Testing the Fisher Hypothesis in the Presence of Structural Breaks and Adaptive Inflationary Expectations: Evidence from Nigeria

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This paper tested for the validity of the Fisher hypothesis in Nigeria during the period 1970 – 2014. The Gregory and Hansen Co-integration test confirmed the existence of a long-run relationship between nominal interest rates and inflation, albeit with a structural break in October 2005. In addition, the obtained Fisher coefficient in the cointegrating relation was 0.08, implying a weak form of Fisher effect in the long-run. On the basis of these findings, we upheld a weak Fisher effect in the long-run and non-existence of Fisher effect in the short-run. This implied that short term nominal interest rate is a good characterization of monetary policy stance. Also, the obtained partial Fisher effect indicated that changes in monetary policy are capable of altering the long term real interest rate and influencing economic growth through the interest rate channel. We therefore recommend a more forward looking monetary policy as a way of anchoring inflationary expectations and ensuring low and stable prices in Nigeria.

Keywords: Fisher effect, Structural change, Co-integration, Breakpoints regression, Interest rates

JEL Classification: C32, E43, E44

1.0 Introduction

A crucial question to central banks relates to the extent to which monetary authorities can affect both the short- and long-term real rates of interest through their policy action, especially in an environment where inflation expectations are becoming increasingly firmly anchored. Usually, in empirical works, this question is addressed by testing the validity of the Fisher hypothesis. The Fisher hypothesis, proposed by Irving Fisher in 1930, posits that monetary measures do not affect the real interest rate in the long-run

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because changes in inflation expectations are believed to be fully absorbed by changes in nominal interest rate. In other words, the ex-ante nominal interest rate fully anticipates movements in expected inflation, therefore leading to one-to-one relationship between the expected inflation rate and the nominal interest rate. The immediate implication of Fisher's postulation is that a permanent change in inflation transmits an equal change to the nominal interest rate so that the real interest rate is only affected by real shocks in the long-run and not by monetary policy.

The empirical testing of this hypothesis is commonplace in monetary economics and of critical importance to monetary policy. This is due to the crucial role played by nominal interest rate and its inflation adjusted variant in the determination of savings and investment behaviors of economic agents. These behaviors matter for the effectiveness of monetary policy as well as the overall growth of the economy. Also, the interrogation of the Fisher hypothesis is becoming more intense as more central banks continue to influence nominal interest rates as against targeting monetary aggregates[2]. It is in this regard that a lot of research efforts have been devoted to describing monetary policy rules based on nominal interest rates.

The empirical question regarding the validity of the Fisher hypothesis is usually approached by testing whether the nominal interest rate moves in tandem with inflation expectations in the long-run, using time series models. In the case of full fisher effect, the nominal interest rate and expected inflation are expected to be cointegrated with a slope coefficient of unity, provided they are individually integrated of order one. Within the framework of Fisher's hypothesis, a positive and significant relationship is expected between interest rates and inflation expectation with the direction of causality flowing from inflation expectations to nominal interest rates. However, in his early empirical work, Fisher himself failed to establish a one-to-one relationship between the two variables. A less than one-to-one Fisher effect indicates that monetary policy has been able to influence the long-run real rate of interest. Of crucial importance is the knowledge of the size of the Fisher coefficient to the central bank as it determines whether monetary policy is able to influence the real interest rate and hence, promote economic growth.

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[2] Monetary targeting is becoming less fashionable due to the instability of money demand function

As widely accepted as the Fisher hypothesis is, empirical results relating to its validity in the different economies in which it has been tested have been mixed. While studies by Fama (1975), Cargill (1977), Carlson (1977), Lahiri (1976), Levi and Makin (1979), Tanzi (1980), Famaand Schwert, 1977, Engsted (1996) and Hatemi (2002) failed to find empirical support for the hypothesis[3],Mishkin (1992), Evans and Lewis (1995), Wallace and Warner (1993), and Crowder and Hoffman (1996), found evidence supporting long-run Fisher effect. However, Ghazali (2003), Meiselman (1963) and Ball (1965) Cooray (2002), and Million(2003), reported weak and conflicting results.

In Nigeria, the situation is not different as some of the empirical works conducted to test the validity of the hypothesis in the country found partial Fisher effect, while others failed to establish any long-run relationship between the two variables in the Fisher equation. Recent studies like Ogbonna (2013) and Alimi and Awomuse(2012) found a significant causal relationship flowing from inflation to interest rates and concluded that full Fisher hypothesis did not hold during their estimation periods of 1970-2012 and 1970-2009, respectively. Other studies which verified partial Fisher effect in Nigeria include Alimi and Ofonyelu (2013) for the period 1970-2011, Adegboyega *et al* (2013) for 1986 – 2011 and Obi *et al.* (2009) for 1970-2007. On the other hand, Asemota and Bala (2011) failed to establish any long-run relationship between the two variables in the Fisher equation during 1961-2009.

