Fisher Effect and the Relationship between Nominal Interest Rates and Inflation: The Case of Nigeria

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Abstracts

This research study carries out empirical investigations of the Fisher effect and the long-run relationship between nominal interest rates and expected inflation in Nigeria making use of annual data covering a period of half of a century. Fisher (1930) postulation is that nominal interest rates should reflect the expected rate inflation rates movements on one-for-one basis. Applying the Nigerian data covering the period between 1961 and 2009, this study uses the 3-month treasury bill rates to proxy for nominal interest rates while the 12-month moving average headline inflation serves as the expected inflation. Apart from the descriptive analyses of the sample data, the econometric approaches which the study employs are the ordinary least square (OLS) regression, the Engle-Granger ADF residual-based cointegration, the Johansen maximal likelihood cointegration and Granger causality test. Testing the data, using the augmented Dickey-Fuller (ADF) unit root test method, it was found out that nominal interest rate and expected inflation were non-stationary in levels but in first differences. This suggests that the OLS regression may be spurious even as the result rejects a full fisher effect in Nigeria. The results of the cointegration tests imply that there is no long-run cointegration relationship between nominal interest rates and inflation in Nigeria. The Granger causality tests report that expected inflation does not Granger cause nominal interest rates in Nigeria, but a one-way directional movement running only from nominal interest rates to inflation. The problem of high inflation identified in the history of Nigeria prompted the recommendation for the adoption inflation targeting policy for the country and other countries in this category while the interest rate should be set in line with the dictates of the economy.

1 Introduction

In Nigeria, there have been rise in the levels and volatilities of inflation and these have altered the performances of and relationship between many economic variables in the country. The Keynesian liquidity effect[1] can no longer explain how increases in money supply have affected nominal interest rates. Probably, the major reason behind this is the increasing weight of the expected rate of inflation as a component of nominal interest rate. It is therefore essential to consider how inflationary expectations are affected by money supply and how these inflationary expectations have, in turn, affected interest rates in Nigeria. Interest rates and changes in the price level are important variables of macro economy that are being regularly monitored by economists and policy makers, globally.

Toward analysing economic relationships in an inflationary economy, we must make clear distinction between nominal interest rates and the interest rates adjusted for inflation. Professor Irving Fisher in 1930 defined the *ex ante* expected real interest rate as the nominal interest rate minus the *ex ante* expected inflation. This is what is known as Fisher equation. Economists are of the view that this equation should be seen as a definition and not a hypothesis relating to the relationships between nominal and real interest rates and expected inflation. Fisher hypothesis is from a theoretical position which states that nominal rates of interest fully adjust to changes in expected inflation. This theory describes the long run relationship between expected inflation and the rate of interest. The interest rate adjustment that occurs whenever there is a change in expected inflation is what is known as the 'Fisher effect'. The concept of Fisher effect (hypothesis) originated from the analyses carried out by Professor Irving Fisher (1896) in his book titled "*Appreciation and Interest*" and which was expanded further in 1930 in another book titled '*The Theory of Interest*'. As at then, the intention of Fisher was to provide solutions to what was known as 'Gibbon's Paradox'.

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[1] Keynesian liquidity effect postulates an inverse relationship between interest changes and money supply changes. Increase in money supply leads to excess supply of money at a prevailing rate which eventually leads to reduced rate of interest.

Gibbon's paradox was the positive correlation discovered between the price level and interest rates during the classical gold standard period. This correlation was named 'Gibbon's Paradox' by John Maynard. Keynes[2]. Keynes (1930) saw it as a paradox because he thought it should not exist in economic theory. As at that point, the position of Fisher was that instead of looking at mere positive correlation between nominal interest rate and the price level, it would have been more accurate and appropriate if there is strong basis for positive correlation between the nominal interest rates and the rate of changes in price level. The view of Fisher then was that 'inflation will always raise the nominal interest rate' and that this rise is however, not instant. In support of his position, Fisher further postulated that a steady expected inflation will fully reflect in the nominal interest rates eventually. This caused him to develop the Fisher equation. The postulations in the Fisher equation is that at any period of time, the nominal interest rate equals the sum of the real interest rate and the expected rate of inflation. The other way round is that the real interest rate equals nominal interest rate minus expected inflation rate. Fisher hypothesised that nominal interest rates move one-for-one with expected inflation. While this theoretical Fisher hypothesis states that 'a rise in an economy's expected inflation rate will eventually cause an equal rise in interest rates', it reflects the Fisher equation and depicts Fisher effect in all ramifications. Fisher Effect is one of the oldest and most basic equilibrium relationships in economics and finance. The Fisher hypothesis has for many years now been an area of many empirical studies of the Fisher equation.

It is an economic belief is that certain pairs of economic variables should not diverge from each other by too great an extent, at least in the long run (Granger, 1986). Some of these economic variables are interest rates, inflation rates (price levels), money supply, wages and so on. Nevertheless, these variables may drift apart in the short run or according to some other factors. The extent of the truth about the close relationship of economic variables in the long run is a question of empiricism.

While there had been numerous studies on Fisher hypothesis in many advanced countries towards proving and establishing the hypothesis, research into in this

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[2] In his book titled '*A Treatise on Money'* published in 1930.

respect in developing countries has been very little. This is a reason why this research is interested in looking at the Fisher effect in the case of the developing nation of Nigeria.

This paper aims at examining the existence of Fisher effect in Nigeria and see if the Fisher's nominal interest rate/inflation one-for-one relationship holds in Nigeria. Therefore, the main objective of the research study is to investigate the long run relationship between nominal interest rates and inflation rate in Nigeria by analysing the country's data of nominal interest rates and expected inflation covering the 49 year-period between 1961 and 2009 which is the entire life of the country as an independent nation. Specifically, the objectives of this study are: (i) to investigate the existence of Fisher effect and long-run relationship between nominal interest rates and inflation in Nigeria; and (ii) to establish the directional movement and the causal factor between nominal interest rate and inflation in Nigeria.

Nigeria as a nation has over the years experienced fluctuating high and low rates of nominal interest and inflation since its independence in 1960. Therefore, the research questions to be answered in this study are tailored toward investigating if the Fisher hypothesis holds in Nigeria. Due to the varied outcomes of past empirical researches on Fisher effect, the research attempt to answer the question on the presence, strength and direction of the relationship between nominal interest rate and inflation in Nigeria over the period covered by the study. Specifically, the following major research questions were answered: (a) what is the nature of the relationship between nominal interest rates and inflation in Nigeria? (b) is there a one-for-one relationship between nominal interest rates and inflation in Nigeria? (c) What is the nature of directional movements (causal factor) between nominal interest rate and inflation in Nigeria? Drawing these research questions, the following hypotheses were tested:

H_0: There is no strong positive correlation between nominal interest rates and expected inflation in Nigeria

H_1: There is strong positive correlation between nominal interest rates and expected inflation in Nigeria.

H_0: Expected inflation is not significant in explaining changes in nominal interest rates in Nigeria.

H_1: Expected inflation is significant in explaining changes in nominal interest rates in Nigeria.

H_0: Nominal interest rates and expected inflation in Nigeria are not cointegrated.

H_1: Nominal interest rates and expected inflation Nigeria are integrated.

H_0: Expected inflation does not Granger cause nominal interest rates in Nigeria.

H_1: Expected inflation Granger causes nominal interest rates Nigeria.

2 Theoretical Framework

Inflation is the persistent rise in the general price level and continuous fall in the value of money and purchasing power. It is a positive growth rate of the general price level (Lipsey and Chrystal, 2007). The rate of price changes is the rate of inflation. Expected inflation rate is about the expectation of the public and/or investors about the inflation rates. Anticipated inflation is the idealised situation in which prices are rising at a rate at which all economic agents expect them to rise (Parking 1998). Interest rate is simply the cost of fund to a borrower and the return of fund to a lender. It is calculated over a period of time, per unit of time as a fraction of the balance of the capital. Interest is usually expressed as a percentage called interest rate. A nominal interest rate is an interest rate that is yet to be adjusted for inflation while a real interest rate is an interest rate that has been adjusted for inflation by removing the effect of inflation so as to reflect the real return on fund to the lender and the real cost of fund to the borrower. The central bank sets the nominal interest rate (and not the real interest rate). Towards achieving the desire real interest rate, the central bank would first make a forecast of inflation and set the nominal interest rate.

From monetary theories, we can deduce a correlation between nominal interest rates and the rate of price changes, rather than the level of price. In spite of this general deduction, Keynes (1930) stressed that this expectation was never confirmed, even with two centuries of data. Keynes (1930) cited the instance of a study over a period between 1730 and 1930, on the British consol yield which displayed co-movement with the wholesale price index but with zero correlation with inflation rate. To Keynes, the strong positive correlation between nominal interest rate and the price level (which he tagged '*Gibson's Paradox*') is "one of the most completely established empirical facts in the whole field of quantitative economics". In the '*Gibson's Paradox*' interest rates movements are not seen as connected with the rate of changes in price, but to the price level. Fisher developed the Fisher hypothesis with the aim of bringing about solutions to the '*Gibson's Paradox'* that was regarded as a positive correlation which was apparent between the price level and interest rates during this classical gold standard period.

The origin of the concept of Fisher hypothesis and Fisher equation is from the analyses carried out by Professor Irving Fisher (1896) in his book titled "*Appreciation and Interest*" and expanded further in 1930 in another book titled '*The Theory of Interest'*. The attempt by Irving Fisher to resolve the *Gibson's Paradox* was made when he combined his hypothesis[3] with a hypothesis that we could form inflationary expectations as long lag on past inflation. Fisher then emphasised the real interest rate versus nominal interest rate[4]. He carried out the estimation of a distributed-lag regression relating to current and past inflation rate, and interpreting the long lags due to delayed adjustment. In effect, Fisher (1930) hypothesised that nominal interest rate responds to inflation rates changes which are with a time lag and by smaller amount. The justification of this is through money illusion which implies that people are (at least in the short run) unable to distinguish between nominal and real variables. Dutt and Ghosh (1995) see a practical manifestation of money illusion when "lending institutions would not fully transmit their expected change in inflation to the nominal interest rate, even if they do correctly estimate the expected inflation".

Fisher (1930) in describing the long run relationship between inflation and the rate of interest, states that for the equilibrium interest rate, the ex-ante nominal

[3] A hypothesis relating to the relationship between nominal interest rates and expected inflation.
[4] A distinction that is often associated with his name

interest rate should fully anticipate movements in expected inflation. Extending this, interest rates should move in a one-for-one basis with expected rates of inflation. To Irving Fisher, there should be a long run relationship in the corresponding adjustment of the nominal rate of interest to changes in expected inflation. If Fisher hypothesis holds, then, short-term interest rates will be an efficient predictor of future inflation (Granville and Mallick, 2004). This should give the monetary authorities the ability to influence long term interest rates towards enhancing long-run stabilisation of macroeconomic policies. Another implication of the one-for-one long-run movement in the nominal interest rate and the expected inflation is that nominal interest rate adjustment would reflect changes in inflation expectations, in conformity to the theory of long run neutrality.

