TODA-YAMAMOTO CAUSALITY TEST BETWEEN MONEY MARKET INTEREST RATE AND EXPECTED INFLATION: THE FISHER HYPOTHESIS REVISITED

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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 1970-2011. We made attempt to advance the field by testing the traditional closed-economy Fisher hypothesis and an augmented Fisher hypothesis by incorporating the foreign interest rate and nominal effective exchange rate variable in the context of a small open developing economy, like Nigeria. We used Johansen cointegration approach, error correction model and the Toda and Yamamoto (1995) causality testing method. This study found: (i) that money market 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 strong Fisher effect in the case of Nigeria over the period under study (ii) consistency with the international Fisher hypothesis, these domestic variables have a long run relationship with the international variables (iii) that in the closed-economy context, the causality run strictly from expected inflation to nominal interest rates as suggested by the Fisher hypothesis and there is no "reverse causation." But in the open economy context, the expected inflation and international variables contain the information that predict the nominal interest rate (iv) finally that only about 22 percent of the disequilibrium between long term and short term interest rate is corrected within the year.

Keywords: Fisher Effect, Cointegration, Error Correction Model, Toda-Yamamoto Causality Test

Introduction

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 behavior 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 establish this hypothesis. In the work of Froyen and Davidson (1978), they confirmed a partial existence of fisher hypothesis, because the reaction of nominal interest rates to an increase in the expected inflation rate is not one-on-one, for the period they studied. Perez and Siegler (2003) employed both univariate and multivariate techniques to estimate the expected price level changes for United State during the pre-World War I period. They found in their study that expected inflation has a significant positive influence on nominal interest rates. Moreso, they confirmed the fisher effect hold in the short-run. Johnson (2005) reported that both inflation and interest rates are co-integrated, even though the fuller fisher effect does not exist. Coppock and Poitras (2000) examined the fisher hypothesis in Brazil and Peru. Their results did not support the evidence of full fisher effect. After controlling for risk, the authors found that interest rates did not fully adjust to changes in inflation. Mitchell-Innes et al (2008) examined whether the fisher effect holds during the period of inflation targeting in South Africa (2000-2005). They found that in the short-run fisher hypothesis did not hold during the inflation targeting period. The authors blamed the South African Reserve Bank's (SARB) for controlling short-term interest rates. But, in the long run a partial fisher effect exists. On his part, Lee (2007) employed the Johansen's technique to test the fisher hypothesis for Singapore for the period 1976-2006. The author discovered a long term fisher effect, and a positive relation was found to exist between inflation rate and interest rates. However, there was no evidence of a full fisher effect. Whereas, Mitchell-Innes (2006) discovered a long run fisher effect, there was no evidence in the short run in South Africa.

Westerlund (2008) used panel co-integration to test the fisher hypothesis among OECD countries. The author confirmed the existence of fisher effect. Beyer et al (2009) investigated the fisher hypothesis for a group of 15 countries, and found a long term relationship between inflation and interest rates. Darby (1975) on the contrary, showed that interest rates change by more than one for a unit change in inflation rate due to the tax effect on interest income. Panpoulou (2005) attempted to test the existence of the fisher effect among 14 OECD countries, and observed a full fisher effect as interest rates move one-to-one with the inflation rate. Weidmann (1997) re-examined the long run relationship between nominal interest rates and inflation in Germany. The results illustrate that interest rates do not fully adjust to changes in inflation, thus rejecting full fisher effect. (see Appendix 1 for a summary of some more empirical Literature on Fisher Hypothesis)

But few studies have been conducted in Nigeria to validate this important hypothesis, among which are; Obi, Nurudeen and Wafure (2009), Akinlo (2011) and Awomuse and Alimi (2012). The finding these works are similar, their results show that the nominal interest rates and 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

Moreso, there has been renewed academic interest in the empirical testing of the 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. This study is important because empirical studies on the existence of the 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 1970-2011 and 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 Methods

Model specification

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 rate 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):

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

Equation (6) is the traditional closed-economy Fisher hypothesis. Incorporating the foreign interest rate and nominal effective exchange rate variable in the context of a small open developing economy, we thus modify equation (6) as

$$i_t = r_t^e + \pi_t^e + fir_t + exch_t + \mu_t \qquad (7)$$

Therefore we estimate the following model:

$$INT_t = \delta + \varphi_1 EXPINFL_t + \varphi_2 USRATE_t + \varphi_3 EXCH_t + \mu_t \qquad (8)$$

where μ_t is the sum of the two stationary error terms (i.e $\varepsilon_t+\upsilon_t$), r_t^e (δ) is the long run real interest rate, π_t^e is the expected rate of inflation, fir_t is the foreign interest rate and $exch_t$ is the nominal effective exchange rate. The strong form Fisher hypothesis is validated if a long-run unit proportional relationship exists between expected inflation ($EXPINFL_t$) and nominal interest rates (INT_t) and $\varphi_1=1$, if $\varphi_1<1$ 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: $\pi_t^e = \pi_{t-1}$.

