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Inflation: How Much is Too Much for Economic Growth in Nigeria

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ABSTRACT

This study follows the methodology of Khan and Sendhadji (2001) to examine the existence of threshold effects in the inflation-growth relationship, using Nigeria data for the period 1970 to 2003. The results suggest the existence of inflation threshold level of 6 percent. Below this level, there exists significantly positive relationship between inflation and economic growth, while above this threshold level, inflation retards growth performance. Sensitivity analyses conducted confirmed the robustness of these results. This finding suggests that bringing inflation down to single digits should be the goal of macroeconomic management in Nigeria, while the optimal inflation target for policy in Nigeria is 6 percent.

Key words: Inflation; Economic Growth; Threshold Level

JEL Classification: C2, F5

1. INTRODUCTION

High and persistent inflation has been a major characteristic of the Nigerian economy for more than two decades, thus the fundamental objectives of monetary policy management in Nigeria, like any other developing or even industrialized country is the sustenance of high economic growth that is accompanied with tolerable level of inflation. Empirical literature is replete with studies focused at establishing the precise relationship between inflation and economic growth, and a consensus that is of policy relevance from these studies is that while moderate inflation helps in promoting economic growth, a high inflationary pressure creates uncertainties that hamper economic growth. Barro (1991), Fischer (1983, 1993), Bruno and Easterly (1998), and Sbordone and Kuttner (1994) had confirmed that inflation has a negative effect on medium and long-term growth. Various studies, including De Gregorio (1992) for Latin America, Hadjimicheal et. al (1995) for Sub-Saharan Africa, and Fischer, Sahay, and Vegh (1996) for transition economies have equally established a link between low inflation and high growth performance.

The foregoing suggests a non-linear relationship between the two variables, such that at some low rate of inflation, the relationship is positive or nonexistent, but negative at some higher inflation thresholds. Fischer (1993), Sarel (1996), Ghosh and Phillips (1998), Christoffersen and Doyle (1998), and Bruno and Easterly (1998) have examined this issue. An interesting policy question that emanates from these analyses is how much of inflation is too much for economic growth, or more generally, at what level of inflation does the relationship between inflation and growth become negative. That is if the inflation-growth nexus is non linear, it becomes of policy relevance to estimate the inflexion point, or threshold, at which the sign of the relationship between the two variables switches. Thus the central focus of this study is to investigate the existence of a statistically significant threshold level of inflation above which inflation affects growth differently than at lower inflation rates.

To set in perspectives the analysis of this study, it is imperative to observe the trends of the relationship between inflation and growth performance in Nigeria over the period of analysis of this study. Figure 1 below illustrates the trend in inflation and GDP growth rates in Nigeria. Quite contrary to suggestions of negative relationship between inflation and growth in most theoretical and empirical literature, a visual examination of trends of movements of the two variables, somehow indicates a direct relationship between both variables. The low inflationary periods of 1970 – 1985 with an average inflation rate of 14% is accompanied with average GDP growth rate of 17%, while the high inflationary period of 1986 – 1996 with an average inflation rate of 29% is accompanied with 32% average annual growth rate of GDP.

