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The Relationship between Nominal Interest Rates and Inflation: New Evidence and Implications for Nigeria

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Abstract
This paper investigates the relationship between expected inflation and nominal interest rates in Nigeria and the extent to which the Fisher effect hypothesis holds, for the period 1970-2009. The real interest rate is obtained by subtracting the expected inflation rate from the nominal interest rate. For the Fisher hypothesis to hold, the resultant ex ante real interest rate should be stationary. Using the Johansen Cointegration Approach and Error Correction Mechanism, our findings tend to suggest: (i) the real interest rates is stationary (ii) that the nominal interest rates and expected inflation move together in the long run but not on one-to-one basis. This indicates that full Fisher hypothesis does not hold but there is a very strong Fisher effect in the case of Nigeria over the period under study (iii) that causality run strictly from expected inflation to nominal interest rates as suggested by the Fisher hypothesis and there is no "reverse causation" (iv) that only about 16 percent of the disequilibrium between long term and short term interest rate is corrected within the year. Policy implication, based on the partial Fisher effect in Nigeria, is that the level of actual inflation should become the central target variable of the monetary policy.
Keywords: Fisher Effect, Co-integration, Error Correction Model, Nigeria

Introduction

Krugman and Obstfeld (2003) define the Fisher effect by saying that all thing being equal, a rise in a country's expected inflation rate will eventually cause an equal rise in the interest rate that deposits of its currency offer: similarly, a fall in the expected inflation rate will eventually cause a fall in the interest rate.

The hypothesis, proposed by Fisher (1930), that the nominal rate of interest should reflect movements in the expected rate of inflation has been the subject of much empirical research in many developed countries. This wealth of literature can be attributed to various factors including the pivotal role that the nominal rate of interest and, perhaps more importantly, the real rate of interest plays in the economy. Real interest rate is an important determinant of saving and investment behaviour of households and businesses, and therefore crucial in the growth and development of an economy (Duetsche Bundesbank, 2001). The validity of the Fisher effect also has important implications for monetary policy and needs to be considered by central banks.

A significant amount of research has been conducted in developed countries and emerging economies to prove and establish this hypothesis: among the most recent papers are those by Choudhry (1997), Yuhn (1996), Crowder and Hoffman (1996), Lardic & Mignon(2003), Dutt and Ghosh (1995), Muscatelli & Spinelli(2000) Hawtrey (1997), Koustas and Serletis (1999) and Mishkin and Simon (1995), Garcia (1993), Miyagawa & Moritai(2003), Carneiro, Divino and Rocha (2002), Lee, Clark & Ahn(1998), Phylaktis and Blake (1993), Jorgensen and Terra(2003), Atkins & Serletis (2002), Ghazali & Ramlee(2003), Wesso(2000), Esteve, Bajo-Rubio and Diaz-Roldan(2003), Laatsch & Klien(2002), Fahmy & Kandil(2003). But few studies have been conducted in Nigeria to validate this important hypothesis, among which are; Obi, Nurudeen and Wafure (2009) and Akinlo (2011).

Evidence on the long-run Fisher effect is mixed (for an excellent and comprehensive survey of recent evidence on long-run monetary neutrality and other long-run neutrality propositions, see Bullard (1999). Moreso, there has been renewed academic interest in the empirical testing of Fisher effect due to inflation-targeting monetary policy in many countries of the world and the advances in the time series techniques for studying non-stationary data with the help of various cointegration techniques and recently developed Auto-regressive Distributed Lag (ARDL).

This study is important because empirical studies on the existence of fisher effect in developing countries are sparse, especially study on Nigeria. Furthermore, the high rates of inflation and interest have continued to be of intense concern to government and policy-makers. Thus, we investigate the relationship between expected inflation and nominal interest rates in Nigeria and the extent to which the Fisher effect hypothesis holds, for the period 1970-2009 and we make use of annual data.

The remainder of this paper is structured as follows: The next section describes the data and methodology employed in this study. This is followed by results and interpretation. The final section concludes this study.