The foregoing results revealed that there is no consensus yet on the exact relationship between the variables in the Fisher equation and the size of the Fisher coefficient in Nigeria. It is also obvious that the mixed findings of the existing studies are due to differences in sample period, variable measurement, model selection and estimation procedure. A major consensus in literature is that, since the concept of Fisher effect is a long-run phenomenon, testing for the presence of structural breaks in the Fisher equation is critical for any meaningful analysis (Mishkin, 1992). This is because policy changes and other exogenous shocks during the estimation sample are capable of injecting structural breaks into the Fisher equation and failure to account for such effects may lead to model misspecification, parameter bias and wrong inferences. It is in this regard that studies such as

[3] This led to an alternative concept known as the inverted Fisher hypothesis (IFH).

Bajo-Rubio *et al*. (2004) tested for the presence of structural change while verifying the Fisher effect using UK data spanning 1963–2004. However, recent studies on Nigeria such as by Ogbonna (2013) and Alimi and Ofonyelu (2013) failed to account for structural breaks in their modeling approach. To the best of our knowledge, the only attempt made at accommodating structural breaks was Asemota and Bala (2011), which found evidence of structural breaks in the Fisher equation but failed to account for it in their model.

Also, the manner in which inflation expectations is modeled may have profound effect on the resultant Fisher coefficient. While the adaptive and rational expectations approaches are common in literature, none of the recent studies on Nigeria introduced inflation expectations into their Fisher equation as their models focused on the contemporaneous relationship between nominal rate of interest and inflation rate, contrary to the dictate of the Fisher hypothesis. It is in the light of these shortcomings that this study seeks to re-examine the Fisher hypothesis in Nigeria while accommodating structural breaks and adaptive inflationary expectations in its modeling procedure.

Therefore, the broad objective of this paper is to empirically test the validity of the Fisher hypothesis in Nigeria during 1970-2014 by obtaining a realistic Fisher coefficient that best fits the data. To achieve this, the order of integration of the variables is identified based on the Augmented Dickey Fuller (ADF) and Zivot-Andrews unit root tests while the Bai-Perron multiple breakpoints test is applied to understand the changing dynamics of the Fisher coefficient over time. The existence of a long-run relationship between nominal interest rate and inflation expectations is investigated using the Gregory and Hansen (1996) co-integration test with structural breaks. Finally, we obtain the short-run Fisher coefficient by setting up an appropriate error correction model that accommodates structural breaks and captures inflation expectations in an adaptive manner. This is to avoid the misspecification errors and possible parameter bias associated with previous empirical works.

This paper is structured into five sections. After this introduction, a review of relevant literature is presented in section two while the third section discusses the econometric procedure adopted. Since the issue of structural change is central to this paper, the bulk of our discussions in section three focuses on endogenous breakpoint detection in testing for the presence of both unit root and co-integration. Section four presents and discusses the results and section five concludes the paper.

2.0 Literature Review

The Fisher hypothesis is a hotly debated concept in monetary economics and has attracted the attention of researchers and policy makers. The empirical testing approach has reflected developments in econometric methods and computational facilities over the years. Generally, results from studies conducted in both developed and developing countries are mixed. While most studies found empirical support for partial Fisher effect, a few others failed to establish any form of long-run relationship between nominal interest rates and inflation expectations.

For instance, Weidmann (1997) tested the Fisher hypothesis in Germany using quarterly data spanning 1957 – 1991 and found that the nominal interest rate moved less than point-for-point with inflation, implying a partial Fisher effect. In a similar study for Pakistan, Hasan (1999) determined the long-run relationship between nominal interest rate and inflation rate and accepted the partial Fisher Hypothesis using co-integration analysis of quarterly data from 1957:Q1 to 1991:Q2. Hasan's result suggests that interest rate does not fully cover or accurately anticipate inflation, which implies that bank deposits deteriorate over time.

Macri (2006) investigated the Fisher Hypothesis for Australia using the Johansen co-integration approach on quarterly short-term interest rate and Consumer Price Index (CPI) data for the period Q1:1979 to Q2:2005. The study found a significant long-run co-integrating relationship between the variables during the study period but failed to validate the full Fisher effect for the Country.

Hatemi and Irandoust (2008) used quarterly data on short-run nominal interest rates and CPI inflation rates to test the Fisher effect in Australia, Japan, Malaysia and Singapore using different estimation periods due to data unavailability[4]. Applying the Kalman filter approach to estimate the time-varying parameters of the Fisher equation, their results generally rejectedthe

[4]March 1973 to April 1998 for Australia, January 1960 to April 1998 for Japan, March 1973 to April 1998 for Malaysia and January 1974 to April 1998 for Singapore

hypothesis of full Fisher effect. This implies that nominal interest rates do not respond point-for-point to changes in the expected inflation rates.

