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# Volatility transmission in the Nigerian financial market

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**Abstract**

This paper examines the return and volatility spillovers in the Nigerian Financial market. We specifically analyse the spillovers in the capital market, money market and foreign exchange market utilizing monthly data for the period January 2002 to June 2017. The paper employs the Diebold and Yilmaz (DY hereafter) (2009, 2012) approach to compute the total spillover, directional spillover, and net spillover indexes. We also consider the rolling window analyses to capture the secular and cyclical movement in the financial markets over the period of consideration. The paper observes weak degree of interdependence as well as cross-market spillovers among the financial instruments.

The stock market is the largest net receiver and sender of return spillovers to other markets, while the foreign exchange market is the net giver of volatility spillovers followed by the money market, and the stock market is the net recipient. In addition, return spillovers unveils slight trends and bursts while volatility spillovers show significant bursts but no trends. Concomitantly, the significant burst was attributed to the removal of currency peg in 2016 by the Central Bank of Nigeria. Our results are robust to the different VAR lag structure.



## 1. Introduction

Modelling integration and spillovers of financial markets is increasingly gaining the attention of financial analysts, investors and policy makers globally who emphasize the relevance of inter-linkages of world markets as well unanticipated contagion effects to respective market agents. The reason for this development are quite obvious and can be traced to past events that have affected the behaviour and performance of markets across the globe: (i) the stock market crumple of October 1987 (ii) the 1992 European exchange rate mechanism crisis and (iii) the most recent global financial crisis of 2007-08. These developments have signalled different transmission of financial contagion from develop to emerging markets. The issues of financial markets volatility transmission and their spread across markets have received sizeable attention in the literature. This has been strengthened over time by the new regulatory

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challenge in securing financial stability and introduction of new technologies that have supported the development of new market structures and practices (see inter alia,[8]).

This paper contributes to the literature on spillovers and interdependence across financial markets by conducting an empirical analysis of return and volatility spillovers in the Nigerian financial markets. The Nigerian financial market faces risk of the global recession as well as the volatility of the financial assets, which further increases during any financial crises due to the exposure of emerging economies to shocks in financial assets. For example, the Nigerian economy was exposed to the global financial crisis and other crises due to over-dependence on crude oil for foreign exchange earnings and revenue, and the crisis impacted all the sectors of the Nigerian economy from the financial to the real economy. The global financial crisis had an impact on different countries' capital market, banking sector, foreign exchange and balance of payments, as well as the real sector.

However, volatility in the financial market can be as a result of variation of time in perception to risk or deviation of prices from their fundamental value. When volatility in financial asset trigger a rise in cost of capital, it is capable of affecting economic growth negatively. This has implication for portfolio allocation, asset pricing and market risk measure.[11] Duncan and Kabundun[7] define volatility spillover as the share of total variability in one asset class attributable to volatility surprises in another asset class. The phenomenon of spillovers occurs when spillovers in one market triggers fluctuations in other markets. This effect can be particularly visible during periods of instability which diminishes the benefits of international portfolio diversification for investors.[18]

A common problem plaguing the low and slow growth of development economies is the lack of depth knowledge of the financial sector. Financial markets play an important role in the process of economic growth and development by facilitating savings and channeling funds from savers to investors, the problem of high instability of the financial sector has adversely affected proper functioning of the market.[12] There has been a good number of empirical studies that analyzed volatility transmission across countries, financial markets and sectors of financial markets[1,2,9,13,16,18] in both advance and emerging markets.

Recently, the volatility of the Nigerian stock exchange has been of concern to investor, analyst, brokers, dealers, regulators, and a central issue for economists, who accentuate the importance of market linkages, returns and volatility transmission to policy makers and market participants. The understanding of uncertainty in the Nigerian financial market due to the variation in time or deviation of prices of financial asset from the fundamental value is of importance to investors as it determines their level of confidence in such economy. For instance, the stock exchange market closed with a negative turnover in the year 2016, to sustain its negative turnover posture. The market volume and value turnover declined by 6.86% and 40.23% to close at 86.21 billion units and N566.24 billion as volume and value traded in the year, respectively. The unimpressive performance trend was observed when compared with a decline of 10.21% and 28.9% recorded in volume and value added for the year 2015, respectively. The market net worth maintained a steady decline pattern, posing N603.65 billion loss for the year against N1.63 trillion loss recorded in 2015. This reflects a significant erosion of investors' confidence, the investors may decide to diversify their portfolios and invest in other financial assets such as the federal government bond where the default risk is nil.

The analysis of domestic volatility transmission in an emerging market during periods of both crisis and non-crisis contribute to a deeper understanding of cross-market linkage in general, as it is the spillover from a particular asset to other financial asset in such market which the investor will like to know in order to manage their assets correctly. Under this condition, the forecast of the rate of return of the security will not be enough information for decision making. The investor must examine the behavior of the conditional variance of the returns to estimate the riskiness of the asset at a certain period of time.[11]

Following this background, several studies have employed a variety of methods and focusing on a wide range of countries (see,[9,10,16,18] among others). These studies support the findings of international volatility spillovers in equity markets despite the fact that the studies were on different countries. Although, few studies have been done on financial market in African which concluded that regional spillovers within Africa are smaller than global ones, and hence, African markets are insulated from global crises.[16] This present study therefore contributes to the literature in the following two ways; Firstly, empirical studies have focused on either advanced economies or emerging economies or both to examine the international integration in Europe, Asia, Latin America, Africa (inter alia see,[13,16,18]). Despite the fact that some studies focused on the financial instruments in Nigeria, especially the study of return and volatility of the stock market,[4,11,14] these studies focused only on the volatility in the stock market,[11] foreign exchange market, or both[15]; Emenike[19]) and found evidence of volatility in the different markets studied. Therefore, this present study adds an important new dimension to the existing literature by examining the

returns and volatility spillovers within the Nigerian financial market as it will be capturing more financial instruments in the domestic emerging market. These financial instruments are stocks, treasury bills and foreign exchange prices.

Secondly, most empirical studies employed the use of Generalized VAR model (see,[8,10,18] Fowowe and Shuaibu[8] dealt with the dynamic interdependence and extent of integration between South African, Nigerian and international equity markets and showed that South African markets is more integrated with international market than the Nigerian market and the lowest spillover between Nigerian and South African markets. Greenwood-Nimmo et al.[10] studied the extent of connectedness among G10 currencies and accentuated that cross-currency spillovers of volatility and especially of skewness increase in times of stress, reflecting greater systematic risk. Yaravaya et al.[18] evaluated the intra and inter regional return and volatility spillover across emerging and developed market in 10 developed and 11 emerging markets using evidence from stock indices and stock index future and found that the spillover between emerging and developed are weaker than between developed markets. Palakkod[13] employed ARCH-GARCH framework to analyze the volatility spillover on the capital, currency and commodity market in India and found that there is volatility spillover from currency markets and commodity markets to capital markets. Likewise, the volatility spillover from capital market to currency markets and there is no spillover from commodity market to currency markets. In case of commodity market there is no evidence of volatility spillover. Thuraisany et al.[17] adopted the use of Bivariate GARCH model to study the relationship between Asian equity and commodity futures markets and suggested that stock markets in the region have heterogeneous responses to commodity market volatility shocks. Vector Error Correction Model (VECM) and the Bivariate ECM-EGARCH model was employed by Srinvasan and Ibrahim (2012)[20] to examine price discovery and asymmetric volatility spillovers in Indian Spot-Futures Gold Markets and found that the spillovers of certain information take place from spot market to futures market and the spot market of gold have the capability to expose the all new information through the channel of its new innovation. Aboura and Chevallier[1] used asymmetric DCC with one exogenous variable (ADCCX) to determine the Cross-Market Spillovers with 'Volatility Surprise' and emphasized that indeed that the traditional asset markets (equities, bonds, FX) as well as commodities are mutually sensitive to each other's volatilities across our model estimates. Salisu and Oloko[15] used variants of the VARMA-AMGARCH model to capture the foreign exchange (FX) and stock markets nexus in Nigeria and discovered that volatility persistence in the stock market is accentuated by bad news in the market and moderated by good news in the FX market. These studies have not dealt with the spillovers effect of the variable used. These studies were only able to indicate the dynamic relationship but not the total and directional volatility spillovers using the generalized autoregressive framework in which the forecast error variance decomposition is invariant to variable ordering.[6] Therefore, this paper employs the measure of spillovers of Diebold and Yilmaz[5,6] which facilitates the assessment of both the total and net contribution of one financial instrument in the information transmission mechanism to another financial instrument.