Data and Methodology

Fisher (1930) asserted that a percentage increase in the expected rate of inflation would lead to a percentage increase in the nominal interest rates. This is described by the following Fisher identity:

$$i_t = r_t + \pi^e_t \qquad (1)$$

where i_t is the nominal interest rate, r_t is the ex ante real interest rate, and π^e_t is the expected inflation rate. Using the rational expectations model to estimate inflation expectations would mean that the difference between actual inflation (π_t) and expected inflation (π^e_t) is captured by an error term (εt):

$$\pi_t - \pi^e_t = \varepsilon t \qquad (2)$$

This rational expectations model for inflation expectations can be incorporated into the Fisher equation as follows.

$$i_t = r_t + \pi_t \qquad (3)$$

Rearranging equation 2:

$$\pi_t = \pi^e_t + \varepsilon_t \qquad (4)$$

where ε_t is a white noise error term. If we assume that the real interest rate is also generated under a stationary process, where r_t^e is the ex ante real interest rate and υ_t is the stationary component, we obtain:

$$r_t = r_t^e + \upsilon_t \qquad (5)$$

Now by substituting equation (4) and (5) into equation (3):

$$i_t = r_t^e + \pi_t^e + \mu_t \qquad (6)$$

We therefore re-specify equation (6) as (7) and estimate the model:

$$NOMINT_t = \theta + \delta EXPINF_t + \mu_t \qquad (7)$$

where μ_t is the sum of the two stationary error terms (i.e $\varepsilon_t + \upsilon_t$), r_t^e (θ) is the long run real interest rate and π_t^e is the expected rate of inflation. The strong form Fisher hypothesis is validated if a long-run unit proportional relationship exists between expected inflation ($EXPINF_t$) and nominal interest rates ($NOMINT_t$) and $\delta=1$, if $\delta<1$ this would be consistent with a weak form Fisher hypothesis.

The first challenge facing any empirical Fisherian study is to derive an inflation expectations proxy. Wooldridge (2003) suggested that the expected inflation this year should take the value of last year's inflation. Next, we examine the stationarity of our variables, nominal interest rate and expected inflation. A non-stationary time series has a different mean at different points in time, and its variance increases with the sample size (Harris and Sollis (2003). A characteristic of non-stationary time series is very crucial in the sense that the linear combinations of these time series make spurious regression. In the case of spurious regression, t-values of the coefficients are highly significant, coefficient of determination (R2) is very close to one and the Durbin Watson (DW) statistic value is very low, which often lead investigators to commit a high frequency of Type 1 errors (Granger and Newbold, 1974). In that case, the results of the estimation of the coefficient became biased. Therefore it is necessary to detect the existence of stationarity or non-stationarity in the series to avoid spurious regression. For this, the unit root tests are conducted using the Augmented Dickey-Fuller (ADF) test and Philips-Perron (PP). If a unit root is detected for more than one variable, we further conduct the test for cointegration to determine whether we should use Error Correction Mechanism.

Cointegration Analysis

Cointegration can be defined simply as the long-term, or equilibrium, relationship between two series. This makes cointegration an ideal analysis technique to validate the Fisher hypothesis: by ascertaining the existence of a long-term unit proportionate relationship between nominal interest rates and expected inflation. Cointegration analysis can thereby establish if nominal interest rates are cointergrated with expected inflation. The cointegration method by Johansen (1991; 1995) has become the most cited cointegration technique used in Fisherian literature, and is used in this study. The Vector Autoregression (VAR) based cointegration test methodology developed by Johansen (1991; 1995) is described as follows;

The procedure is based on a VAR of order p:

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + Bz_t + \varepsilon_t \quad (10)$$

where y_t is a vector of non-stationary I(1) variables (interest rate and expected inflation), z_t is a vector of deterministic variables and ε_t is a vector of innovations. The VAR may therefore be reformulated as:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} + \Gamma_i \Delta y_{t-p} + Bz_t + \varepsilon_t \quad (11)$$

