH Model

The GARCH model was developed by Bollerslev (1986) and Taylor (1986) in order to solve the problems encountered with the ARCH model. The GARCH model avoids over fitting and it is more parsimonious which makes it a better model than

the ARCH model. It is less likely to violate non-negativity constraints i.e. the variance cannot be negative (Brooks 2008, 392). The ARCH model assumes shocks of either sign have similar effect on volatility which may not be true because asset prices respond differently to shocks (Tsay 2005). According to Brooks (2008), the GARCH model enables the conditional variance to depend on its own previous lag. The conditional variance can be expressed in the equation below as:

$$h_t = \alpha_0 + \sum_{j=1}^{q} \propto_j \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_j h_{t-i}^2 \quad (2)$$

A sufficient condition for the positive conditional variance with probability one is $\alpha_0 > 0$, $\alpha_j \geq 0$, $j = 1,\ldots,q$; $\beta_j \geq 0$ and $i = 1,\ldots,p$. The conditional variance in equation (2) possesses the property that the unconditional autocorrelation function of ε^2_t slowly decays although exponentially (Teräsvirta 2006). The GARCH (*p, q*) as suggested by Bollerslev (1986) can be interpreted as an Autoregressive Moving Average process (ARMA) for the conditional variance. In practice, most of the GARCH models are used to forecast volatility. In particular, the GARCH (1, 1) with one lag for the conditional variance and one lag for the squared error is one of the most robust models (Fabozzi & Pachamanova 2016). The maximum likelihood methods are used to estimate the parameters α_j and β_j in GARCH models. In application, the most popular GARCH model is the GARCH (1, 1) model i.e. *p=q=1* in equation (2).

4.3 Multivariate GARCH Models

The main application of the Multivariate GARCH models is the study of the relationship between volatilities and co-volatilities of different markets. While the centre of attention has been to model volatility of returns, it is also important to understand the comovements of financial returns. Therefore, it is necessary that the multivariate GARCH models are considered. MGARCH models have been adopted to investigate correlation and volatility transmission and spillover effects (Bae, Stulz & Karolyi 2003; Tse & Tsui 2002). Bollerslev, Engle and Wooldridge (1988) introduced the MGARCH model by extending in the univariate case,

GARCH representation to the vectorized conditional variance matrix. Their findings indicate that over time, conditional variances vary and are a significant element in the risk premium (Tse & Tsui 1998).

There exist some problems associated with the MGARCH models; large numbers of parameters are required in order to capture changes of the covariance and conditional variance. The model may not be suitable if it does not have enough parameters. Also, the model suffers from estimation difficulty as a result of the positive definiteness restriction on the variance-covariance matrix i.e. the matrix needs to be positive at all time (Vrontos, Dellaportas & Politis 2003). By implying positive definiteness to the MGARCH structure, the model can realize positive definiteness with the covariance matrix. Another problem with the model relates to the numerical optimization of the likelihood function. The conditional covariance matrix is dependent on the time index *t* and generally has to be inverted for all *t* in all iteration of the numerical optimization (Silvennoinen & Teräsvirta 2008).

The general MGARCH model was described by Bollerslev, Engle and Wooldridge (1988) as follows:

$$y_{it} = b_i + \delta \sum_j \omega_{jt}\ h_{ijt} + \ \epsilon_{it},$$

$$h_{ijt} = \ \gamma_{ij} + \alpha_{ij}\epsilon_{it-1}\epsilon_{jt-1} + \ \beta_{ij}h_{ijt-1}, \quad i,j = 1,\dots,N,$$

$$\epsilon_t|\emptyset_{t-1} \sim N(0, H_t), \tag{3}$$

Where h_{ijt} indicates the *N* X 1 vector of conditional expectation of y_{it} at period *t,* ϵ_t denotes the *N* X 1 vector of shock at time *t,* $\emptyset_{t-1}$ captures all information at time *t*-1. The i subscript is the ith element of the corresponding vector, and the ij subscript is the ijth element of the matrix (Bollerslev, Engle & Wooldridge 1988)

The MGARCH model can be categorised into four categories which includes; conditional covariance matrix models (such as BEKK GARCH model), factor models where the conditional covariance matrices are motivated by parsimony, conditional variance and correlation models which is built on the premise of modelling correlation and conditional variance (such as CCC, DCC, ADCC), and finally nonparametric and semi parametric approaches which form an alternative to parametric estimation of the structure of conditional covariance (Orskaug 2009). The research would adopt the BEKK GARCH in modelling volatility, while the CCC, DCC and ADCC would model correlation.

4.3.1 BEKK GARCH Model

The ARCH model proposed by Engle (1982) and the GARCH model proposed by Bollerslev (1986) are known in modelling volatility of asset returns in univariate setting. However, the preferred approach used to estimate volatility linkage is the multivariate GARCH models. Estimation of such models can be done by imposing specific restrictions on the variance-covariance matrix. The BEKK model introduced by Engle and Kromer (1995), ensured that the variance covariance matrix H_t is positive definite always. The model complies with constant correlation hypothesis and allows for volatility transmission across markets by using quadratic forms in order for positive definiteness to be ensured.
The bivariate VAR-GARCH (1, 1) model is specified by accommodating at lagged one period, each market returns and other market returns.

$$r_t = a + \beta r_{t-1} + \mu_t$$

$$\begin{bmatrix} r_{1,t} \\ r_{2,t} \end{bmatrix} = \begin{bmatrix} a_{1,0} \\ a_{2,0} \end{bmatrix} + \begin{bmatrix} \beta_{1,1} & \beta_{1,2} \\ \beta_{2,1} & \beta_{2,2} \end{bmatrix} \begin{bmatrix} r_{1,t-1} \\ r_{2,t-1} \end{bmatrix} + \begin{bmatrix} \mu_{1,t} \\ \mu_{2,t} \end{bmatrix}, \quad (4)$$

$$u_t \,|\, \Omega_{t-1} \sim N(0, H_t),$$

Where r_t is represented by *nx1* vector of weekly returns for each market at time t (in equation (4), we assume $n = 2$). The random errors μ_t is an *nx1* vector which

indicates the innovation at time t for each market with its corresponding variance-covariance matrix. The available information of the market at time *t-1* is depicted by the information set Ω_{t-1}. The β estimates represent the own market spillovers i.e. the vector autoregressive term.

Based on the expression above, the conditional covariance matrix following Engle and Kromer (1995) is represented as:

$$H_t = \omega\omega' + \gamma\varepsilon'_{t-1}\varepsilon'_{t-1}\gamma' + \delta H_{t-1}\delta' \quad (5)$$

Where ω_0 parameter matrices is the variance equation which are the lower triangular restricted matrix and unrestricted matrices γ_{11} and δ_{11}. The matrix γ estimates captures the ARCH effects while the matrix δ estimates captures GARCH effects. The second moment BEKK model is expressed as:

$$H_t = C'_0 C_0 + \begin{bmatrix}\gamma_{11} & \gamma_{12}\\ \gamma_{21} & \gamma_{22}\end{bmatrix}\begin{bmatrix}\varepsilon^2_{1t-1} & \varepsilon_{1t-1}\varepsilon_{2t-1}\\ \varepsilon_{1t-1}\varepsilon_{2t-1} & \varepsilon^2_{2t-1}\end{bmatrix}\begin{bmatrix}\gamma_{11} & \gamma_{21}\\ \gamma_{12} & \gamma_{22}\end{bmatrix} + \begin{bmatrix}\delta_{11} & \delta_{12}\\ \delta_{21} & \delta_{22}\end{bmatrix}\cdot \cdot \begin{bmatrix}h_{11t-1} & h_{12t-1}\\ h_{21t-1} & h_{22t-1}\end{bmatrix}\begin{bmatrix}\delta_{11} & \delta_{21}\\ \delta_{12} & \delta_{22}\end{bmatrix} \quad (6)$$

4.3.2 Constant Conditional Correlation

Bollerslev (1990) proposed the Constant Conditional Correlation (CCC) GARCH model in which the conditional correlation matrix is time invariant. The conditional covariance in the CCC model is represented by using nonlinear combinations of univariate GARCH models. By construction, the conditional covariance matrix is positive definite and possess a simple structure which aid parameter estimation. Though, the model guarantees positive definiteness of variance covariance matrix, it is not entirely flawless. Its major problem is that most of the time, constant correlation seems to be a very strong assumption. Results from empirical studies tend to reject the assumption that both unconditional and conditional correlation is constant for most assets and markets (see Tsui & Yu 1999). However, in regards to modelling correlation, the CCC model remains a benchmark model.

The Constant Conditional Correlation model derived by Bollerslev (1990) can be expressed as:

$$y_t = Cx_t + \epsilon_t$$

$$\epsilon_t = H_t^{1/2} v_t$$

$$H_t = D_t^{1/2} R D_t^{1/2} \quad (7)$$

Where *m* x 1 vector of dependent variables is represented by y_t, *m x k* matrix of parameters is represented by *C*, *k x 1* vector of independent variables is represented by x_t which may include lags of y_t, $H_t^{1/2}$is the Cholesky factor of the conditional covariance matrix H_t, v_t is an m x 1 vector of independent and identically distributed (i.i.d.) innovations, and the diagonal matrix of conditional variances is represented by D_t;

$$D_t = \begin{pmatrix} \sigma_{1,t}^2 & 0 & \cdots & 0 \\ 0 & \sigma_{2,t}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_{m,t}^2 \end{pmatrix}$$

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

$$\sigma_{i,t}^2 = s_i + \sum_{j=1}^{pi} \propto_j \epsilon_{i,t-j}^2 + \sum_{j=1}^{qi} \beta_j \sigma_{i,t-j}^2 \quad (8)$$

By default, or

$$\sigma_{i,t}^2 = \exp(\gamma_i z_{i,t}) + \sum_{j=1}^{pi} \alpha_j \epsilon_{i,t-j}^2 + \sum_{j=1}^{qi} \beta_j \sigma_{i,t-j}^2 \quad (9)$$

Where $\gamma_t$is a 1 x *p* vectors of parameters, p x 1 vector of independent variable is represented by z_i including a constant term, the $\alpha_j's$ and $\beta_j's$ are ARCH and GARCH parameters respectively; and

The R below is the time invariant unconditional correlation matrix of standardized residuals $D_t^{-1/2}\epsilon_t$,

$$\mathrm{R} = \begin{pmatrix} 1 & p_{12} & \cdots & p_{1m} \\ p_{12} & 1 & \cdots & p_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ p_{1m} & p_{2m} & \cdots & 1 \end{pmatrix}$$

Due to the fact that R is time invariant, this model is regarded as the Constant Conditional Correlation GARCH model.