Type and Sources of Data

The empirical analysis was carried out using time series model. The study uses long and up-to-date annual time-series data (1970-2011), with a total of 42 observations for each variable. The data on nominal interest (INT), inflation (EXPINFL) and nominal effective exchange rates (EXCH) are obtained from the Central Bank of Nigeria Statistical Bulletin, Annual Report and Statements of Account for different years. We use money market interest rate as nominal interest variable and last year inflation as a proxy for expected inflation. We use US six month London Interbank Rate (USRATE) obtained from the World Economic Outlook Publication Report as a proxy for the foreign interest rate. All the variables are in percentage and linear form.

Cointegration Approach and Toda and Yamamoto Causality Testing

This section highlights the econometric model used to study the relationship between expected inflation and nominal interest rates in Nigeria. We use Johansen (2001) cointegration approach and the Toda and Yamamoto (1995) causality testing procedure.

Cointegration can be defined simply as the long-term, or equilibrium, the relationship between two series. This makes cointegration an ideal analysis technique to ascertain the existence of a long-term relationship between expected inflation and nominal interest rates. The cointegration method by Johansen (1991; 1995) is used in this study. The Vector Autoregression (VAR) based cointegration test methodology developed by Johansen is described as follows;

The procedure is based on a VAR of order p:

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + Bz_t + \varepsilon_t \quad (9)$$

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

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} + \Gamma_i \Delta y_{t-p} + Bz_t + \varepsilon_t \quad (10)$$

$$\text{Where } \Pi = \sum_{i=1}^{p} A_i - I \quad (11)$$

$$\text{and } \Gamma_i = \sum_{j=i+1}^{p} A_j \quad (12)$$

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). 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:

$$\Pi = \alpha\beta' \qquad (13)$$

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:

$$\lambda\text{- max} = -T \ln (1- \lambda_{r+1}), \quad . \qquad (14)$$

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

$$\lambda\text{-trace} = -T\sum_{i=r+1}^{n} \ln(1 - \lambda i), \qquad (15)$$

where the null being tested is r = g against the more general alternative r ≤ 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.

The causality analysis

The most common way to test the causal relationship between two variables is the Granger-Causality proposed by Granger (1969). The test involves estimating the following simple vector autoregressions (VAR):

$$X_t = \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{j=1}^{n} \beta_j X_{t-j} + \mu_{1t} \qquad (16)$$

$$Y_t = \sum_{i=1}^{m} \lambda_i X_{t-i} + \sum_{j=1}^{m} \delta_j Y_{t-j} + \mu_{2t} \qquad (17)$$

Where it is assumed that the disturbances μ_{1t} and μ_{2t} are uncorrelated. Equation (16) represents that variable X is decided by lagged variable Y and X, so does equation (17) except that its dependent variable is Y instead of X.

Granger-Causality means the lagged Y influence X significantly in equation (16) and the lagged X influence Y significantly in equation (17). In other words, researchers can jointly test if the estimated lagged coefficient $\Sigma\alpha_i$ and $\Sigma\lambda_j$ are different from zero with F-statistics. When the jointly test reject the two null hypotheses that $\Sigma\alpha_i$ and $\Sigma\lambda_j$ both are not different from zero, causal relationships between X and Y are confirmed. The Granger-Causality test is easy to carry out and be able to apply in many kinds of empirical studies. However, traditional Granger-Causality has its limitations.

First, a two-variable Granger-Causality test without considering the effect of other variables is subject to possible specification bias. As pointed out by Gujarati (1995), a causality test is sensitive to model specification and the number of lags. It would reveal different results if it was relevant and was not included in the model. Therefore, the empirical evidence of a two-variable Granger-Causality is fragile because of this problem.

