Available online at www.elixirpublishers.com (Elixir International Journal)

Finance Management

Elixir Finance 42 (2012) 6410-6414

ISSN: 2229-712X

The direction of volatility spillover between stock prices and exchange rate: evidence from Nigeria

Godwin Chigozie Okpara[1] and Joseph Chukwudi Odionye[2]
[1]Department of Banking and Finance, Abia State University Uturu – Nigeria.
[2]Department of Economics, University of Nigeria Nsukka-Nigeria.

ARTICLE INFO

Article history:
Received: 28 November 2011;
Received in revised form:
15 January 2012;
Accepted: 26 January 2012;

Keywords
Volatility Spillover,
EGARCH,
Stock Market Capitalization,
All Share Index.

ABSTRACT

The study investigates the direction of volatility spillover between exchange rate and stock prices in Nigeria using quarterly data for the period of 1990-Q_1 to 2009-Q_4. Exponential Generalized Autoregressive Conditional Heteroskedastic (EGARCH) framework due to Nelson (1991) was employed. Two different stock exchange indicators were used as proxy for stock prices to test the direction of volatility spillover between the variables. Thus we have two EGARCH models. The ADF and PP tests suggest that the series are random walk processes in their level form. The empirical findings suggest evidence of no long run equilibrium relationship between exchange rate and stock prices. It further shows that there is a robust unidirectional volatility spillover running from exchange rate to stock prices irrespective of the stock market indicator used. The result supports the findings of Beer and Hebeins (2008) for industrialized countries. The estimated mean equation showed that there is instantaneous positive response of stock market volatility to exchange rate fluctuation. Evidence from variance equation revealed that volatility persists longer when SMC was used as proxy for stock prices than ASI. The standard deviation statistic showed that stock market indicator is positively related to risk, validating the capital asset market hypothesis.

Introduction

The recent emergence of new capital markets, the relaxation of foreign capital controls and the adoption of more flexible exchange rate regimes have increased the interest of academics and practitioners in studying the interactions between the stock and foreign exchange markets. The gradual abolition of foreign exchange controls in emerging and developing economies has opened the possibility of international investment and portfolio diversification. At the same time, the adoption of more flexible exchange rate regimes by these countries in the late 1980s and early 1990s has increased the volatility of foreign exchange markets and the risk associated with such investments.

There is theoretical consensus neither on the existence of relationship between stock prices and exchange rates nor on the direction of the relationship. Considering flow oriented models (FOM) and stock oriented models (SOM) as two basic approaches to the exchange rate determination, a cardinal disagreement can be found. Flow Oriented Models assume that the exchange rate is determined largely by a country's current account or trade balance performance. These models posit that changes in exchange rates affect international competitiveness and trade balance, thereby influencing real economic variables such as real income and output and hence changes in stock prices (Dornbusch and Fisher, 1980). On the other hand, stock oriented models put much stress on the role of capital account in the exchange rates determination. A rise in domestic stock prices leads to the appreciation of domestic currency through direct and indirect channel. A rise in stock prices encourages investors to buy more domestic assets selling simultaneously foreign assets to obtain domestic currency indispensable for buying new domestic stocks. Described shifts in demand and supply of currencies cause domestic currency appreciation. An increase in domestic assets prices results in growth of wealth, which leads investors to increase their demand for money, which in turn raises domestic interest rates. Higher interest rates attract foreign capital inflow and initiate an increase in foreign demand for domestic currency and its subsequent appreciation (Branson, 1983; Frankel, 1983). Evidently, there is no general consensus on any definite pattern and relationship between stock prices and exchanges rates and empirical studies are inconclusive.

Most studies on the examination of the stochastic behavior of the stock prices and exchange rates, primarily employed autoregressive conditional heteroskedastic (ARCH) model of Engle (1982). Some of these studies were carried for developed and emerging economies, only few attempts have been made in developing countries like Nigeria. In addition, GARCH model has been used to study volatility spillovers between stock markets across countries and between different assets. Hamoe et al (1990) investigate the price and volatility spillover in New York, Tokyo and London stock markets. Koutmos and Booth (1995) examine asymmetric volatility spillover across the New York, Tokyo and London. . Schwert (1989) in his paper studied the relationship between stock market volatility and volatility of real and nominal Macro-economic variables and found that fluctuations in inflation and real output have weak predictive power on volatility of stock market returns. Hamilton and Lin (1996) have variously found from their study that other macroeconomic factors such as GDP growth, and short term interest rates are important explanatory variable in explaining volatility in stock market returns. Yaya and Shittu (2010) studied the impact of inflation and exchange rate on conditional