$$\text{Where } \Pi = \sum_{i=1}^{p} A_i - I \quad (12)$$

$$\text{and } \Gamma_i = \sum_{j=i+1}^{p} A_j \quad (13)$$

Estimates of Γ_i contain information on the short-run adjustments, while estimates of Π contain information on the long-run adjustments, in changes in y_t. The number of linearly dependent cointegrating vectors that exist in the system is referred to as the cointegrating rank of the system. This cointegrating rank may range from 1 to n-1 (Greene 2000:791). There are three possible cases in which $\Pi y_{t-1} \sim I(0)$ will hold. Firstly, if all the variables in y_t are I (0), this means that the coefficient matrix Π has r=n linearly independent columns and is referred to as full rank. The rank of Π could alternatively be zero: this would imply that there are no cointegrating relationships. The most common case is that the matrix Π has a reduced rank and there are $r<(n-1)$ cointegrating vectors present in β . This particular case can be represented by:

$$\Pi = \alpha\beta' \quad (14)$$

where α andβ are matrices with dimensions n x r and each column of matrix α contains coefficients that represent the speed of adjustment to disequilibrium, while matrix β contains the long-run coefficients of the cointegrating relationships.

In this case, testing for cointegration entails testing how many linearly independent columns there are in Π , effectively testing for the rank of Matrix Π

(Harris, 1995:78-79). If we solve the eigenvalue specification of Johansen (1991), we obtain estimates of the eigenvalues $\lambda_1 > \ldots > \lambda_r > 0$ and the associated eigenvectors $\beta = (\nu_1, \ldots \nu_r)$. The co-integrating rank, r, can be formally tested with two statistics. The first is the maximum eigenvalue test given as:

$$\lambda\text{- max} = -T \ln (1 - \lambda_{r+1}), \quad . \quad (15)$$

Where the appropriate null is r = g cointegrating vectors against the alternative that $r \leq g+1$. The second statistic is the trace test and is computed as:

$$\lambda\text{-trace} = -T\sum_{i=r+1}^{n} \ln(1 - \lambda i), \quad (16)$$

where the null being tested is r = g against the more general alternative $r \leq n$. The distribution of these tests is a mixture of functional of Brownian motions that are calculated via numerical simulation by Johansen and Juselius (1990) and Osterwald-Lenum (1992). Cheung and Lai (1993) use Monte Carlo methods to investigate the small sample properties of Johansen's λ-max and λ-trace statistics. In general, they find that both the λ-max and-λ trace statistics are sensitive to under parameterization of the lag length although they are not so to over parameterization. They suggest that Akaike Information Criterion (AIC) or Schwarz Bayesian Criterion (SBC) can be useful in determining the correct lag length. Essentially, for Fisher hypothesis to hold, these cointegration tests should indicate the presence of cointegration vector between R_t and π^e_t (Booth and Ciner, 2001).

The empirical analysis was presented by time series model. The study uses long and up-to-date annual time-series data (1970-2009), with a total of 40 observations for each variable. The data for the study are obtained from Central Bank of Nigeria Statistical Bulletin and Annual Report and Statements of Account for different years. We use money market interest rate as nominal interest variable and last year inflation as proxy for expected inflation. Nominal Interest and Expected Inflation are in percentage and linear form. We therefore estimate Equation (7) using the ordinary least square (OLS) method. The software application utilized was E-views 7.0.

Results And Interpretation

Unit root test

Appropriate tests have been developed by Dickey and Fuller (1981) and Phillips and Perron (1988) to test whether a time series has a unit root. Tables 1 and 2 therefore provide the results of the unit root tests. Table 1 shows the Dickey and Fuller (ADF) and the Phillips and Perron (PP) tests with constant only while Table 2 shows the ADF and PP tests with constant and linear trend. The hypothesis of unit root against the stationary alternative is not rejected at both the 1 and 5% levels for interest rates with or without deterministic trend under the two test. However, the first differences of these variables are stationary under the two tests. Hence, we conclude that these variables are integrated of order 1. We also test the stationarity of the real interest rate (obtained by subtracting the expected inflation rate from the nominal interest rate). For the Fisher hypothesis to hold, the resultant ex ante real interest rate should be stationary. The results show that real interest rate is stationary, I(0), at 1% level of significance using Dickey and Fuller (ADF) test and at 5% level with Phillips and Perron (PP) tests.