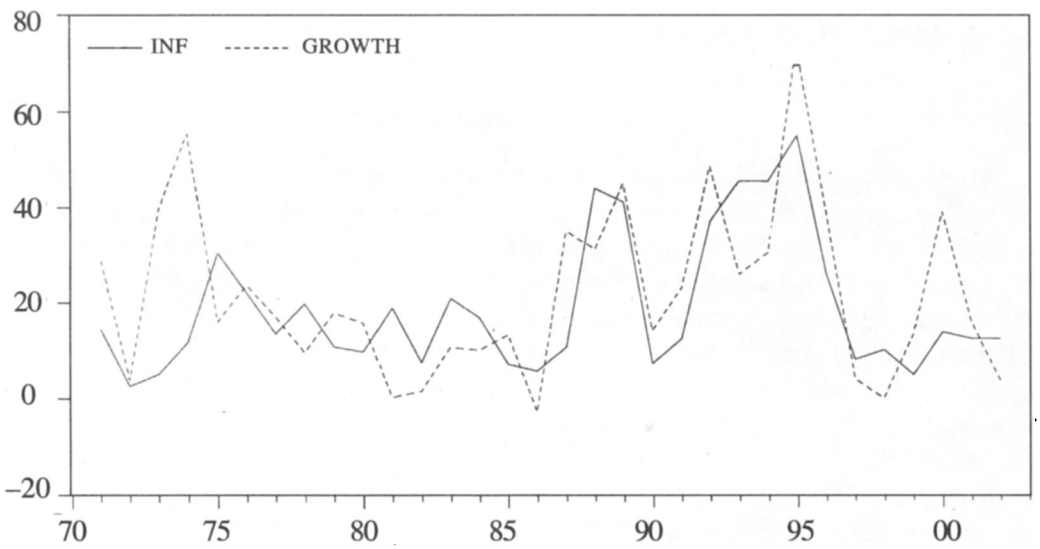

Figure 1: Inflation and Growth Rates of GDP : 1970-2003

However, Yasir (2005) and Khan and Senhadji (2001) provided an approach that offer a more precise picture of the historical nature of the relationship between the two variables than the trend observation provided above. This approach involves reducing the whole sample (1970 –2003) to few observations. For our purpose, the full samples were reduced to ten observations. These observations were derived as the arithmetic means of ten equal sub samples corresponding to increasing levels of inflation. The relationship between average GDP growth and inflation derived from these sub samples is depicted in figure 2.

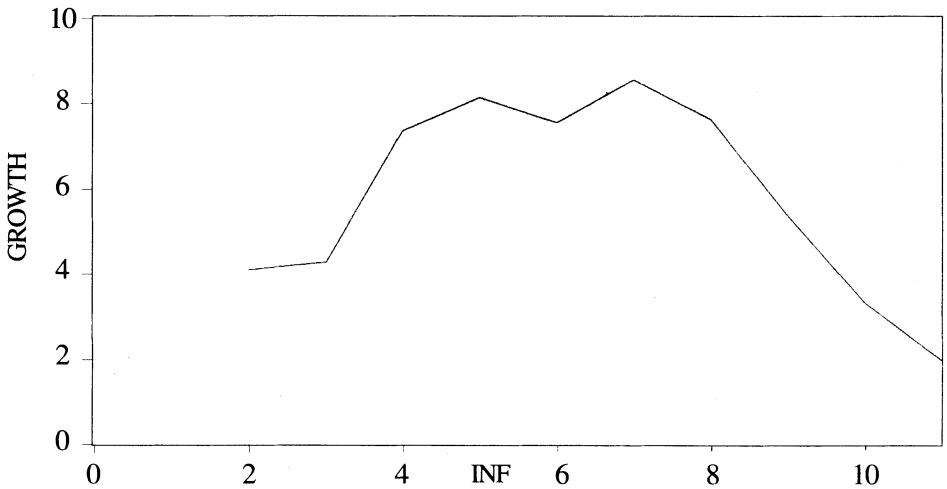

Figure 2: Average Growth Rates of GDP and Inflation

Figure 2 succinctly shows that a positive relationships dominates the inflation/growth nexus at low levels of inflation, and up to 7 percent inflation rate, while it turns negative at higher levels of inflation, suggesting the existence of a threshold around that inflation level. This is clearly in support of findings of existing empirical literature on inflation/ growth thresholds.

The rest of the paper takes the following form: section 2 presents a theoretical and empirical review of literature on inflation and growth. Section 3 presents the data and the model used for the analysis in this study, Section 4 contains estimation and analysis of results. Concluding remarks follow in section 5.

2. INFLATION AND GROWTH: THEORY AND EVIDENCE

2.1 Theory

Economic theories reach a variety of conclusions about the responsiveness of output growth to inflation. In what follows, we will discuss Classical, Keynesian, Neo-Keynesian,

Monetarist, Neo-classical and Endogenous growth theories, each with their respective contribution to the inflation-growth relationship. Classical economics recalls supply-side theories, which emphasize the need for incentives to save and invest if the nation's economy is to grow, linking it to land, capital and labour. Keynesian and Neo-Keynesian theory provided a more comprehensive model for linking inflation to growth under the AD-AS framework. Monetarism updated the Quantity Theory, reemphasizing the critical role of monetary growth in determining inflation, while Neo-classical and Endogenous Growth theories sought to account for the effects of inflation on growth through its impact on investment and capital accumulation.

