EE
E u r o E c o n o m i c a
Issue 1(34)/2015 *ISSN: 1582-8859*

All share price and inflation volatility in Nigeria. An application of the EGARCH model

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Abstract. This paper used EGARCH estimation techniques to analysis data sourced from 1985 to 2012 on the Nigerian economy to examine the ability of All Share Index to hedge against inflation in Nigeria. It relies on the Discount Cash Flow theory to examine this relationship. The results show that All Share Index provides a good platform to hedge against inflation in Nigeria. It is therefore recommends that investors on the one hand should adopt share pricing mechanism when hedging against inflation is in view. For policy makers on the other hand, policy that will advance the stock market should be put in place when controlling inflation is being pursued.

Keywords: all share price, inflation rate, EGARCH, Nigeria, discount cash flow theory.

1 Introduction

The Discount Cash Flow (DCF) or Present Value Theory propounded by Campbell and Shiller (1988) among others provides a theoretical background that connects inflation with stock price determination (Glisten et al 1993). According to this theory, a functional relationship exists between the stock prices of an asset, its expected cash flows and the discount rate of these cash flows. It explains that macroeconomic variables that influences expected cash flows and the discount rate should also exert on stock price determination of the underlying assets.

Understanding the relationship between the two variables (Inflation rate and stock price movement) is important to virtually all the various economic agents especially the policy makers on the one hand and market practitioners on the other hand. For market practitioners, the knowledge of the relationship between the two variables will help them develop investment strategies that factored in or accommodate the fluctuation in inflation rate, thereby hedging against inflation. To the policy makers on the other hand, the knowledge of the relationship between two will aid policy formulation that will support stock market growth and of course aggregate growth.

The essence of this paper is to examine if inflation rate volatility exerts on stock market pricing in Nigeria. The study also intends to know if stock market prices can be used as hedging strategies against inflation in Nigeria?

This paper is as structured as follows: while section 1 provides the introductory section; section 2 provides the literature review; section 3 provides the data and methodology and estimation techniques; section 4 presents the results and interpretation of results while section 5 concludes the study and

makes recommendations.

2 Literature review and theoretical framework

The theoretical connection between inflation and stock market return can be classified into seven theoretical models as: Fisher's hypothesis by Fisher (1930); Inflation illusion hypothesis by Modigliani and Cohn (1979) which observed that investors do undervalued stocks in the 1970's based on the inclusion of nominal interest rates in discounting cash flows and exclusion of capital gains that accrued to firms with fixed rate debt liabilities; Feldstein (1980) real after –tax hypothesis which centers on the existence of an inverse relationship between corporate profits and inflation rate as induced by higher effective tax rates provoked by higher inflation; Fama (1981) proxy hypothesis that stresses the existence of an inverse relationship between inflation rate and stock returns; The Discount Cash Flow (DCF) or Present Value Theory propounded by Campbell and Shiller (1988); Devereux and Yetman (2002) risk – premium hypothesis that observed that the relationship between inflation rate and stock market returns can best be known by examining the risk inherent in stock and the impact of inflation on premium; and lastly Anari and Kolari (2010) simulation risk-premium hypothesis which observed that nominal discount rate negatively impacts on stock returns in the short run through simulation of inflation premium as induces by discount rate.

As earlier noted, a direct theoretical linkage between inflation rate and stock market prices can be traced to the Discount Cash Flows framework which states that stock market prices reflects changes in inflation rate (see Campbell and Shiller, 1988). Ever since Campbell and Shiller's (1988) observation of the direct linkage between the two variables of inflation rate and stock market returns, a number of literature have attempted to inquire into the relationship using difference methods to analyze data sourced from different economies. Reviewing some of these studies is the focus of this section.

Schmeling and Schrimpf (2011) examined the relationship between expected inflation and stock market return for a number of industrialized economies using Survey – based measures to analyze both in-sample and out-of sample data and observed that a positive relationship exist between expected inflation and stock returns for the samples economies considered. They reported that variants of the proxy hypothesis and money illusion hypothesis give a perfect prediction about the relationship. They further use Model-free test to examine the behaviour of subjective investors expectation about future growth output, inflation rate and stock returns, and observed that expect inflation either proxies for future output movement nor for higher risk aversion given condition of rational account based on the fact that subjective expectations are not consistent with the rational expectations. They concluded that money illusion is the core factor that influences the impact of inflation on stock market behavior. (see also Campbell and Diebold, 2009).