4.3.3 Dynamic Conditional Correlation

The DCC GARCH model was proposed by Engle (2002) as a more generalized version of Bollerslev's CCC GARCH (Bollerslev 1990) in which each asset volatilities were allowed to vary over time but with time invariant correlations and allows for dynamics in the correlation. The DCC GARCH is estimated by using the standard quasi-maximum likelihood method. The model can be consistently determined by estimating in the first stage the univariate GARCH model and in the second stage, the conditional correlation matrix. The model parameters can be estimated in stages like the two-step approach which avoids the problem of dimensionality experienced in most multivariate GARCH model (Sheppard 2001; Engle 2002). Moreover, the DCC GARCH model is parsimonious and guarantees that time varying correlation matrix between market returns are positive definite (Gallegati & Semmler 2014). While the model takes into account volatilities of each variables, it allows for time varying characteristics by assigning lower weight to past observations which is one of the merit of the model over the simple rolling correlation analysis (Devereux et al. 2011)

The model as proposed by Engle (2002) can be expressed as:

$$y_t = Cx_t + \epsilon_t$$

$$\epsilon_t = H_t^{1/2} v_t$$

$$H_t = D_t^{1/2} R_t D_t^{1/2}$$

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

$$Q_t = (1 - \lambda_1 - \lambda_2)R + \lambda_1 \epsilon_{t-1}\epsilon_{t-1} + \lambda_2 Q_{t-1} \quad (10)$$

Where *m x 1* vector of dependent variable is represented by y_t, *m x k* matrix of parameters is represented by C, *k x 1* vector of independent variables is represented by x_t which may include lags of y_t, $H_t^{1/2}$is the Cholesky factor of the time variant conditional covariance matrix H_t, v_t is an m x 1 vector of independent and identically distributed (i.i.d.) innovations, λ_1 and λ_2 are parameters that control the conditional quasi correlation dynamics. λ_1 & λ_2 satisfy 0 ≤ λ_1 + λ_2 < 1 and are nonnegative, ϵ_t is an m x 1 vector of standardized residuals $D_t^{-1/2}\epsilon_t$ and the diagonal matrix of conditional variance is represented by D_t;

$$D_t = \begin{pmatrix} \sigma_{1,t}^2 & 0 & \cdots & 0 \\ 0 & \sigma_{2,t}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_{m,t}^2 \end{pmatrix}$$

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

$$\sigma_{i,t}^2 = s_i + \sum_{j=1}^{pi} \propto_j \epsilon_{i,t-j}^2 + \sum_{j=1}^{qi} \beta_j \sigma_{i,t-j}^2 \quad (11)$$

By default, or

$$\sigma_{i,t}^2 = \exp(\gamma_i z_{i,t}) + \sum_{j=1}^{pi} \alpha_j \epsilon_{i,t-j}^2 + \sum_{j=1}^{qi} \beta_j \sigma_{i,t-j}^2 \quad (12)$$

Where $\gamma_t$is a 1 x *p* vectors of parameters, p x 1 vector of independent variable is represented by z_i including a constant term, the $\alpha_j's$ and $\beta_j's$ are ARCH and GARCH parameters respectively;

R_t is a matrix of conditional quasi correlations,

$$R_t = \begin{pmatrix} 1 & p_{12,t} & \cdots & p_{1m,t} \\ p_{12,t} & 1 & \cdots & p_{2m,t} \\ \vdots & \vdots & \ddots & \vdots \\ p_{1m,t} & p_{2m,t} & \cdots & 1 \end{pmatrix}$$

A stationary Q_t implies that the R matrix in (10) is said to be a weighted average of the unconditional covariance matrix of ϵ_t, represented by $\overline{R}$, and unconditional mean of Q_t, represented by $\overline{Q}$. Because $\overline{R} \neq \overline{Q}$ as highlighted by Aielli (2009), R is neither the unconditional mean nor the unconditional correlation matrix of Q_t. On this basis, the parameters in (*R*) are regarded as quasi correlations (see Engle 2009; Aielli 2009).

4.3.4 Asymmetric Dynamic Conditional Correlation

The Dynamic Conditional Correlation model overcomes the problem of heteroscedasticity since returns residuals are standardized with conditional standard deviation on the basis of GARCH (1, 1) process. However, asymmetries are not accounted for in the conditional variance, correlation and covariance hence the introduction of the asymmetric version of the DCC known as the Asymmetric Dynamic Conditional Correlation (ADCC) model (Saleem 2011).

The ADCC GARCH model proposed by Cappiello (2006) is an extension of the DCC GARCH model to allow for leverage effects in the correlation structure. One of the limitations of the DCC GARCH model is that conditional correlation dynamics do not account for asymmetric effect and asset specific news impact. This means that the model accounts for the impact of past shocks on future conditional correlation and volatility, it does not distinguish between the shock effects (of either signs). The ADCC GARCH model was introduced to overcome the limitation associated with the DCC model.

The DCC model (equation 10) has been modified to ADCC model in order to account for asymmetric effect and can be expressed as:

$$Q_t = \left(\overline{P} - A'\overline{P}A - B'\overline{P}B - G'\overline{N}G\right) + A'\varepsilon_{t-1}\,\varepsilon'_{t-1}\,A + G'n_{t-1}\,n'_{t-1}G + B'Q_{t-1}B \qquad (13)$$

Where *A, B*, and *G* represent *k x k* diagonal parameter matrices, $n_t = \mathrm{I}[\varepsilon_t < 0]o\varepsilon_t$ ($\mathrm{I}[.]$ is a *k x 1* indicator function; if the argument is true, it take on value 1

and 0 otherwise, "∘" is the Hadamard product) and $\overline{N} = E[n_t n'_t]$. The expectation for both $\overline{P}$ and $\overline{N}$ are infeasible and are substituted with sample analogues i.e. $T^{-1}\sum_{t=1}^{T}\varepsilon_t\,\varepsilon'_t$ and $T^{-1}\sum_{t=1}^{T}n_t\,n'_t$, respectively. If there is significant k x k parameter matrix G, it implies that the sample period has asymmetric effect. In equation (12), it is clear that a condition for Q_t to be positive definite for every feasible realization is that the intercept is positive semi- definite i.e. $\overline{P} - A'\overline{P}A - B'\overline{P}B - G'^{\overline{N}}G$ and the initial covariance is positive definite i.e. Q_0 (Cappiello 2006; Ding & Engle 2001).

5. DATA

In this research study, data comprises of weekly total returns for stock and bond covering a 15 years period (i.e. January 2001 to December 2015) for the MINT economies. Weekly data is used instead of high frequency data such as daily data because weekly frequency may provide accurate volatility and correlation estimation. Andersen and Bollerslev (1998) suggest that problem may be encountered in GARCH modelling when high frequency data is used i.e. it could lead to inaccurate forecasting. The data is retrieved from DataStream and standardised in US dollars using the MSCI for stock, and JP Morgan Emerging Bond Index for Mexico, Indonesia and Turkey. Also, the Citigroup Emerging Market US Dollars Government Bond Index (EMUSDGBI) was used for the Nigeria bond due to problem encountered with the JP Morgan Emerging Index data. The Nigerian bond data showed a constant value between the periods of 2007 to 2011 followed by a sharp decline with the JP Morgan Emerging Bond Index giving cause to believe there is a problem with the data. The total number of observations for each market is 782 with the exception of Nigeria stock index and Indonesia bond index. Data for the Nigeria stock index had a total observation of 708 due to available data starting in 3rd June 2002 and the Indonesia bond index had a total observation of 604 due to available data starting in 31st May 2004. Despite the difference in starting date for some dataset as previously mentioned, individual market economy is analysed separately. This difference in the starting dates would not affect the general result since the study is not a comparative analysis but a study of individual emerging market economy. In order to avoid problem that may arise in the MGARCH models due to empty series, a uniform starting date is used for the Nigerian (3rd June 2002) and Indonesian (31st May 2004) stock and bond market. The weekly price is transformed into a series of percentage returns continuously compounded using the formula;

$$Return = 100*Log (Y_t / Y_t(-1)).$$

Furthermore, to provide a general picture of the data under investigation, the graphical presentation in figure 4 below depicts rising trends in the stock market

for Mexico, Indonesia and Turkey. It can also be observed a downward slope in the graph from 2008 until 2009 probably due to the global financial crisis for all the economies. The trend in the Nigerian stock market remained low until 2011 where it gradually increased. From 2013, the growth trend in the stock market had begun to decline gradually in the MINT economies. On the other hand, the growth trend in the Mexican and Indonesian bond market has been relatively low probably due to restrictions as well as inactive domestic investor in the market. The Nigerian bond market experienced a rising growth trend until 2006 where the trend became stable until 2011 followed by an increased growth. Also, the Turkish bond market has experienced continuous growth trend and surprisingly there was no significant decline during the global financial crisis.