As initially put forward by Fisher (1930), the relationship between interest rates and inflation indicates that at any period of time, the nominal interest rate equals the sum of the real interest rate and the expected rate of inflation. The other way round this Fisher effect is that the real interest rate equals nominal interest rate minus expected inflation rate. The proposition of Fisher is that the real interest rate is therefore independent of the nominal interest rate and other monetary measures. In this respect, the vital Fisher equation relating to inflation and interest rates were then given as:

$$i_t = r_t + \pi_t \qquad 1$$

where: r_t is real interest rate at time *t;* i_t is nominal interest rate at time *t;* and π_t is inflation rate at time *t.*

Equation (1) given above shows that Fisher (1930) hypothesised the decomposition of nominal interest rate into two components which are a real interest rate component (r_t) and an inflationary expectation component (π_t.) He predicted a one-to-one relationship between nominal interest rate and expected inflation, thereby, making the real interest rate to be independent of the rate of inflation (Cooray 2003). The principle is that if a lender is to enjoy compensation for any purchasing power loss during the life of a loan, he would require interest rate, while expected inflation represents such loss. The redistribution of the purchasing power between creditors and debtors is made possible by changes in the value of money.

Due to this, a unity response of nominal interest rate to changes in expected inflation is required to avoid such redistributions and insulate the real rate of interest (Weidmann, 1997).

Therefore, if the nominal interest rate equals the sum of the real interest rate and the expected change in inflation rate, the fisher equation can be restated as:

$$i_t = r_t + \pi_t^e \qquad 2$$

Where i_t is the nominal interest rate, at the period t and $\pi^e{}_t$ is the expected inflation. If the real interest rate is to be constant in the long run, any change in the expected inflation should transmit to the nominal interest rate. With the following equation, we can test the Fisher effect:

$$i_t = \alpha + \beta\pi_t^e \qquad 3$$

Where: α stands for the real interest rate.

Equation (3) shows that with the assumption that the real interest rate is constant; changes in inflation rate should be the reflection of changes in the nominal rate. This response of the nominal interest rate to anticipated inflation rate is the "Fisher Effect". If $\beta=1$, a full Fisher effect is apparent. Therefore, Equation (3) depicts Fisher effect to be one and nominal interest will consequently reflect one-for-one inflationary expectations movements.

The Fisher hypothesis says that real interest rate do not change much and that there would be large excess supply or demand for loan if they do. In order to stop the real interest rate from changing much, higher nominal interest rate should be in place to offset higher inflation. In the short run, it is believed that higher inflation must induce a larger rise in nominal interest rate if real if real interest rates are to push inflation back towards its target (Begg, Fisher and Dornbusch 2008). However, it is expected that faster nominal money growth leads to both higher inflation and higher nominal interest rates. Therefore, a rise in nominal interest rates could be caused by a rise in the rate of money growth.

If a rational expectation is to be inflicted, the expected inflation ($\pi^e{}_t$) would equal true inflation and a random error (ε_t), thus:

$$\pi_t^e = \pi_t + \varepsilon_t \qquad 4$$

Where ε_t is the rational expectation of the forecast error.

If Equation (4) is incorporated into Equation (3), we will arrive at:

$$i_t = \alpha + \beta\pi_t^e + \eta_t \qquad 5$$

where: η_t equals ε_t

If i_t and π_t have a unit root and η_t/ η_t/ ε_t is stationary, the Fisher effect would hold thus indicating that both variables (nominal interest rates and inflation) are cointegrated, and a long run relationship would be established.

It is clear that in consideration of the Fisher equation for a zero economy, the nominal interest rate equals the real interest rate. On the other hand, in an inflationary economy, providers of funds must demand for a higher interest rate while borrowers would not able to pay these higher interests. Therefore, in order to keep the supply and demand for loanable funds in balance, the nominal interest rate must change on a one- for-one basis with the expected inflation.

In their various research studies, Gibson (1970), Lahiri(1976), Sargent (1969) and Yohe and Karnosky (1969) made efforts about the verification of the results put forward by Fisher about presence of a distributed lag structure in expected inflation. They all adopted the basic mechanism of a distributed lag, but their specifications involved the lagged variable differed from the declining weights. Originally, Fisher proposed the arithmetically declining weight. Using geometrically declining weights while Gibson (1970) and Sargent (1969) were able to confirm a good degree of distributed lag effect in inflation expectations formation. Gibson found out that a cyclical factor was apparent in the formation of price expectations which might have been caused by "a high order weighting pattern past price changes". A vital deduction from Gibson's study was that price expectation has actually been affected by policy action which was meant to influence nominal interest rates. However, as from the 1960's, research efforts by Yohe and Karnosky (1969) and Lahiri (1976), gathered evidence in support of the need to shorten the time lag in inflation expectation formation. Yohe and Karnosky, in comparing the speed of expectation formation and the price expectation for two periods, found out that speed of expectation formation for the period 1961- 1969 was much greater than that of 1952 – 1960. Lahiri (1976) confirmed the position of Yohe and Karnosky when they found that for periods after 1960, inflation expectations were formed more rapidly. In these studies, there were evidence that with a significantly shortened time lag in expectation formation from the 1960s onwards, there had been positive relationship between nominal interest rates and inflation. It is interesting to note that during this period, Fisher hypothesis took a twisting turn due to integration of the efficient market theory and the theory of rational expectations

The theories of rational expectations and efficient markets were incorporated into Fisher effect by Fama (1975) when he argued against Fisher's position that though, past changes in the price level is reflected in the current interest rate, as ought to have been evident by an efficient market, future price changes should reflect in the current nominal interest rates. In 1975, Fama conducted an extensive investigation of the Fisher effect in the US covering the period between 1953 and 1971, in which he concludes that nominal interest rates correctly incorporated ' all information about future inflation'. His argument is that future price changes were embodied in the current rate of interest. This was a clear rejection of the Fisher's conclusions of distributed lag structure in the formation of inflation expectation. However, there were subsequent opposition to Fama's position by Carlson (1977), Joines (1977) and Nelson and Schwert (1977). These researchers all rejected Fama's conclusion that short-term interest rates predict subsequent inflation rates. They concluded that information about inflation was fully embodied in interest rate. In a study on Livingstone covering 1953 -1971, Carlson incorporated a business cycle (represented by the ratio of employment to population, lagged by six months) as an independent variable into Fama's regression model. In this model, there was significant deviation by interest rate coefficient, leading to the suggestion that the ratio is a reflection of information on inflation which was not incorporated in nominal interest rates. Joines (1977) queried the price data used by Fama because of the inconsistency between market efficiency and the seasonal pattern in the forecast errors of the price inflation rate that was used by Fama (1975) in his study. Based on the past inflation rates, Nelson and Schwert (1977) used the Box Jenkins approach in constructing a predicator of inflation, they found out that nominal interest rates contain no information about inflation as revealed by the forecaster. If rational expectations and efficient markets are incorporated into Fisher effect we expect that in an efficient market, nominal interest rates and inflation should exhibit a random walk.

Lack of correlation between prior information and nominal interest and past inflation changes are essential feature of the random walk model. This contradicted the distributed lag effect in the formation of inflation expectations with the implication of high, positive correlation between nominal rates and inflation rates.

There was evidence that a strong Fisher effect (a high correlation between the level of interest rate and inflation) arises specifically during some period and fails to reflect in other periods. The position of Mishkin (1992) is that "empirical evidence finds no support for a short-run Fisher effect, but supports the existence of a long-run Fisher effect in which inflation and interest rate have a common stochastic trend when they exhibit trends". The indication of some of the results is that there will be strong Fisher effect when interest rates and inflation rates have trends.

Taking a casual look at data on inflation and interest rates, one might conclude that there is tendency for countries with high inflation rates to have experienced high nominal interest rate. Nevertheless, this conclusion appears unsound. The hypothesis of Fisher (1930) is that over a long term, movements in the nominal rates of interest would be one- for-one movements in inflation rates. Because this hypothesis indicates that an x% increase in inflation rate would be followed by the same x% increase in interest rates, this may therefore imply that an economy would have recorded high nominal interest, if the expected inflation is to be high. In other words, there may not be high nominal interest rate if interest rate is low.

The popular use of short term interest rate (a leading economic indicator) assumes that movement in the short term interest rate will primarily reflect fluctuations in expected inflation. Therefore, policy reaction can be ascribed to be a reason why high nominal interest rate countries have high inflation rates since these could come up when such countries run tight monetary policy which dictates higher real interest rates. This makes the Fisher (1930) equation which expresses the nominal interest rate as the sum of expected real rate of interest and expected inflation is imperfect. If the Fisher equation holds, the movements in short-term interest rates will reflect fluctuations in expected inflation and will therefore be a good indicator of future inflation (Mishkin 1992). An investigation into the Fisher effect is therefore an investigation into the appropriateness of interest rate as an indication of monetary policy. Fisher effect has important policy implications for the economy, the financial system and interest rate, and this makes an investigation into the Fisher effect extremely valuable.

As part of post-Fisher hypothesis developments, there had been series of investigations about the Fisher-formalised model of 'nominal interest rates responding one-to-one to expected inflation. Many empirical researchers have put forward alternative explanations toward reconciling and explaining the contradictory evidences and findings obtained about the Fisher hypothesis. These theoretical economists challenged the Fisher's position by concluding that due to some factors not considered by Fisher, the Fisher coefficient may differ from unity. They shed more light on why many empirical studies could not hold the Fisher hypothesis strictly. Some of these factors are: wealth[5], taxation[6], risk aversion[7], and market regulations[8]. The following sections provide a brief review of these explanations.

The Wealth Effect: Mundell (1963) and Tobin (1965) provided the theoretical justification for a partial adjustment in Fisher hypothesis in terms of wealth effect and subsequently savings. In proposing the direct relationship of nominal interest rates and expected inflation, Fisher (1930) empirically failed to prove a one-for-one relationship. What Fisher found out was a less than one-for-one relationship. Cooray (2003) cities Mundell (1963) and Tobin (1965) as demonstrating that the nominal interest rate would rise by less than unity in response to a change in inflation through the impact of inflation on the real interest rate.

The argument of Mundell (1963) was that the real rate interest rate would go down as a result of inflationary pressure. The reason for this is that inflation will cause a fall in the real money balances and this lead to a decline in wealth which stimulates savings in the form of equities and bonds. This situation brings down the pressure on the real rate of interest. Similarly Tobin (1965) opines that inflation

[5]Mundell (1963) and Tobin (1965)
[6] Crowder and Hoffman (1996)
[7] Shome, Smith and Pinkerton (1988)
[8] Carmichael and Stebbing (1983)

prompts people to increase the level of real capital they hold. Therefore the nominal interest rate would be less than one-for-one with the expected rate of interest.
This shared views of Mundell and Tobin is referred to as the Mundell-Tobin Effect or the Wealth Effect.