As earlier noted, Fisher hypothesis provides the theoretical connections that links interest rate and inflation in an economy. According to this hypothesis, if the ex-ante real rate of interest is assumed constant, economic agents will expect a compensation for the marginal utility of forgone consumption (determined by the real rate of interest) and a fall in the value of money as induced by nominal return on investment. The implication of the above is that, interest rates move one -for-one with inflation, thus no long run effect exist between permanent change in the rate of inflation and the level of the real interest rate (Fisher (1930)). When we transpose this hypothesis into the stock market - inflation relationship, then it connotes that a positive one –to – one relationship exist between stock market returns and inflation. This simply implies that given a condition of competition stock market can offer good ground to hedge against inflation (see Alagidede and Panagiotidis (2010), Anari and Kolari (2001)).

This hypothesis, however have being criticized by a number of literature for instance Bodie(1976), Fama and French (1988) have documented a weak ability of stock return to hedge against inflation when compared with other financial and real variables especially during inflationary period especially in US.

Anari and Kolari (2001) used cointegration techniques to analysis data sourced from six industrialized economies of Canada, France, and Germany, Japan the UK and the US and observed that a long run generalized Fisher elasticity of stock return in term of inflation changes was higher than unity for the economies studied. Their findings validates Fisher's hypothesis that a functional relationship exist between stock returns and inflation rates.

Alagidede and Panagiotidis (2010) investigated the relationship between stock return and inflation for six African countries of Egypt, Kenya, Morocco, Nigeria, South Africa and Tunisia for 1999 to 2006 using cointegration estimation techniques to analysis monthly data source from these economies. They observed that a significant and positive relationship exist between stock market and inflation in the long run for all the economies studied except for Kenya and Tunisia. This finding supports long –run generalized Fisher's effect on stock returns – inflation nexus.

Alagidede and Panagiotidis (2012) revisited the relationship between stock market returns and inflation for the G-7 countries using a quantile regression analysis that specifically focused on the short run dynamics between the two variable in the economies studied and observed that a positive relationship exist between the two variables for most of the economies except for Canada. They concluded that stocks market provides good hedging bases against inflation for the G7 countries (see also Florakis et al 2014; Kontonikas and Kontonikas 2013).

Lee (2010) examined the relationship between stock market prices and inflation rate for a number of developed economy based on data sourced 1927 to 2007. The study used S&P 500 composite index and dividends form Robert Shillers website, and CRSP value- weighted returns as a proxy for stock returns and dividend yields and both the pre and post war data on consumer price index as proxy for inflation. The study observed that though the inflation illusion hypothesis explains the post – war relationship effectively, its result is not compatible with some characteristics of the pre – war relationship. The study submitted that though mispricing component plays significant role in stock return – inflation nexus for both sample periods, these roles differs in both periods (see Kontonikas *et al*, 2013, Cia *et al*, 2009, Basistha and Kurov,2008).

For the Kenyan economy, Olweny and Omondi (2011) used both EGARCH and TGRACH models to examine monthly data sourced from January 2001 to Dec. 2010 and observed that stock market returns are essentially symmetric but leptokurtic and not normally contributed. The result further revealed that volatility persistence from inflation to stock market is low though significant, and a significant leverage effect exists between inflation and stock return for the Kenyan's economy.

For the Greek economy, Filis (2010) documented existence of a positive and significant relationship between stock market and consumer price index in the long run using cointegration and vector error correction models. The results from the Vector Autoregressive (VAR) model shows that the Consumer Price Index (CPI) negatively influence the stock prices significantly for the period studied; and that the cyclical component of the Greek stock market exerts negatively on CPI. The result further revealed that a bidirectional relationship exist between the cyclical component of the inflation rate and the stock market (see Croux and Reusens, 2013); Henry *et al* (2010) Kaplan,(2008); Mao, Y (2007), Panopoulou (2009), Florackis et al (2014) Maio (2014), Blinder (2012) Fernandez – Amador *et al*, (2013); Kontonikas *et al* (2013)).

Yu (2011) using EGARCH observed a negative relationship exist between stock market prices and

inflation for the South Africa economy. For the same economy, Chinzara (2011) observed that there are negative spillovers from inflation to stock market

3 Data and methodology

The data used in the study consisted of time series on inflation rate and All Share Index (a proxy for the stock market return) sourced from the Central Bank of Nigeria Statistical Bulletin (2012). The data spanned from 1985 to 2012. The Choice of the starting period was based on the fact that stock market data became officially known publicly in the year 1985, and the closing or ending period is influenced based on the fact that the most recent data available at the public domain end at the year 2012 for the two variables under consideration.