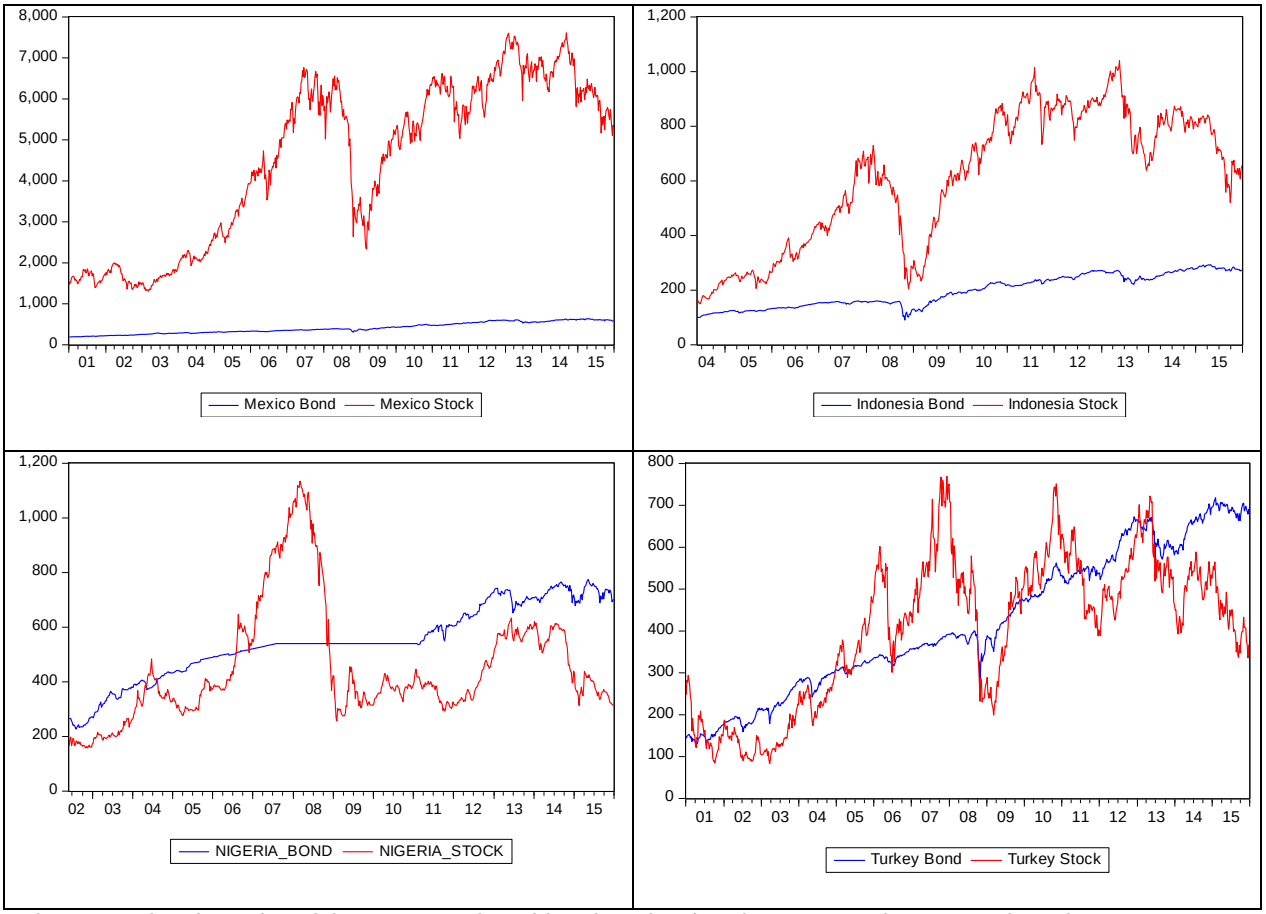

Figure 4: Price dynamics of the MINT stock and bond market (x axis represent the year and y axis represent closing price)

The Figure 4 above also depicts similar interest by investors in both assets in Indonesia and Turkey seen from the growth trend albeit low in Indonesia. In

addition, Mexico has the highest stock return index among the MINT economies followed by Turkey, Indonesia and Nigeria. Whereas, Turkey has the highest bond return index followed by Nigeria, Indonesia and Mexico in that order. The charts indicate decline in trends for both the stock and bond market during the 2008 global financial crisis with the exception of Mexico and Nigeria Bond market and as a result of this scenario, structural breaks can be observed in the data. The structural break in the data may result in the unreliability of our model and forecasting error and as such our analysis is done in two phases. In the first phase, analysis is done on the whole dataset and in the second phase, analysis is done for post-crisis period which ranges from 2011 to 2015.

5.1 Descriptive Statistics

In order to detail the distributional properties of the weekly return index of stocks and bonds in the MINT economies for the periods under examination, the descriptive statistics is reported in table 1 below. It highlights details such as the mean, standard deviation, kurtosis, Skewness, Jarque-Bera statistics, probability as well as the total number of observation in the analysis. The mean statistics indicates the average asset returns and having a positive value is highly desirable in contrast to a negative value. It can be observed the MINT economies all possess positive mean returns indicating that over the periods, prices have increased in these markets. Indonesia has the highest mean stock return followed by Mexico, Nigeria and Turkey while for the bond market; Turkey has the highest bond mean return followed by Indonesia, Mexico and Nigeria. The standard deviation is a measure of risk and the volatility of the assets. In the MINT economies, the stock market exhibits higher volatility than the bond market. Turkey possess the most volatile stock followed by Indonesia, Nigeria and Mexico in that order while in the case of the bond market, Indonesia is the most volatile followed by Turkey, Mexico and Nigeria.

The Jarque-Bera test is used to test for normality of our time series data. The main idea behind the test is that normally distributed data has a skewness coefficient of zero as well as a kurtosis coefficient of three (i.e. excess kurtosis is zero). From

the distribution statistics in table 1 below, the MINT economies exhibit a negative skewness indicating that asset returns are skewed to the left and non-normally distributed and also, there is high chance of earning returns in both assets. On the other hand, the MINT economies exhibit kurtosis greater than 3 (leptokurtosis) for both asset returns which imply that the return series is fat tailed and non-normally distributed. The Jarque-Bera test confirms this at a significance level of 5% where the null hypothesis which states that data is normally distributed is rejected. It can be observed that the Jarque-Bera values for all both asset series for MINT economies are very high and statistically significant at 5% level. Interestingly, during the post-crisis period (see appendix I, table 12), the mean return for stock among the MINT economies depicts negative value indicating prices have reduced in these market over the period while the bond return depicts positive value indicating price increase in bonds.

Table 1: Descriptive statistics for MINT economies for period 2001-2015

The descriptive statistics are calculated using standardised weekly stock and bond returns of the MINT economies and output generated through the EVIEWS software.

	Asset	Mean	Standard Deviation	Skewness	Kurtosis	Jarque-Bera	Prob.	Obs.
Mexico	Stock	0.16	3.99	-0.34	9.16	1254.11	0.00	782
	Bond	0.14	1.19	-0.38	19.55	8953.33	0.00	782
Indonesia	Stock	0.22	4.77	-0.60	8.53	807.08	0.00	604
	Bond	0.16	2.27	-1.26	56.94	73386.78	0.00	604
Nigeria	Stock	0.09	4.28	-0.34	7.54	624.11	0.00	708
	Bond	0.13	1.16	-0.57	11.07	1962.00	0.00	708
Turkey	Stock	0.05	6.66	-0.31	5.85	278.63	0.00	782
	Bond	0.20	2.01	-1.32	20.47	10184.29	0.00	782

5.2 Unconditional Correlation

Correlation measures the linear relationship between two or more variables and the range needs to be between -1.0 and 1.0. In the case of our dataset, the correlation coefficient is examined for both full and post-crisis periods. In the table 2 below, it can be deduced that Turkey had the highest correlation value for the different periods and Nigeria had the lowest correlation value for the different periods among MINT economies. Correlation value close to 1 indicates the variables move in the same direction and as such there is little chance of diversification. Among the MINT economies, Mexico has a correlation of less than 0.5 in both periods while Indonesia and Turkey depicts a correlation value of over 0.5 in both period which indicates that there may be some possibility for diversification benefit in the Mexico markets because its correlation value is less than 0.5 but not the Indonesian and Turkish market due to its high correlation value. On the other hand, Nigeria has a correlation of less than 0.3 for the post crisis period and the correlation value is close to zero for the full sample period implying that there is low correlation between stock and bond thus depicting the market with the best portfolio diversification possibilities among MINT economies.

Table 2: Unconditional correlation

This table reports the unconditional correlations between stock and bond returns in the MINT economies				
	Mexico	Indonesia	Nigeria	Turkey
Full Period	0.46	0.54	0.09	0.60
Post-Crisis Period	0.47	0.56	0.26	0.62

5.3 Preliminary Test

Before using financial time series data in ARCH family models, certain preliminary tests need to be carried out in order to ascertain if our data is fit for the study. This is to confirm that data is stationary or does not contain unit root, have ARCH

effect, free from serial correlation, and have volatility clustering. The Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test is used to check for stationarity. Breusch-Godfrey test is used to ascertain if the data is free from serial correlation and also, the residuals of our model would enable us determine if the data have volatility clustering. Before building our model, we check whether the financial time series data depicts volatility clustering (see appendix II, figure 5) to ascertain if it indicates a period of low volatility followed by another period of low volatility for a prolonged period and period of high volatility followed by another period of high volatility for a prolonged period in order to have the justification to run ARCH family model. In the Mexico and Indonesia stock market, relative tranquillity for prolonged period can be observed i.e. before 2007 and after 2009 evidenced by relatively little returns of either sign. The Nigeria and Turkey stock market shows similar volatility pattern but this can be seen only after 2009. During the global financial crisis between 2008 and 2009, MINT stock market depicts more volatility where many huge returns of either sign were observed. Also, the Nigeria and turkey stock market show relatively high volatility before 2004. The Mexico, Indonesia and Turkey bond returns shows prolonged period of low volatility probably due to bonds risk free nature. The Nigeria bond return shows relatively high volatility before 2005 and after 2011 for a prolonged period. Similar volatility pattern can be observed during the global financial crisis in bond returns for Mexico, Indonesia and Turkey. Also, the constant values seen in the Nigerian bond data is reflected in the volatility clustering graph.