Piccinino (2011) investigated the existence of the Fisher effect in Euro area during the period 1999-2001using the European interbank offered rate as a measure for interest rates, and the six-month maturing German Federal Securities as a measure of expected inflation. Having found evidence of a cointegrating relationship between the variables, he proceeded to estimate an error correction model with a view to obtaining the Fisher coefficient. The study found support for the full Fisher hypothesis based on the entire data set. However, it failed to provide evidence for a unitary relationship between the two variables for the sub-period September 2008 - March 2011.

Jareno and Tolentino (2012) studied if majority of nominal Interest rates movements are caused by inflation rate variability, holding real Interest rates constant using ARIMA models for Spanish data between 1993 and 2004. The researchers found that there is a positive and significant relationship between the variables as a 100% increase in inflation rate leads to a 20% increase in nominal interest rates and therefore concluded that there is partial Fisher effect in the Spanish case.

Arisoy (2013) employed co-integration and time varying parameter methods to investigate the strength of Fisher hypothesis in Turkey during 1987:Q1-2010:Q3. The study found a weak form of Fisher hypothesis in Turkish economy.

Turanand Curri (2014) examined the validity of Fisher Hypothesis in Albania during the period 1997-2013. Employing the Johansen Co-integration Test for the Albanian quarterly nominal interest rate and quarterly inflation rate, the study found evidence of a long-run relationship between nominal interest rates and inflation. These findings are similar to those of Carneiro, *et al*. (2002) who did similar studies for Australia and Brazil. However, the obtained Fisher coefficient by Turan and Curri (2014) indicated that full Fisher hypothesis did not hold during the estimation period.

Ayub,*et al*. (2014) investigated the causal relationship of inflation rate with nominal interest rate in Pakistan using time series data for 1973-2010. The stationarity of the data was checked using the conventional unit root tests while both the Johansen and Engle- Granger (Residual Based) co-integration tests were used to gain insight into the nature of the long-run relationship between the variables. They found evidence of a long-run equilibrium relationship between the nominal interest rate and inflation in Pakistan during their estimation period.

Also, Shalishali(2009) examined International Fisher Effect in Selected Asian Countries; China, India, Japan, South Korea, Malaysia, Thailand, Vietnam, and Indonesia using quarterly money market interest rates and percentage change in the exchange rates from Q1:1990 to Q4:2009. Regression analysis was applied to the exchange rates and interest differentials data for the selected countries. Also, each of these countries was interchangeably used as the home country, and foreign country to track the trail of the effect. The results showed full Fisher effect holds for some countries and does not hold for others.

A few other studies have also showed results that failed to support the existence of a long-run relationship between nominal interest rates and inflation expectations. For instance, Peyavali and Sheeefeni (2013) investigated the relationship between interest rate and inflation by testing whether the Fisher hypothesis holds in Namibia. Employing unit root tests and co-integration test on monthly data from January 1992 to December 2011, they showed that the series were non-stationary and not co-integrated. Therefore, the study rejected the Fisher hypothesis in the Namibian context and concluded that the variables were not causally related.

Jayasinghe and Udayaseelan (2008) investigated the long-term relationship between nominal interest rate and inflation and examined whether there is a difference in this relationship across different frequencies of data such as monthly, quarterly and annual in the context of Sri Lankan financial markets. Monthly and quarterly data cover a period from 1978 to 2007 while the annual data covered 1953 to 2007. They used Autoregressive Distributed Lag bounds testing approach developed in Pesaran, *et al.* (2001) and concluded that there is no long-term relationship between nominal interest rate and inflation in the Sri Lankan financial markets.

In a study on selected ECOWAS countries, Asemota and Bala (2011) investigated the Fisher effect using annual data from 1961 to 2011. The countries included in their study are Burkina Faso, Côte d'Ivoire, Gambia, Ghana, Niger, Nigeria, Senegal and Togo. Their results showed that nominal interest rates respond less than one-for-one to changes in the inflation rates, implying the existence of partial Fisher effect for most of the ECOWAS countries. However, they also found periods of full Fisher effect for Gambia and Ghana.

Obi, *et al*. (2009) studied the existence of Fisher effect in Nigeria by regressing the interest rates on inflation from 1970 to 2007 using the co-integration and error correction model. The finding showed that there exists a long-run partial Fisher effect in the country as an increase in inflation rate leads to a less proportionate increase in nominal interest rate. However, this study did not capture the effect of inflation expectations as proposed by Fisher (1930).

Alimi and Awomuse (2012) employed the Johansen co-integration approach to examine the long-run relationship between expected inflation and nominal interest rates in Nigeria using annual data for the period 1970 – 2009. The study showed that the nominal interest rates and expected inflation move together in the long-run, but not on one-to-one basis. Having found evidence of long-run relationship, they set up an error correction model to investigate the extent to which the Fisher hypothesis held in the short-run. The results of the Wald test on the Fisher coefficient failed to validate the standard Fisher hypothesis. However, it found evidence of partial but strong Fisher effect during the estimation period. Also, only about 16 percent of the disequilibrium error in the fisher equation is corrected with a year.