Second, time series data are often non-stationary (Maddala, 2001). This situation could exemplify the problem of spurious regression. Gujarati (2006) had also said that when the variables are integrated, the F-test procedure is not valid, as the test statistics do not have a standard distribution. Although researchers can still test the significance of individual coefficients with t-statistic, one may not be able to use F-statistic to jointly test the Granger-Causality. Enders (2004) proved that in some specific cases, using F-statistic to jointly test first differential VAR is permissible, when the two-variable VAR has lagged length of two periods and only one variable is nonstationary. Other shortcomings of these tests have been discussed in Toda and Phillips (1994).

Toda and Yamamoto (1995) propose an interesting yet simple procedure requiring the estimation of an augmented VAR which guarantees the asymptotic distribution of the Wald statistic (an asymptotic χ^2-distribution), since the testing procedure is robust to the integration and cointegration properties of the process.

We use a bivariate VAR (m + d_{max}) comprised of expected inflation and nominal interest rate, following Yamada (1998);

$$X_t = \omega + \sum_{i=1}^{m} \theta_i X_{t-i} + \sum_{i=m+1}^{m+dmax} \theta_i X_{t-i} + \sum_{i=1}^{m} \delta_i Y_{t-i} + \sum_{i=m+1}^{m+dmax} \delta_i Y_{t-i} + v_1 \quad (18)$$

$$Y_t = \psi + \sum_{i=1}^{m} \phi_i Y_{t-i} + \sum_{i=m+1}^{m+dmax} \phi_i Y_{t-i} + \sum_{i=1}^{m} \beta_i X_{t-i} + \sum_{i=m+1}^{m+dmax} \beta_i X_{t-i} + v_{2t} \quad (19)$$

Where X= expected inflation and Y=nominal interest rate, and ω, θ's, δ's, ψ, ϕ's and β's are parameters of the model. dmax is the maximum order of integration suspected to occur in the system; $\nu_{1t} \sim N(0, \Sigma_{v1})$ and $\nu_{2t} \sim N(0, \Sigma_{v2})$ are the residuals of the model and Σ_{v1}

and Σ_{v2} the covariance matrices of ν_{1t} and ν_{2t} , respectively. The null of non-causality from expected inflation to nominal interest rate can be expressed as H_0: $\delta_i = 0, \forall\ i=1, 2, ..., m$.

Two steps are involved with implementing the procedure. The first step includes the determination of the lag length (m) and the second one is the selection of the maximum order of integration ($d$max) for the variables in the system. Measures such as the Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), Final Prediction Error (FPE) and Hannan-Quinn (HQ) Information Criterion can be used to determine the appropriate lag order of the VAR.

We use the Augmented Dickey-Fuller (ADF) test for which the null hypothesis is non-stationarity as well as Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test for which the null hypothesis is stationarity to determine the maximum order of integration. We choose KPSS to have a crosscheck. Many economists have argued against using the standard unit root tests and proposed using other powerful tests, such as tests that can be used to test the null of stationarity against the alternative of non-stationarity. A number of tests have been developed; the most popular one is the KPSS test developed by Kwiatkowski, Phillips, Schmidt, and Shin (1992). Kwiatkowski *et al*. (1992) argue that their test is "intended to complement unit root tests, such as the Dickey-Fuller tests. By testing both the unit root hypothesis and the stationarity hypothesis, we can distinguish between series that appear to be stationary, series that appear to have unit root, and series for which the data (or the tests) are not sufficiently informative to be sure whether they are stationary or integrated." Joint testing of both nulls can strengthen inferences made about the stationarity or non-stationarity of a time series especially when the outcomes of the two nulls corroborate each other. This joint testing has been known as "*confirmatory analysis.*" For example, if the null of stationarity is accepted (rejected) and the null of non-stationarity is rejected (accepted), we have confirmation that the series is stationary (non-stationary). Conversely, we cannot have confirmation if both nulls are accepted or both are rejected.

Empirical Findings

Our main reason for conducting unit root tests is to determine the extra lags to be added to the vector autoregressive (VAR) model for the Toda and Yamamoto test.

Table 1: Augmented Dickey-Fuller (ADF) Unit Root Test

Variables	Constant, with Trend		Order of Integration
	I(0)	I(1)	
EXPINFL	-3.521994 (-3.529758)	-6.116158* (-3.533083)	I(1)
INTR	-0.372509 (-3.529758)	-7.161797* (-3.529758)	I(1)
EXCH	-0.614710 (-3.523623)	-4.859365* (-3.526609)	I(1)
USRATE	-5.620988* (-3.526609)	-	I(0)

Notes: * denotes rejection of the null hypothesis of unit root the at 5% level. Critical values at 0.05 are in parenthesis.