The Augmented Dickey-Fuller (ADF) test is widely used in econometrics to test for unit root. The null hypothesis for the ADF test states that variable is not stationary and the alternative hypothesis states that variable is stationary. As reported in table 3, the result depicts no constant and no lagged term. The t-statistics is compared to the critical values to test the hypothesis and where the t-statistic is greater than the critical values in absolute term at 1%, 5% and 10% level of significance, the null hypothesis is rejected. For the MINT economies, the t-statistics for both assets return is greater than the critical values in absolute term even at 1% level of significance implying that the return series is stationary. Also, to further confirm the stationarity of the return series, Kwiatkowski-Phillips-

Schmidt-Shin (KPSS) test is adopted. The null hypothesis for the KPSS test states that variable is stationary and alternative hypothesis states that variable has unit root. The t-statistics is compared to the critical values and where the t-statistics is smaller than the critical value, the null hypothesis cannot be rejected. In the case of the MINT economies, the return series for both assets is smaller than the critical values implying that the return series is stationary.

Table 3: Preliminary test

	Asset	ADF test	KPSS	B-G LM test F-stat	ARCH-LM F-stat
Mexico	Stock	-30.907***	0.193***	0.78**	104.62**
	Bond	-28.393***	0.207***	1.11**	22.18**
Indonesia	Stock	-26.837***	0.266***	0.18**	33.99**
	Bond	-25.198***	0.085***	0.61**	36.96**
Nigeria	Stock	-25.363	0.256***	0.32**	18.07**
	Bond	-25.803***	0.403***	0.61**	36.34**
Turkey	Stock	-30.893***	0.076***	1.58**	5.79**
	Bond	-30.336***	0.162***	1.04**	198.87**

* significant level at 10%
** significant level at 5%
*** significance level at 1%

The Breusch-Godfrey LM test is carried out to ascertain if the return series is free from serial correlation. The null hypothesis for the B-G LM test states that there is no serial correlation in return series and the alternative hypothesis states that there is serial correlation in return series. The results indicate the model is insignificant at 5% level for all asset returns thereby null hypothesis is not rejected implying that the return series is free from serial correlation. ARCH effect for all return series is tested with the ARCH LM test where the null hypothesis states that there is no ARCH effect and alternative hypothesis states that there is ARCH effect. The Lagrange Multiplier (LM) test is an ARCH test for autoregressive conditional heteroscedasticity in the residuals. The test confirms ARCH effect in the return series for the MINT economies. The p-value for all return series are below 5% significance level therefore the null hypothesis is rejected.

6. EMPIRICAL RESULTS

This chapter provides outcome of the research study thereby attempting to answer research questions formulated in the introduction. Volatility and correlation dynamics between stock and bond returns in the MINT markets are examined with the GARCH (1, 1) family models and estimated with the use of Regression Analysis of Time Series (RATS) econometric software. The analysis is carried out in two phases i.e. full sample period (2001-2015) and post-crisis period (2011-2015). The empirical findings are expected to provide investors and portfolio managers etc. information on the diversification benefits that can be derived in emerging economies such as the MINT markets. Before proceeding with the analysis, asset prices were converted to percentage returns and preliminary test were carried out to ensure suitability of our data for the models implemented.

6.1 Volatility Spillover

The result on the volatility dynamics was obtained by implementing the bivariate GARCH (1, 1) BEKK estimation and summarised in tables 4 & 5 below. The β matrix in the mean equation is represented by the first four parameters which captures linkages with regards to mean returns. The parameters β_{ii} and β_{jj} represents own market returns spillovers, and the parameters β_{ij} and β_{ji} captures the relationship in terms of return transmission across the stock and bond market. On the other hand, the variance-covariance effect is examined from the matrices γ and δ as depicted on table 4 & 5 below. The volatility dynamics within and between the respective markets is captured by these matrices. The matrix γ diagonal estimates captures the own ARCH effects within each market while the matrix δ diagonal estimates captures own GARCH effects. Also the off-diagonal estimates present the shock and volatility transmission between the pairs.

The result in table 4 for the full sample period is examined where the own return spillover is assessed and it can be observed that the diagonal parameters β_{ii} for all the stock markets are negative and significant with the exception of Nigeria

stock market which is statistically non-significant implying that the stock market of Mexico, Indonesia, and Turkey are dependent on its own past returns or their first lag while the Nigeria stock market is not dependent on its past returns. On the other hand, the diagonal parameter β_{jj} for the Nigeria bond market is significant implying that it is dependent on past returns while Mexico, Indonesia and Turkey is non-significant and does not depend on their past returns. The return transmission across the markets is represented by the off-diagonal parameters β_{ij} and β_{ji}. The Indonesia and Nigeria stock market receives past return spillovers of 36% and 34% respectively from the bond market implying a unidirectional relationship. Conversely, the bond market does not receive past returns spillovers from the stock market among the MINT economies. The diagonal parameter estimates γ_{ii}, γ_{jj}, δ_{ii} and δ_{jj} are statistically significant indicating own past shocks and volatility have significant influence on the conditional variance of stock and bond market among the MINT economies. The off-diagonal estimates γ_{ij} and γ_{ji} present the shock transmission (ARCH effect) between the stock and bond market. As depicted in table 4 below, stock market receives limited shock transmission from the bond market for Mexico only at less than 4%. Also, the stock market transmits significant shock to the bond market for Mexico (48%), Indonesia (36%) and turkey (57%). This implies that only Mexico depicts a bidirectional relationship between stock and bond market. The off-diagonal estimates δ_{ij} and δ_{ji} present the volatility transmission (GARCH effect) between the stock and bond market. It can be observed that the stock market does not receive any volatility transmission from the bond market for all economies examined. Although, the bond market receives volatility transmission from the stock market for Mexico (-24%), Indonesia (-18%) and Turkey (-25%) implying a unidirectional volatility spillovers.

The result in table 5 for the post-crisis period is also examined where the own return spillover is assessed and it can be observed that the diagonal parameters βii for all the stock markets are significant with the exception of Turkey stock market which is statistically non-significant implying that the stock market of Mexico, Indonesia, and Nigeria are dependent on its own past returns while Turkey stock market is not dependent on its past returns. The diagonal parameter

β_{jj} for the Turkey bond market is significant implying that it's dependent on past returns while Mexico, Indonesia and Nigeria is statistically non-significant. The off-diagonal parameters β_{ij} and β_{ji} shows that Indonesia, Nigeria and Turkey stock market receives past return spillover of 42%, 35% and 59% respectively from the bond market and only the Indonesia and Nigeria bond market receives past return spillover from the stock market. The diagonal parameter estimates γ_{ii} and γ_{jj} are statistically significant for Indonesia stock and bond market, Nigeria and Turkey bond market. Additionally, the parameter estimate δ_{ii} and δ_{jj} are statistically significant for Mexico bond market, Indonesia, Nigeria and Turkey stock and bond market indicating own past shocks and volatility has significant influence on the conditional variance of stock and bond market in these economies. The off-diagonal estimates γ_{ij} and γ_{ji} present the shock transmission (ARCH effect) between the stock and bond market. As depicted in table 5 below, the stock market receives shock transmission from the bond market for Nigeria and Turkey albeit a small percentage of less than 17%. Also, the stock market transmits shock to the bond market for Mexico and Indonesia. The off-diagonal estimates δ_{ij} and δ_{ji} present the volatility transmission (GARCH effect) between the stock and bond market. It can be observed from table 5 below, that the stock market does not receive volatility spillover from the bond market for all economies examined. Although, the bond market receives volatility transmission from the stock market for Indonesia (-26%) and Nigeria (87%) implying a unidirectional volatility spillover.

Based on the findings of the full and post-crisis periods, it can be observed some little difference with regards to the ARCH and GARCH effect. In terms of shock transmission where during full period, only Mexico stock market received shock from the bond market and during post-crisis period, Nigeria and Turkey stock market received shock transmission from the bond market while Turkey stock market transmit shock to the bond market during post-crisis period. Also, in terms of volatility spillover, the bond market of Mexico and Turkey receives volatility transmission from the stock market during full period. The difference in the findings for the two periods could be as a result of the structural breaks seen on the full sample period due to the global financial crisis.