Tele:
E-mail addresses: chigoziegodwino@yahoo.com

stock market volatility in Nigeria using QGARCH and found that there is significant relationship of inflation and exchange rate to conditional stock market volatility. Beer and Hebein (2008) studied the relationship between stock prices and exchange rates using EGARCH model for developed and emerging countries. Their result showed mixed result for the two groups. This result lends support for country specification.

The recent global financial crisis, which was precipitated by the United States Mortgage crises, liberalization of global financial regulations and boom and burst in the housing market and its effect on other weaker countries like Nigeria necessitates the need for an empirical study of this nature. Evidence in Nigeria shows that between 2008 and 2009 the stock market collapsed by 70% point (Adamu,2008). This coincides with the period of global financial crisis which began in middle 2007 in United States and spread into Nigeria in 2008 (Okpara, 2010).

This paper concentrates on the direction of volatility spillover between stock market and foreign exchange market using EGARCH framework for Nigeria. The paper is organized as follows: section 1 is the forgone introduction, section 2 reviews related literature, section 3 specifies the model, section 4 presents the empirical result and discussion, and section 5 is the summary and conclusion.

Literature Review

Adjasi *et al* (2008) studied the effect of exchange rate volatility on the Ghanaian stock exchange using quarterly data with EGARCH model. The result showed a negative relationship between exchange rate volatility and stock market returns. In addition, the consumer price index had a strong positive relationship with stock market volatility. This means that increase in consumer price index which is a proxy for inflation will lead to a rise in stock market volatility.

In assessing the dynamic relationship between stock market prices and exchange rates for emerging and industrialized countries, Beer and Hebein (2008) used EGARCH model framework. The stock indices they used were S&P500, S&PTSE Composite, FTSE100, Nikei 225, Hangseng, Strait Times, Seoul composite, BSE30 and Phillipines Composite Index as proxy for individual country's stock prices while US per local currency exchange rate was used as proxy for exchange rate. They found evidence of some positive price spill over from foreign exchange rates to stock prices for Canada, Japan, the US and India but to the opposite direction for the emerging economies.

Yaya and Shittu (2010) employed Q-GARCH model to study the impact of inflation and exchange rate on conditional stock market volatility in Nigeria using monthly share indices from 1991 to 2008. The result showed that previous exchange rates and inflation rates have significant effect on conditional stock market volatility in Nigeria. They further explained that changes in exchange rates and inflation rates have greater impact in predicting stock market volatility in Nigeria.

Zhao (2010) examined the relationship between exchange rate and stock prices for China. He employed multivariate VAR and multivariate generalized autoregressive conditional Heteroskedasticity (GARCH) model using monthly data from January 1991 to June 2009. He used Shanghai Composite Stock Price Index and real exchange rate as proxies for stock prices and exchange rate respectively. The results showed that there is no stable long-run relationship between the variables. The results further showed evidence of bi-direction volatility spillovers effect between the variables.

Research Methodology

The autoregressive conditional heteroskedastic (ARCH) model introduced by Engle (1982) and generalization ARCH by Bollerslew (1986) are models widely used to measure volatility. The main drawback of these models is that it cannot capture the asymmetric response of volatility to news.

In order to capture this problem, EGARCH model is used. EGARCH model was first proposed by Nelson in (1991) to capture skewness and asymmetry. In its formulation, the conditional variance is an exponential function of the previous conditional variances and excess return. Other models that capture asymmetric effect are GJR-GARCH and Quadratic GARCH models. The good attribute of EGARCH over others mentioned is that the log form of conditional variance guarantees the variance to be positive (Hamilton, 1994).