Table 2: Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Unit Root Test

Variables	Constant, with Trend	Order of Integration
EXPINFL	0.133313 (0.146000)	I(0)
INT	0.177541 (0.146000)	I(1)
EXCH	0.173273 (0.146000)	I(1)
USRATE	0.085406 (0.146000)	I(0)

Notes: * denotes rejection of the null hypothesis of stationarity the at 5% level. Critical values at 0.05 are in parenthesis.

Table 3: Confirmatory Analysis

Variables	ADF	KPSS	Decision
EXPINFL	I(1)	I(0)	Inconclusive Decision (Insufficient Information)
INT	I(1)	I(1)	Conclusive Decision (Non-Stationary)
EXCH	I(1)	I(1)	Conclusive Decision (Non-Stationary)
USRATE	I(0)	I(0)	Conclusive Decision (Stationary)

Confirmatory analysis presented in Table 3 is drawn from the two unit root tests shown in Table 1 and Table 2 and it shows that only USRATE is stationary at level while the variables INT and EXCH are non-stationary at level. However, for EXPINFL variable, the unit root decision is inconclusive. Hence, VAR models will add only one extra lag (i.e dmax=1) for the implementation of the causality test. Following the modelling approach described earlier, we determine the appropriate lag length and conducted the cointegration test.

Table 4: Lag Length Selection

Lag	LR	FPE	AIC	SC	HQ
0	NA	1.26e+08	30.00559	30.17974	30.06699
1	154.3346	2428155*	26.04750	26.91826*	26.35448*
2	18.89087	3035786	26.23769	27.80507	26.79026
3	28.02917*	2441756	25.93467*	28.19866	26.73283
4	13.29489	3543459	26.13479	29.09540	27.17854

*indicates lag order selected by the criterion

Table 4 reports the optimal lag length of one (i.e m=1) out of a maximum of 4 lag lengths as selected by Final Prediction Error (FPE), Schwarz Information Criterion (SC) and Hannan-Quinn Information Criterion. We employed VAR Residual Serial Correlation LM Tests and inverse roots of the characteristic AR polynomial and found that the VAR is well-specified; there is no autocorrelation problem at the optimal lag at 10% level, all the inverse roots of the characteristic AR polynomial must lie inside the unit circle and the modulus values are 0.89, 0.78, 0.78, 0.67, 0.67, 0.31, 0.19 and 0.19 thus VAR satisfies the stability condition.

Table 5: Result of Cointegration Test

	Null Hypothesis	Test Statistics	0.05 Critical Value	Probability Value
Lags		1		
Trace Statistics	r=0	52.66960	47.85613	0.0165
	r=1	19.14699	29.79707	0.4824
Max-Eigen Statistics	r=0	33.52261	27.58434	0.0077
	r≤1	14.01310	21.13162	0.3640
Trace	No of Vectors	1		
Max-Eigen	No of Vectors	1		
[a]Denotes rejection of the null hypothesis at 0.05 level				

Table 5 provides the results from the application of Johansen cointegration test among the data set. Empirical findings show that both the maximum eigenvalue and the trace tests reject the null hypothesis of no cointegration at the 5 percent significance level according to critical value estimates. The result shows a cointegration rank of one in both trace test and max-eigen value test at 5% significance level. Thus the maximum order of integration (*dmax*) for the variables in the system is one (dmax=1)

The results above are based on the assumptions of linear deterministic trend and lag interval in first differences of 1 to 2. Overall, the Johansen cointegration test suggests that there exists a sustainable cum long-run equilibrium relationship between the variable. This suggests causality in at least one direction.

Since the existence of a long-run relationship has been established between long-term interest rates and expected inflation and other variables, 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;

$$INT_t = \delta + \varphi_1 EXPINFL_t + \varphi_2 USRATE_t + \varphi_3 EXCH_t + \mu_t \quad \text{(from equation 8)}$$

$$\mu_t = INT_t - \delta - \varphi_1 EXPINFL_t - \varphi_2 USRATE_t - \varphi_3 EXCH_t \quad (20)$$

where μ_t is the residual term and φ is a cointegrating coefficient. From equation (20), we can formulate a simple ECM as:

$$\Delta INT_t = \lambda_1 + \lambda_2 \Delta EXPINFL_t + \lambda_3 \Delta USRATE_t + \lambda_4 \Delta EXCH_t + \Omega\mu_{t-1} + \nu_t \qquad (21)$$

Specifically from the ECM expressed in equation (21), λ captures any immediate, short term or contemporaneous effect that the explanatory variables have on INT. The coefficient φ_i reflects the long-run equilibrium effect of EXPINFL, USRATE and EXCH on INT and the absolute value of Ω decides how quickly the equilibrium is restored. We can therefore say that λ_i and Ω are the short-run parameters while φ_i is the long-run parameter.