Employing this measure has a number of advantages over other methods because it is not only used to measure the magnitude of volatility spillover, but it also indicates the direction of spillovers.[3] The DY framework (2009) introduced a volatility spillover measure based on forecast error variance decompositions from Vector autoregressive (VARs) which is used to measure spillovers in returns and volatility across individual assets of stocks, treasury bills and foreign exchange in Nigeria revealing spillover trends, cycles, bursts, etc. It is used to get the direction of volatility spillovers across the financial assets in Nigeria.

The rest of the paper is organised as follows. In section 2, the Diebold and Yilmaz[6] approach is illustrated for the computation of return and volatility spillovers. The preliminary analyses involving descriptive statistics and graphical illustrations are provided in section 3. In section 4, the spillover tables are presented and discussed while rolling window analyses are rendered in section 5 to add to the spillover tables. Thereafter, some robustness checks are carried out in section 6 and the study is concluded in section 7.

## 2. The Diebold-Yilmaz[6] framework

This study employs the Diebold and Yilmaz[5,6] framework to model the returns and volatility spillovers in the Nigerian Financial market. This methodology employed, indicate the total and directional volatility spillovers using the generalized autoregressive framework in which the forecast error variance decompositions are invariant to variable ordering.

The underlying framework for the spillover analysis is the Generalized Vector autoregressive (VAR) model of KPSS which is invariant to variable ordering. Essentially, four different spillover types can be generated using the Diebold and Yilmaz[6] and they are Total Spillovers, Directional Spillovers, Net Spillovers and Net Pairwise Spillovers. In setting up the spillover indexes, a covariance stationary VAR (ρ) is considered (see pages 159−160 of[5] and pages 58−59 of[6]

$$r_t = \Phi r_{t-1} + \varepsilon_t;\ \varepsilon_t \sim \left(0, \sum\right) \tag{1}$$

where $r_t = (r_{1t}, r_{2t,.....,} r_{Nt})$ is an $N \times 1$ vector of return/volatility series, $\Phi$ is an $N \times N$ matrix of parameters, $\varepsilon_t$ is a vector of independently and identically distributed disturbances and $\sum$ is the variance matrix for the error vector $\varepsilon$. The moving average representation can be written as:

$$r_t = \sum\nolimits_{i=0}^{\infty} A_i \varepsilon_{t-1} \tag{2}$$

where $A_i$ is assumed to obey the recursion $A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + ... + \Phi_p A_{i-p}$. $A_0$ is an identity matrix with an $N \times N$ dimension and $A_i = 0$ for $i < 0$. Equation (2) forms the basis for the derivation of variance decompositions required to determine the spillover indexes. Before providing the representations for the various indexes, the following preliminary considerations are important:

1. Own variance shares are defined as the fractions of the H-step-ahead error variances in forecasting $r_i$ *that* are due to shocks to $r_i$, for $i = 1, 2....N$.
2. Cross variance shares or spillovers are defined as the fractions of the H-step ahead error variances in forecasting $r_i$ that are due to shocks to $r_j$, for $i, j = 1, 2, ...., N$ .for such that $i \neq j$.
3. Based on the generalized VAR framework of KPPS, $H$ -step-ahead forecast error variance decompositions denoted by $\theta_{ij}^{g}$ is written as:

$$\theta_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} \left(e_i' A_h \sum e_j\right)^2}{\sum_{h=0}^{H-1} \left(e_i' A_h \sum A_h' e_i\right)} \tag{3}$$

where $\sigma_{jj}$ is the standard deviation of $\varepsilon$ for the *jth* equation and $e_i$ is the selection vector, with one as the *ith* element and zeros otherwise.

4 Since the sum of the contributions to the variance of the forecast error is not equal to one − that is $\sum_{j=i}^{N} \theta_{ij}^{g}(H) \neq 1$ ; Diebold and Yilmaz[6] normalized each entry of the variance decomposition matrix by the row sum in order to use the full information of the matrix. The normalized KPPS $H$ -step-ahead forecast error variance decompositions represented by $\tilde{\theta}_{ij}^{g}(H)$ is expressed as:

$$\tilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N} \theta_{ij}^{g}(N)} \tag{4}$$

where $\sum_{j=1}^{N} \tilde{\theta}_{ij}^{g}(H) = 1$ and $\sum_{1,j=1}^{N} \tilde{\theta}_{ij}^{g}(H) = N$ by construction.

Given these preliminaries, the total spillover index is written as:

$$S^{g}(H) = \frac{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H)}{\sum_{1,j=1}^{N} \tilde{\theta}_{ij}^{g}(H)} \times 100 = \frac{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H)}{N} \times 100 \tag{5}$$

All the parameters in equation (5) have been previously defined. Essentially, equation (5) measures the contribution of spillovers of return/volatility shocks across the assets under consideration. In our case, the total spillover index

captures the contribution of spillovers of return/volatility shocks across the three (3) financial market to the total forecast error variance.

Also, it is possible to assess quantitatively the direction of spillovers across the three financial markets using the Diebold and Yilmaz[6] approach. These directional spillovers are classified into two namely '*Directional Spillover To' and 'Directional Spillover From'*. The former measures the directional spillovers whether return or volatility transmitted by market *i* to all other markets *j* while the latter relates to return or volatility received by market *i* from all other markets *j*. The index for the computation of '*Directional Spillover To'* denoted by $S^g_{\cdot i}$ is given as:

$$S^g_{\cdot i}(H) = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{N} \tilde{\theta}^g_{ji}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}^g_{ji}(H)} \times 100 = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{N} \tilde{\theta}^g_{ji}(H)}{N} \times 100 \tag{6}$$

Also, the *'Directional Spillover From'* denoted as $S^g_{i\cdot}$ is measured using the index given below:

$$S^g_{i\cdot}(H) = \frac{\sum_{\substack{i=j \\ i\neq j}}^{N} \tilde{\theta}^g_{ij}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}^g_{ij}(H)} \times 100 = \frac{\sum_{\substack{i=j \\ i\neq j}}^{N} \tilde{\theta}^g_{ij}(H)}{N} \times 100 \tag{7}$$

Equally, the Net Spillovers can be obtained using the index expressed below:

$$S^g_i(H) = S^g_{\cdot i}(H) - S^g_{i\cdot}(H). \tag{8}$$

Equation (8) gives the difference between the gross return/volatility shocks transmitted to and received from all other markers. In other words, information about each market's contribution to the return/volatility of other markers can be obtained through the net spillovers.

To examine the net pairwise volatility spillover between markets *i* and *j*, we compute the difference between the gross volatility shocks transmitted from market *i* to market *j* and those transmitted from *j* to *i*:

$$S^g_{ij}(H) = \left[ \frac{\tilde{\theta}^g_{ji}(H)}{\sum_{i,k=1}^{N} \tilde{\theta}^g_{ik}(H)} - \frac{\tilde{\theta}^g_{ij}(H)}{\sum_{j,k=1}^{N} \tilde{\theta}^g_{jk}(H)} \right] \cdot 100 = \left[ \frac{\tilde{\theta}^g_{ji}(H) - \tilde{\theta}^g_{ij}(H)}{N} \right] \cdot 100 \tag{9}$$

## 3. Data and preliminary analyses

This paper considers monthly data on stocks prices (SP), treasury bills (TB) and foreign exchange rate (EXR) from January 2002 to June 2017. The data on treasury bill and foreign exchange rate are obtained from International Financial Statistics (IFS) while that stocks price is obtained from the Securities and Exchange Commission (SEC). This study uses 91-days treasury bills to represent treasury bills, All-Shares Index to represent stocks and Naira to USD to represent foreign exchange for modelling the returns and volatility spillovers in the Nigerian Financial market.