The Tax Effect: Another important point to make is that up to this point, Fisher hypothesis had been without the consideration of tax. The 'simple' Fisher hypothesis would be altered if taxes are taken into account. Nevertheless, tax implications are now being recognised as an important factor that can influence interest rates. In past studies, equation (3) above has been used in testing Fisher hypothesis. Where α and β are parameters to be estimated, where: i_t is the nominal interest rate and πt is the expected inflation for period t. When there is a full fisher effect or a strong Fisher hypothesis, β should one ($\beta=1$). Where the estimate of β is positive but significantly lower than one $\beta<1$, the fisher hypothesis is in its weak form and Fisher effect would be regarded as partial thus making the changes in the expected inflation rate to be transmitted to the nominal interest rate in the proportion of $\beta<1$. When β is greater than one ($\beta>1$), this suggests tax effect. When the nominal interest rate is taxed, the Fisher relationship implies that the change in the nominal interest rate is greater than the change in expected inflation so as to maintain the constant ex-ante real interest rate.

Illustrating the tax effect on Fisher hypothesis, Summers (1983) concluded that nominal interest rates would move up to between 1.3 and 1.5 when marginal tax rates are taken into consideration. This was also predicted by Darby (1975) and Feldstein (1976) when they put forward this same strong alternative argument in the area of the influence of the tax structure on the Fisher relationship. They posited that taxes on interest income would cause nominal interest rates to rise more than unity when they respond to expected inflation. The position of Darby (1975) is that for each basis point increase in the expected inflation rate, the nominal rate of interest is expected to rise at a rate of $\frac{1}{1-\tau}$ where τ is the marginal (proportional) interest income tax rate.
This will leave borrowers and lenders expected payments and receipts unaffected in real terms (Darby 1975).

This causes the Fisher equation to become:

$$(1-\tau)i_t = \pi_t + \varepsilon_t \qquad 6$$

The suggestion being brought to the fore by this is that the nominal interest rate will adjust more than one-for-one to changes in expected inflation.

However, there had been limited success for this argument. The suggestion of Tanzi (1980) with an opposing position to the proposition of the tax-effect suggests the “fiscal illusion” suffered by economic agents must be considered in the analysis of the rise in nominal interest rates. Carr, Pesando and Smith (1976) could not find convincing evidence about if income tax causes nominal interest rates to increase more than the increase in expected inflation. When they investigated the relationship between expected inflation, income tax and nominal interest rates in Canada for the period 1959 – 1971, they applied various interest rate models. Likewise Cargill (1977) was unable to get evidence to support the existence of expected inflation - income tax – nominal interest rate relationship in a study using the US data.

However, for a study of thirteen OECD countries, Engsted (1996) was able to find support for the tax- adjusted Fisher effect on the long run. Crowder and Hoffman (1996) used the US quarterly data from January 1952 to April 1991 to find evidence to support the tax-adjusted Fisher equation, so also Peek (1982) who found strong evidence to support the inclusion of tax income tax effects in the Fisher effect in a US study. This tax-effect argument is known as Darby-Feldstein Effect.

Further modifications (relating to the incorporation of capital gains taxation) of the Darby-Feldstein position were made by Neilson (1981) and Gandolfi (1982). They discovered that the rate of increase in the nominal interest rate, in response to a change in inflation rate was not as high as what was suggested Darby (1975) and Feldstein (1976). However, contrary to all discussion so far on tax effect, Weidmann (1997), in a study on using Germany data, found out that the full Fisher effect cannot be rejected in its tax adjusted form if a threshold cointegration model could be estimated.

Inverted Fisher Effect or Fisher Paradox: Carmichael and Stebbing (1983) put forward a different suggestion about the inflation-nominal interest rate - real interest rate relationship, as an alternative to that of Fisher (1930). They called this an “Inverted

Fisher Effect" or Fisher Paradox. They argued that for a given level of financial market regulation and the "substitutability" between regulated and non regulated money and financial assets, the nominal interest rates (after tax) on financial assets would be constant over time and the real interest rate (after tax) would move inversely one-for-one with inflation rate.

Despite the above, Graham (1988) and Moazzami (1991) tested the same data set used by Carmichael and Stebbing (1983) and could not find evidence to support the Inverted Fisher Effect. Likewise Woodward (1992) found no evidence to support a Fisher Inversion in a study on UK data over the period 1982-1990. However, Choudhry (1997) employed longer time data of Belgium, France and Germany for the period 1955 to 1994 to find a very little support for the inverted Fisher effect.

Risk-Aversion Effect: Shome, Smith and Pinkerton (1988) while re-examining the relationship between purchasing power of money and nominal interest rates postulate that a risk-averse investor will require a premium. This risk premium will serve as compensation for the risk they take in holding financial assets. They argue that empirically, the strong form of Fisher Effect could not hold because the expected inflation measure adopted by Fisher (1930) failed to consider the covariance of real output and future prices. It only took cognisance of total variability in price. Given the assumption that investors have power utility function and that consumption and price index are jointly log-normally distributed, they thought that Fisher equation should embody the additional risk covariance risk (Mitchell-Inness 2006). Shome, Smith and Pinkerton (1988) therefore showed that it is not likely for the long run coefficient between nominal rate of interest and expected inflation to be one-for-one in an environment where uncertainty abounds.

It is evident that there were claims and counter claims on these deviations from Fisher effect. Many attempts to reconcile Fisher's findings with the theory, policy and practice caused the eruption of many literatures. One will agree with Dutt and Ghosh (1995) who identified two issues that seem to stand out in these existing literatures. First is the conflicting results in respect of validity and/or otherwise (in absolute terms) of the hypothesis. Secondly, the co-movement of nominal interest rates and inflation is on the long run, partial and not corresponding one-for-one because of the 'on-again/off-again' relationship between nominal interest rates and inflation rates.

3 Review of Empirical Studies

Many of the empirical studies on Fisher hypothesis applied the model that stemmed from basic the Fisher's equation of the relationship between nominal interest rates and inflation expectations in equation (3). This led to the basic model used in many of the past research works on the Fisher relation which is:

$$i_t = \alpha + \beta \pi_t^e + u_t \qquad 7$$

where: i_t is the short-term nominal interest rate; $\pi^e{}_t$ is the expected inflation rate; and u_t is the residuals (error term).

With the assumption that a distributed lag structure serves as the basis for inflationary expectations, Fisher (1930) carried out studies on the relationship between nominal interest rates and inflation rates in the United Kingdom covering the period between 1820 and 1924 and the United States for the period 1890-1927. In these studies, Fisher could not find an apparent relationship between inflationary expectations and interest rates in the short run. Without lagging the data for the two countries, there were correlation coefficients of -0.46 and 0.29 for the UK and the US respectively. Fisher went further to use distributed lag of past inflation as proxy for the expected inflation and this resulted in the substantial increase in the correlation coefficient obtained for the two countries. For the United Kingdom price-changes data which spread over 28 years, the highest correlation coefficient was 0.98 while the price-changes data for the United States which were lagged over 20 years produced a correlation coefficient of 0.857. This led Fisher (1930) to conclude that:

> *'....we have found evidence general and specific….. that price changes do , generally and perceptibly affect interest rate in direction indicated by a prior theory… But since forethought in imperfect, the effects are smaller than the theory requires and lag behind price movements, in some periods, very greatly. When the effects of price changes upon interest rates are distributed over several years, we found*

remarkably high coefficient of correlation, thus indicating that interest rates follow price changes closely in degree, though rather distantly in time.'[9]

Here, Fisher first gave his empirical test of Fisher hypothesis. We can note that the Fisher's results indicated that the Fisher hypothesis nominal interest rates responded to changes in inflation with amount that is a bit smaller than one and with delay that was substantial. This indicates that we would only have a partial or near-full satisfaction of Fisher's hypothesis as against what the theory suggests. In explaining his results, Fisher identified to the presence of money illusion that made economic agents to be unable to differentiate between changes in nominal values changes and real values changes in economic variables[10]. This Fisher's assertion led to many literatures having the aim of reconciling Fisher's findings with the theory.

In his efforts to explain the reason behind why there are strong results of a Fisher effect for some periods and not for others, Mishkin (1992) carried out a study on the US between 1952 and 1991. Mishkin could not find support for a short run Fisher effect but finds evidence to support the long run Fisher effect. Though, the study reveals inconsistency in the correlation coefficients, there were explanations on the reason behind the high correlation between the level of interest rates and inflation in some period and which resulted otherwise in some other periods. Mishkin concludes that the Fisher effect would hold only when interest rates and inflation display stochastic trend. In this study, Mishkin used Monte Carlos experiments to take the non-stationarity of inflation and nominal interest rates as a hypothesis. In testing for common stochastic trend, he applied the technique of Engle-Granger (1987) to investigate Fisher effect when inflation and interest rates have trends. Mishkin (1992) gathered a strong empirical support for a long run Fisher effect (but not a short run Fisher effect). A subsequent study by Mishkin and Simon (1995) on Australia was in this same vein, with further conclusions that interest rate long-run movement is due

[9] This explains the "Gibson Paradox" which relates to the correlation observed between the price level and interest rate during the pre-Fisher effect World War II period.

[10] The presence of money illusion in the context of the Fisher effect would be equivalent to the case in which the lenders (due to their lack of market power, because of strategic considerations, and the like) choose not fully to transmit to the nominal interest rate any expected change in the inflation rate, even if they anticipate changes in inflation correctly (Bajo-Rubio *etal* 2010)

to inflationary expectation while the short run changes in interest rates are caused by monetary policy.

In a study of US quarterly data from 1952 to 1991, Crowder and Hoffman (1996) used a bivariate vector error correction model to reveal a dynamic behaviour of inflation and nominal interest rate and got evidence which suggest that inflation has "predictive content for the future course of interest rates". This result confirms one –for-one relationship between interest rate and inflation rate. From this study, we can see sensitivity to data frequency, period and country involved as vital factors to consider in testing for Fisher effect and this what other research studies might not have considered.

Weidmann (1997) used a threshold cointegration model to investigate Fisher effect in Germany in which he was able to gather that 'the stochastic process governing the bivariate system of inflation and interest rates depends on the level of the variables and can be designed by the threshold cointegration model. The model assumed *Bundesbank's* commitment to price stability. Consequently, Weidmann's findings, in another dimension, explain that Fisher effect would hold only in countries with independent central bank that considers the issue of credibility. Disagreeing with this position, we can see that there are many countries where central banks are not independent, yet Fisher effect would hold.