Table 4: Volatility spillovers for full sample period estimated using weekly stock bond return indices

VAR(1)- GARCH(1,1) BEKK Estimation												
	Mexico			Indonesia			Nigeria			Turkey		
Parameters	Coeff	Std Error	Sig.	Coeff	Std Error	Sig.	Coeff	Std Error	Sig.	Coeff	Std Error	Sig.
Bii	-0.109***	0.036	0.003	-0.125***	0.044	0.004	0.053	0.038	0.169	-0.133***	0.039	0.000
Bij	-0.014	0.106	0.894	0.361***	0.122	0.003	0.346**	0.126	0.006	-0.014	0.136	0.912
Bji	0.009	0.008	0.269	0.009	0.009	0.332	0.000	0.000	0.337	-0.001	0.007	0.841
Bjj	-0.017	0.035	0.635	0.067	0.044	0.132	0.219***	0.053	0.000	-0.053	0.042	0.202
ωii	0.492**	0.176	0.005	0.971***	0.216	0.000	0.827***	0.118	0.000	0.847***	0.222	0.000
ωij	0.266***	0.061	0.000	0.220***	0.065	0.000	0.000	0.002	0.807	0.302***	0.102	0.003
ωjj	0.195***	0.061	0.001	0.337***	0.046	0.000	-0.011***	0.000	0.000	0.237**	0.102	0.019
γii	0.230***	0.028	0.000	0.344***	0.075	0.000	0.356***	0.039	0.000	0.178***	0.031	0.000
γij	0.039***	0.009	0.000	-0.021	0.021	0.311	0.000	0.000	0.973	0.009	0.011	0.415
γji	0.475***	0.110	0.000	0.363**	0.131	0.005	0.160	0.119	0.178	0.567***	0.154	0.000
γjj	0.430***	0.043	0.000	0.565***	0.050	0.000	0.449***	0.033	0.000	0.648***	0.061	0.000
δii	0.970***	0.009	0.000	0.920***	0.036	0.000	0.911***	0.016	0.000	0.989***	0.011	0.000
δij	-0.006	0.005	0.207	0.007	0.010	0.450	-0.000	0.000	0.829	0.009	0.006	0.114
δji	-0.242***	0.060	0.000	-0.177**	0.073	0.015	-0.032	0.031	0.303	-0.251***	0.068	0.000
δjj	0.839***	0.029	0.000	0.805***	0.030	0.000	0.930***	0.006	0.000	0.754***	0.035	0.000

* 10% level of significance
** 5% level of significance
*** 1% level of significance

Table 5: Volatility spillovers for post-crisis period estimated using weekly stock bond return indices

VAR(1)- GARCH(1,1) BEKK Estimation												
	Mexico			Indonesia			Nigeria			Turkey		
Parameters	Coeff	Std Error	Sig.	Coeff	Std Error	Sig.	Coeff	Std Error	Sig.	Coeff	Std Error	Sig.
Bii	-0.109**	0.055	0.048	-0.124*	0.066	0.059	0.137**	0.056	0.015	0.055	0.076	0.467
Bij	-0.126	0.228	0.577	0.423**	0.185	0.022	0.348***	0.122	0.004	-0.585**	0.238	0.014
Bji	0.026	0.021	0.222	0.054***	0.019	0.004	0.056**	0.024	0.023	0.035	0.023	0.136
Bjj	-0.057	0.064	0.378	0.012	0.072	0.860	-0.005	0.066	0.939	-0.234***	0.078	0.002
ωii	2.001***	0.620	0.001	0.692**	0.289	0.016	1.643***	0.250	0.000	1.589	1.017	0.118
ωij	-0.325	0.397	0.413	0.210*	0.117	0.074	-0.178	0.166	0.283	0.259	0.180	0.149
ωjj	0.269	0.621	0.664	0.269***	0.080	0.000	0.444***	0.171	0.009	-0.000	0.538	0.999
γii	-0.046	0.135	0.729	0.322***	0.077	0.000	-0.106	0.128	0.407	-0.094	0.079	0.234
γij	0.069*	0.042	0.105	0.009	0.028	0.745	0.163***	0.031	0.000	-0.135***	0.022	0.000
γji	1.474***	0.324	0.000	0.735***	0.233	0.001	0.164	0.173	0.344	0.134	0.277	0.627
γjj	0.287	0.199	0.149	0.479***	0.070	0.000	0.440***	0.077	0.000	0.308***	0.078	0.000
δii	0.079	1.003	0.936	0.911***	0.039	0.000	0.625***	0.131	0.000	0.916***	0.108	0.000
δij	0.081	0.199	0.683	-0.004	0.013	0.724	-0.056	0.039	0.149	-0.010	0.020	0.622
δji	1.538	2.040	0.450	-0.260**	0.121	0.032	0.874***	0.256	0.000	0.114	0.213	0.591
δjj	0.724*	0.382	0.058	0.859***	0.039	0.000	0.751***	0.110	0.000	0.931***	0.045	0.000

* 10% level of significance
** 5% level of significance
*** 1% level of significance

6.2 Constant Conditional Correlation

The results on the constant conditional correlation were obtained by implementing the GARCH (1, 1) CCC model which are summarised in table 6 & 7 below. Following Bollerslev (1990), constant conditional correlation in a MGARCH setting is assumed where variance-covariance terms is constant over time. The ideal starting point is to estimate the CCC GARCH model because it guarantees positive definiteness of variance covariance matrix and avoids computational complexities. Analysis was carried out by estimating the mean and the variance equation. The μ parameters is the mean equation which explains the dependence between the assets lag returns while ω, α and β parameters correspond to the variance equation of stock and bond returns. Also, the ρ parameter corresponds to the correlation between stock and bond returns. Therefore, the parameters significance denotes conditional heteroscedasticity presence in the asset returns.

The result in table 6 for the full sample period shows the constant conditional correlation between stock and bond returns in the MINT economies. The mean and variance equation coefficients are positive and highly significant for all economies with the exception of the parameter α for the Indonesia stock and bond return. The coefficients are statistically significant at level of 5% indicating the dependence of assets returns on their lag returns. The constant conditional correlation between stock and bond returns estimated for the MINT economies is below 0.65. Since the coefficients are all positive, it can be argued that the stock and bond market are exposed to macroeconomic factors. Nigeria exhibit the lowest correlation coefficient of 0.08 followed by Mexico (0.36) and Indonesia (0.44) which is consistent with previous literature (see Campbell & Ammer 1993), implying diversification opportunities in these markets. On the other hand, Turkey exhibits the highest correlation coefficient of 0.62 among the MINT economies. The correlation coefficient exceeding 0.5 can infer that assets returns are correlated strongly and move together which can lower diversification benefits. The correlation coefficient of 0.62 is high implying that diversification benefits may not be derived in the Turkish capital market.

Table 6: Constant conditional correlation for full sample period estimated with CCC GARCH (1, 1) model

Countries	Assets	μ	ω	α	β	ρ
Mexico	Stock	0.350***	1.121***	0.134***	0.791***	0.358***
	Bond	0.196***	0.122***	0.237***	0.680***	
Indonesia	Stock	0.373***	1.371***	0.211	0.732***	0.443***
	Bond	0.223***	0.213***	0.313	0.612***	
Nigeria	Stock	0.258**	0.711***	0.152***	0.808***	0.081**
	Bond	0.000	0.001***	0.252***	0.827***	
Turkey	Stock	0.409**	1.060***	0.054***	0.917***	0.619***
	Bond	0.244***	0.152***	0.360***	0.653***	

* 10% level of significance
** 5% level of significance
*** 1% level of significance

The result in table 7 for the post-crisis period shows the constant conditional correlation between stock and bond returns in the MINT economies. The coefficients are statistically significant at 5% level for the mean and variance equation with the exception of the stock mean returns for all economies examined. The significance of the bond mean return coefficients indicates the dependence of bond returns on their lag returns. The stock mean return coefficient on the other hand are non-significant implying stock return are not dependent on its lag return. The constant conditional correlation between stock and bond returns estimated for the MINT economies is below 0.67. Since the coefficients are all positive, it can be argued that the stock and bond market are exposed to macroeconomic factors. Nigeria exhibit the lowest correlation coefficient of 0.21 followed by Mexico (0.43) and Indonesia (0.49) implying diversification opportunities in these markets. Turkey exhibits the highest correlation coefficient of 0.67 among the MINT economies. The correlation coefficient exceeding 0.5 can infer that assets returns are correlated strongly and move together which can lower diversification benefits. The correlation coefficient of 0.67 is high implying that diversification benefits may not be derived in the Turkish capital market. An ideal scenario could be to invest in similar assets from different markets in order to have diversification opportunities. The findings for the full and post-crisis period are similar, in that the constant

conditional correlation between stock and bond returns for Mexico, Indonesia and Nigeria are below 0.5 and Turkey is above 0.6. This implies, irrespective of the period, the correlation dynamic is similar.

Table 7: Constant conditional correlation for post-crisis period estimated with CCC GARCH (1, 1) model

Countries	Assets	μ	ω	α	β	ρ
Mexico	Stock	0.179	1.557**	0.112***	0.741***	0.434***
	Bond	0.143**	0.147**	0.109***	0.781***	
Indonesia	Stock	0.083	1.255**	0.196***	0.713***	0.496***
	Bond	0.170**	0.196***	0.246***	0.665***	
Nigeria	Stock	0.094	1.138**	0.190**	0.698***	0.208***
	Bond	0.183**	0.347***	0.292***	0.563***	
Turkey	Stock	0.188	44.926***	-0.059***	-0.779***	0.665***
	Bond	0.193**	0.479***	0.149**	0.632***	

* 10% level of significance
** 5% level of significance
*** 1% level of significance

6.3 Dynamic Conditional Correlation

The results on the dynamic conditional correlation were obtained by implementing the GARCH (1, 1) DCC model which are summarised in table 8 & 9 below. The DCC model proposed by Engle (2002) is implemented because the dynamic market conditions are not revealed in the constant correlation coefficient. While the model takes into cognisance the volatilities of each asset, it allows for the time varying characteristics by assigning lower weight to past observation. The correlations and volatilities is estimated in two steps i.e. each asset mean equation and the time varying correlation matrix. The μ parameter correspond to the mean equation while the ω, α and β parameters are bivariate GARCH process. Also, the δ_{DCCs} and δ_{DCCb} parameters are the estimated DCC GARCH of stock and bond returns. As previously described, analysis is done for each individual economy.