The choice of All-Share index as a proxy for stock prices is made due to the fact that it reflects the major capital market activity in the financial market which is the major indicator of stock prices. This study further includes Treasury bills which is the 91-days Treasury bill is usually measured in percentage (%) to characterise the behaviour of the money market. As regards the definition of foreign exchange rate it is measured in Naira (₦) per US dollar ($), meaning that an increasing in exchange rate refers to a depreciation in the Naira while a decrease means appreciation of the Naira. The returns of the series ($r_t$) are computed as the first difference of the natural logarithm of the level series ($P_t$); this is expressed in equation below:

$$r_t = (\Delta \log(P_t))^*100$$

where $r_t$ represents the calculated market returns, is the level of returns to each market, and is the first difference lag operator. Meanwhile, the volatility series is obtained from the estimation of GARCH (1,1) model

$$\left(\hat{\sigma}^2 = \hat{\omega} + \hat{\alpha}\, \hat{v}_{t+1}^2 + \hat{\beta}\, \hat{\sigma}_{t-1}^2\right)$$

A statistical analysis of returns and volatilities of the considered financial markets is rendered here in order to elicit their statistical properties. In this research, monthly data is adopted over a sixteen-year period from 01/01/2002 to 30/06/2017 using 185 data points. The summary statistics for the two series are Returns and Volatility series are illustrated below.

The description in Table 1 shows that mean which is the average returns of SP, TB and EXR over the considered time period are 0.61%, −0.24% and ₦0.53. Therefore, on an average only stock returns and Exchange rate returns have positive returns while treasury bills return is negative with an average of −0.24%. Intuitively, the returns of stock prices and exchange rate are positive because they both increase over time while the returns on treasury bills does not increase only discount is given to investors in this short-term investment, more so, the profit made in this money market is riskless. Therefore, this backs up the intuition that the risker the business, the higher the level of returns.

Table 1 also indicate that the maximum returns obtainable values of these return series (i.e. SP, TB and EXR) given the values of the return series from January 2002 to June 2017 are 32.35%, 117.83% and ₦23.98 which coincided with May 2009, November 2005 and July 2016 respectively. On the other hand, the minimum returns values of the stated return series are −36.59%,−80.66% and -₦3.4 which coincided with January 2009, March 2010 and December 2007 respective periods. In the light of 2008 financial crisis, the stock prices crashed at the end of 2008 through to the beginning of 2009 evident in January 2009. The stock market was saved by the intervention of the government as well as the apex bank through the pumping of money into circulation which revitalized the Nigerian Stock market and increased the returns in May 2009.

The maximum returns for treasury bills in November 2005 was as a result of the huge amount of treasury bills that was issued by the Central Bank of Nigeria (CBN, thereafter) in 2005. In fact, the CBN was unable to provide enough treasury bills for banks and discount houses which reduced domestic investment in the Money market but foreign investment increased. In March 2010, the 91-days treasury bills decreased. In the case of the exchange rate of Naira to dollar, the increase in the returns on July 2016 called the Devaluation of Naira to Dollar which the Naira has been to weaken against U.S Dollars since June 2016 when the CBN scrapped the currency peg that had kept it at an artificially-high value of ₦198 per $1. As the peg was removed on June 20, the currency lost over 40% of its value against dollar as which by July 28, the currency exchange rate recorded a low of ₦322 per $1. The Exchange rate returns in December 2007 showed an appreciation of Naira to Dollar which was about ₦118.11 per $1.

The standard deviation values showed the extent at which the observations are dispersed around their respective means and the standard deviation to mean returns of SP and TB which have greater with 7.37% and 19.67% respectively suggest high coefficient of variation (i.e. high dispersion) while EXR indicate a lower dispersion since their standard deviation to mean returns of ₦2.69. This implies that the stock prices and treasury bills are greater dispersed from their mean values, hence they are more volatile based on the returns series than the exchange rate market. Intrinsically, the returns on stock prices and treasury bills vary over time.

In addition, considering the skewness statistics whose threshold value for symmetry (or normal distribution) is zero, none of the variable is exactly zero. With the skewness statistics of −0.44 for Stock returns, it implies that Stock returns is negatively skewed (since they are less than zero), Treasury Bills and Exchange rate returns are positively skewed since their skewness statistics are greater than zero with 0.92 and 5.79 respectively. On the other hand, the kurtosis value reveals that the return series of all the three financial markets are highly peaked or leptokurtic.

Table 1
Descriptive statistics of returns series.

| Statistics | SP_R | TB_R | EXR_R |
|---|---|---|---|
| Mean | 0.613 | −0.242 | 0.533 |
| Maximum | 32.351 | 117.834 | 23.981 |
| Minimum | −36.588 | −80.664 | −3.400 |
| Standard Deviation | 7.370 | 19.670 | 2.688 |
| Skewness | −0.442 | 0.923 | 5.791 |
| Kurtosis | 7.781 | 13.892 | 42.776 |
| Observation | 185 | 185 | 185 |

Source: Authors Computation

Table 2
Descriptive statistic for volatility series.

| Statistics | SP_VOL | TB_VOL | EXR_VOL |
|---|---|---|---|
| Mean | 6634751 | 2.339629 | 255.867 |
| Maximum | 5003952 | 27.15174 | 27697.76 |
| Minimum | 237087.1 | 0.371376 | 0.048 |
| Standard Deviation | 9266317 | 3.549 | 2140.270 |
| Skewness | 2.694 | 3.600 | 11.800 |
| Kurtosis | 9.948 | 19.356 | 148.840 |
| Observation | 185 | 185 | 185 |

Source: Authors Computation

From Table 2, it shows the descriptive statistics for the volatility series of all the financial markets under the whole sample period (see Fig. 1). Drawing from Fig. 2, all the three-market pairs are volatile (though some are more volatile than others) with evidence of volatility clustering, i.e., periods of high volatility are followed by periods of relatively low volatility. Also, virtually all these financial market pairs exhibit notable spikes that coincide with the global financial crisis.

The average unpredictability nature of each financial instrument is captured by the mean in Table 2. The Treasury bills volatility has the least mean volatility value while the Stock exchange market volatility has the highest mean value. In terms of deviation from the mean, the Stock exchange market has the highest values followed by the Exchange rate market while the Treasury bills volatility has the least value. Thus, the Stock exchange market is more volatile than others considering their standard deviations. In addition, all the volatility series are positively skewed and have fat tails. The Kurtosis show that all the financial markets under consideration using the volatility series are leptokurtic.

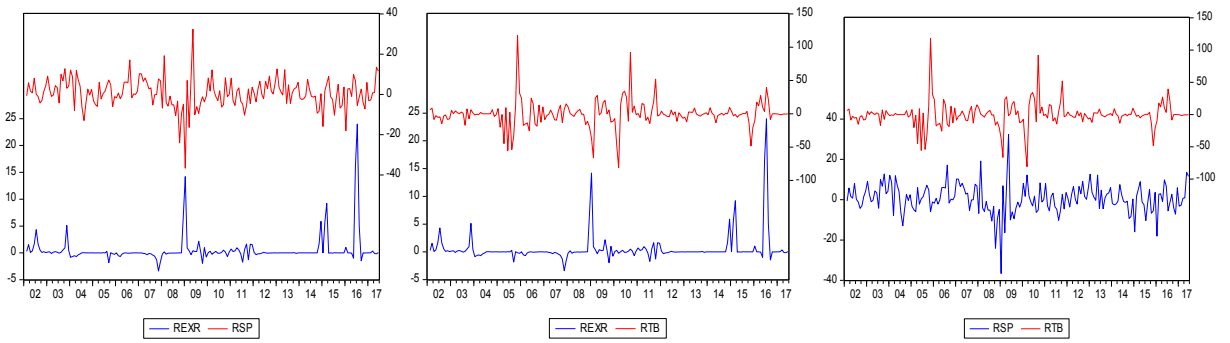


Fig. 1. Combined graph for Financial instruments levels and their returns.