Using Spanish data for the period 1962-1996, Esteve, Bajo-Rubio and Diaz-Roldan (2004) were able to find out that 'nominal interest rates only partially adjust to shifts in inflation' through the use of Johansen cointegration method. Using the same cointegration method, in a recent study on the United Kingdom economy by Bajo-Rubio,Diaz-Roldan and Esteve (2010) carried out to test the Fisher effect through the analysis of structural breaks in nominal interest rates and inflation rates over the period 1960 – 2007, it was discovered that the two time series were non-stationary but were able to record a deterministic cointegration with a coefficient of 0.33. There was a strong presence of many structural changes in the cointegration relationship. The overall result of this study was that of partial Fisher effect for the UK economy. For each point increase in inflation rate, one-third was passed through to a higher nominal interest rate. The reason for this was the presence of some degrees of money illusion in the UK financial markets and this is already observed by Fisher. The effect of this is that in the UK, nominal interest rates would not be a predictor of inflation. It is believed that the strong independence of the Bank of England is a factor that reduced inflation expectations in the UK "so that the Fisher effect would seem no longer to hold (Bajo-Rubio et al, 2010).

It is worthy of note to state that there were sparse empirical works on Fisher hypothesis in less developed, emerging and developed economies. It is however evident that the empirical studies carried out in countries in these categories have produced results that are inconsistent.[11]

The existence of long run Fisher effect was specifically examined over two decades (1970-1990) by Phylaktis and Blake (1993) with the data of three high inflation developing countries (Argentina, Brazil and Mexico). They were able to find for these three economies 'strong evidence for a long run unit proportional relationship between nominal interest rates and anticipated inflation. This result is seen as against the mixed evidence in low-inflation economies. This means that agents in high inflation economies tended to invest more in inflation forecasts and hence have greater incentive to incorporate inflationary expectations in yield returns (Cooray, 2003). This is a supported view. Phylaktis and Blake (1993) discovered that it took longer time for high inflation economies (Argentina, Brazil and Mexico) to adjust to unanticipated inflation when compared to the economies of Australia and the United States. Fisher effect could only be confirmed in Mexico and Argentina in an empirical research carried out by Jorgensen and Terra (2003) in a study on the relationship between interest rates and inflation in Latin American economies of Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela. In another study on Mexico between 1978 and 1994, Thornton (1996) used the cointegration technique and the study produced results that were in line the findings of Phylaktis and Blake (1993).

[11] Though, few of these studies could not report one-for-one relationship according to Fisher hypothesis, many were able to establish a positive long run relationship between nominal interest rates and expected inflation.

In a study of nine developing countries (Argentina, Fiji, India, Malaysia, Niger, Sri-Lanka, Pakistan, Singapore and Thailand), Payne and Ewing (1997) employed the Johansen (1988) and Johanses and Juselius (1990) procedures to investigate the Fisher effect. For these countries, unit root tests showed that nominal interest rates and inflation were integrated to the order of one, but there were mixed results. The cointegration tests revealed no evidence of a fisher effect in Argentina, Fiji, India, Niger and Thailand. There was evidence of a unit proportional nominal interest rate-inflation relationship. This approach however, produced evidence to support a long run relationship between nominal interest rates and inflation for Malaysia, Pakistan, Singapore and Sri-Lanka. This raised the questions as to why there are mixed results.

An empirical investigation of Fisher effect in Nigeria during the period 1970 to 2007 as carried out by Obi, Nurudeen and Nwagbure (2009) lends support to the existence of partial Fisher effect in Nigeria over the period covered by the research. They further found out that money supply significantly impacted interest rates in Nigeria. The study by Obi *et al* incorporated fiscal deficit in the cointegration analysis which could not be considered to be a vital factor in testing for Fisher effect. My research study will therefore add to this existing knowledge in this regard by going further step beyond the efforts of Obi *et al* (2009) by covering the entire life of Nigeria as an independent nation (1960-2009).

There were inconsistencies in the various results for the developed and developed countries investigated. Many of the studies have evidence of positive long run relationship between nominal interest rates and expected inflation. The general shortcoming is the failure of some of the empirical investigations to establish the one-for-one relationship as hypothesised by Fisher (1930). There were explanations offered by some authors for the inability to find practical evidence for Fisher hypothesis theoretical one-for-one relationship between nominal interest rates and inflation in some undeveloped economies.

As truly observed, this may be due to the fact that interest rates and inflation in these countries are non-stationary series integrated to the order of one or more. Jansen (2006) in a study of 17 industrialised countries using a bivariate maximum likelihood estimator to a fractionally integrated model of inflation and the nominal interest rate, supports this position as he could gather evidence that most industrialised countries in which Fisher effect could be confirmed have not experienced monetary shocks that could lead to the necessary permanent change to inflation. There was evidence that 'inflation in these countries follows a mean-reverting, fractionally integrated long memory processes'. This is absolutely true.

The test of the Fisher hypothesis could also be seen as sensitive to both time period and technique used and thereby raising concern as to its validity. Boudoukh and Richardson (1993) are of the views that positive interest rate-inflation relationship exist at all horizontal lengths. This position is wrong as there were opposing evidences. Although, Mishkin (1992) got the evidence of the presence of the relationship on the long run, Yuhn (1996) got a short run Fisher effect for Germany, even as he had evidence of strong Fisher effect over long horizons for some countries in another study. Therefore, it is possible for the test of Fisher hypothesis to be influenced by the selected time horizon.

Theoretically, Fisher hypothesis is sound, but the consistency is little. On the overall, there are supports for the existence of a positive long-run Fisher effect but the results are mixed. Empirically many of the studies either found evidence of more than or less than one-for-one adjustment of nominal interest rate to expected inflation. This situation caused researchers to offer the explanations on why the one-for –one proposition by Fisher (1930) failed to hold in the affected countries.

4 Data and Methods:

For the analysis of Fisher effect in Nigeria, the annual data for Nigeria short-term nominal interest rates and inflation between 1961 and 2009 were used. This period covers the entire life of Nigeria as an independent nation. Nigeria got her independence from the British Colonial rule on 1 October 1960.

This research employed the use of secondary sources of data collection. These are quantitative secondary data. These data were sourced mainly from the various editions of the Statistical Bulletin of the Central Bank of Nigeria collated from information gathered from the Annual Abstract of Statistics of the Nigeria's National Bureau of Statistics. These are sources considered reliable. The nominal interest rates are short-term interest rates measured by the three-month Nigerian Treasury Bills rates. For inflation, the Twelve-month Moving Average Headline Inflation was used as proxy for inflation. These time series annual data collected span over 49 years covering the period between 1961 and 2009. Consequently, this research study is carried out with 49 data points representing the annual values of nominal interest rates and inflation rates.

Gathered from the experience of previous researchers in this field, treasury bill rate is the most risk free measure of interest rates (Berument and Jelassi 2007). As a proxy for inflation, "any econometric study of Fisher effect using the Consumer Price Index (CPI) would be misleading". If interest rates and inflation were found to be cointegrated, it would be impossible to separate whether the relationship was due to Fisher effect or was the direct link between mortgage rates and the consumer price index.

As the first step in data analysis, the descriptive analyses of the plots and statistical properties of nominal interest rate and expected inflation for the sample period covered by the study were carried out. Statistical figures were produced and the correlation matrix were analysed. It will be interesting to look at the correlation between the two variables being examining simply because Fisher (1930) considered correlation analysis in his initial investigation. Using this technique would mean going the same way as Fisher in his initial study in order to ensure a genuine comparison. Modern approaches in analysing the relationship between interest rates and inflation place reliance on regression methods. Regression aims at seeing if one variable is dependent on other variables. Generally, regression results are better than correlation results for some reasons. One of these reasons is that regression estimation produces a number of diagnostic tests that can alert us of problems with the regression. The result of regression estimation should appropriately be treated as unreliable if such regression fails one or more diagnostic tests.

However, the data were transformed by taking the logarithm of the data set. This arose because of the possibility of the presence of outliers in the data sets. It is believed that this power transformation would make our data analysis easier and will counteract our datasets that straggle upward. Consequently, the model for our regression estimation and analysis of the relationship between interest rate and inflation in Nigeria which is a distributed lag log linear model is specified as:

$$lni_t = \alpha + \beta ln\pi_t^e + u_t \quad 8$$

where: lni_t is the logarithmic nominal rates; $ln\pi^e{}_t$ is the logarithmic expected inflation; and u_t = error terms. Consequently, the specific model to estimate in this study is:

$$lnINTR_t = \alpha + \beta lnEXINFL_t + u_t \quad 9$$

where: *lnINTR* is logarithmic 3-month Treasury Bill rates in Nigeria; *lnEXINFL* is the logarithmic first difference of 12-month moving average headline inflation in Nigeria. However, there may be spurious results arising from the ordinary least square (OLS) estimate if the variables in regression estimation have stochastic trend Granger and Newbold (1974) and Philips (1986). This therefore makes statistical inference procedure not to be appropriate

Because nominal interest rate and inflation are known to be trended, I determined if the series are consistent with an I(0) process with a deterministic trend or if they are consistent with an I(1) process with a stochastic trend. A unit root test is necessary because if the variables are non-stationary, the best analysis would be through cointegration. The test for stationarity involved the determination of the integration properties of the two variables. This test was carried out through the Augmented Dickey-Fuller (ADF) test in which I used two lags which are appropriate for annual data like nominal interest rates and inflation. Generally, the method for Δy_t series which correspond to ADF regression with a constant and a trend is:

$$\Delta y_t = \alpha_0 + \alpha_{1t} + \alpha_2 y_{t-1} + \Sigma\beta_j \Delta y_t + u_t \quad 10$$

Using the Engle -Granger ADF residual based cointegration method, I estimated the regression the nominal interest rates on expected inflation, and obtained the residuals; conducted a unit root tests for the residual of the regression, using ADF test. For the Johansen (1998, 1990) maximum likelihood approach, the likelihood ratios statistics of maximal eigenvalue tests and trace tests were considered against the critical values as appropriate. With cointegration analyses, it would be established if there is a long run relationship between nominal interest rates and inflation in Nigeria.

As a further means of analysing the relationship between nominal interest rates and expected inflation rates, I investigated causality among the variables, using a causality method that was developed by Granger (1969). The general intuition behind Granger causality test method is that if a previous value of variable inflation (expected inflation) significantly influences current value of nominal interest rate, then, one can say that expected inflation causes nominal interest rate (Gul and Ekinci 2006). This test was carried out to determine the directional movement between nominal interest rate and inflation rates. Granger-causality method measures whether one thing happen before another thing and helps in predictions (Sorensen 2005).