Adegboyega*et al*. (2013) examined the Fisher effects in Nigeria using annual data from 1986 to 2011. They employed an Autoregressive Distributed Lag (ARDL) model to investigate the existence of a long-run relationship among the series, and also the existence of Fisher effect. The study revealed a partial Fisher effect for the post-SAP era in Nigeria and a negative relationship between interest rate and consumer price index.

Alimi and Ofonyelu (2013) tested the validity of the Fisher hypothesis in Nigeria by applying the Johansen co-integration approach and error correction model to annual data spanning 1970-2011.The Toda and Yamamoto causality test was also employed to investigate the causal relationship between the variables in the Fisher equation. They found that, in line with the Fisher hypothesis, causality runs from expected inflation to nominal interest rates and not *vice versa*. They found empirical support for a relationship between money market interest rates and expected inflation in the long-run but the Fisher effect was partial, even though strong. Their error correction parameter showed that about 22 percent of disequilibrium error in the Fisher equation is corrected within a year.

Ogbonna **(**2013) examined the causal link between interest rates and inflation in Nigeria using quarterly data for the period 1970 – 2012. An Autoregressive Distributed Lag models was used to investigate the causal link between interest rates and inflation and the results indicated a unidirectional causality running from inflation to interest rates in the short-run. However, the co-integration test failed to establish the existence of a long-run relationship between the variables, implying the rejection of the Fisher hypothesis.

Asemota and Bala (2011) adopted a combination of co-integration test with structural breaks and Kalman filter approached to investigate the Fisher hypothesis in Nigeria using quarterly CPI inflation and nominal interest rates data for the period 1961-2009. The co-integration test indicated that there is no long-run relationship between the variables. However, the study failed to find empirical evidence in support of full Fisher effect in the country based on the Kalman filter results. Even though this study found significant structural breaks during the estimation period, the breaks were not accounted for.

Umoru and Oseme (2013) estimated the relationship between inflationary expectations and the variations in interest rate in Nigeria using the Generalized Method of Moment (GMM) estimator. The study reveals that interest rate variations have no significant impact on inflation expectations in the country.

The literature is somewhat scanty on studies that accommodated structural breaks in their modeling approach while testing the Fisher hypothesis, with most of them focusing on developed countries. Beyer, *et al*. (2009) argued that a break in the cointegrating relation could introduce a spurious unit root that leads to a rejection of co-integration between the variables in the Fisher equation. Thus, they investigated Fisher hypothesis for 15 countries in the post-war period using structural break tests and tested for nonlinearity in the cointegrating relation. Having accounted for breaks, the study found empirical support for co-integration and a linear Fisher relation in the long-run. They concluded by arguing that it is essential to correctly establish the time series properties of the variables involved, which are inflation and interest rates while testing for Fisher effect.

Also, Bajo-Rubio, *et al*. (2004) provided an empirical test of the Fisher effect in the UK using co-integration techniques, where the existence of instabilities in the cointegrating or long-run relationships is explicitly tested. They adopted a methodology that allowed the instability in the cointegrating relationship to occur at an unknown date. Based on a study period of 1963:1-2004:1, they found evidence of partial Fisher effect in the country with a Fisher coefficient of 0.42. Based on the detected structural break dates, the Fisher coefficients for the different sub-samples were obtained and it ranged from 0.09 for the period 1973:2-1980:4 and 0.51 for 1987:1-1997:3. They concluded that for each point increase in the inflation rate, something less than a half would have been passed through a higher nominal interest rate, with the rest being reflected in a lower real interest rate.

Million (2004) examined the long-run relationship between nominal interest rates and inflation while allowing for structural breaks and asymmetric mean reversion. Based on the Threshold Autoregressive (TAR) test applied to the residuals of the co-integration relationship, the study found strong evidence for non-linear mean reversion properties for the real interest rates of the US Treasury Bill market, suggestive of asymmetric changes to inflation shocks in the Central Bank's reaction function.

Overall, there seems to be a preponderance of studies confirming the existence of partial Fisher effect both in developed and developing countries, with most of the studies employing time series models. However, only few of these studies accounted for the presence of structural breaks in their modeling approach. The implication of this is that their findings may be incorrect due to parameter bias associated with misspecification errors in their models. Failure to accommodate structural breaks while testing the Fisher effect is counter intuitive given that the Fisher hypothesis itself is a long-run phenomenon and the variables in the Fisher equation are usually vulnerable to structural breaks resulting from policy changes and other exogenous shocks. To bridge this gap with respect to testing the Fisher effect in Nigeria, this paper fully accounts for the possibility of structural breaks in the cointegrating relationship of the Fisher equation.