Table 6: ECM Short Run Coefficient Estimates

Dependent Variable=D(INT)		
Regressors	Co-efficient	Prob-value
C	0.112493	0.8304
D(EXPINFL)	0.070709	0.0695
D(EXPINFL(-1))	-0.099703	0.0080
D(USRATE)	-0.387117	0.1529
D(USRATE(-1))	0.082323	0.7563
D(EXCH)	-0.003907	0.9000
D(EXCH(-1))	0.015763	0.6057
ECM(-1)	-0.213886	0.8909

Table 6 provides us the proportion of disequilibrium error that is accumulated in the previous period, which is corrected in the current period. The P-value of the error correction term coefficient in Table 6 shows that it is statistically insignificant at a 10% level although it has the correct negative sign, thus suggesting that nominal interest rate adjust to the explanatory variables. The coefficient of ecm(-1)is equal to -0.213886 for short run model implying that the deviation from the long-term inequality is corrected by about 22% each year. The lag length of short run model is selected on the basis on AIC and SIC.

Table 7: ESTIMATED LONG RUN COEFFICIENTS

Variables	Co-efficient	t-statistics	P-value
C	16.32977	8.053242	0.0000
$EXPINFL_t$	0.068979	1.934382	0.0612
$USRATE_t$	-0.512215	-2.793959	0.0084
$EXCH_t$	-0.043219	-2.512797	0.0167
AR(1)	0.517751	3.436226	0.0015
R-Squared = 0.7355284 Durbin-Watson Stat. 1.968842 F-Stat = 24.30433 Prob(F-stat) = 0.0000			

We estimate the equation (8) and report the estimation results, including the estimated first-order autoregressive coefficient of the error term in Table 7, using OLS. All the estimated long-run coefficients are significant at 5% except for expected inflation which is significant at 10% level. The result of long run estimated coefficient shows that a one percentage increase in expected inflation rate will lead to about 0.7 percentage rises in nominal interest rate while a ten percentage rise in foreign interest rate (USRATE) will bring about a fall in nominal interest rate by 5.12 percent. Furthermore, a unit increase in nominal effective exchange rate will lead to about 0.45 unit fall in nominal interest rate. The coefficient of determination (R2) is about 0.74. The result shows that about 74% of variation in nominal interest rate is caused by variations in the explanatory variables. The Durbin-Watson statistics are 1.968842 which shows the absence of serial correlation.

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 8 and 9. The Wald test results shown in Table 8 reveal that full (standard) Fisher's hypothesis does not hold in the Nigerian economy. The Wald tests in table 10 show that Fisher effect is strong in the economy and that the other variables are significantly different from zero.

Table 8: Wald coefficient test for strong Fisher Hypothesis

Estimated equation; $INT_t = \delta + \varphi_1 EXPINFL_t + \varphi_2 USRATE_t + \varphi_3 EXCH_t$			
Null Hypothesis; $\varphi_1=1$			
Test Statistics	Value	Df	Probability
t-statistics	-26.10862	35	0.0000
F- statistics	681.6602	(1,35)	0.0000
x^2 – statistics	681.6602	1	0.0000

Table 9: Wald coefficient test for the significance of constant and other dependent variable

Estimated equation; $INT_t = \delta + \varphi_1 EXPINFL_t + \varphi_2 USRATE_t + \varphi_3 EXCH_t$			
Null Hypothesis; $\delta=0$, $\varphi_1=0$, $\varphi_2=0$, $\varphi_3=0$,			
Test Statistics	Value	Df	Probability
F- statistics	40.46246	(4,35)	0.0000
x^2 – statistics	161.8499	4	0.0000

Toda-Yamamoto Granger Causality Test

Having ascertained that a cointegrating relationship exist between among nominal interest rates, expected inflation rate, foreign interest rate and nominal effective exchange rate, the final step in this study is to verify if inflation Granger Cause nominal interest as posed by Fisher Hypothesis using the Toda and Yamamoto causality test. If so then we can say that it is nominal interest rates that respond to movements in inflation expectations. The empirical results of Granger Causality test based on Toda and Yamamoto (1995) methodology is estimated through MWALD test and reported in Table: 11. The estimates of MWALD test show that the test result follows the chi-square distribution with 3 degrees of freedom in accordance with the appropriate lag length along with their associated probability.