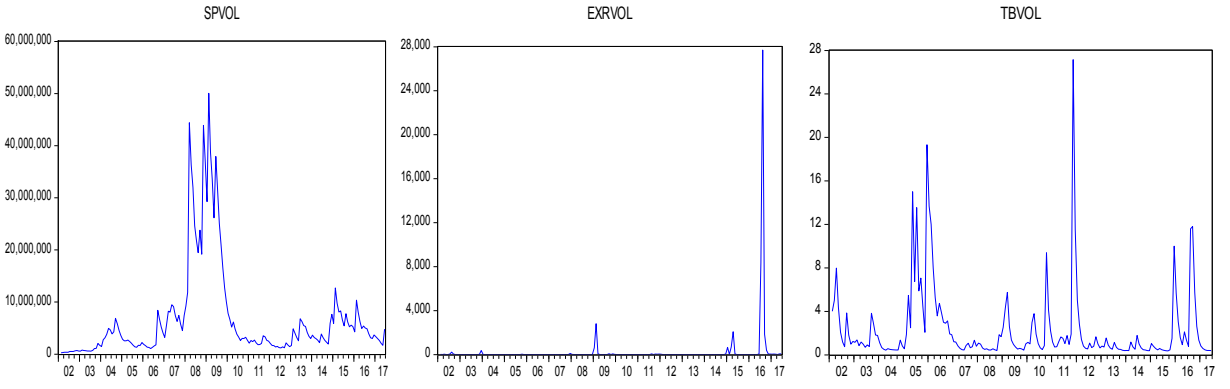


Fig. 2. Volatility graph for Markets.

## 4. Analysis of spillover tables

The Nigerian financial market is analysed based on the DY approach which is distributed into two the spillovers tables (returns spillovers and volatility spillovers) and the rolling windows analyses.

The spillovers tables show a single-fixed (scalar) value for each indices over the period of interest which is used to show the estimates of the aggregate spillovers over the period January 2002 and June 2017. However, a deeper and intuitive result can be obtained where unique events characterizing the behaviour of the spillovers are reflected in the analysis. This is the essence of the rolling window analyses. Thus, the latter complements the former as it reveals the cyclical and secular movements explaining the behaviour of the spillovers from one period to another.

The analysis of the spillover tables for both returns and volatilities of the Nigerian Financial Market are presented in Tables 3 and 4 respectively. Table 3 presents the return spillovers computed for the whole sample based on a second order 3-variable VARs with 10-stepahead forecasts. The off-diagonal column sums give the "contribution to others" while the off-diagonal row sums provide the "contribution from others". Both are directional spillovers where "Directional spillovers to" is represented by "contribution to others" while "Directional spillovers from" is denoted by "contribution from others" in both tables. Thus, each element in each column, other than the main diagonal elements, captures individual market's contribution to the forecast error variance of other markets. In the same vein, each element in each row, excluding the main diagonal elements, measures the amount of contributions of other markets to the forecast error variance of a particular market under consideration.

More precisely, "contribution to others" measures the total contribution of shocks to a particular market to the forecast error variance of other markets while "contribution from others" measures the total contribution of shocks to other markets to the forecast error variance of a particular market. In essence, the spillovers table is analogous to the input-output table as it shows how shocks are absorbed and transmitted within the system under consideration.

The net spillovers are obtained by subtracting the "contribution from others" from "contributions to others" or vice versa. In other words, the net spillovers reflect the difference between the contribution a market gives to and receives from others. Using the former definition, a positive magnitude is an indication that the market under consideration has a greater influence in other markets than the influence it receives from them. This makes the market under consideration less vulnerable to external shocks. Conversely, a negative magnitude implies that the market under examination is more vulnerable to shocks to other markets. Furthermore, the total spillover index is presented in the lower

Table 3
Return Spillovers of the financial markets in Nigeria.

| TO | FROM | | | | |
|---|---|---|---|---|---|
| | SP_R | TB_R | EXR_R | FROM OTHERS | NET SPILLOVERS |
| SP_R | **94.3** | 2.3 | 3.4 | 6 | −1 |
| TB_R | 2.4 | **97.1** | 0.4 | 3 | 0 |
| EXR_R | 3.0 | 0.4 | **96.6** | 3 | 1 |
| Contributions to others | 5 | 3 | 4 | 1 | |
| Contribution including own | 100 | 100 | 100 | **SPILLOVER INDEX = 4%** | |

The bold terms refer to variable own-shocks, coming from the concept of diagonal matrix.
Source: Authors Compilation

Table 4
Volatility spillovers of Nigerian financial market.

| TO | FROM | | | | |
|---|---|---|---|---|---|
| | SP_VOL | TB_VOL | EXR_VOL | FROM OTHERS | NET SPILLOVERS |
| SP_VOL | **98.8** | 0.9 | 0.3 | 1 | 0 |
| TB_VOL | 0.5 | **89.1** | 10.4 | 11 | −7 |
| EXR_VOL | 0.1 | 3.0 | **96.9** | 3 | 8 |
| Contributions to others | 1 | 4 | 11 | 12 | |
| Contribution including own | 99 | 93 | 108 | **SPILLOVER INDEX = 5%** | |

The bold terms refer to variable own-shocks, coming from the concept of diagonal matrix.
Source: Authors Compilation

right corner of the spillover table and it is computed by expressing the sum of "contributions to others" (or the sum of "contributions from others") as a percentage of sum of "contributions including own". This renders the various directional spillovers into a single index; therefore, it effectively captures the total spillovers transmitted among the markets under consideration.

Table 3 shows the return spillovers of the three markets which are stock exchange market (SP), the treasury bills (TB) which is representing the money market and the exchange rate market (EXR). From Table 3 above, exchange rate returns accounts for the highest contribution to the forecast error variance of the Stock exchange returns with about 3.4% followed by treasury bills with 2.3%. Therefore, the shocks to Exchange rate returns are more likely to affect the behaviour of the stock exchange market returns than shocks to treasury bills returns. Based on the aforementioned, investors would pay more cognizance to shocks in the exchange rate returns as it significantly affects the stock returns, especially investors those who are risk averse.

More interestingly, shocks to stock market have greater impact on the forecast error variance of the currency market than shocks from money market. The stock market explains about 3.0% of the forecast error variance of the exchange rate returns while distantly followed is treasury bills returns with 0.4%. Moreover, relatively smaller compared to the stock returns and exchange rate returns is the forecast error variance of the treasury bills returns which implies that it is influenced less by the shocks from other two markets. Hence, this confirms that treasury bills are make riskless in the Nigerian financial market. The stock market returns explain 2.4% of the forecast error variance followed exchange rate returns with 0.4%. Therefore, since the treasury bills has the least contribution from the other two markets then it is the least vulnerable to returns spillovers from Stock market and currency market.

Intuitively, bidirectional returns spillovers seem more evident between the currency market and stock market as well as between money market and stock market. Also, the stock market receives the highest directional contribution from others with 6%, followed by money market and currency market with the same rate of 3%. Therefore, shocks to other markets accounts for a lesser percentage of the Forecast error variance of the stock market returns, treasury bills returns and exchange rate returns than the own generated returns shocks of the markets which are 98.8%, 89.1% and 96.9% respectively.

Quite similar to the gross directional spillovers from other markets is the gross directional spillovers to other markets which showed that the shocks to the stock market returns have greater impact on exchange rate with 3.0%, followed by treasury bills with 2.4% with a total of 5% contribution to others by stock returns. Followed by Exchange rate returns with 3.4% to stock returns and 0.4% to treasury bills returns with a total of 4%. Lastly, with the least contribution to other markets is the treasury bills returns with a total of 3.0%. Therefore, the impact of stock return spillovers to other markets is significant while the contribution of treasury bills returns to other markets is minimal amongst the three markets. Treasury bills is a short-term deficit financing of the government which has zero default risk to the investor since its interest is paid upfront as discount. Substantially, in all the three markets, the Nigerian financial market is more vulnerable to returns shock of the stock market, followed by the currency market and lastly money market.