3.0 Econometric Procedure and Data

The usual approach for testing the validity of the Fisher hypothesis involves conducting a co-integration test on the Fisher equation while the measurement of the Fisher effect is by checking the statistical significance and size of the slope coefficient of inflation expectations in the Fisher equation. Following the work of Carneiro, *et al* (2002), we represent the Fisher equation as:

$$NIR_t = RIR_t + INFE_t \tag{1}$$

where *NIR* denotes nominal interest rate, *RIR* is real interest rate and *INFE* is the expected inflation rate. As in Fama (1975), we assume that the expected inflation is different from the actual inflation rate by a white noise stationary term and that the RIR is stationary. Consequently, we can estimate a Fisher equation of the form:

$$NIR_t = \alpha + \beta\, INFE_t + \varepsilon_t \tag{2}$$

where *NIR* is proxied by 91-day Treasury bill rate, *INFE* is arrived at based on the adaptive expectations approach, where economic agents are assumed to have foresight of future inflation. We proxied INFE by allowing the contemporaneous inflation rate (i.e. inflation at time *t*) to assume the next period's inflation rate (i.e. inflation rate at time *t*+1). The inflation rate was computed as seasonally adjusted year on year change in the headline Consumer Price Index (HCPI). β denotes the Fisher coefficient and ε_t is the random error term. If $\beta = 1$, a full Fisher effect is verified and if $\beta < 1$, the Fisher effect is said to be partial. However, if $\beta = 0$, there is absence of long-run relationship between *NIR* and *INFE*. This section presents a detailed econometric procedure adopted by this study to obtain a realistic β for the Nigerian economy.

This study uses monthly data covering the period 1970M01 to 2014M07 on nominal interest rate and headline CPI. These are sourced from the Central Bank of Nigeria statistics database.

3.1 Unit Root

The first step in any time series analysis is the identification of the order of integration of the variables. This is to avoid the spurious regression problem. In this study, we employ the Augmented Dickey-Fuller (ADF) unit root test to investigate if the two variables included in the Fisher equation are stationary. If the variables have unit roots, we difference them accordingly to achieve stationarity.

In order to address the issue of possible structural breaks in the series[5], we employ the Zivot and Andrews (1992) unit root test to further interrogate the order of integration of the included variables. This test accommodates one endogenously determined structural break in its approach to unit root test testing. The null hypothesis in this case is the presence of unit root with drift that excludes any structural break in the series while the alternative is a trend stationary series process that allows for a one-time break in the trend function (Zivot and Andrews, 1992).

3.2 Bai and Perron (1998) Test for Structural Breaks in the included Variables

In a second step, we interrogate the possibility of multiple structural breaks in the fisher equation, in which the fisher coefficient is assumed to be changing at different regimes in the estimation period. To investigate this phenomenon, the Bai and Perron (1998) test procedure is employed. This procedure enables us to endogenously detect unknown break dates in the variables by testing the null hypothesis of ‘M’ breaks against an alternative of ‘M+1’ number of breaks in a sequential manner.

According to Carrion-i-Sylvestre and Sans´o (2006), the dynamic algorithm of Bai and Perron (1998) is appropriate for detecting breakpoints if the break date in a model is unknown. This is because the method minimizes the sum of squared residuals from Dynamic Ordinary Least Squares (DOLS) regressions over a closed subset of break fractions. Thus, the long-run model (equation 1) is subjected to this test in order to have an insight into the presence and dates of structural breaks in the Fisher equation during the estimation period.

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[5] Which is absent in the ADF unit root test

3.3 Co-integration Test

As earlier stated, testing for the validity of Fisher hypothesis involves conducting a co-integration test on the Fisher equation. A popular approach for testing for co-integration, especially between two variables is the Engle and Granger two step procedure. However, It has been argued in literature that the Engle and Granger (1987) approach tends to under-reject[6] the null of no co-integration if there is a co-integration relationship that has changed at some (unknown) time during the sample period (Harris and Sollis, 2003). This implies that the Engle-Granger procedure has low power in the presence of structural breaks.

To circumvent the shortcoming of the Engle and Granger two step procedure, we employ a residual based co-integration test proposed by Gregory and Hansen (1996) to investigate whether NIR and INFE share similar stochastic trends in the long-run relationship, which may have changed as certain period. This is an extension of the Engle and Granger (1987) approach and it involves testing the null hypothesis of no co-integration against an alternative of co-integration with a single break in an unknown date based on extensions of the traditional *ADF*-, Z_α and Z_t – test types. Thus, this test accommodates the possibility of structural breaks in the cointegrating relationship and is residual based. If the null hypothesis is rejected, it implies that the linear combination of the variables exhibits stable properties in the long-run, but with structural break. This concept is useful to this study as it helps to define the existence of a long-run equilibrium to which the two variables in the equation (1) converge over time.