The result in table 8 for the full sample period shows the estimated dynamic conditional correlation of stock and bond returns in the MINT economies. The

coefficients are statistically significant at 5% level for the mean and variance equation and consistent with time varying volatility. The sum of the δ_{DCCs} and δ_{DCCb} coefficient is expected to be close to 1 in order to suggest a time varying conditional correlation. The sum of the DCC GARCH parameter for the MINT economies is either close to 1 or approximately 1 indicating a time varying conditional correlation or volatility, thus displaying a highly persistent behaviour with the exception of Nigeria. It can be deduced that the asset returns for stock and bond are positive indicating investor's participation in both markets excluding the Nigerian bond return which depicts a negative value.

Table 8: Dynamic conditional correlation for full sample period estimated with DCC GARCH (1, 1) model

Countries	Assets	μ	ω	α	β	δ_{DCCs}	δ_{DCCb}
Mexico	Stock	0.420***	0.804**	0.115***	0.844***	0.056***	0.924***
	Bond	0.204***	0.723***	0.177***	0.776***		
Indonesia	Stock	0.420***	1.131**	0.222***	0.769***	0.112***	0.856***
	Bond	0.223***	0.112***	0.162***	0.776***		
Nigeria	Stock	0.377	10.314***	0.753***	0.223***	0.039***	0.600***
	Bond	-0.001***	0.000***	1.155***	0.530***		
Turkey	Stock	0.410**	0.939***	0.064***	0.912***	0.029***	0.969***
	Bond	0.239***	0.129***	0.374***	0.658***		

* 10% level of significance
** 5% level of significance
*** 1% level of significance

The result in table 9 for the post-crisis period shows the estimated dynamic conditional correlation of stock and bond returns in the MINT economies. All DCC GARCH parameters for the MINT economies with the exception of Nigeria δ_{DCCs} coefficient reveal statistical significance at 5% level. The sum of the DCC GARCH parameter for the MINT economies is either close to 1 or approximately 1 indicating a time varying conditional correlation or volatility display a highly persistent behaviour. It can be observed that the mean coefficient of the MINT economies is positive with the exception of turkey stock return displaying a negative value. Although the mean coefficient for the stock return is non-significant

for all economies. The negative coefficient value for turkey stock return may be as a result of high liquidation of Turkey stock market thereby investors are tilting towards investing more in the bond market. The MINT economies during the post-crisis period reveal time varying conditional correlation, thus diversification benefit can be derived from these markets. The findings for the full and post-crisis period are similar with the exception of the Nigerian market. During the post-crisis period, the Nigerian market depicts a time varying conditional correlation which is not the case for the full sample period. The difference in the findings for the two periods could be as a result of the structural break highlighted especially for the Nigerian bond data.

Table 9: Dynamic conditional correlation for post-crisis period estimated with DCC GARCH (1, 1) model

Countries	Assets	μ	ω	α	β	δ_{DCCs}	δ_{DCCb}
Mexico	Stock	0.087	1.376***	0.132***	0.746***	0.044**	0.925***
	Bond	0.150***	0.122**	0.112***	0.801***		
Indonesia	Stock	0.077	1.128***	0.253***	0.700***	0.084**	0.867***
	Bond	0.202***	0.168***	0.251***	0.685***		
Nigeria	Stock	0.053	1.328***	0.262***	0.680***	0.016	0.968***
	Bond	0.146**	0.505***	0.418***	0.557***		
Turkey	Stock	-0.058	1.976	0.023	0.894***	0.069***	0.922***
	Bond	0.159**	0.367***	0.194***	0.638***		

* 10% level of significance
** 5% level of significance
*** 1% level of significance

The stock-bond conditional correlation in the MINT capital market produced by the DCC model for the full sample period and post-crisis period were also plotted (see Appendix III figure 6 & 7). It can be observed that the correlations in both assets for the full sample period are positive for Mexico and Turkey with the exception of 2007-2008 periods in the Indonesian market and almost all period in the Nigerian market which depicts a negative correlation. The correlation between both assets fluctuated substantially during most of the period which is a clear indication that over time the stock and bond return relationship has been rather unstable further

confirming the time varying correlation hypothesis. The post-crisis period also depicts negative conditional correlation for most of the period in the Nigerian market. Also, a similar pattern of fluctuation between stock and bond can be observed among MINT economies which depict unstable assets returns relationship over time, thus against the hypothesis of constant correlation.

6.4 Asymmetric Dynamic Conditional Correlation

The results on the asymmetric dynamic conditional correlation were obtained by implementing the bivariate GARCH (1, 1) ADCC model which are summarised in table 10 & 11 below. In the DCC model, asymmetries are not accounted for in the conditional variance, covariance and correlation, thus the implementation of the ADCC GARCH model proposed by Cappiello et al. (2006) to account for these asymmetries in the assets. The μ parameter correspond to the mean equation while the ω, α and β parameters are bivariate GARCH process. Also, γ represent the asymmetric behaviour which if positive, signifies that negative shocks have a high impact than positive shock of equal magnitude upon conditional volatility, and the δ_{DCCs} and δ_{DCCb} parameters are the estimated DCC GARCH of stock and bond returns.

The result in table 10 for the full sample period shows the estimated asymmetric dynamic conditional correlation of stock and bond returns in the MINT economies. It can be deduced that both asset returns and asymmetric parameter exhibit positive coefficients in all economies examined with the exception of Turkey stock returns. This implies that both conditional correlation and variance respond to negative shock than positive shock of equal magnitude. During market turmoil in the MINT economies, the conditional variance and correlation of stock and bond return increases than in normal situation. The Mexican and Indonesian stock return depicts higher positive asymmetries when compared to bond return while the Nigerian and Turkish bond return depicts higher positive asymmetries when compared to stock return. This indicates that the Mexican and Indonesian stock returns are more sensitive to negative shock than bond return in their respective capital market. Also, the Nigerian and Turkish bond return are more volatile than

stock return towards negative shock in their respective capital market. The sum of the DCC GARCH parameter for Mexico, Nigeria and Turkey is close to unity and significant. On the contrary, Nigeria depicts a non-significant DCC GARCH as well as a summed coefficient of 0.21. The model indicates a time varying conditional correlation in Mexico, Indonesia and Turkey markets as well as asymmetric effect in the MINT economies, thus indicating diversification benefits for investors.

Table 10: Asymmetric dynamic conditional correlation for full sample period estimated with ADCC GARCH (1, 1) model

Countries	Assets	μ	ω	α	β	γ	δ_{DCCs}	δ_{DCCb}
Mexico	Stock	0.335*	1.008**	-0.006	0.831*	0.210*	0.058*	0.918*
	Bond	0.191*	0.086*	0.100**	0.758*	0.139**		
Indonesia	Stock	0.356*	1.072**	0.121**	0.786*	0.139**	0.113*	0.858*
	Bond	0.211*	0.105*	0.093**	0.782*	0.120**		
Nigeria	Stock	0.470*	6.597*	0.485*	0.666*	0.503*	0.000	0.210
	Bond	0.001	0.004*	0.721*	0.784*	0.799*		
Turkey	Stock	0.156	1.083*	0.049**	0.908*	0.030	0.036*	0.962*
	Bond	0.166*	0.139*	0.087*	0.703*	0.395*		

* 1% level of significance
** 5% level of significance
*** 10% level of significance

The result in table 11 for the post-crisis period shows the estimated asymmetric dynamic conditional correlation of stock and bond returns in the MINT economies. It can be observed that MINT economies exhibits positive and significant asymmetries indicating that both conditional correlation and variance respond to negative shock than positive shock of equal magnitude. The Mexican stock return shows a higher positive asymmetry when compared to bond return while the Indonesian, Nigerian and Turkish bond returns shows higher positive asymmetries when compared to stock returns. These findings indicate that the Mexican stock returns respond to negative shock than bond return in the capital market while the Indonesian, Nigerian and Turkish bond returns are more sensitive to negative

shock than stock return in their respective capital market. The sum of the DCC GARCH parameter for MINT economies is close to unity although the Nigeria δ_{DCCs} coefficient is non-significant. The model indicates a time varying conditional correlation in MINT economies as well as asymmetric effect, thus indicating diversification benefits for investors. The findings for the full and post-crisis periods are similar with the exception of the Indonesian market whereby during the full period, Indonesian stock return are more sensitive to negative shock than bond return while during the post-crisis period, the Indonesian bond return is more sensitive to negative shock than stock return.

Table 11: Asymmetric dynamic conditional correlation for post-crisis period estimated with ADCC GARCH (1, 1) model

Countries	Assets	μ	ω	α	β	γ	δ_{DCCs}	δ_{DCCb}
Mexico	Stock	-0.178	1.397**	-0.116*	0.800*	0.357*	0.032***	0.946*
	Bond	0.090	0.223*	-0.096*	0.745*	0.317*		
Indonesia	Stock	-0.115	1.191**	0.106	0.723*	0.206**	0.083**	0.870*
	Bond	0.150**	0.173*	0.121***	0.690*	0.207*		
Nigeria	Stock	-0.184	1.030*	-0.039	0.839*	0.270*	0.019	0.974*
	Bond	-0.078	0.541*	-0.062	0.602*	0.808*		
Turkey	Stock	-0.219	2.086	-0.045	0.905*	0.093***	0.058**	0.931*
	Bond	0.104	0.353*	-0.046	0.677*	0.368*		

* 1% level of significance
** 5% level of significance
*** 10% level of significance

7. CONCLUSION

In the research study, the stock-bond volatility transmission and correlation dynamic in emerging markets such as MINT is examined. Volatility and correlation between asset classes is an important element in portfolio management, asset allocation and risk management. In regards to volatility transmission, only own market volatility spillover was carried out because there is no economic integration between the countries examined. The MINT economies was selected for the study because they are regarded as a new group of emerging markets after BRICS and CIVETS with growth potentials which makes it an attractive market for investors. The study was carried out in two phase i.e. full sample period and post-crisis period because the Nigerian bond returns displayed structural break in the full data which may lead to forecasting error. The phenomenon was examined using the MGARCH models such as the BEKK model, CCC GARCH, DCC GARCH and ADCC GARCH. The BEKK model proposed by Engle and Kromer (1995) in a VAR GARCH framework, examined the stock-bond volatility transmission in a bi-variate setting. The GARCH (1, 1) framework of the CCC model proposed by Bollerslev (1990) and DCC model proposed by Engle (2002) was used to examine the nature of the stock-bond conditional correlation in MINT economies, and the ADCC model proposed by Cappiello (2006) was used to examine the asymmetries in the conditional variance, covariance and correlation between stock and bond. Further analysis was carried out where stock-bond conditional correlation produced by the DCC model were plotted to provide confirmation on the results.