In relations to the net spillovers, the positive value was recorded for exchange rate returns with 1% and no value (0%) for treasury bills returns. Based on this, the exchange rate market is less vulnerable to shocks from the other two markets compared to the money market. The stock returns on the other hand have a negative value of −1% indicating that the stock market is more vulnerable to shocks than the other two markets. This finding further strengthens the decision that exchange rate returns have a significant effect on stock returns.

Looking at the total spillovers index, the computed value of 4% indicates a less total variance of forecast error explained by shocks across the market, whereas the remaining 96% is explained by idiosyncratic shocks. Idiosyncratic shocks in this case refers to shocks that pertain to individual markets which are internally generated shocks from the financial instruments of the markets itself, which are the highest in the three markets returns spillovers.

The distribution of the volatility spillovers differs from the returns spillovers. Unlike the returns spillovers, the directional volatility spillovers from and to other markets have greater impact except for the case of the volatility spillovers of stock market. Therefore, a small amount of returns spillovers may not imply small amount of volatility spillovers.

Nevertheless, on the basis of volatility spillovers, stock market contributions to other markets is equivalent to what it receives from other markets with the net spillovers of 0%. On the other hand, money market seems to be the most vulnerable to volatility shocks in all the markets with the net spillovers of −7%. The currency market has a positive net volatility spillovers of 8% showing it is less vulnerable to volatility shocks from all the other two markets. The

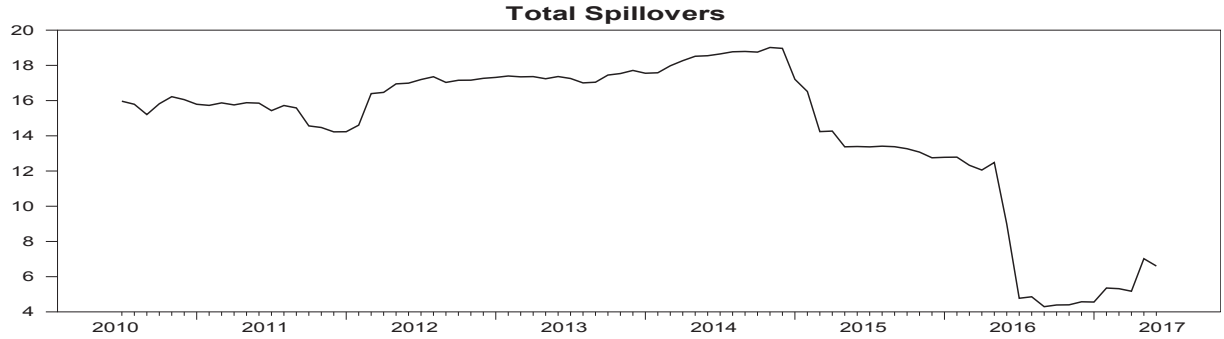


Fig. 3. Total Return Spillover Plot for the Nigerian Financial market.

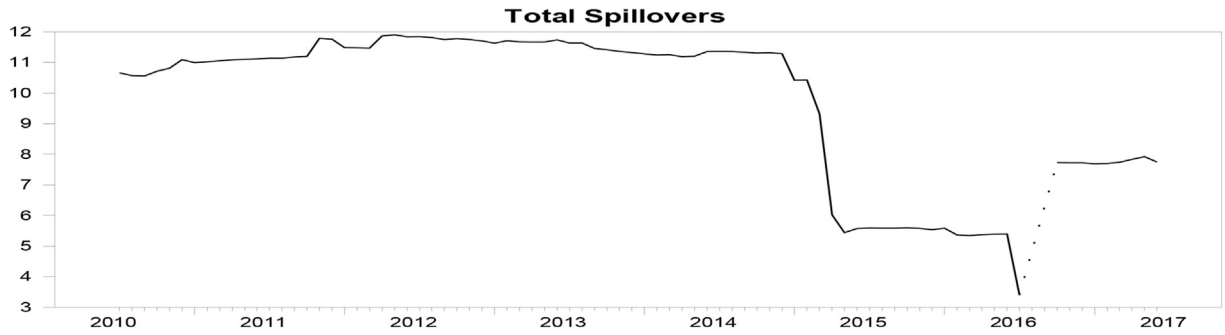


Fig. 4. Total Volatility Spillover Plot for the Nigerian Financial market.

spillover index of 5% for volatility is higher than the spillovers index of the returns. This suggests both the returns and volatility spillovers of the three financial instruments are driven by exogenous factors that are not captured in the VAR system used.

Relating to existing studies, the inclusion of the commodity market will improve its risk-adjusted return performance (see, Diebold and Yilmaz.[6] The commodity market has a significant part to play in the Nigerian financial market as it includes the sales of groundnut, cocoa, palm oil and hard commodity which are mined like oil and gold. The commodity exchange actually serves a vital role in the economy and its volatility in this market may likely have effect on the Nigerian financial market. Nevertheless, the spillover index of 4% and 5% for the returns and volatility spillovers respectively suggests some level of interdependence among the three financial instruments but not to a great extent.

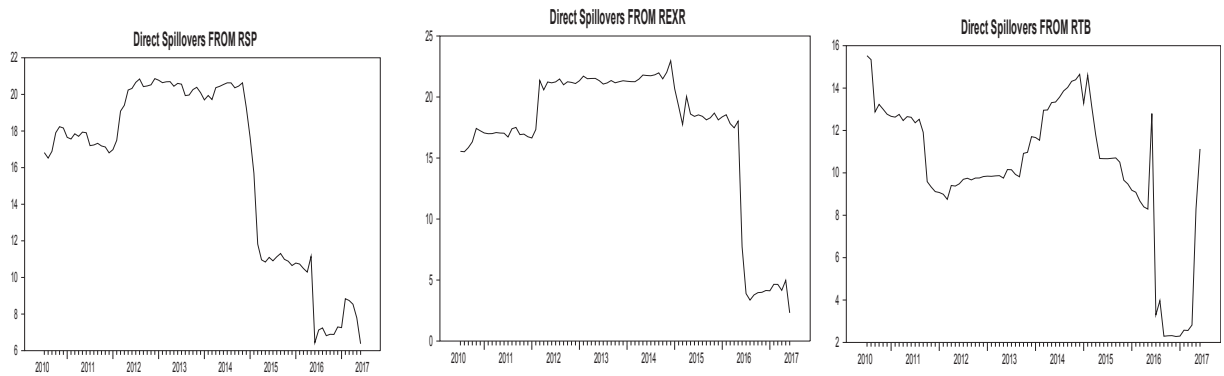


Fig. 5. Directional Returns from individual markets.

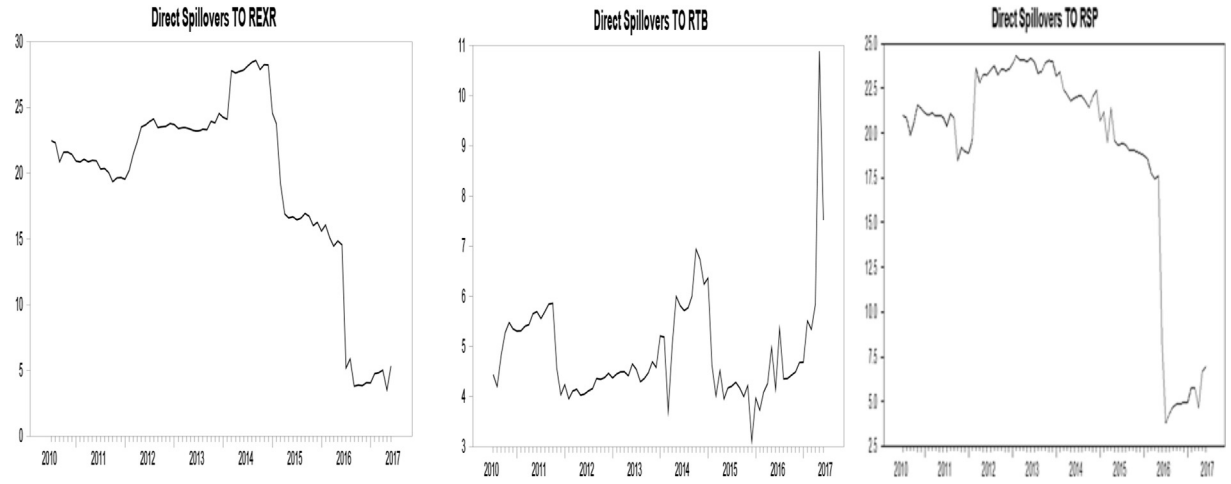


Fig. 6. Directional returns spillovers to individual markets.