3.4 Error Correction Model

The Granger's representation theorem shows that if there exists co-integration amongst a group of variables, there must also exist an error correction representation. In order to understand the short-run dynamics in our model, we estimate an error correction model that is consistent with the results of the tests for unit roots, structural breaks and co-integration. This is specified as:

[6] For studies that have applied this methodology, the implication is that they tend to erroneously conclude that the Fisher hypothesis is invalid, when indeed, it is actually valid.

$$\Delta NIR_t = \alpha_0 + \sum_{i=0}^{s} \beta_i \, \Delta INFE_{t-i} + \sum_{j=1}^{q} \gamma_j \, \Delta NIR_{t-j} + \rho\varepsilon_{t-1} + \mu_t \qquad (3)$$

Where Δ denotes the first difference operator, $\mathcal{E}_t$ is the estimated residual from the selected Gregory-Hansen equation, s and q are the number of lag lengths selected on the basis of information criterion. For a stable system, the coefficient ρ is negative and statistically significant. Moreover, the value of ρmeasures the speed of adjustment of the NIR to the value implied by the long-run equilibrium relationship. In other words, it captures the speed at which the NIR returns to its equilibrium level following a shock.

4.0 Results

4.1 Time Path of Included Variables

The time series plot of the variables shown in Chart 1 revealed that the nominal interest rate (proxied by 91-day Treasury bill rate) could be non-stationary and susceptible to structural breaks in the mid-nineties and mid-2000s. Also, there seems to be indications of structural break in inflation expectations in the mid-nineties.

These observed characteristics of the two series were helpful in selecting the appropriate econometric techniques for our analysis.

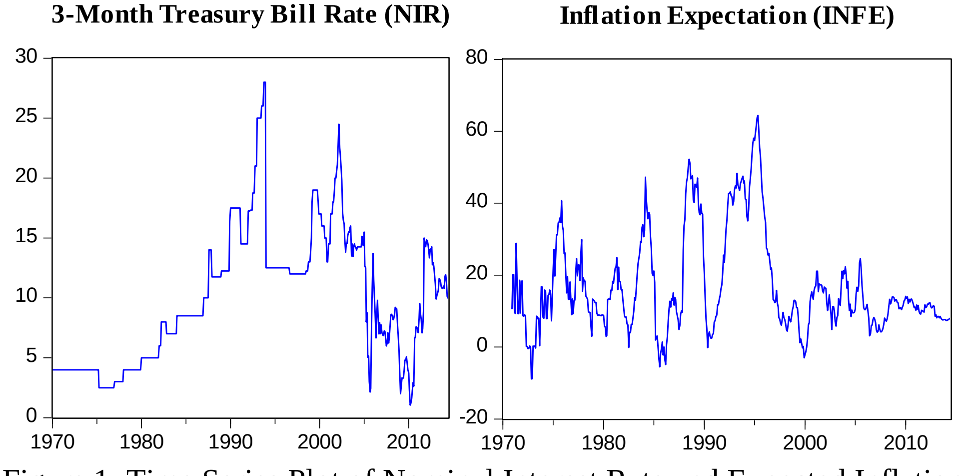

Figure 1: Time Series Plot of Nominal Interest Rate and Expected Inflation

4.2 Unit Root Test Results

In this section, we present the results of the two unit root tests conducted to test for stationarity in our variables. The results of the ADF unit root test presented in Table 1 show that both the nominal interest rate and inflation expectations are not stationary at levels. However, at first difference, the null of unit roots in the series was rejected at the 1 per cent significance level. This implies that the variables are integrated of order 1, i.e. I (1).

Table 1: ADF Unit Root Test Results

Variable	ADF Test Statistic		Decision
	Level	First Difference	
NIR	-2.3684	-21.1848	I(1)
INFE	-2.8172	-9.3714	I(1)

The ADF critical values at 1%, 5% and 10% are -3.4430, -2.8670 and -2.5700, respectively

Since the conventional ADF test is biased towards non-rejection of the null hypothesis in the presence of structural breaks, we have also conducted the Zivot-Andrews (1992) unit root test and the results are shown in Table 2.

Table 2: Zivot and Andrews Unit Root Test Results

ZA Model	Variable	Level		First Difference		Decision
		ZA Test Statistic	Break Date	ZA Test Statistic	Break Date	
Model A	NIR	-4.7939	2005M02	-13.4992	1993M11	I(1)
	INFE	-4.261	1996M08	-8.2227	1994M12	
Model B	NIR	-4.1847	1992M11	-13.2098	1982M05	I(1)
	INFE	-3.5346	1993M03	-7.9317	1997M06	
Model C	NIR	-4.7568	2005M02	-13.4874	1993M11	I(1)
	INFE	-4.5148	1996M08	-8.2232	1994M12	

The Asymptotic Zivot Andrews critical values at 5% for Models A, B and C are -4.80%, -4.42% and -5.08%, respectively

Based on the results shown in Table 2 and the asymptotic critical values of Zivot and Andrews at 5 per cent, we further confirm that nominal interest rate and inflation expectations are integrated of order 1, albeit with structural breaks occurring at different time periods, depending on the assumptions made in respect of the nature of the structural break. Overall, the results using the Zivot Andrews test supported the findings of Table 1, hence, we concluded that inflation and nominal interest rates are I (1) variables.