EGARCH model is therefore stated as follows:

Model 1

$$SMP_t^1 = \alpha_1 + \alpha_2 \; SMP_{t-1}^2 + EXR_{t-1} + \ell_t \text{------------------------} (1)$$

$$\log\left(\sigma_t^2\right) = \beta_1 + \sum_{j-1}^{2} \gamma_j \log\left(\sigma_{t-j}^2\right) + \sum_{j-1}^{2} \delta_j \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} - E\frac{\left(\varepsilon_{t-1}\right)}{\sigma_{t-1}} \right| + \sum_{j=i}^{2} \theta_i \frac{\varepsilon_{t-1}}{\sigma_{i=k}} \text{-----} (2)$$

Model 2

$$SMP_t^2 = \alpha_1 + \alpha_2 SMP_{t-1}^2 + EXR_{t-1} + \ell_t \text{------------------------------------} (3)$$

$$\log\left(\sigma_t^2\right) = \beta_1 + \sum_{j-1}^{2} \gamma_j \log\left(\sigma_{t-j}^2\right) + \sum_{j-1}^{2} \delta_j \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} - E\frac{\left(\varepsilon_{t-1}\right)}{\sigma_{t-1}} \right| + \sum_{j=i}^{n} \theta_i \frac{\varepsilon_{t-1}}{\sigma_{i=k}} \text{-----------------} (4)$$

α_i, α_2, and α_3 are the parameters to be estimated. The persistent of volatility implied by equations 2 and 4 is measured by γ_j. If volatility persists over a long time, γ will be large and significant. The leverage effect is modeled by the parameter θ_i. Finally δ_j measures the size effect of an innovation.

Quarterly series data were interpolated from annual series. Data were sourced from Central Bank of Nigeria statistical bulletin (2009). The study covered the period 1990: Q_1 to 2009: Q_4

The All share Index (ASI) and Stock Market Capitalization (SMC) as the indicators of the Nigeria Stock Exchange Market performance were used as a proxy for Stock market Prices (SMP) market capitalization respectively. While, the nominal exchange rate of the Nigerian naira vis-à-vis the US dollar was used as a proxy for exchange rate (EXR). To fully explore the date generating process, we first examined the time series properties of the variables of the model using the Augmented Dickey- Fuller and Phillip- Perron test.

The ADF test regression equations with constant are represented thus:

$$\Delta SMP_T = \alpha_0 + \alpha_1 SMP_{T-1} + \sum_{j=1}^{k} a_j \Delta SMP_{T-1} + \varepsilon_T \text{.........................} (5)$$

$$\Delta EXR_T = \beta_0 + \beta_1 EXR_{T-1} + \sum_{j=1}^{k} b_j \Delta EXR_{T-1} + \varepsilon_T \text{..................} (6)$$

where Δ is the first difference operator, ε_T is random error term that is iid, k = no of lagged differences

In equations (5) and (6), the null hypothesis holds as:Ho: $\alpha_i = \beta_i = 1$ (unit root), H1: $\alpha_i \neq \beta_i \neq \; < 1$ (level stationary) The Johanson (1988) co-integration procedure was employed to determine the number of co-integrating vectors. This approach was chosen because it does not suffer normalization problem and it is robust to departure from normality (Gujarati, 2003). The procedure requires all series in the model to exhibit same order of integration. The Johansen co-integration test is given as:

$$Y_t = A_1Y_{t-1} + \ldots + A_p Y_{t-p} + BX_t + \varepsilon_T \ldots \quad (7)$$

Where Y_t is a vector of non stationary I(1) variables; X_t is a vector of deterministic variables and ε_T is a vector of innovations. We may rewrite this as in VAR form as:

$$\Delta Y_t = \pi Y_{t-1} + \sum_{i=1}^{p-1} \delta_i Y_{t-p} A_p Y_{t-p} + BX_t + \varepsilon_t \ldots (8)$$

where

$$\pi = \sum_{i=1}^{p} A_i - 1, \quad \delta_i = -\sum_{j=i+1}^{p-1} A_p + BX_t + \varepsilon_t \ldots \quad (9)$$

If the coefficient matrix π has reduced rank r < k, then there exist k < r, matrices α and β each with rank r such that π = αβ and βY_t is I(0) (Granger 1987). r is the number of co-integrating relation (the co-integrating rank) and each column of β is the co-integrating vector. Johansen's method is to estimate the π matrix from unrestricted VAR and to test whether the rejection implies by the reduced rank π.