## 5. Rolling-sample analysis

The returns and volatility spillovers tables represented the three financial markets "average" spillover behaviour in the Nigerian financial market, it is however insufficient in capturing important secular and cyclical in spillover.[6] Based on this, the study proposed a rolling window framework using a 100-month sub sample rolling windows in order to address these insufficiencies and properly capture events on crises episodes that may have occurred under the period of consideration.

The outcome plots for total spillover indexes for both returns and volatilities are presented in Figs. 3 and 4 respectively. Both total spillovers start at a value above 10% with returns spillover slightly higher than volatility spillover in the first window. The total return spillover plot reveals that spillover effects across the major financial instrument pairs were quite higher than volatility fluctuations between 16% and 20%with an exception in 2015−2017 where it fell the 20% mark. However, the total volatility spillover mostly varied between 10% and 12% with an important exception to 2015 down to 2017 which was prominently characterized by the economic recession era in Nigeria.

The total return and volatility spillovers steadily fell below 18% and 12% respectively from late 2014 and all through down to 2017 as the economic contracts as a result of hike in prices, increase in cash reserve requirement by

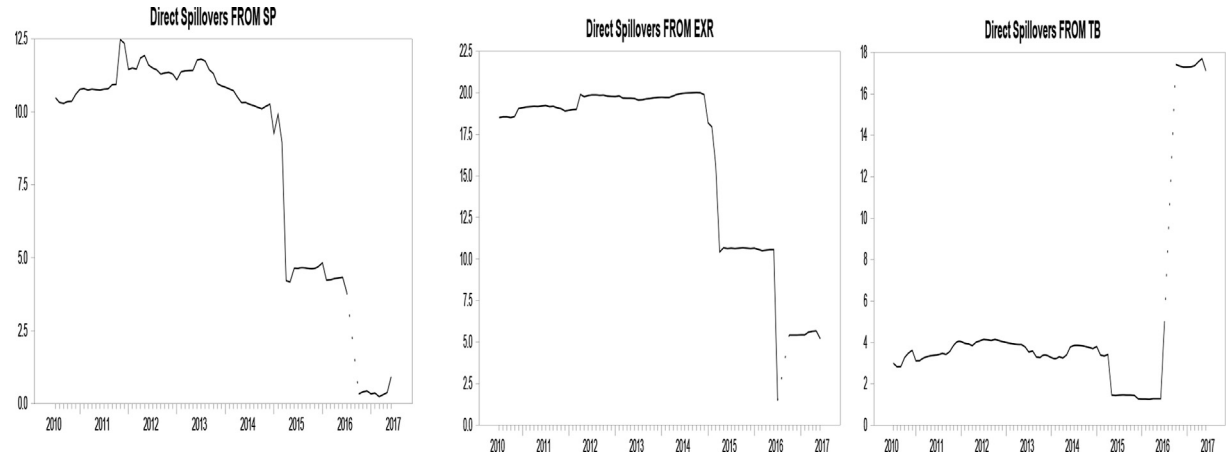


Fig. 7. Directional Volatility spillover from individual markets.

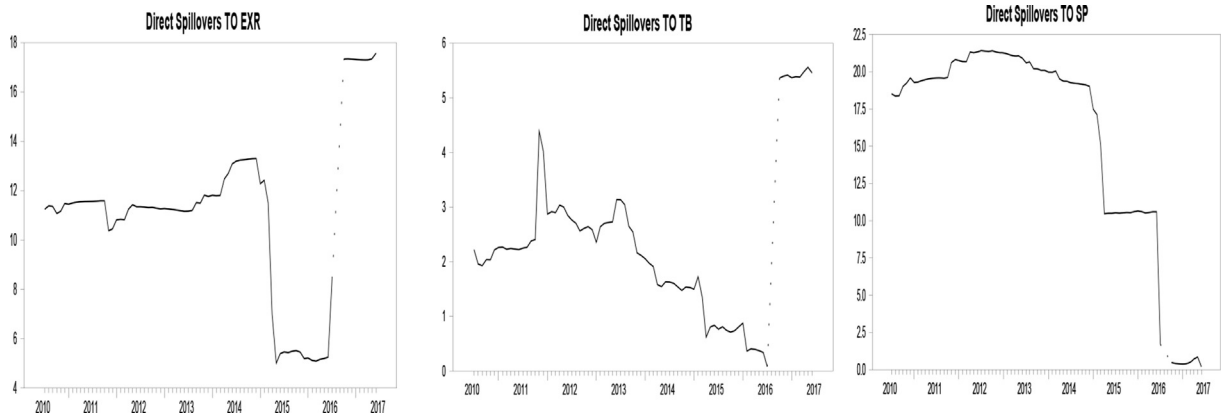


Fig. 8. Directional Volatility spillovers to other markets.

CBN as well as increase in monetary policy rate. The inability of the Naira Exchange rate to rise against other international currency, the crash in oil price, Niger Delta unrest, delay in the presentation and passage of 2016 budget as well as treasury issues are not left out on the decrease in both the total return and volatility spillovers market.

### *5.1. Directional spillovers*

After analysing total spillovers in the Nigerian financial market, it is important to examine the directional spillovers from and to others among the three financial instruments for both the returns and volatilities. The directional return spillovers to and from others seem to be different for the period under consideration (see Figs. 5 and 6). There was a sharp decline as a result of the economic recession of 2015 followed by a slight increase in 2015 for all the financial instrument. The directional spillovers to stock prices fell greatly in 2016 prior to the global financial crisis.

The investment in 2016 year remain indelible in the minds of investors in the Nigerian Stock Exchange Market just like 2008 financial meltdown. The nation's stock market in the review period experienced a major setback which eroded the investors' confidence as over ₦1 trillion drop in market capitalisation. The All-Shares Index which opened trading for the year at 28,642.25 shed about 7.53% to close trading in December 23, 2016 at 26,416.02. The market was also negatively impacted by the hike in inflation, increase in cash reserve requirement by the CBN as well as

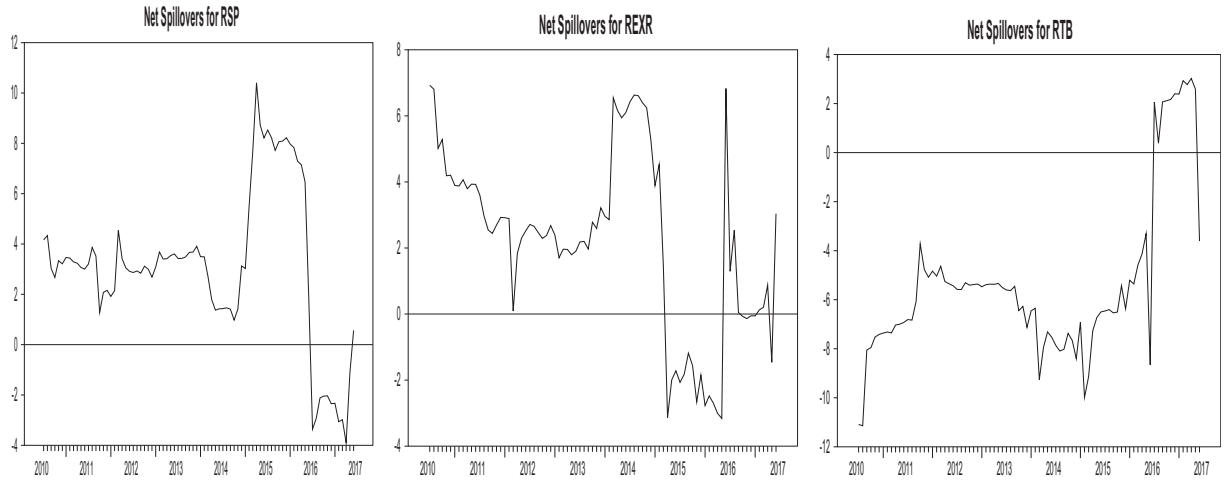


Fig. 9. Net Returns Spillover for individual markets.