In a bivariate context of nominal interest rate and expected inflation, the Granger causality test can be specified generally as:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \cdots + \alpha_n y_{t-1} + \beta_1 x_{t-1} + \cdots + \beta_n x_{t-1} + \varepsilon_t \qquad 11$$

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \cdots + \alpha_n x_{t-1} + \beta_1 y_{t-1} + \cdots + \beta_n y_{t-1} + \varepsilon_t \qquad 12$$

Granger causality test model for this study is specified as:

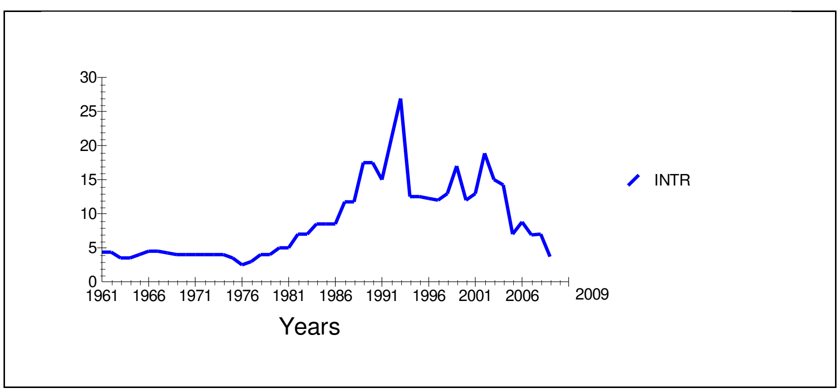
$$lnINTR_t = \alpha_0 + \alpha_1 lnINTR_{t-1} + \cdots + \alpha_n lnINTR_{t-1} + \beta_1 lnEXINFL_{t-1} + \cdots + \beta_n lnEXINFL_{t-1} + \varepsilon_t \qquad 13$$

$$lnEXINFL_t = \alpha_0 + \alpha_1 lnEXINFL_{t-1} + \cdots + \alpha_n lnEXINFL_{t-1} + \beta_1 lnINTR_{t-1} + \cdots + \beta_n lnEXINT_{t-1} + \varepsilon_t \qquad 14$$

5 Results and Findings:

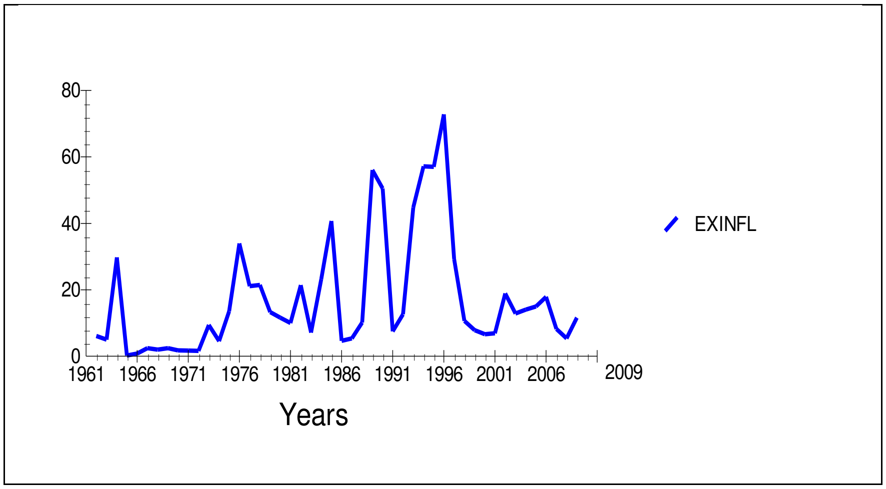
Descriptive Statistics: Figure 1 and Figure 2 below show the plots of interest rate and expected inflation respectively, over the period under study.

Figure 1: Plot of 3-month Treasury Bills Rates (1961 – 2009)



Microfit 4.1Output

Figure 2: Plot of 12-month Moving Average Headline Inflation (1961 – 2009)

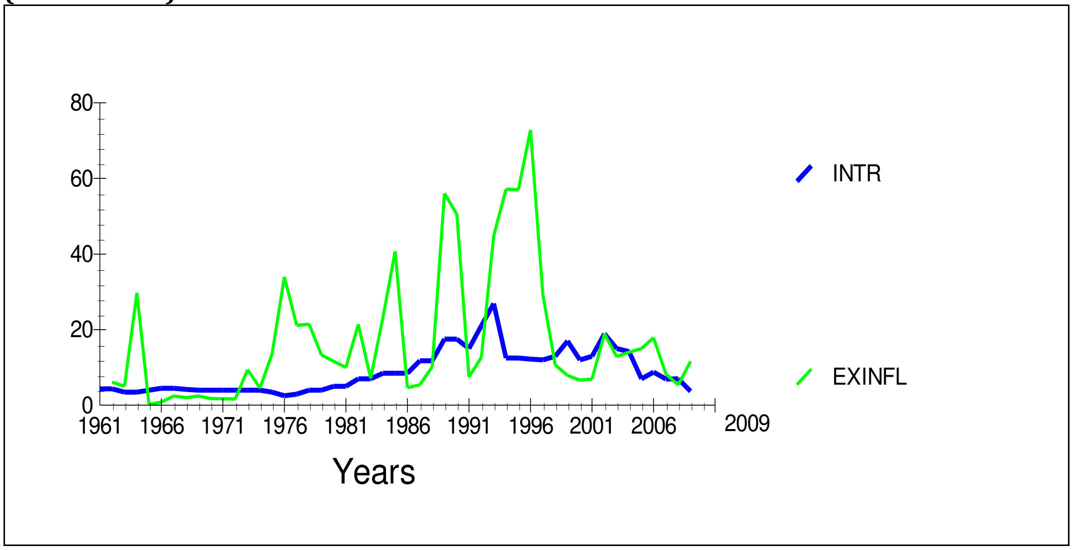


Source: Microfit 4.1Output

We can read from Figure 1 that interest rates had steady static movements from 1961 up to 1976 when it started its upward movements to a peak in 1993. The movements became galloping afterwards up to 2004 when it started the downward movements up to 2009. It could be observed that during the era of the Structural Adjustment Programme (SAP) which commence in 1986, interest rates soared high because of high demands for credit due to the policy reforms that focused on home production of goods.

It is apparent from Figure 2 that there was no deterministic trend for inflation during the period covered by the study. This appears to as a stochastic trend. There were downward and upward movement movements of expected inflation as the graph could reveal. There were sharp increases in 1962, 1973, 1974, 1982, 1987 1992 and 1994. In spite of these sharp increases, there were sharp drops in 1964, 1982, 1983, 1989, 1996 and 2005. These unstable movements in expected inflation in Nigeria could be attributed to high factor costs, poor money supply control and ineffective monetary policy due largely to the long presence of the military in governance. High inflation in Nigeria could be attributed to lack economic management which characterised the military era which spanned from 1966 – 1979, and 1984 – 1999. Within short periods of time there were strange fluctuations in the movements of inflation.

Figure 3: Plots of 3-month Treasury Bill Rate and 12-month Moving Average Headline Inflation (1961 – 2009)



Microfit 4.1Output

The plot of nominal interest rates against expected inflation failed to reflect co-movements between the two economic variables for the majority of years studied, hence failed to align with the underlying principle of Fisher effect. The two plots fail to show trends. However, from 1963 to 1970, the graph revealed parallel movements of interest rates and expected inflation, which is a pointer to the fact Fisher relation for Nigeria is not apparent within this eight-year period. Interestingly, in the history of Nigeria, this was a period characterised by two extremes of stability. The first half of this period (1963 to 1965) was the First Republic when everything was stable (though, towards the end of 1965, political instability started creeping in). The first military coup and government surfaced in January 1966, up to mid-1967 when the Nigerian Civil War started. This war ended in 1970. Interestingly, during the civil war nominal interest rates and inflation were stable, parallel at the low levels.

Table 1: **Descriptive Statistics: Nominal interest rates and Expected Inflation in Nigeria (1961 – 2009**)

Variables	***INTR***	***EXINFL***
Mean	8.8796	17.2862
Standard Deviation	5.7021	17.6310
Skewness	1.0222	1.5107
Kurtosis – 3	0.50889	1.4258
Coefficient of Variation	0.64216	1.0199

Source: Author's estimation and Microfit 4.1Output

Table 1 above shows sample statistics of nominal interest rates and expected inflation for the sample period. On the average, interest rate and expected inflation were 8.88%

and 17.28% respectively, for the period under study. The co-efficient of variation for expected inflation is 1.02 as against 0.64 for interest rate. This implies that the rate of variation among data sets in expected inflation is about 1.58% over and above the rate of variation among data sets in interest rate. We can infer that this lack of uniformity in the variation rates is not lending supports for Fisher's one-for-one movement. This shows that in nominal interest rate is more constant when compared with expected inflation in Nigeria at a rate of 1.58%. Average deviation of interest rate from its means was 5.70% compared to expected inflation figure of 17.63%. This indicates in that on the average, between 1961 and 2009, nominal interest rates moved between 3.17% and 14.57%, while expected inflation implies an average movement between a negative figure of -0.35% and a 34.91%. These failed the test of Fisher effect.

Table 2: Correlation Matrix of Nominal interest rates and Expected Inflation in Nigeria (1961- 2009)

	Nominal Interest Rate	***Expected Inflation***
Nominal Interest Rate	1.0000	0.42557
Expected Inflation	0.42557	1.0000

Source: Author's estimation and Microfit 4.1Output

As reflected on Table 2, there is a low positive correlation coefficient of 0.42557 between nominal interest rate and expected inflation in Nigeria. This means that during the period covered by this study, interest rates and expected inflation in Nigeria change in the same direction, but at a low magnitude. The strength of the correlation is weak. This negates the underlying one-for-one movement of Fisher effect at correlation coefficient of 1.00.