The research study focused on emerging market in order to fill in the research gap of limited studies done on emerging economies despite the economic potentials and benefits. Although, certain limitations were encountered in the research study which include different starting date for the Nigerian stock market and Indonesian bond market, constant value discovered in the Nigeria bond data for a four years period signifying structural breaks, limited study on volatility and correlation dynamics in emerging markets etc. In order to counter some of the limitations, a uniform starting date is used for the Nigerian (3rd June 2002) and Indonesian (31st May 2004) stock and bond market to avoid any problem that may arise as a

result of empty series in the MGARCH models. Also, data is split to include post-crisis period, 2011 – 2015, in order to ensure reliability of our results. The study provided interesting insights on the behavioural pattern of capital market in emerging economies such as MINT markets. The findings expatiated more below reveal that diversification benefits exist among the MINT economies.

In regards to answering the research questions, empirical findings suggest that return and volatility transmission exist between stock and bonds among MINT economies. Evidence from the full period shows that only Indonesia and Nigeria stock market receives past returns spillover from the bond market but the bond market does not receive past return spillover from the stock market for all economies examined. In the case of the post-crisis period, Indonesia, Nigeria and Turkey stock market received past return spillover from the bond market and interestingly, contrary to the findings of the full period analysis, Indonesia and Nigeria bond market receive past return spillover from the stock market. Also, the stock market does not receive volatility spillover from the bond market in both the full and post-crisis period but bond market receives volatility spillover from the stock market. Volatility spillover from the Mexican, Indonesian and Turkish stock market to the bond market is seen in the full period analysis but only the Indonesian and Nigerian bond market received volatility spillover from the stock market during post crisis period. A similar result was discovered in the Malaysian market (see Kim 2013). Also, Bichi, Dikko and Nagwai (2016) discovered a bi-directional volatility transmission between stock and bond return in the Nigerian market which is contrary to the finding of this research work which depicted a unidirectional volatility transmission.

With regards to nature of correlation (research question 2), empirical findings from the CCC and DCC models suggest that during full period, Nigeria, Mexico and Indonesia exhibited the low constant conditional correlation of less than 0.5 between stock and bond returns while Turkey had a relatively high constant conditional correlation which could be as a result of its sensitiveness towards world market. Also, similar findings can be seen during post-crisis period with only Turkey depicting a high constant conditional correlation. The MINT economies

during full and post-crisis period depict a time varying conditional correlation with the sum of the DCC GARCH parameters close to 1 or unity with the exception of Nigeria during full period. A graphical presentation further confirms the finding of the DCC model which depicts a correlation between stock and bond that fluctuated substantially, thus displaying persistent behaviour (see appendix III).

Furthermore, to answer research question 3, the ADCC GARCH model indicates asymmetric effects among MINT economies whereby both conditional correlation and variance respond to negative shock than positive shock of equal magnitude i.e. both assets respond more to bad news than good news. The Mexican and Indonesian stock returns shows higher asymmetries while the Nigerian and Turkish bond return shows higher asymmetries during full period. During the post-crisis period, the findings were slightly similar with the exception of Indonesian bond return having a higher asymmetry in comparison to stock return. These results on conditional correlation are in line with previous findings on both developed and emerging market (See Chiang & Li 2009; Saleem 2011; Padji & Lagesh 2010).

As previously stated in the introduction, stock and bond are basically the most traded assets in most capital markets and major components of financial portfolio. It is important for investors to diversify their portfolio because in the long run, portfolio diversification can aid in risk reduction. To answer research question 4, during full period and post-crisis periods, findings show evidence of stock-bond volatility transmission, dynamic correlation and asymmetries among the MINT markets and as such, diversification benefit can be derived. The existence of asymmetric effect among the MINT capital markets suggests that bad news have great impact on different assets than good news and investors should design and manage trading strategies so as to manage their portfolios. Also, it is necessary to note that since emerging markets share similar characteristics, findings from this study can be applied to other emerging markets. For further research, it would be interesting to incorporate other asset classes in volatility transmission and conditional correlation analysis. Furthermore, the research can be extended by incorporating portfolio analysis and asset allocation strategies in MINT economies.

The findings also give implications for risk management and diversification. Portfolio managers and investors should take into cognisance volatility, correlation, asymmetric effect and feedback when portfolio is formed that comprises of assets from emerging markets.

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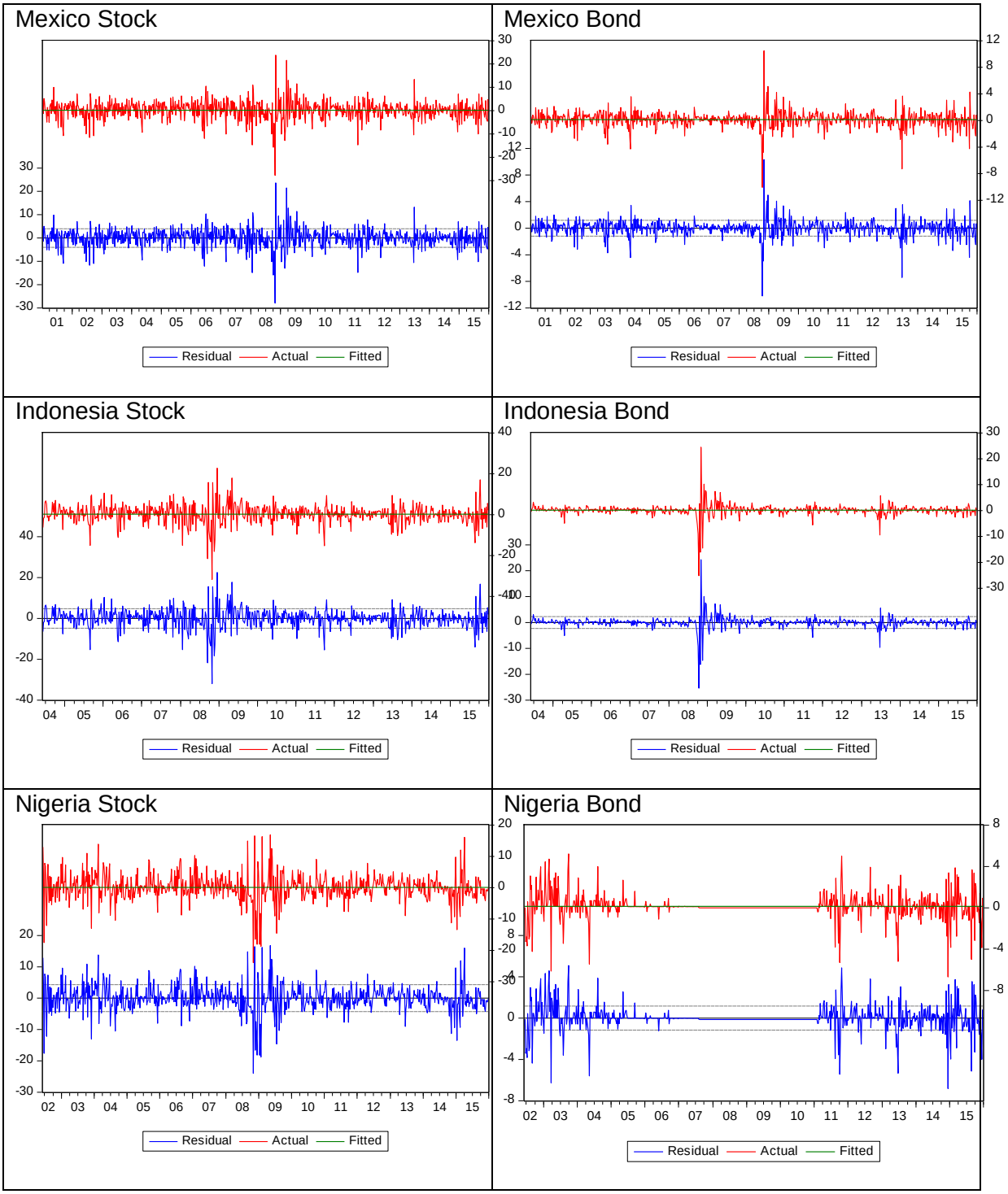
APPENDIX I: Descriptive Statistics

Table 12: Descriptive statistics for post-crisis period

	Asset	Mean	Standard Deviation	Skewness	Kurtosis	Jarque-Bera	Prob.	Obs.
Mexico	Stock	-0.07	3.22	-0.33	5.63	39.31	0.00	260
	Bond	0.08	1.15	-1.01	6.18	10.38	0.00	260
Indonesia	Stock	-0.09	3.83	-0.26	5.83	90.28	0.00	260
	Bond	0.83	1.36	-1.37	13.65	1311.67	0.00	260
Nigeria	Stock	-0.08	3.25	0.16	7.04	178.72	0.00	260
	Bond	0.10	1.43	-0.76	7.12	210.30	0.00	260
Turkey	Stock	-0.20	4.77	-0.53	4.44	34.93	0.00	260
	Bond	0.09	1.51	-1.49	19.93	2201.32	0.00	260