4.3 Bai Perron Multiple Breakpoint Test Results

The least squares regression with breaks was estimated to gain insight into the changing dynamics of the Fisher coefficient during the estimation period of 1970 – 2014. The result of the Bai Perron multiple breakpoint regression is presented in Table 3. The test identified four break dates at 1978M09, 1987M07, 1994M01 and 2005M04. While the 1987M07 break date coincided with the SAP period, the 2005M04 breakpoint also coincided with the banking consolidation era. Based on the identified structural break points, the regression was partitioned into five regimes. The Fisher coefficients for the first two regimes, even though statistically insignificant were positive and less than one. Statistically significant and positive Fisher effect was found shortly after the adoption of the SAP in 1986. Thus, during the period 1987M07 – 1993M12, the Fisher coefficient was about 0.05, implying partial Fisher effect. It is important to note that it was only at this period that the Fisher effect was correctly validated. In Contrast, the fisher coefficients in regimes 4 and 5 were negative and significant.

Table 3: Bai Perron Multiple Breakpoint Test Results

Variable	Regime 1	Regime 2	Regime 3	Regime 4	Regime 5
C	4.1096***	6.7380***	15.2384***	15.8750***	10.9924***
INFE	0.0389^{ns}	0.0054^{ns}	0.0460**	-0.0666***	-0.2728***
Standardized INFE Coefficient	-0.0496	0.0071	0.1021	-0.1394	-0.2218
Regime Duration	1970M12 - 1978M08	1978M09 - 1987M06	1987M07 - 1993M12	1994M01 - 2005M03	2005M04 - 2014M06
No of Observations	93	106	78	135	111

In terms of the magnitude of the Fisher effect across the regimes, the estimated standardized Fisher coefficients showed that the Fisher effect was strongest (at 0.1021) in regime 3, an era immediately following the introduction of SAP in Nigeria.

4.4 Gregory Hansen Co-integration Test Results

Based on the fact that the two variables in our Fisher equation are integrated of order 1, it is reasonable to interrogate the possibility of long-run cointegrating relationship between them. As earlier noted, Engle and Granger (1987) approach breaks down if there is evidence of structural breaks in the co-integration regression and tend to under-reject the null of no co-integration. Thus, we adopted the Gregory and Hansen approach and the results are presented in Table 4. Based on the Schwarz Information Criterion (SIC), the Gregory Hansen model with level shift and trend (GH-2) was selected and it indicated the presence of co-integration between nominal interest rate and inflation expectation. These results imply the presence of long-run relationship between NIR and INFE and confirm the validity of the Fisher hypothesis for Nigeria in the long-run.

Table 4: Gregory Hansen Co-integration Test Results

GH Model	ADF	Break Date	Z_t	Break Date	Z_α	Break Date	SIC
Level Shift (GH-1)	-3.9418	1988M01	-3.7279	1984M12	-27.2281	1984M12	6.2488
Intercept Shift with Trend (GH-2)	-5.2790	2005M10	-4.8507**	2005M10	-45.8241	2005M10	5.6561
Intercept & Regime Shifts (GH-3)	-4.0237	1988M01	-3.7963	1984M05	-28.2670	1984M05	6.2422

The 5 per cent critical values for ADF (and Z_t) are -4.61, -4.99 and -4.95 for GH-1, GH-2 and GH-3 models, respectively while the Z_a for the same models are -40.48, -47.96 and -47.04, respectively (Table 1 of Gregory and Hansen, 1996)

***** indicates the existence of cointegration at 5% level***

Also, the model detected a significant break point in 2005M10, which coincided with the period of the banking consolidation exercise. The long-run regression results corresponding to the GH-2 model are presented in Table 5.

4.5 Long-run Model

The estimated long-run Fisher equations are presented in Table 5.The effects of structural breaks are accommodated in the estimated coefficients. In a bid to ensure that our coefficient estimates are efficient, we correct for possible heteroscedasticity and serial correlation in the residuals of the model by applying the Newey-West procedure (Newey and West, 1987). This procedure produced heteroscedasticity and autocorrelation consistent standard errors that correct for both heteroscedasticity and autocorrelation in our long-run model.

Table 5: Long-run Model

Variable	Coefficients
C	1.7658**
@TREND>455-2	-9.0476***
Trend	0.0302***
INFE	0.0818**
Standardised INFE Coefficient	0.2029
Adjusted R2	0.4669
SIC	5.6887
Serial Correlation LM Test	446.7091
ARCH LM Test	194.1559

We found empirical support for a significant and positive long-run relationship between inflation expectation and nominal interest rate with the Fisher coefficient estimated at 0.0818, implying a partial fisher effect. The estimated scaled coefficient for inflation expectation is 0.2029 (Table 5). Based on the WALD test, the null hypothesis that the Fisher coefficient was equal to zero was rejected at the 5 per cent significance level (Table 6). These results confirmed the presence of the weak form of Fisher effect in Nigeria, suggesting that nominal interest rates adjust less than one-for-one to changes in inflationary expectations in the long-run. These findings were contrary to Asemota and Bala (2011) who found no empirical support for a long run relationship between interest rate and inflation in Nigeria, possibly due to methodological issues.