Regression Analyses: The results of the Ordinary Least Square (OLS) estimation are revealed in Table 3 below:

Table 3: Results of OLS Estimation and Diagnostic Tests

α	***β***	***R^2***	***DW***	***Standard Error***	***P-value of LEXINFL***
1.4504	0.23388	0.19	0.37263	0.57197	0.002

Post Estimation Diagnostic Tests	***Results –(t-statistics and p-value)***
(a) Serial Correlation	LM Version→ 32.6874 (0.000) F Version→ 96.605 (0.000)
(b) Functional Form	LM Version→ 0.77165 (0.781) F Version→ 0.7246 (0.789)
(c) Normality	LM Version→ 0.92224 (0.631) F Version→ N/A
(d) Heteroscedasticity	LM Version→ 3.7510 (0.053) F Version→ 3.8994 (0.054)

Source: Author's estimation and Microfit 4.1Output

Going by the basic Equation (7) that is being used to test the Fisher hypothesis, β is expected to be one if the one-to-one relationship between interest rates and expected inflation is to hold. Specifically, this is what we require for Fisher effect to hold. From

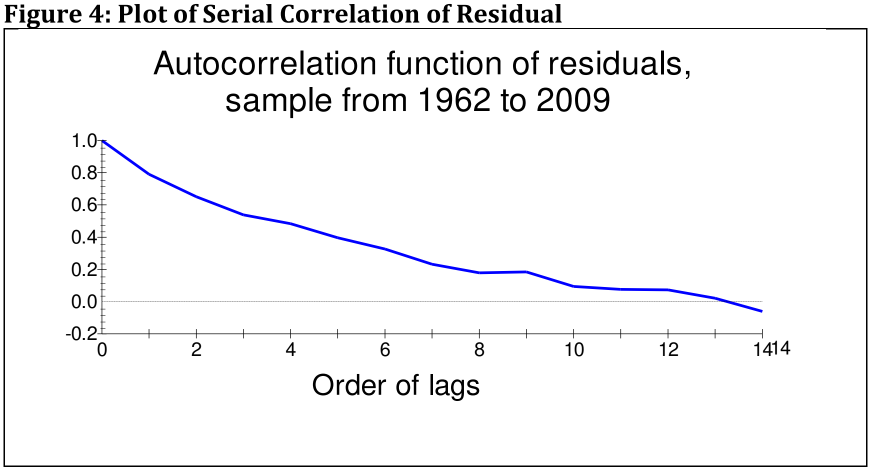
Table 3 above, our result (β = 0.233), though, not negative, is far from being one (1). What this result is telling us is that when expected inflation increases by one, nominal interest rate would increase by 0.23. According to Tobin (1965), since this result is positive (even if it is less than one), it could be taken to be the weak form of the Fisher hypothesis. This is probably based on the position that all forms of Fisher hypothesis specifications suggest that β is positive. In the actual sense, our result is too weak to be regarded as an indication of full Fisher effect in Nigeria. However, the p value of 0.002 for the expected inflation is not statistically significant at 5% significance level, indicating that we have to reject the null hypothesis in favour of the alternative and conclude that expected inflation is significant in explaining changes in nominal interest rates in Nigeria. R-Squared of show that 19% of 0.19 of variations in nominal interest rates are accounted for by expected inflation. This is too low for Fisher effect to hold. The DW statistic of 0.37 is much less than 2 and this represents the presence of positive autocorrelation. These results appear conflicting. However, there are no visible outliers since from the list of the residuals and fitted values of the regression; there is no observation whose residual is greater than 1.71591 which is three times the Standard Error of the regression which is reported as 0.57197.[12] This is an indication that the coefficient of determination is not affected by any outlier.

In spite of the results from the Ordinary Least Square estimation, it is necessary to look at the diagnostic tests in order to determine if our regression satisfied the assumptions of classical linear regression model. These tests were carried out at 5% level of significance under either the LM Version or F Version. Diagnostic Test A is the Lagrange multiplier test of residual serial correlation. With the p-values 0.00, we can reject the null hypothesis of no autocorrelation, with the implication that the model serially correlated. Though, this serial correlation diagnostic test is better than the DW tests, it goes further to support the DW statistic result of 0.37. Diagnostic Test B is the Ramsey's Regression Specification Error Test (RESET) test which examines general misspecification and tests if the functional form of the model was specified correctly. Given the p-values of 0.78 and 0.79 respectively, we cannot safely reject the null

[12] This is reported in Appendix B

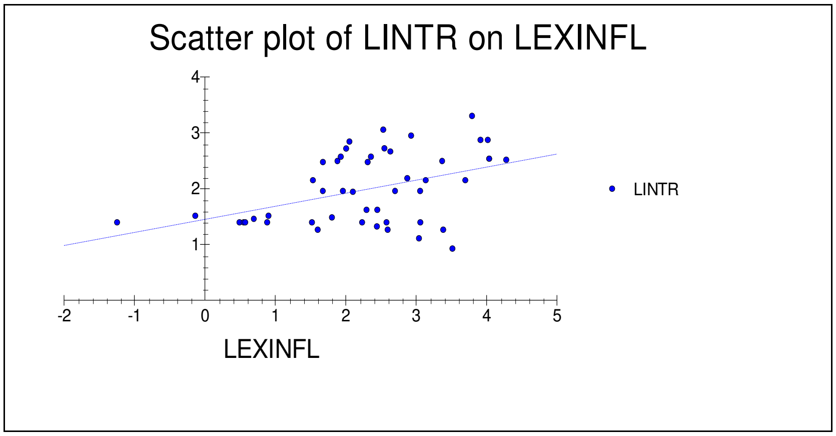
hypothesis and we conclude that our model is not misspecified. Under Diagnostic Test C which tests normal distribution of the residuals, the p-value of 0.63 informs us that the null hypothesis cannot be rejected. This is suggesting that with 95% confidence that our data sets fit the test of normality. Diagnostic Test D examines heteroscedasticity (unequal variance) in our model. This finds out if error terms are related to expected inflation which is our explanatory variable. It is appropriate for our residuals to random. This regression result would not be reliable if the residuals have a clear pattern. The null hypothesis is that there is no heteroscedasticity. With p-values of 0.053 and 0.054 (though, very slightly over the benchmark of 0.05, the suggestion is that the null hypothesis cannot be rejected. Therefore, the regression does not have the problem of heteroscedasticity. It is clear that our regression passed three of the four diagnostic tests, but fails the test for serial correlation and this is reflected in Figure 4 below. This makes our regression estimation results unreliable. Further analysis are through the examinations of other appropriate plots.

Figure 4: Plot of Serial Correlation of Residual



Microfit 4.1Output

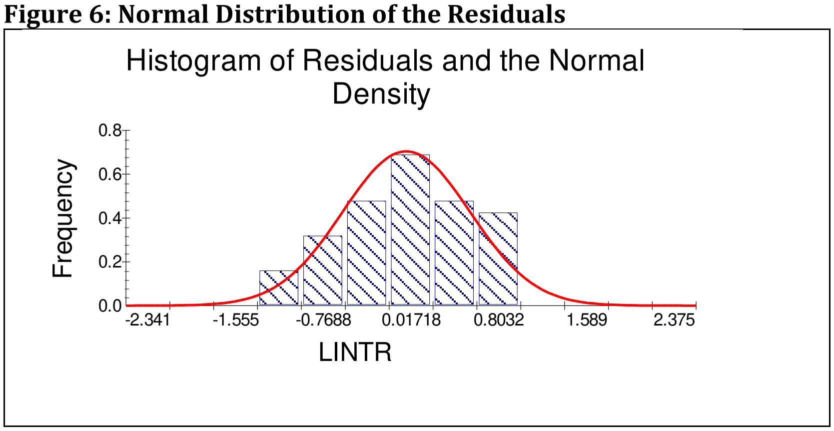
Figure 5: Scatter Plot of the Regression of Nominal Interest Rates on Inflation



Microfit 4.1Output

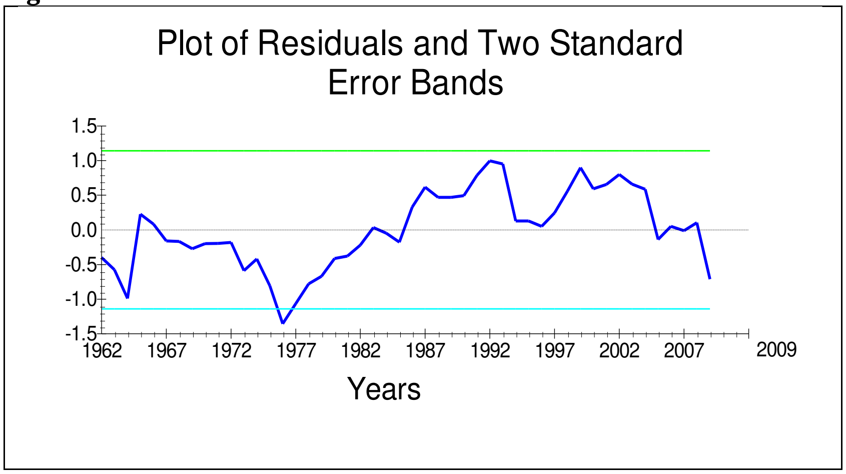
Figure 4 above reveals the problem of autocorrelation in the model while Figure 5 which shows the scatter plot of the regression of nominal interest rates on inflation suggests that the relationship between nominal rates and inflation is slightly nonlinear. The plot of the distribution of the residuals and the plot of residuals and two standard error bands are shown in Figures 6 and Figure 7 respectively.

Figure 6: Normal Distribution of the Residuals



Microfit 4.1Output

Figure 7: Plot of Residuals and Two Standard Error Bands



Microfit 4.1Output

Figure 6 above clearly reveals the regression almost passed the normality test because the distribution of the model residuals is close to that of normal distribution, with a shape that looks almost bell-like. The plot of residual shows a drift process which indicates that the residuals are not randomly distributed around zero. Visibly, the residuals move from negative to positive, to negative and to positive back to positive and finally to negative thereby breaking the assumption that the random errors have zero mean.

These analyses were made toward finding a strong case in favour of the use of the simple regression model for the data. The regression results could not fully justified as a measure of Fisher effect in Nigeria. Though, the regression results is useful in pointing out that full Fisher effect could not be established in the country, however, there is the risk of spurious regression. This now took us to go a step further to test the log run relationship between nominal interest rates and inflation in Nigeria through the cointegration approaches.

Cointegration Tests Analyses: As the first step in the process, an augmented Dickey Fuller (ADF) unit root test on interest rate and expected inflation was carried out. This test is based on the estimation of the regression model, expressed in Equation 10. Using two lags, our test statistics for ADF unit root test at levels is as reflected shown in Table 4 below. Because the plots of the nominal interest rates and inflation clearly failed to display trends, I therefore opted for the version of the result that does not include a trend, but with intercept. The Akaike Information, Schwarz Bayesian and

Hannan Quinn criteria were used to select the number of lagged differences for the test.

Table 4: ADF Unit Root Test Result for Stationarity at Levels[13]

Variables	*With Intercept*	*95% Critical Value*	*Intercept & Trend*	*95% Critical value*
Nominal Interest Rate	-1.2519	-2.9256	-0.0099263	-3.5088
Expected Inflation	-2.6808	-2.9271	-3.4677	-3.5112

Source: Author's estimation and Microfit 4.1Output

For the nominal interest rate, Table 4 shows the highest value at ADF (1) test and a test statistic of -1.2519 which is less than the 95% critical value of -2.9256 in absolute terms. Therefore, we cannot reject the null hypothesis of no unit root. Therefore, nominal interest rate is not stationary. For expected inflation, the table reveals the highest value at ADF (1) test and a test statistic of -2.6808 which is less than the 95% critical value of -2.9271 in absolute terms. Also, we cannot reject the null hypothesis of no unit root. Therefore, expected inflation is equally not stationary. The implications here are that we need to do the same test for the first difference of nominal interest rate and expected inflation.