APPENDIX II: Volatility Clustering



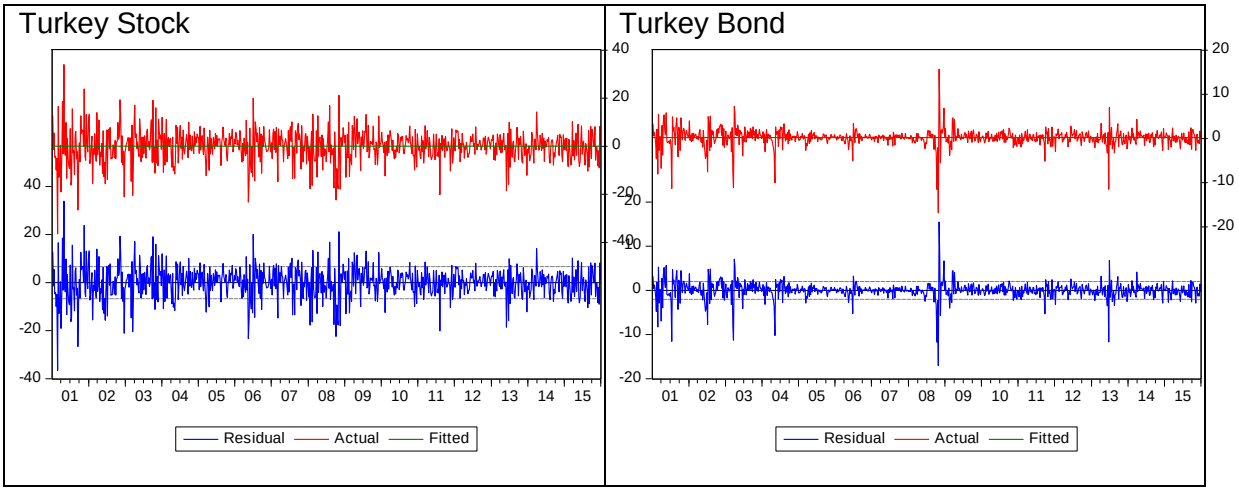


Figure 5: Volatility clustering in the MINT stock and bond market

APPENDIX III: Conditional Correlation between Stock and Bond in the MINT Economies

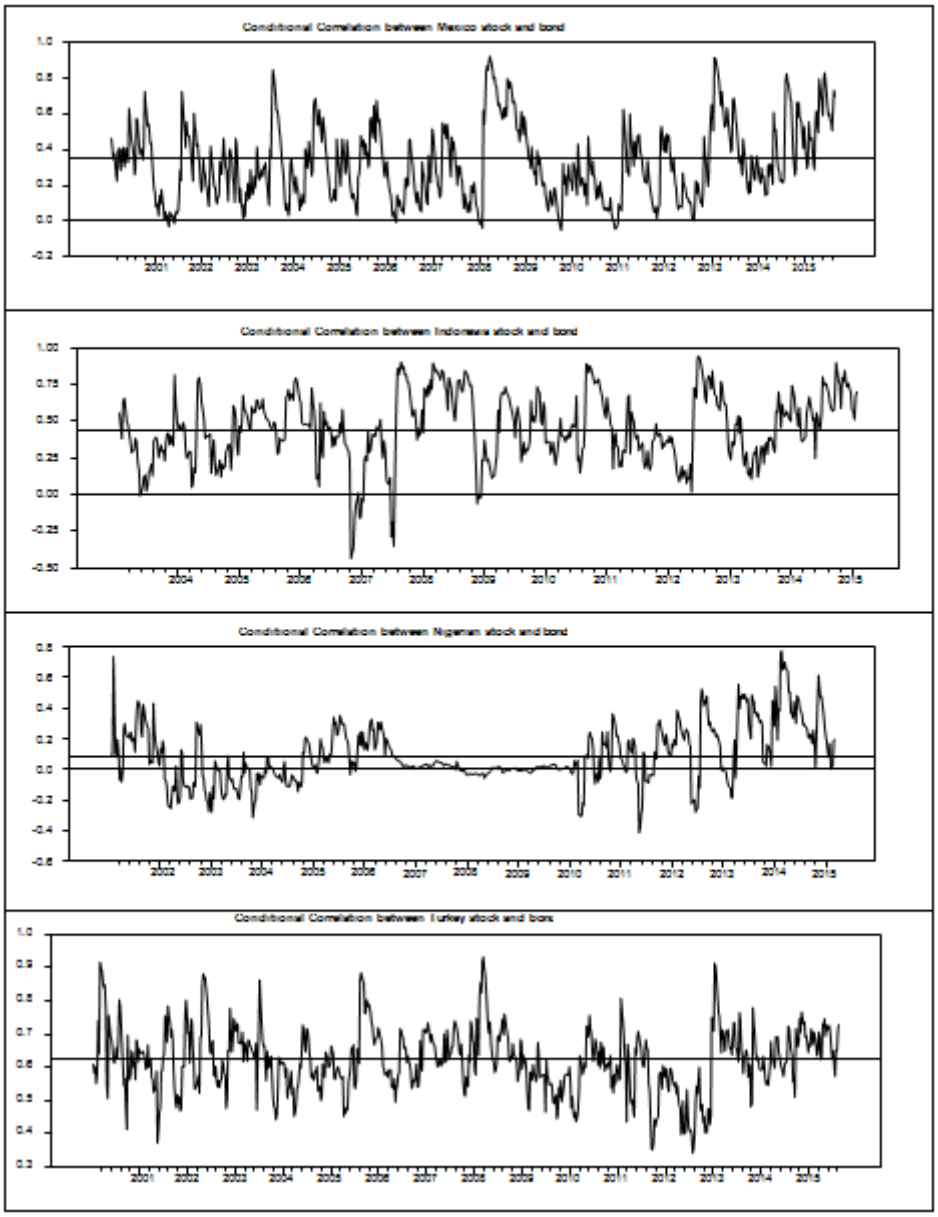


Figure 6: Conditional correlation for full sample period

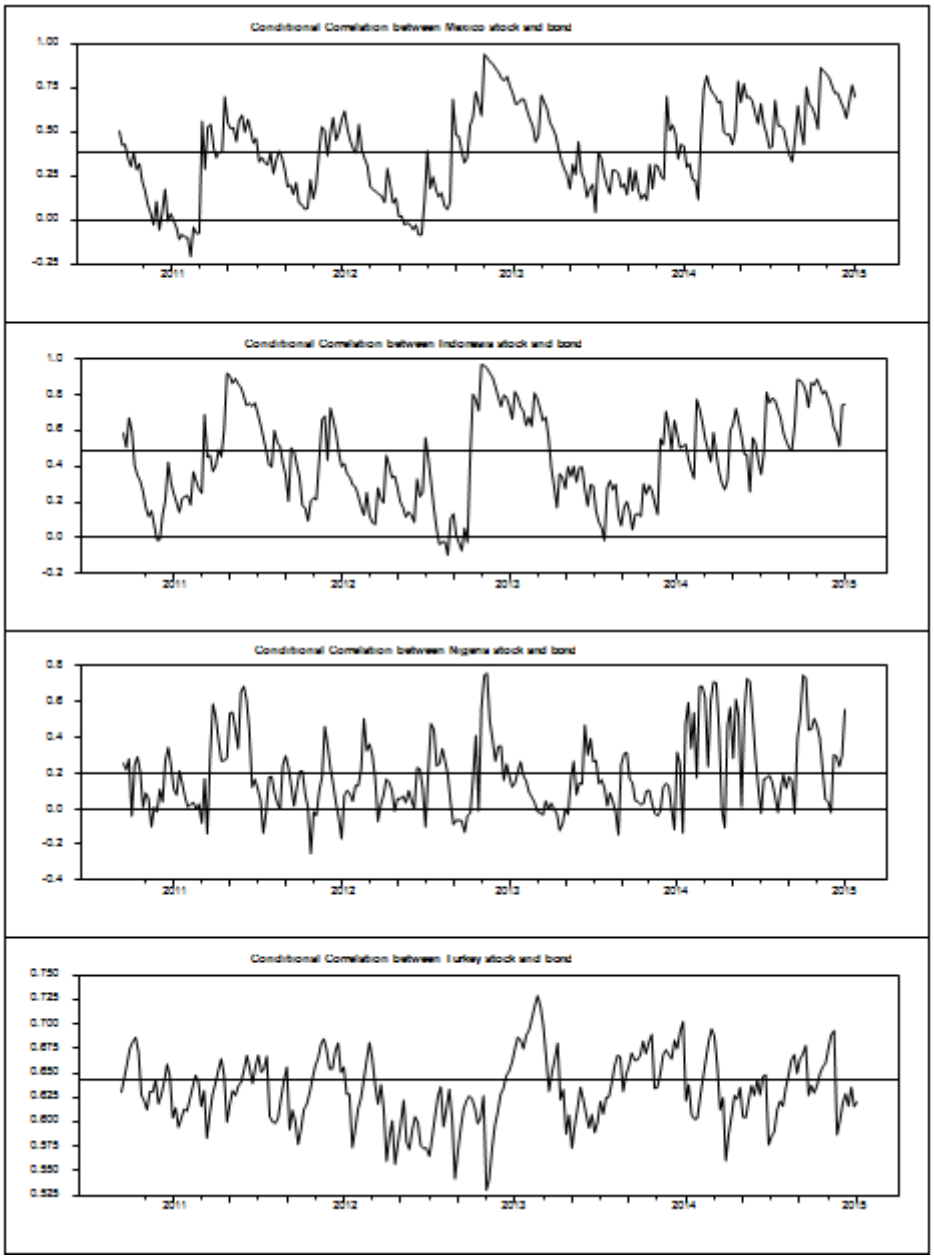


Figure 7: Conditional correlation for post-crisis period