Table 1: Results of (ADF) and (PP) unit root test, constant only

Variable level	ADF Test	PP
$nomint_t$	-1.518178	-1.774944
$EXPINF_t$	-3.750433***	-3.287390**
$\Delta NOMINT_t$	-3.384367**	-6.904677***
$\Delta EXPINF_t$	-6.230838***	-11.28416***
REALINT	-4.307344*	-3.174416**

ADF Critical values: -3.4533 at 1% (***) and -2.8715 at 5% (**)
(PP) Critical values: -3.4529 at 1% (***) and -2.8714 at 5% (**)

Table 2: Results of (ADF) and (PP) unit root test, constant and linear trend

Variable level	ADF Test	PP
$NOMINT_t$	-1.476210	-1.965189
$EXPINF_t$	-3.686009**	-3.219410
$\Delta NOMINT_t$	-6.893290***	-6.861831***
$\Delta EXPINF_t$	-6.202885***	-12.02996***
REALINT	-4.310596*	-3.131457**

ADF Critical values: -3.9908 at 1% (***) and -3.4258 at 5% (**)
PP Critical values : -3.9904 at 1% (***) and -3.4256 at 5% (**)

Following from the results presented in tables 1 & 2, interest rate and expected inflation variables are integrated of order one, l(1), it therefore necessary to determine whether there is at least one linear combination of the variables that is l(0). The Cointegration test performed for the long run relationship among series by using Johansen and Juselius cointegration test is presented in Table 3. The result show a cointegration rank of one in both trace test and max-eigen value test at 5% significance level.

Table 3: Cointegration Rank Test Assuming Linear Deterministic Trend

Null Hypothesis	Alternative Hypothesis	Test Statistics	0.05 Critical Value	Probability Value
		Trace Statistics		
r=0	r=1	21.09661[a]	15.49471	0.0064
r=1	r=2	2.811294	3.841466	0.0936
		Max-Eigen Statistics		
r=0	r>0	18.28531 [a]	14.26460	0.0110
r≤1	r>1	2.811294	3.841466	0.0936

[a]Denotes rejection of the null hypothesis at 0.05 level

In other words, a long-run stable relationship between nominal interest rates and expected inflation exists. This implies that nominal interest rates and inflation move together in the long run. This tends to provide support for the long-run Fisher hypothesis.

Since the existence of a long-run relationship has been established between long-term interest rates and expected inflation, the short-run dynamics of the model can be established within an error correction model. In order to estimate the Fisher effect we will use a simple formulation of an error correction model. We specify the error correction term as follows;

$NOMINT_t = \theta + \delta EXPINF_t + u_t$ (from equation 7)

$u_t = NOMINT_t - \theta - \delta EXPINF_t$ (17)

where u_t is the residual term and δ is a cointegrating coefficient. From equation (17), we can formulate a simple ECM as:

$\Delta NOMINT_t = \omega_0 + \omega_1 \Delta EXPINF_t + \Omega u_{t-1} + \nu_t$ (18)

$u_{t-1} = NOMINT_{t-1} - \theta - \delta EXPINF_{t-1}$ (19)

Specifically from the ECM expressed in equation (18), ω_l captures any immediate, short term or contemporaneous effect that EXPINF has on NOMINT. The coefficient δ reflects the long-run equilibrium effect of EXPINF on NOMINT and the absolute value of Ω decides how quickly the equilibrium is restored. We can therefore say that ω_l and Ω are the short-run parameters while δ is the long-run parameter.

Table 4: OLS Result (with $NOMINT_t$ as dependent variable)

Variable	Coefficient	Probability
C	8.245693	0.0000
$EXPINF_t$	0.118311	0.0245

From Table 4, we conclude that our cointegrating parameter is 0.118311. Estimating equation (18), we have the regression result presented in Table 5

Table 5: OLS Result (with DNOMINT as dependent variable)

Variable	Coefficient	Probability
C	0.232163	0.6150
DEXPINF	0.042539	0.1102
ECM(-1)	0.163502	0.0640

The P-value of the error correction term coefficient in Table 5, shows that it is statistically significant at a 10% level, thus suggesting that nominal interest rate adjust to expected inflation rate with a lag. We therefore infer that only about 16 percent of the disequilibrium between long term and short term interest rate is corrected within the year. If the interest rate is one percentage point above the inflation rate, then the interest rate will start falling by about 0.163502 percentage points on average in the next year.