Table 5: ADF Unit Root Test Result for Stationarity at First Difference[14]

Variables	*With Intercept*	*95% Critical Value*	*Intercept & Trend*	*95% Critical value*
Nominal Interest Rate	-4.5300	-2.9271	-4.8550	-3.5112
Expected Inflation	-8.2894	-2.9271	-8.3318	-3.5112

Source: Author's estimation and Microfit 4.1Output

The results on Table 5 show that an ADF (1) is to be chosen again, but the test statistics are now greater than the 95% critical value at -2.9271 in absolute terms. For nominal interest rate, the test statistic is -4.5300 while expected inflation has -8.2894. These results imply that we can reject the null hypothesis of no unit root at first difference for the two variables. Therefore, the nominal interest rates and expected inflation are stationary at first difference, indicating that they are I (1). Therefore, since these variables are integrated to the same order, we therefore proceeded to test for a long run relationship through cointegration by checking in the linear combination between the series is stationary. The results of the ADF test on the residuals of the regression are revealed as:

[13] Full results in Appendix C

14 Full results in Appendix D

Table 6: Unit Root Test for Residuals of OLS Regression of Nominal Interest Rate on Expected Inflation[15]

Test Statistic - ADF (1)	Critical value
-2.2193	-3.4747

Source: Author's estimation and Microfit 4.1Output

The results in Table 6 show the highest value at the ADF (1) tests and the test statistics of -2.2193 which is less than the 95% critical value of -3.17 which is the in absolute terms. This indicates that the residuals are integrated to the order of 1 and non-stationary. Therefore, we cannot reject the null hypothesis of no cointegration between the nominal interest rate and expected inflation in Nigeria. This indicates that there is no long run relationship between nominal interest rate and expected inflation in Nigeria. The Johansen Maximum Likelihood Cointegration Approach is further test for cointegration relationship.

Before proceeding with this method, it is necessary to select the lag length. From the maximum of 4-lag length (which is appropriate for annual data), Table7 below reports the optimal lag length of 1, using the Akaike Information and Schwarz criteria. The log likelihood ratio statistics from the results suggest a VAR order of 1

Table 7: Test Statistic results for the Selection of Order of the VAR Model

Order	*LL*	*AIC*	*SBC*
4	-44.7394	-60.7394	-75.0129
3	-45.9106	-57.9106	-68.6157
2	-47.5767	-55.5767	-62.7135
1	-50.2837	-54.2837	-57.8521
0	-157.6482	-157.6482	-157.6482

Source: Author's estimation and Microfit 4.1Output

In the process, the number of the cointegration relationship is tested and the parameters of the co-integrating relationships are estimated. The 95% critical value and the Likelihood Ratio (LR) test statistics are reported in Table 8 below.

Table 8: Johansen Maximal Likelihood Cointegration Test[16]

Maximal Eigenvalue				***Trace***			
Null (H_o)	***Alternative (H_1)***	***Likelihood Ratio Statistic***	***95% Critical Value***	***Null (H_o)***	***Alternative (H_1)***	***Likelihood Ratio Statistic***	***95% Critical Value***
r = 0	r = 1	14.69*	14.88	r = 0	r = 1	16.43*	17.86
r <= 1	r = 2	1.73	8.07	r <= 1	r = 2	1.73	8.07

Source: Author's estimation and Microfit 4.1Output
**5% level of significance*

15 Full results in Appendix E
[16] Full results in Appendix F

For the maximal eigenvalue test the likelihood ratio (LR) statistic is 14.69 which is less than the 95% critical value of 14.88. The trace test reports an LR statistic of 16.43 which is equally less than the 95% critical value of 17.86. Since these results show likelihood ratio statistics that are lower than the 95% critical values we cannot reject the null hypothesis of no cointegration. This therefore implies that nominal interest rates and inflation has no co-integrating relationship at 5% level of confidence. This is a confirmation of the suggestion arising from the Engle-Granger residual based ADF test that nominal interest rate and expected inflation in Nigeria are not cointegrated. For this reason, we can say that there is no long run relationship between nominal interest rate and inflation in Nigeria since it is evident that these series wandered apart (without bound) in the long run.

Granger-causality Analyses: The results of the Granger-causality test carry out in order to determine if the past (lag) value of inflation (expected inflation) was the caused for changes in nominal interest rates is as reflected below. These results are interpreted within 5% level of significance.

Table 9: Granger Causality Tests Results[17]

Null Hypotheses	***LL Statistic***	***P-Value***	***Lag***
Nominal interest rate does not Granger cause inflation	3.9082	0.048	1
Inflation does not Granger cause nominal interest rate	0.16492	0.685	1

Source: Author's estimation and Microfit 4.1Output

From Table 9, the LR test ratio is reported to be 0.16492 while the p-value is at 0.685 and with this at 5% level of significance; we cannot reject the null hypothesis that expected inflation does not Granger cause nominal interest rate. This suggests that expected inflation does not Granger cause nominal interest rate in Nigeria. This is another failure for Fisher effect in Nigeria. However, with a p-value of 0.048 and LR test ratio of 3.9082, the results from Table 9 suggest the rejection of the null hypothesis that nominal interest rate does not Granger cause expected inflation in Nigeria.

[17] Full results in Appendix G

5 Summary and Conclusions

The main objective of the research work is to investigate the Fisher effect and the relationship between nominal interest rates and inflation in Nigeria, over the period between 1961 and 2009 which covers the entire life of the country as an independent nation. The hypothesis of Fisher is that nominal interest rates and expected inflation share a common trend and that they are cointegrated. Therefore, what this work focused upon is the investigation of the strong version of Fisher effect which is about finding out if the nominal interest rates rise 'point-for-point' or 'one-for-one with expected inflation. The nominal interest rates are taken to be the 3-month Nigeria treasury bills rates while expected inflation is measure by a lag of the 12-month average headline inflation.

In this research study, I used descriptive statistics analytical to carry out a preliminary investigation of this relationship. The ordinary least square (OLS) method was employed to check a bivariate relationship between nominal interest rates and expected inflation in Nigeria. The Augmented Dickey-Fuller (ADF) unit root test was performed on the variables and because the variables displayed non stationarity, I proceeded to use the Engle-Granger ADF residual test cointegration approach and the Johansen's maximum likelihood cointegration method to test for if the variables have a long-run relationship. In testing for the directional movements of the nominal interest rates and expected inflation, the Granger causality test was carried out on the two variables. These various methods and approaches were used in testing various hypotheses which led to some conclusions.

The descriptive statistics shows a very weak positive correlation between nominal interest rates and expected inflation in Nigeria. The regression results of the OLS estimation showed the evidence of a very low level of variations in nominal interest rates that were accounted for by expected inflation. The estimation results got the evidence of a very weak version Fisher effect in Nigeria. Actually, if the Fisher equation is that of positive function of expected inflation that is characterised by a unit coefficient, then the OLS results suggest that the Fisher equation does not exist in Nigeria.

The results derived from the cointegration tests carried out through the Engle-Granger residual based ADF test and the Johansen's maximum likelihood test method suggest that there is no cointegrating long-run relationship between nominal interest rates and expected inflation in Nigeria, although, many authors found the Johansen approach to be sensitive to choice of lag length. The results of the Granger causality test indicate that nominal interest rates Granger caused expected inflation. However, this test fail to report that causality run from expected inflation to nominal interest rates in Nigeria. What these imply is that the nominal interest rate in Nigeria has information about future movements in inflation and that nominal interest rate could serve as future predicator for inflation, and not vice versa.

It is suffice to say that this research study show evidences to support the rejection of full Fisher effect in the case of Nigeria. There are no strong evidences to support the position that the nominal interest rates adjust on 'one-to-one' basis with the change in expected inflation. Therefore, going by the results derived from various hypotheses tested in this research study, the research study therefore conclude that the full and long-run Fisher effect is not evident in Nigeria. Ultimately, the outcome would be due to the extent of the existence money illusion and uncertainties in the Nigerian money and capital markets.

A limitation in this study is the inability to directly observe inflation expectation in Nigeria. But the major problem identified is that of the lack of the required expertise in managing the Nigeria's economy over this long period of military rule in the life of Nigeria as an independent nation.

Going by the findings derived from this research effort, it is necessary to recommend that Nigeria and countries with high rate of inflation should embrace inflation targeting in their monetary policy framework. This would be possible in the situation of an independent central bank that would be able to control and monitor the rate of nominal interest rate and prescribe a targeted inflation rates in line with the dictates of the economy.

There might many factors that were responsible for the failure of the Fisher effect to hold in Nigeria' and which might have greatly impacted the long-run movement on nominal interest rates and expected inflation in Nigeria. The major problem is high inflation and strange swing in the rate of inflation which may prompt this researcher to query the reliability and validity of the data set. These are the area that could be explored in future researches on relationships between many other economic variables in Nigeria. Due to the fact that the Central Bank of Nigeria is proposing the adoption of inflation targeting policy for Nigeria, future research emphasis could be placed on this area regarding Nigeria's monetary economics. This is necessary because of the importance of the development of accurate forecasts for expected inflation in Nigeria. This would solve the major economic problems of Nigeria and other countries in same category. Future researches on in this regard could be on aspects relating to relationships between actual and expected inflation and relationships between real and nominal interest rates in Nigeria.

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Appendix A

Results of the OLS Estimates of Log of Nominal Interest Rates on Log of Expected Inflation

```
                        Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is LINTR
 48 observations used for estimation from 1962 to 2009
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 C                          1.4504            .18337              7.9096[.000]
 LEXINFL                    .23388           .071009              3.2936[.002]
*******************************************************************************
 R-Squared                     .19082   R-Bar-Squared                    .17323
 S.E. of Regression            .57197   F-stat.    F(  1,  46)   10.8480[.002]
 Mean of Dependent Variable    1.9897   S.D. of Dependent Variable       .62904
 Residual Sum of Squares      15.0489   Equation Log-likelihood        -40.2715
 Akaike Info. Criterion      -42.2715   Schwarz Bayesian Criterion     -44.1427
 DW-statistic                  .37263
*******************************************************************************


                               Diagnostic Tests
*******************************************************************************
*    Test Statistics  *        LM Version        *         F Version          *
*******************************************************************************
*                     *                          *                            *
* A:Serial Correlation*CHSQ(   1)=  32.6874[.000]*F(   1,  45)=  96.0605[.000]*
*                     *                          *                            *
* B:Functional Form   *CHSQ(   1)=  .077165[.781]*F(   1,  45)=  .072458[.789]*
*                     *                          *                            *
* C:Normality         *CHSQ(   2)=   .92224[.631]*       Not applicable       *
*                     *                          *                            *
* D:Heteroscedasticity*CHSQ(   1)=   3.7510[.053]*F(   1,  46)=   3.8994[.054]*
*******************************************************************************
   A:Lagrange multiplier test of residual serial correlation
   B:Ramsey's RESET test using the square of the fitted values
   C:Based on a test of skewness and kurtosis of residuals
   D:Based on the regression of squared residuals on squared fitted values
```

Appendix B

Residuals and Fitted Values of the Regression of Nominal Interest Rates and Expected Inflation