Empirical result and Discussion

Unit Root Test Result

In this study, the Augmented Dickey Fuller (ADF) and Phillip Perron (PP) unit root tests were employed to test for the time series properties of model variables. The null hypothesis is that the variable under investigation has a unit root against the alternative that it does not. The choice of lag length was based on Akaike and Schwartz-Bayesian information criteria. Thus, the optimum lag length for EXR, ASI and SMC were 2 for ADF and 3 for PP respectively. The decision rule is to reject the null hypothesis if the ADF and PP statistic value exceeds the critical value at a chosen level of significance (in absolute term). These results are presented in table I below.

The results of table 1 above show that all the variables are non-stationary in level form since their ADF and PP in absolute values are less than the critical values at 1%, 5% and 10%, the null hypothesis of no unit root was accepted for all the variables but was rejected in 1st difference. Thus, suggesting that the variables under investigation are integrated of order one, (I(1)). And that the variables are integrated of the same order.

Co-integration Test Result

A necessary but insufficient condition for co-integrating test is that each of the variables be integrated of the same order (Granger, 1986 The Johansen co-integration test utilizes two statistics test namely: the trace test and the maximal Eigenvalue test. The first row of the table test the hypotheses of no co-integrating relation, the second row test the hypothesis of one co-integrating relation and so on, against the alternative of full rank of co-integration. The results are presented in table 2 below.

In table above, the likelihood and maximal Eigenvalue statistics indicate the presence of no co-integrating equation at 5% significance level which implies that exchange rate (EXR) and the stock price indicators (ASI and SMC) used as proxies for stock prices (SMP) are not co-integrated. These show acceptance of null hypothesis of no co-integration. Thus, the results show evidence of no stable long run relationship between exchange rate (EXR) and stock market prices (SMP).

Jarque-Bera is a statistical test that determines whether the series is normally distributed. This statistic measures the difference of the skewness and the kurtosis of the series with those from the normal distribution. The null hypothesis is that the series is normally distributed against the alternative that it is not. Evidently, the Jarque-Bera statistic accepts the null hypothesis of normal distribution for all the variables in the model. This implies that all the variables are normally distributed.

Kurtosis measures the peakedness or flatness of the distribution of the series. The statistic for Kurtosis shows that all share index is normally peaked. However, Stock market capitalization and exchange rate are platykurtic, suggesting that its distribution is flat (less than 3) relative to the normal. Lastly, skewness is a measure of asymmetry of the distribution of the series around its mean. The statistic for skewness shows that stock market capitalization has bell shaped while all share index and exchange rate are positively skewed implying a long right tails.

The sample means for all the variables are statistically different from zero. The standard deviations are high and positive implying that the markets are highly volatile. This validates the capital linear market hypothesis.

The Results show that foreign exchange rate is significant in both models while stock exchange is not significant. This suggests the presence of exploitable excess profit invalidating the efficient market hypothesis. This also suggests some price spillover from foreign exchange markets to stock exchange markets.

There is a positive and significant coefficient in current period of exchange rate but negative and significant in previous period of exchange rate while insignificant and significant coefficients in previous and current periods of stock prices for model 1 and 2 respectively. This implies that there is a spontaneous positive response of stock prices to exchange rate fluctuation, meaning that when a country's currency is depreciated, an increase in stock prices is expected as depreciation suggests higher international competitiveness, which in turn, will increase firms' output and profit and hence increase in stock prices.

The results further show that there is positive and significant volatility persistence in both models for exchange rate while volatility is insignificant for stock prices. The effect of volatility persistence is larger on stock market capitalization than all share index. This implies that while stock prices have weak predictive power on exchange rate fluctuations, stock market volatility is caused by exchange rate fluctuations, more through stock market capitalization than all share index.

δ which measures the size effect of an innovation is negative and significant for both models in foreign exchange rate but also not significant in stock market.

Finally ϴ, indicating the presence of leverage effect are positive and significant in foreign exchange but insignificant in stock market for both models. The results from variance equation suggest that there is unidirectional volatility spillover from foreign exchange to stock market. This outcome supports the findings of Beer and Hebeins (2008) for industrialized countries

Summary and Conclusion

The main objective of this study was to investigate the effect of transmission of volatility spillover between stock market and foreign exchange market in Nigeria. Given the nature of the objectives, EGARCH model was used. Two different Nigerian stock indictors namely the All Share Index and Stock Market Capitalization were used. Thus we have two

EGARCH models. The summary of the result drawn from the findings are stated below:

The variables are non stationary, therefore, random walk series. When the first differences of the series were taken, the ADF and PP test statistics became significant. Therefore, the series are

I (1) processes and they are integrated of the same order.