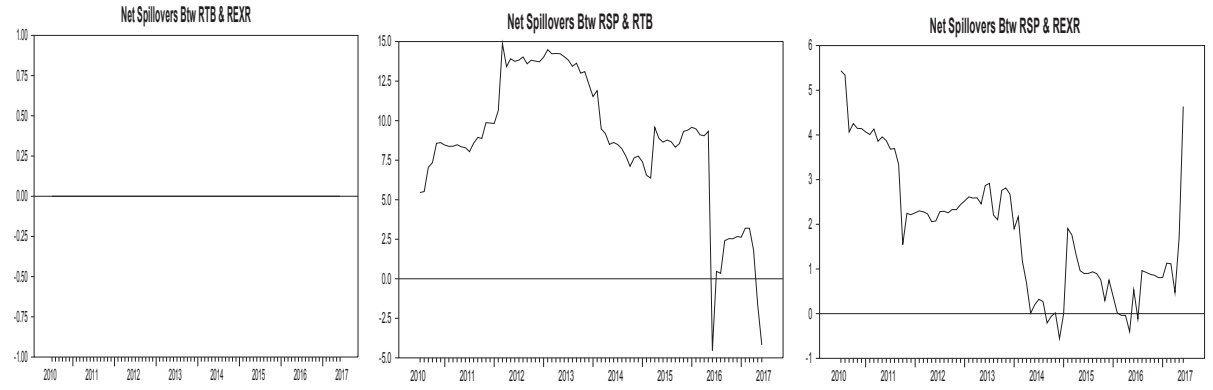


Fig. 10. Net Return Spillovers between markets.

increase in monetary policy rates. The issue of insecurity in that period was not left out as it led to significant erosion in the investors' confidence.

Based on the directional volatility spillovers presented in Figs. 7 and 8, like the directional returns spillover in 2015 and 2016, there was a fall in the movement of all financial instruments. Based on directional spillovers from the financial instruments, except for treasury bills that increased in 2016, all other financial instruments directional volatility spillover fell in 2016. In 2016, foreign investors bought ₦557 billion worth of treasury bills and demanded for ₦ 994 billion worth of treasury bills which led to huge outflow of treasury bills. However, this triggered scarcity of funds in the interbank money market prompting the cost of funds to rise over 100%. The directional volatility to other market shows that the directional spillovers to treasury bills increased in 2011 and 2016 as well as the directional spillovers to exchange rate in 2016. The directional spillovers to stock prices decreased in 2015 and further decreased in 2016 due to the economic meltdown of 2015.

### 5.2. Net spillovers

The net directional spillover effects enable the discovery of the net transmitters and receivers of spillovers and their contribution to total spillovers. Fig. 9 through to 10 present the respective net return and volatility spillovers for the financial instruments. From the figures below, the Net Return spillovers of the Stock Prices and the Exchange rate are almost mainly positive for the period 2002 to 2014, this implies that they are ultimately “net returns transmitters” for that period while the treasury bills was a “net returns recipient” between 2002 and 2014, until mid-2016 which it was positive then dropped back to being a net returns spillover receiver after mid-2017. The slight increase in net returns

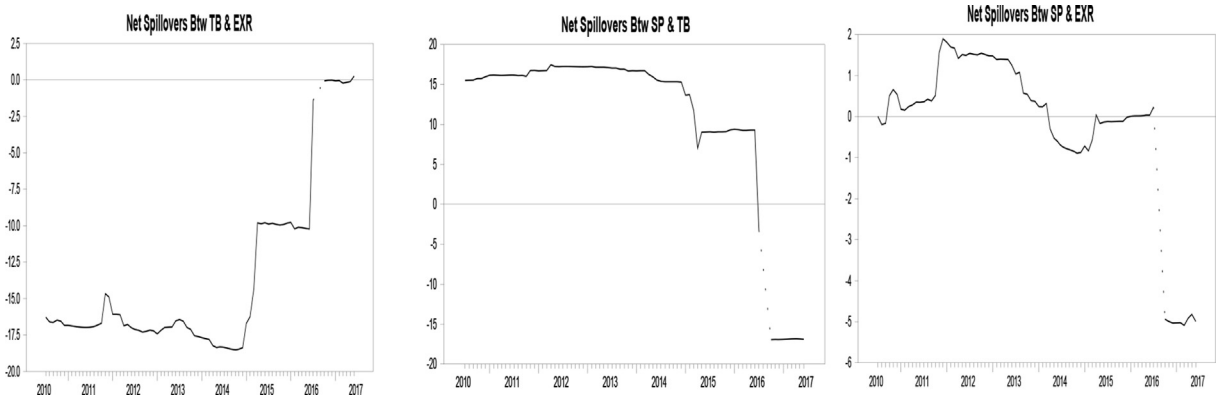


Fig. 11. Net volatility spillovers between markets.

Table 5
Return Spillovers of the financial markets in Nigeria (Quarterly data).

| TO | FROM | | | | |
|---|---|---|---|---|---|
| | SP_R | TB_R | EXR_R | FROM OTHERS | NET SPILLOVERS |
| SP_R | **68.6** | 16.8 | 14.6 | 31 | 0 |
| TB_R | 6.1 | **83** | 10.8 | 17 | 13 |
| EXR_R | 25 | 13.4 | **61.6** | 38 | −13 |
| Contributions to others | 31 | 30 | 25 | 87 | |
| Contribution including own | 100 | 113 | 87 | **SPILLOVER INDEX = 8.9%** | |

The bold terms refer to variable own-shocks, coming from the concept of diagonal matrix.
Source: Authors Computation

spillovers of Treasury bills between mid-2016 and mid-2017 can be attributed to the rise in the issuance of Treasury Bills by the government based on the fact that they decided to favour the local source of financing in the first-quarter of 2017. Intrinsically, this findings from the rolling windows sample provide more evidence to support the spillovers table as the stock market is the net receiver of returns spillover while the foreign exchange market is the net transmitter of returns spillover as it has greater shocks to returns of other financial instruments than it receives from others.

In the light of the net volatility spillover, the net volatility spillovers for the stock market was initially positive from 2002 up to mid-2016 where the value dropped drastically. From the mid- 2016, the Stock market became a net recipient of volatility spillover, while on the other hand, the currency market in that same period rose to be a net transmitter of volatility spillover as the government in June 20, removed the currency peg of Naira to Dollar allowing for the exchange rate to fluctuate freely.

In summary, the foreign exchange market has a greater influence for both the net returns and volatility in the Nigerian financial, more supposedly as a result of the removal of the pegged exchange rate in June 20, 2016. This made the Stock and money markets become a net receiver of volatility spillovers as from the second half of 2016 which is depicted in Fig. 10. The rolling windows analyses reveals substantial return and volatility spillovers for some periods than others due to some secular and cyclical events explained. These variations are not explained in the spillovers table; thus, the rolling windows analyses is important (see Fig. 11).

## 6. Robustness check

The robustness check was conducted in order to ascertain the reliability of our results. This study further assesses the robustness of the spillover models in order to determine whether the estimates are sensitive to different data sets and measurement. To do this, we carry out another round of estimation having replaced the monthly data with quarterly data sets. For the sake of space, we report only the spillover results, as given in Tables 5 and 6.