Table 6: WALD Coefficient Test Results (Long-run Model)

Statistic	*Null Hypothesis: Long Run $\beta = 0$*	
	Test Statistic Value	**P Value**
t-statistic	2.2367	0.0257
F-statistic	5.0030	0.0257
Chi-square	5.0030	0.0253

The weak form of Fisher effect obtained above suggests that the long-term real rate of interest was not constant over the estimation period. In other words, monetary policy decisions implemented by the central bank have led to changes in the long-term real rate of interest.

4.6 Short-run Model

In order to investigate the short-run dynamics of the Fisher equation, we estimated an error correction model and the results are presented in Table 7. The error correction model presented is associated with the long run model in Table 5. For a stable system, the error correction coefficient must be negative and significant. The results showed that the error correction model is stable as the error correction term is negative and statistically significant.

Table7: Short-run Model

Variable	Coefficient
C	0.0113^{ns}
DINFEXPSA	-0.0220*
ECM	-0.0287**
Adjusted R2	0.0138
SIC	3.0353
Serial Correlation LM Test	5.6780
ARCH LM Test	0.0020

Contrary to the findings from the long-run equation, the Fisher coefficient in the error correction model is wrongly signed and statistically insignificant, implying the absence of Fisher effects in the short-run. There is therefore no evidence to support short-run Fisher effect in Nigeria. The results of the WALD test presented in Table 8 showed that the null hypothesis of the Fisher coefficient being zero cannot be rejected at the 5 per cent significance level. Thus, the short-run Fisher hypothesis does not hold empirically in Nigeria during the period 1970 - 2014. The implication of this is that short term movements in the nominal interest rate basically reflects the stance of monetary policy rather than inflation expectations as proposed by Fisher (1930). This could be explained by the fact that short-term interest rates are determined by monetary authorities as part of their monetary policy framework and not by expectations formed by economic agents. Thus, short term interest rates are a good indicator of monetary policy in the country. These findings are similar to the results obtained for Australia by Mishkin and Simon (1995) who argued that obtaining empirical support in favor of short term Fisher effect implies that the short term nominal interest rate becomes a poor indicator of monetary policy stance and *vice versa*.

Table 8: WALD Coefficient Test Results (Short-run Model)

Statistic	***Null Hypothesis: Short Run β = 0***	
	Test Statistic Value	**P Value**
t-statistic	-1.6488	0.0998
F-statistic	2.7187	0.0998
Chi-square	2.7187	0.0992

5.0 Conclusion and Policy Implication

A review of relevant extant literature showed that a significant amount of research has been conducted to interrogate the Fisher hypothesis both in developed and developing countries, with conflicting results. Based on recent econometric techniques that allow for structural change in the cointegrating Fisher equation, this paper investigated the validity of the Fisher Hypothesis in Nigeria during the period 1970 to 2014. Time series plots of the included variables revealed that the nominal interest rate could be non-stationary and susceptible to structural breaks. On the other hand, the headline CPI revealed a steady upward trend. Based on these time series properties of the variables, we employed econometric techniques that incorporate structural breaks in modeling their short and long-run relationships. The results of the ADF and Zivot-Andrews unit root tests showed that the two variables were non-stationary at levels. The Bai-Perron breakpoints regression also indicated four (4) structural breakpoints in the Fisher equation located at 1978M09, 1987M07, 1994M01 and 2005M04. Consequently, the observations were partitioned into five regimes with the Fisher coefficient ranging between -0.2728 in regime five and 0.0460 in regime 3. Estimates of the standardized coefficients across the regimes showed that the Fisher effect was strongest during the period 1987M07 – 1993M12.

The Gregory and Hansen co-integration test, which was conducted to investigate long-run Fisher effect, revealed that the long-run Fisher Hypothesis was valid for Nigeria. However, there was a structural change in the cointegrating relationship between inflation and nominal interest rates in 2005M10. This coincided with the period of banking consolidation in Nigeria. Based on the long run model, we estimated a Fisher coefficient of 0.0818, implying weak for of Fisher effect. However, the error correction model failed to find any empirical support in favour of short-run Fisher effect in the country.

What are the implications of these findings? First, the absence of Fisher effect in the short-run implies that changes in short term interest rates are not driven by inflation expectation. Thus, short-run changes in the short-term interest rate reflect changes in the real interest rate and hence the stance of monetary policy, rather than expected inflation. This is explained by the fact that short-term interest rates are determined by the monetary authorities as part of their monetary policy framework and not by expectations formed by economic agents. Second, the verification of a partial Fisher effect in the long-run suggest that the real interest rate was not constant over the estimation period and that monetary policy decisions implemented by the central bank are capable of altering the long-term real rate of interest, and hence the direction of economic growth through the interest rate channel of monetary policy. Thus, we recommend a forward looking type of monetary policy rule that ensures that economic agents' inflationary expectations are anchored within limits that are conducive to the low and stable price objectives of the CBN.

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