We conducted next the Wald coefficient tests to investigate whether full Fisher Hypothesis holds for Nigeria or not, and if not, to verify if there is Fisher effect at all. The results of these tests are reported in tables 6 and 7. The Wald test results shown in table 6 reveal that full (standard) Fisher's hypothesis does not hold in the Nigerian economy. The Wald tests in table 7 show that Fisher effect is strong in the economy.

Table 6: Wald coefficient test for strong Fisher Hypothesis

Estimated equation; $NOMINT_t = \theta + EXPINF_t + \mu_t$			
Substituted coefficients; $NOMINT_t = 8.285693 + 0.118311EXPINF_t$			
Null Hypothesis; δ=1			
Test Statistics	Value	Df	Probability
t-statistics	-17.47430	37	0.0000
F- statistics	305.3512	(1,37)	0.0000
x^2 – statistics	305.3512	1	0.0000

Table 7: Wald coefficient test for the significance of constant and inflation

Estimated equation; $NOMINT_t = \theta + EXPINF_t + \mu_t$			
Substituted coefficients; $NOMINT_t = 8.285693 + 0.118311EXPINF_t$			
Null Hypothesis; θ =0			
Null Hypothesis; δ=0			
Test Statistics	Value	Df	Probability
F- statistics	75.78018	(2,37)	0.0000
x^2 – statistics	151.5604	2	0.0000

* see Appendix for diagnostics test results

Causality Test

Having ascertained that a cointegrating relationship exist between both nominal interest rates and expected inflation, the final step in this study is to verify if inflation Granger Cause nominal interest as posed by Fisher Hypothesis. If so then we can say that it is nominal interest rates that respond to movements in inflation expectations. The results of the Pair-wise Granger Causality Test are reported in Table 8.

Table 8: Pair-wise Granger Causality Test

Direction of Causality	Lag	F Value	Prob.	Decision
NOMINT does not Granger Cause EXPINF	2	2.632886	0.0874	Do Not Reject
EXPINF does not Granger Cause NOMINT	2	3.41261	0.0454	Reject

With 2 lags at 5% level of significance, the test suggests that causality run strictly from expected inflation to nominal interest rates as suggested by the Fisher hypothesis.

Summary And Conclusion

This article investigated the cointegrating relationship between nominal interest rates and expected inflation in the Nigerian economy. The results of the unit root tests indicated the variables under study were I(1) processes. Consequently, the Error Correction Model was employed. The cointegration results show that there is long run relationship between nominal interest rates and expected inflation, which implies that nominal interest rates and expected inflation move together in the long run. This provides evidence in support of the long run Fisher hypothesis. Next we estimated short run dynamics of the model which suggested that about 16 percent of the disequilibrium between long term and short term interest rate is corrected within the year. Following this, we performed Wald coefficient test to verify full Fisher hypothesis for Nigeria. The results show that standard Fisher hypothesis does not hold in the country. Moreso, the real interest rate is obtained by subtracting the expected inflation rate from the nominal interest rate. For the Fisher hypothesis to hold, the resultant ex ante real interest rate should be stationary. Our stationarity finding for real interest rates provides convincing foundation for the applications of various capital asset pricing models. (Johnson, 2006).

This finding lends support to the existence of partial fisher effect in Nigeria, because both interest rates and inflation rate do not move with one-for-one. The study is also consistent with the findings by Fama and Gibson (1982), Huizing and Mishkin (1986), Kandel et al (1996), Lee (2007), Obi, Nurudeen and Wafure (2009) and Akinlo (2011), that interest rates and inflation do not move with one-for-one.

Policy implication based on the partial Fisher effect in Nigeria is that more credible policy should anchor a stable inflation expectation over the long-run and the level of actual inflation should become the central target variable of the monetary policy. In addition, the government should encourage and support the real sector through subsidies and investment in infrastructure as a way of curbing inflation. This gesture in turn will reduce interest rate, consequentially promote economic growth.

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