Table 10: Toda-Yamamoto Causality (modified WALD) Test Result

Null Hypothesis	Chi-sq	Prob.	Granger Causality
EXPINFL does not granger cause INT	4.352457	0.0370	Unidirectional Causality EXPINFL → INT
INT does not granger cause EXPINFL	0.162342	0.6870	
EXCH does not granger cause INT	0.253860	0.6144	No causality
INT does not granger cause EXCH	1.582799	0.2084	
USRATE does not granger cause INT	0.884133	0.3471	No causality
INT does not granger cause USRATE	0.085641	0.7698	
EXPINFL does not granger cause EXCH	2.492041	0.1144	No causality
EXCH does not granger cause EXPINFL	0.193592	0.6599	
EXPINFL does not granger cause USRATE	0.580315	0.4462	No causality
USRATE does not granger cause EXPINFL	0.864172	0.3526	
USRATE does not granger cause EXCH	0.011221	0.9156	No causality
EXCH does not granger cause USRATE	0.002975	0.9565	

It is clear from Table 10 that there is a unidirectional causality between expected inflation and nominal interest rate, which run strictly from expected inflation to nominal interest rate. However, the rest show no causality results.

Summary And Conclusion

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 1970-20011. We use Johansen (2001) cointegration approach and the Toda and Yamamoto (1995) causality testing procedure. The study attempted to advance the field by testing the traditional closed-economy Fisher hypothesis and an augmented Fisher hypothesis by incorporating the foreign interest rate and nominal effective exchange rate variability in the context of a small open developing economy, such as, Nigeria. The results of the unit root tests (ADF and KPSS) indicated the variables under study were I(1) processes except foreign interest variable. Consequently, the Error Correction Model was employed. The cointegration results show that there is a long run relationship between nominal interest rates, expected inflation and the international variables, which implies that all the variables move together in the long run. With the use of Wald coefficient test, this study tends to suggest 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 strong Fisher effect in the case of Nigeria over the period under study. Moreso, the paper revealed that in the closed-economy context, the causality run strictly from expected inflation to nominal interest rates as suggested by the Fisher hypothesis and there is no “reverse causation.” This conclusion is consistent with other studies like Obi, Nurudeen and Wafure (2009), Akinlo (2011) and Awomuse and Alimi (2012). However, in the open economy context, the result showed that aside expected inflation, the international variables- foreign interest and nominal effective exchange rates- do not contain information that predict the nominal interest rate.

Next we estimated short run dynamics of the model which suggested that about 22 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 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 rates and consequentially promote economic growth.

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APPENDIX 1:

Summary of some empirical Literature on Fisher Hypothesis

Author and Date	Country	Methods	Expected Inflation Proxy	Period	Fisher Effect
Choudhry, 1997	Belgium*	E&G= Engle & Granger and Harris & Inder cointegration analysis	CPI	1955-1994	Rejected
Cameriro, Divino and Rocha, 2002	Brazil*	Johansen cointegration analysis	REH, Moving Average	1980-1998	Accepted
Atkins & Serletis, 2002	Canada*	Pesaran, M. H., Shin, Y. and Smith, R.J. ARDL bound;	CPI	1880-1983	Rejected
Ghazali & Ramlee, 2003	Canada*	Autoregressive fractionally integrated moving average;	CPI	1974-1996	Rejected
Ghazali & Ramlee, 2003	Canada*	Ordinary least squares	CPI	1974-1996	Accepted
Jorgensen & Terra, 2003	Chile	Four Variable VAR	CPI	1977-1999	Rejected
Junita, 2001	Finland	Johansen cointegration analysis	ARIMA	1987-1996	Rejected
Lardic & Mignon, 2003	France	Granger fractional cointegration analysis	CPI	1970-2004	Accepted
Wesso, 2000	South Africa	Johansen cointegration analysis	CPI	1985-1999	Accepted
Esteve, Bajo-Rubio & Diaz-Roldan, 2003	United Kingdom	Stock & Watson (DOLS) dynamic ordinary least squares	GDP Deflator	1961-2001	Accepted
Fahmy & Kandil, 2003	USA	Johansen cointegration analysis	CPI	1980's 1990's	Accepted
Laatsch & Klien, 2002	USA	Regression	Break-even	1997-2001	Accepted