The Johansen co-integration test result however, showed no co-integrating vector between exchange rate and stock prices. This means that there exists no stable long-run equilibrium relationship between exchange rate and stock prices.

The descriptive statistics showed that stock market capitalization and exchange rates are platykurtic, while all share index is mesorkurtic. The standard deviation statistic is highly positive implying that risk and returns are positively related. This corroborates the capital linear market hypothesis.

The hypothesis that the current and lagged coefficients for the exchange market are not different from zero cannot be rejected in both models.

There is a spontaneous positive response of stock prices volatility to exchange rate fluctuation, meaning that when a country's currency is depreciated, an increase in stock prices is expected as depreciation suggests higher international competitiveness and hence increase in firms' output and stock prices.

Evidence from the variance equation showed that there is unidirectional volatility spillover from exchange rates to stock prices in Nigeria. This suggests that volatility in exchange rate impacts on stock markets fluctuation without feedback, effect,

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Table 1: Unit Root Tests Result

Variable	ADF statistics			PP statistics		
	Level	1st different	Critical values	Level	1st different	Critical
EXR	-1.25	-6.42	1% -3.52	-1.11	-10.2.5	1% -3.52
			5% -2.89			5% -2.89
			10% -2.59			10% -2.59
ASI	-1.33	-6.36	1% -3.52	-1.77	-14.15	1% -3.52
			5% -2.89			5% -2.89
			10% -2.59			10% -2.59
SMC	-1.77	-6.51	1% -3.52	-1.53	-13.54	1% -3.52
			5% -2.89			5% -2.89
			10% -2.58			10% -2.58

Table 2: Co-integrating Test Result between ASI and EXR

Model	Eigen value	Likelihood Ratio	5% critical value	1% critical value	Hypothesized No of CE(s)
1.	0.055678	6.392482	15.41	20.04	None
	0.022297	1.736315	3.76	6.65	At most 1
2	0.054684	6.735137	15.41	20.04	None
	0.030751	2.404996	3.76	6.65	At most

*(**) denotes rejection of the hypothesis at 5% (1%) significance level.
L.R. test indicates no co-integrating equation(s) at 5% level of significance for both models

Table 2: summary of the descriptive statistics of the variables

	ASI	SMC	EXR
Mean	13907.64	1779.234	75.41954
Median	7195.975	444.6500	96.22283
Maximum	57990.20	10301.00	148.9100
Minimum	513.8000	12.10000	8.037800
Std. Dev.	13816.00	2616.175	51.26438
Skewness	0.844460	0.192292	0.886304
Kurtosis	2.879445	2.005000	2.381684
Jarque-Bera	3.583729	1.422412	3.524452
Probability	0.166649	0.491052	0.171008
Observations	80	80	80

Table 3: Results of the Bivariate EGARCH Model

Parameters	Model 1		Model 2	
	EXR	SPM	EXR	SPM
α_1	(-0.8313) -59.01732	(6.412) ** 29.99510	(-0.982585) -1.358129	(10.31) ** 51.52972
α_2	(21.67) ** 0.912838	(0.001633) 2.729095	(159.90) ** 0.965451	(1.827903) 0.006184
α_3	(-6.19) ** -50.00353	(1.250758) 0.000897	(5.53) ** -1.320035	(1.581484) 0.004421
β_1	(-0.504) -0.2855	(0.442371) 2.075577	(0.580641) 0.314181	(0.579591) 3.109600
Υ_i	(4.47) ** 1.218564	(0.331438) 0.252964	(9.47) ** 3.942561	(1.094638) 1.447710
Δ	(-0.5380) -0.1505	(0.64648) 0.294177	(-2.35) ** -0.547480	(0.171040) 0.152552
Θ	(28.52) ** 0.964597	(1.047369) 0.663834	(18.33) ** 0.676648	(0.461198) 0.373403

*(**) denotes variable is significant at 5% (1%) significance level.
Figures in Parenthesis are t-statistics