****
Based on OLS regression of LINTR on:
C LEXINFL
48 observations used for estimation from 1962 to 2009
****

Observation	Actual	Fitted	Residual
1962	1.4748	1.8745	-.39970
1963	1.2528	1.8273	-.57451
1964	1.2528	2.2438	-.99106
1965	1.3863	1.1609	.22542
1966	1.5041	1.4205	.083584
1967	1.5041	1.6638	-.15968
1968	1.4469	1.6148	-.16791
1969	1.3863	1.6590	-.27272
1970	1.3863	1.5866	-.20026
1971	1.3863	1.5813	-.19498
1972	1.3863	1.5675	-.18122
1973	1.3863	1.9747	-.58840
1974	1.3863	1.8078	-.42152
1975	1.2528	2.0596	-.80686
1976	.91629	2.2746	-1.3584
1977	1.0986	2.1636	-1.0649
1978	1.3863	2.1677	-.78143
1979	1.3863	2.0556	-.66932
1980	1.6094	2.0246	-.41520
1981	1.6094	1.9889	-.37948
1982	1.9459	2.1671	-.22116
1983	1.9459	1.9108	.035127
1984	2.1401	2.1859	-.045876
1985	2.1401	2.3173	-.17719
1986	2.1401	1.8108	.32923
1987	2.4639	1.8444	.61948
1988	2.4639	1.9931	.47076
1989	2.8622	2.3920	.47020
1990	2.8622	2.3675	.49468
1991	2.7081	1.9216	.78642
1992	3.0445	2.0448	.99971
1993	3.2921	2.3397	.95243
1994	2.5257	2.3967	.12906
1995	2.5257	2.3961	.12963
1996	2.5055	2.4532	.052298
1997	2.4849	2.2403	.24465
1998	2.5611	2.0041	.55701
1999	2.8332	1.9326	.90061
2000	2.4849	1.8924	.59246
2001	2.5611	1.9035	.65761
2002	2.9381	2.1374	.80068
2003	2.7094	2.0483	.66109
2004	2.6539	2.0681	.58584
2005	1.9459	2.0839	-.13799
2006	2.1748	2.1246	.050191
2007	1.9330	1.9436	-.010671
2008	1.9488	1.8439	.10483
2009	1.3110	2.0236	-.71260

****

Appendix C

ADF Unit Root Test Results - Nominal Interest Rates (Levels)

Unit root tests for variable LINTR
The Dickey-Fuller regressions include an intercept but not a trend
****
46 observations used in the estimation of all ADF regressions.
Sample period from 1964 to 2009
****

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.4215	-1.1383	-3.1383	-4.9670	-3.8234
ADF(1)	-1.2519	-.75505	-3.7550	-6.4980	-4.7826
ADF(2)	-1.2698	-.70251	-4.7025	-8.3598	-6.0725

****
95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood   AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion   HQC = Hannan-Quinn Criterion

Unit root tests for variable LINTR
The Dickey-Fuller regressions include an intercept and a linear trend
****
46 observations used in the estimation of all ADF regressions.
Sample period from 1964 to 2009
****

	Test Statistic	LL	AIC	SBC	HQC
DF	-.46056	-.93736	-3.9374	-6.6803	-4.9649
ADF(1)	-.0099263	-.24587	-4.2459	-7.9031	-5.6159
ADF(2)	.0058939	-.24495	-5.2449	-9.8166	-6.9575

****
95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood   AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion   HQC = Hannan-Quinn Criterion

ADF Unit Root Test Results – Expected Inflation (Levels)

Unit root tests for variable LEXINFL
The Dickey-Fuller regressions include an intercept but not a trend
****
45 observations used in the estimation of all ADF regressions.
Sample period from 1965 to 2009
****

	Test Statistic	LL	AIC	SBC	HQC
DF	-3.3835	-61.6302	-63.6302	-65.4369	-64.3037
ADF(1)	-2.6808	-61.3939	-64.3939	-67.1039	-65.4042
ADF(2)	-2.0302	-60.6181	-64.6181	-68.2314	-65.9651

****
95% critical value for the augmented Dickey-Fuller statistic = -2.9271
LL = Maximized log-likelihood   AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion   HQC = Hannan-Quinn Criterion

Unit root tests for variable LEXINFL
The Dickey-Fuller regressions include an intercept and a linear trend
****
45 observations used in the estimation of all ADF regressions.
Sample period from 1965 to 2009
****

	Test Statistic	LL	AIC	SBC	HQC
DF	-4.1586	-59.1403	-62.1403	-64.8503	-63.1505
ADF(1)	-3.4677	-59.1397	-63.1397	-66.7530	-64.4867
ADF(2)	-2.7224	-58.9402	-63.9402	-68.4569	-65.6240

****
95% critical value for the augmented Dickey-Fuller statistic = -3.5112
LL = Maximized log-likelihood   AIC = Akaike Information Criterion

Appendix D

ADF Unit Root Test Results - Nominal Interest Rates (Differenced)

```
                      Unit root tests for variable DLINTR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 45 observations used in the estimation of all ADF regressions.
 Sample period from 1965 to 2009
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -7.2301      -2.0251       -4.0251       -5.8317       -4.6986
 ADF(1)      -4.5300      -2.0164       -5.0164       -7.7264       -6.0267
 ADF(2)      -3.4720      -2.0160       -6.0160       -9.6293       -7.3630
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9271
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

```
                      Unit root tests for variable DLINTR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 45 observations used in the estimation of all ADF regressions.
 Sample period from 1965 to 2009
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -7.5499      -.53158       -3.5316       -6.2416       -4.5418
 ADF(1)      -4.8550      -.52798       -4.5280       -8.1413       -5.8750
 ADF(2)      -3.7998      -.52140       -5.5214      -10.0381       -7.2052
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5112
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

ADF Unit Root Test Results – Expected Inflation (Differenced)

```
                     Unit root tests for variable DLEXINFL
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 45 observations used in the estimation of all ADF regressions.
 Sample period from 1965 to 2009
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -9.9515     -53.9164      -55.9164      -57.7231      -56.5899
 ADF(1)      -8.2894     -50.9147      -53.9147      -56.6247      -54.9249
 ADF(2)      -6.2767     -50.4609      -54.4609      -58.0742      -55.8079
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9271
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

```
                     Unit root tests for variable DLEXINFL
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 45 observations used in the estimation of all ADF regressions.
 Sample period from 1965 to 2009
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -9.9038     -53.3589      -56.3589      -59.0689      -57.3691
 ADF(1)      -8.3318     -50.1630      -54.1630      -57.7764      -55.5101
 ADF(2)      -6.3420     -49.6520      -54.6520      -59.1686      -56.3357
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5112
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

Appendix E

Results of the Unit Root Test for the Residuals of Nominal Interest rates on Expected Inflation

```
*********************************************************************
 Based on  OLS regression of LINTR on:
 C               LEXINFL
 48 observations used for estimation from 1962 to 2009
*********************************************************************
```

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.3766	-13.4438	-14.4438	-15.3471	-14.7805
ADF(1)	-2.2193	-13.4333	-15.4333	-17.2399	-16.1068
ADF(2)	-2.0045	-13.3445	-16.3445	-19.0545	-17.3548

```
*********************************************************************
 95% critical value for the Dickey-Fuller statistic =  -3.4747
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

Appendix F

Johansen Maximal Likelihood Cointegration Test Results

Cointegration with unrestricted intercepts and no trends in the VAR
Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

****

47 observations from 1963 to 2009. Order of VAR = 1.
List of variables included in the cointegrating vector:
LINTR LEXINFL
List of eigenvalues in descending order:
.26852 .036280

****

Null	Alternative	Statistic	95% Critical Value	90%Critical Value
r = 0	r = 1	14.6964	14.8800	12.9800
r<= 1	r = 2	1.7369	8.0700	6.5000

****

Use the above table to determine r (the number of cointegratingvectors).

Cointegration with unrestricted intercepts and no trends in the VAR
Cointegration LR Test Based on Trace of the Stochastic Matrix

****

47 observations from 1963 to 2009. Order of VAR = 1.
List of variables included in the cointegrating vector:
LINTR LEXINFL
List of eigenvalues in descending order:
.26852 .036280

****

Null	Alternative	Statistic	95% Critical Value	90%Critical Value
r = 0	r>= 1	16.4332	17.8600	15.7500
r<= 1	r = 2	1.7369	8.0700	6.5000

****

Use the above table to determine r (the number of cointegratingvectors).

Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria

****

47 observations from 1963 to 2009. Order of VAR = 1.
List of variables included in the cointegrating vector:
LINTR LEXINFL
List of eigenvalues in descending order:
.26852 .036280

****

Rank	Maximized LL	AIC	SBC	HQC
r = 0	-72.3093	-74.3093	-76.1594	-75.0055
r = 1	-64.9611	-69.9611	-74.5865	-71.7017
r = 2	-64.0927	-70.0927	-75.6431	-72.1813

****

AIC = Akaike Information Criterion SBC = Schwarz Bayesian Criterion
HQC = Hannan-Quinn Criterion

Appendix G

Granger Causality Tests Results: From Nominal Interest Rates to Inflation

```
             LR Test of Block Granger Non-Causality in the VAR
********************************************************************************
 Based on 48 observations from 1962 to 2009. Order of VAR = 1
 List of variables included in the unrestricted VAR:
 LINTR           LINFL
 List of deterministic and/or exogenous variables:
 C
 Maximized value of log-likelihood =  -64.2872
********************************************************************************
 List of variable(s) assumed to be "non-causal" under the null hypothesis:
 LINTR
 Maximized value of log-likelihood =  -66.2413
********************************************************************************
 LR test of block non-causality, CHSQ(  1)=   3.9082[.048]
********************************************************************************
 The above statistic is for testing the null hypothesis that the coefficients
 of the lagged values of:
 LINTR
 in the block of equations explaining the variable(s):
 LINFL
 are zero. The maximum order of the lag(s) is 1.
********************************************************************************
```

Granger Causality Tests Results: From Inflation to Nominal Interest Rates

```
             LR Test of Block Granger Non-Causality in the VAR
********************************************************************************
 Based on 48 observations from 1962 to 2009. Order of VAR = 1
 List of variables included in the unrestricted VAR:
 LINTR           LINFL
 List of deterministic and/or exogenous variables:
 C
 Maximized value of log-likelihood =  -64.2872
********************************************************************************
 List of variable(s) assumed to be "non-causal" under the null hypothesis:
 LINFL
 Maximized value of log-likelihood =  -64.3697
********************************************************************************
 LR test of block non-causality, CHSQ(  1)=   .16492[.685]
********************************************************************************
 The above statistic is for testing the null hypothesis that the coefficients
 of the lagged values of:
 LINFL
 in the block of equations explaining the variable(s):
 LINTR
 are zero. The maximum order of the lag(s) is 1.
********************************************************************************
```