Interestingly, the spillover index for both return and volatility grossly increased to 8.9% and 9.2% respectively. However, this does not change the fact that the study observes weak degree of interdependence as well as cross-market spillovers among the financial instruments. The stock market is the largest net receiver and sender of volatility spillovers to other markets as against what was observed in the main analysis, while the treasury bills market is the net

Table 6
Volatility Spillovers of the financial markets in Nigeria (Quarterly data).

| TO | FROM | | | | |
|---|---|---|---|---|---|
| | SP_VOL | TB_VOL | EXR_VOL | FROM OTHERS | NET SPILLOVERS |
| SP_VOL | **93.9** | 4.3 | 1.9 | 6 | 5 |
| TB_VOL | 8.2 | **87** | 4.8 | 13 | −3 |
| EXR_VOL | 3.1 | 5.4 | **91.4** | 9 | −2 |
| Contributions to others | 11 | 10 | 7 | 28 | |
| Contribution including own | 105 | 97 | 98 | **SPILLOVER INDEX = 9.3%** | |

The bold terms refer to variable own-shocks, coming from the concept of diagonal matrix.
Source: Authors Computation

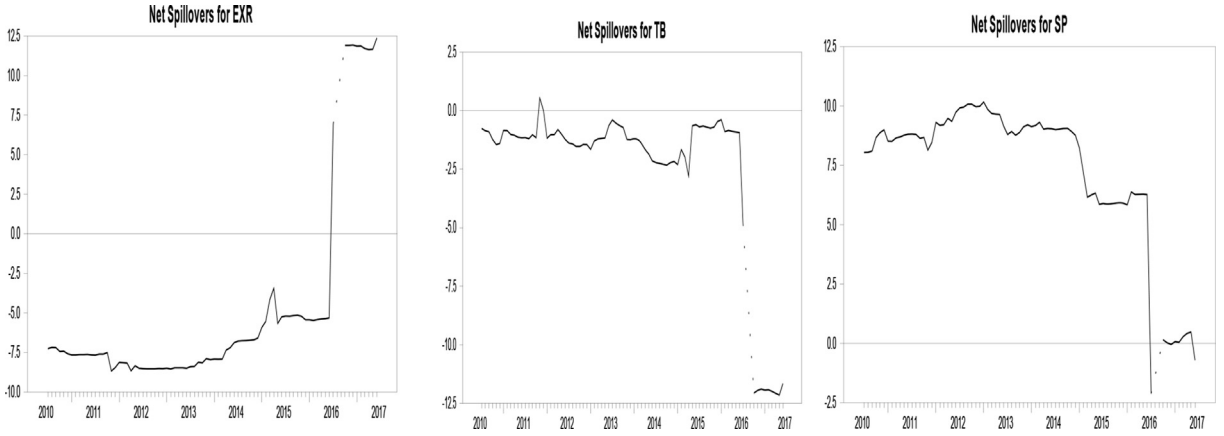


Fig. 12. Net Volatility Spillover for individual market.

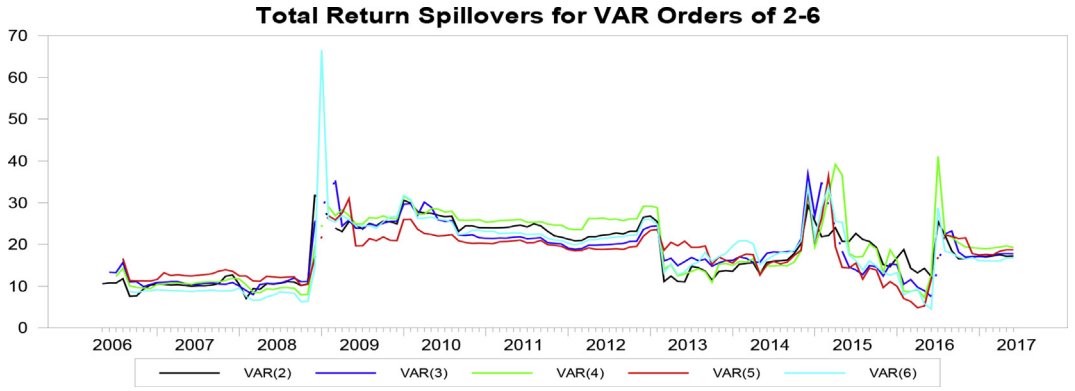


Fig. 13. Sensitivity of return & volatility spillover indexes to VAR lag structure.

giver of return. Above all, return spillovers unveils slight trends and bursts while volatility spillovers show significant bursts but no trends. These results show that these markets in Nigeria are too isolated, hence preventing reliable transmission for proper functioning of the financial sector in the country.

In addition, the study equally considers different VAR lag order to identify the sensitivity of the spillover indexes for both returns and volatilities (see Fig. 12). Consequently, considering the scenario of VAR orders of 2−6, the resulting graphs are presented in Figs. 13 and 14. As depicted in all these figures, the results for both returns and volatilities are robust to all the considered scenarios. In other words, the calculated spillover indexes for the return and

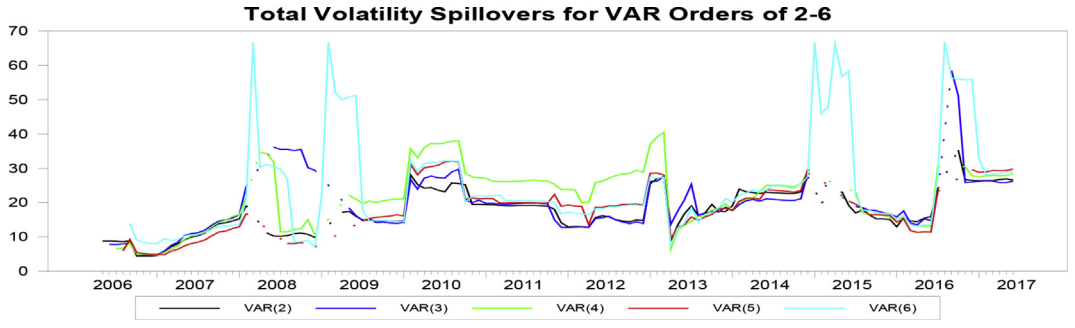


Fig. 14. Sensitivity of volatility spillover indexes to VAR lag structure.

volatility in the financial markets are not sensitive to VAR lag structure. Figs. 13 and 14 deals with VAR lag structure. Basically, the results show that regardless VAR lag, the model is well-behaved shown by the accordance of all the VAR orders from 2 to 6 of both the total return and volatility spillovers indexes.

## 7. Concluding remarks

The paper examines the returns and volatility spillovers in the Nigerian financial market utilizing monthly data for the period between January 2002 to June 2017 in other to assess the total spillovers, directional spillovers, net spillovers and gross spillovers using the novel approach of Diebold and Yilmaz[6] amongst the financial instruments. The data was obtained from International Financial Statistics (IFS) and the Securities and Exchange Commission (SEC). The variables employed in the study includes All-Shares Index (ASI) to represent the capital market (stock market), Treasury bills rate to represent the money market and exchange rate of Naira to Dollar to represent the foreign exchange market (currency market). There is evidence of fair degree of interdependence in the Nigerian financial market based on the findings in this paper, as well as the presence of cross-market spillovers. It is important to note that in this study, exchange rate returns have significant effect on the behaviour of both the stock markets returns and treasury bills returns as well as the volatility in the Nigerian financial market. The currency market gives out more shocks to other markets than it receives from other markets in terms of returns and volatility spillovers. Therefore, the foreign exchange market has greater influence on the other financial markets as it is less vulnerable to fluctuations from other markets. Practically, attention should be paid to the fluctuations in the foreign exchange market. Concomitantly, the stock market returns are more susceptible to fluctuations in the Nigerian financial market than any other market returns in relation to return spillovers. Intuitively, the stock market is more vulnerable and risky due to the fact that it can be easily influenced by the fluctuations in both the currency and money markets.

Finally, the money market is more susceptible to variations in other financial instruments as fluctuations in both the capital market and the foreign exchange market have significant influence on the treasury bills based on the volatility spillovers. More so, considering the rolling windows analyses reveals substantial return and volatility spillovers for some periods than others due to some secular and cyclical events explained which were not explained in the spillovers table. Lastly, from the VAR lag structure as well as using another set of data structure, it showed that the model is well-behaved shown by the accordance of all the VAR orders from 2 to 6 of both the total return and volatility spillovers indexes, thus the results are robust.

## Conflict of interest

There is no conflict of interest.

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