The Autoregressive Conditional Heteroskedasticity (ARCH) model was developed by Engle (1982) to explain that the variance of the residuals at time t depends on the square error terms from past periods. it simply emphasis the need to simultaneously model the mean and variance of a series when evidence abound that the conditional variance is not constant. ARCH models has been extensively used in finance and economics literature especially when issues relating to risk and volatility measurement are being studied. Ever since it was originally developed by Engle in 1982, many version of the ARCH models have been developed. For instance, the model was generalized by Bollerslev (1986) to form Generalized Autoregressive Conditional Heteroskedasticity (GARCH), Later on Glosten *et al* (1993) and Zakoian (1994) developed the Threshold ARCH or TGARCH model, Nelson (1991) developed the Exponential GARCH or the EGARCH (see Asteriou and Hall (2007); Enders, (2008); Lawal *et al*, (2012)).

The GARCH in mean specification is as specified as follows:

$$r_t = \mu + \lambda h_t + \epsilon_t, \quad \epsilon_t \sim N(0, h_t) \tag{1}$$

where r_t is the return on All Share Index, u is the risk free return, h_t is the conditional variance and λ is the coefficient that represent the risk-return trade-off.

The EGARCH or the Exponential GARCH model was developed by Nelson [1991], it provides a good ground to capture the missing link or inability of GARCH in mean (Athanasios *et al* (2006)) to provide an even function of the past disturbances, u_{t-1}, u_{t-2}....u_{t-n}. For this work, we used estimates of the followings augmented version of the E-GARCH model

$$R_t = \beta R_{t-1} + \gamma h^2_t + u_t \tag{2}$$

Where

R_t is the logarithm of the All Share Index at time t

h^2_t is the conditional heteroskedastic term at time t

u_t is the error term

$h^2_t = V(u_t/\Omega_{t-1}) = E(u^2_t/\Omega_{t-1})$.

However, it is important to note that for h^2_t, Nelson(1991) used an exponential form which is written as:

$$\text{Log } h^2_t = \alpha_0 + {}^{q}\textstyle\sum_t = {}_1\alpha_l(u_{t-l}/h_{t-l}) + {}^{q}\textstyle\sum_l = {}_1\alpha_l(|u_{t-l}/h_{t-l}|-\mu) + {}^{q}\textstyle\sum_l = {}_1\varphi_l \log h^2_{t-l} \tag{3}$$

where $\mu=E(|u_t/h_t|)$

As noted by Athanasios K. et al (2006), the value of μ depends on the density function assumed for the standard disturbances, $\varepsilon_t = ut/ht$, under this condition $\mu = (2/\prod)^{1/2}$, if $\varepsilon_t \approx N(0,1)$.

Also, it should be noted that for unconditional variance to exist,

$$1\text{-}p\sum_{l=1}\varphi t\ \varepsilon_t^t = 0 \qquad (4)$$

The implication is that the root of our equation will fall outside the unit cycle. Furthermore, Athanasios k. Et al (2006) explained that if ${}^{p}\sum_{l} = 1\ \varphi t\ \varepsilon_t^t < 1$, then the log of unconditional variance will be given by: $\log(h2t) = \alpha_0(1\text{-}p\sum_{l=1}\varphi t\ \varepsilon_t^t\ t)^{-1}$. This makes it clear that the E-GARCH model will always yield a positive conditional variance.

Following Somoye *et al* (2015) we modified the EGARCH model to effectively capture the impact of inflation as provided for in the Discount Cash Flow framework such that:

$$log\ h_t = w + \beta\ log\ h_{t-1} + \gamma\ \frac{\epsilon_{t-1}}{h_{t-1}^{1/2}} + \alpha\ \left[\frac{|\epsilon_{t-1}|}{h_{t-1}^{1/2}} - \sqrt{\frac{2}{\pi}}\right] \qquad (5)$$

Where h_t connotes the conditional variance for year *t*; $h_t^{1/2}$ represents the conditional volatility prediction for year *t;* $\frac{\epsilon_t}{h_t^{1/2}}$ is the standardized shock for year *t*. it represents the number of standard deviation that ϵ_t has deviated from its mean and ϵ_t represent the error term of a prediction model of a time series.

In order to deepen our knowledge of the news impact of the model, we followed Engle and Ng (1993) to derive equation (6) as follows

$$h_t = h_{t-1}^{\beta}\ \text{x}\ e^{w + \gamma\frac{\epsilon_{t-1}}{h_{t-1}^{1/2}} + \alpha\left[\frac{|\epsilon_{t-1}|}{h_{t-1}^{1/2}} - \sqrt{\frac{2}{\pi}}\right]} \qquad (6)$$

When we re-arrange the terms, we will derive:

$$h_t = h_{t-1}^{\beta}\ \text{x}\ e^{\left(w - \alpha\sqrt{\frac{2}{\pi}}\right) + \gamma\frac{\epsilon_{t-1}}{h_{t-1}^{1/2}} + \alpha\left[\frac{|\epsilon_{t-1}|}{h_{t-1}^{1/2}} - \sqrt{\frac{2}{\pi}}\right]} \qquad (7)$$

Under this condition, the $e^{\gamma\frac{\epsilon_{t-1}}{h_{t-1}^{1/2}}}$ implies a normal variate skewed to the left, and the γ determines the degree of skewness.

To determine the combined impact of both the α and γ, we derived equations (8) and (9) as follows

$$h_t = h_{t-1}^{\beta}\ \text{x}\ e^{\left(w - \sqrt{\frac{2}{\pi}\ \alpha}\right) + (\gamma + \alpha)\frac{\epsilon_{t-1}}{h_{t-1}^{1/2}}} \qquad \text{when } \epsilon_{t-1} > 0 \qquad (8)$$

and

$$h_t = h_{t-1}^{\beta} \text{ x } e^{\left(w - \sqrt{\frac{2}{\pi}}\,\alpha\right) + (\gamma - \alpha)\frac{\epsilon_{t-1}}{h_{t-1}^{1/2}}} \quad \text{when } \epsilon_{t-1} \qquad (9)$$

4 Results and interpretation

The result shows that the coefficient of α is positive at 0.770775 and significant at 1% level of significant, however the coefficients of γ is negative at -0.039144 and not significant. This connotes that large shocks in All Share Price as induced by inflation rate volatility will increase volatility in All Share Price irrespective of the sign of the volatility. The magnitude of volatility (β) is positive at 0.701229 and significant at 1% level of significant, an indication that the size of volatility of inflation on All Share Prices is large and highly significant.

Table 1 All share price and inflation

	INF	**Probability**	**ASI**	**Probability**
Ω	-0.069909	0.6850	0.440987	0.0510
Λ	0.716847	0.0000	0.770775	0.0000
Γ	-0.147992	0.0614	-0.039144	0.6382
B	0.856836	0.0000	0.701229	0.0000

The result of inflation also shows that the coefficient of α is positive at 0.716847 and highly significant at 1% level of significance. Furthermore, the coefficient of γ is negative at -0.147992 but not significant at 5% level of significant. From literature, when the coefficient of α is significant but γ is not, then we can conclude that large shocks increases volatility, regardless of the direction of the sign (see nelson (1991), Engle and Ng (1993, Asteriou and Hall (2007), Enders (2008)). We can therefore conclude that large shocks in inflation transmit itself into the All Share Prices. This is supported by the theoretical framework of the Discount Cash Flows or Present Values Theory that recognizes the impact of inflation rate volatility on All Share Index.

5 Conclusions and recommendations

This paper examined the impact of inflation rate volatility as it exerts on stock market prices in Nigeria. We employed Exponential General Autoregressive Conditional Heteroskedascity (EGARCH) estimation techniques to analyses data sourced from Central Bank of Nigeria (CBN) Statistical Bulletin (2012) on All Share Index and inflation rate within the context of Discount Cash Flow Theory. Our results show that inflation rate do exerts on All Share Price Index in Nigeria. Given the fact that inflation rate exerts on stock market return as evidence in our report, we can therefore conclude that evidence abound that stock market prices or returns provides good ground to hedge against inflation rate in Nigeria, thus investors should take appropriate hedging strategy against inflation by intelligently investing in the Nigerian stock market. For the policy makers, as evidence in our result that stock market have the ability to hedge against inflation in Nigeria, it is essentially recommended that policies should be put in place to ensure that the Nigerian stock market is viable

and sound so as to be able to provide better platform for asset prices/ returns capacity to hedge against inflation in Nigeria.

We therefore, recommend that market practitioner should consider volatility in inflation rate when making investment decision strategies involving asset price determination. Similarly, policy makers should put in place policies that guarantee sound inflationary measure. Efforts should be put in place to ensure that monetary-fiscal discipline is pursued so as to enhance sound and robust stock market pricing. It should also be noted that since inflation rate volatility exerts on stock market pricing in Nigeria, factoring inflation rate volatility into stock pricing mechanism can serve as a good measure to hedge against inflation

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