Classical theorists laid the foundation for a number of growth theories. The foundation for Classical growth model was laid by Adam Smith who posited a supply side driven model of growth and his production function was as follows: $Y = f(L, K, T)$. Where Y is output, L is labour, K is capital and T is land, so output was related to labour, capital and land inputs. Consequently, output growth (gY was driven by population growth (gL), investment (gK) and land growth (gT) and increases in overall productivity (gf). Therefore: $gY = (gf, gK, gL, gT)$. Smith argued that growth was self-reinforcing as it exhibited increasing returns to scale. Moreover, he viewed savings as a creator of investment and hence growth, therefore, he saw income distribution as being one of the most important determinants of how fast (or slow) a nation would grow. He also posited that profits decline – not because of decreasing marginal productivity, but rather because the competition of capitalists for workers will bid wages up. The link between the change in price levels (inflation), and its "tax" effects on profit levels and output were not specifically articulated in classical growth theories. However, the relationship between the two variables is implicitly suggested to be negative, as indicated by the reduction in firms' profit levels through higher wage costs.

The Traditional Keynesian model comprises of the Aggregate Demand (*AD*) and Aggregate Supply (*AS*) curves, which aptly illustrates the inflation – growth relationship. According to this model, in the short run, the (*AS*) curve is upward sloping rather than vertical, which is its critical feature. If the *AS* curve is vertical, changes on the demand side of the economy affect only prices. However, if it is upward sloping, changes in *AD* affect prices and output, (Dornbusch, et al, 1996). This holds with the fact that many factors drive the inflation rate and the level of output in the short-run. These include changes in: expectations; labour force; prices of other factors of production, fiscal and/ or monetary policy. In moving from the short-run to the hypothetical long-run, the above-mentioned factors, and its 'shock' on the 'steady state' of the economy are assumed to balance out. In this 'steady state' situation, 'nothing is changing', as the name suggests. The 'dynamic adjustment' of the short-run AD and AS curves yields an 'adjustment path' which exhibits an initial positive relationship between inflation and growth, however, turns negative towards the latter part of the adjustment path.

The initial positive relationship between output and inflation, illustrated by the movement from point E^0 to E^1 in Figure 3, usually happens due to the 'time-inconsistency problem'. According to this concept, producers feel that only the prices of their products have increased while the other producers are operating at the same price level. However in reality, overall prices have risen. Thus, the producer continues to produce more and output continues to rise. Blanchard and Kiyotaki (1987) also believe that the positive relationship can be due to agreements by some firms to supply goods at a later date at an agreed price. Therefore, even if the prices of goods in the economy have increased, output would not decline, as the producer has to fulfill the demand of the consumer with whom the agreement was made.

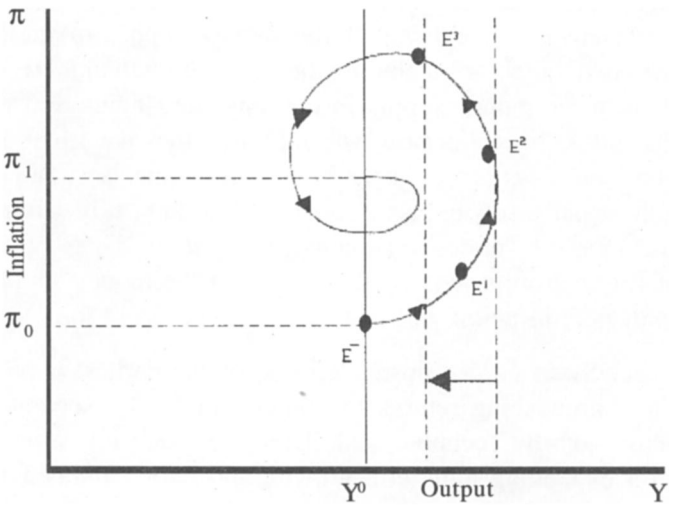

Figure 3

Two further features of the adjustment process are also important to note. Firstly, there are times when the output decreases and the inflation rate increases, for example, between E^2 and E^3. This negative relationship between inflation and growth is important, as it quite often occurs in practice, as ascertained by empirical literature. This phenomenon is stagflation, when inflation rises as output falls or remains stable. Secondly, the economy does not move directly to a higher inflation rate, but follows a transitional path where inflation rises then falls. Under this model, there is a short-run trade-off between output and the change in inflation, but no permanent trade-off between output and inflation. For inflation to be held steady at any level, output must equal the natural rate (Y*). Any level of inflation is sustainable; however, for inflation to fall there must be a period when output is below the natural rate.

Monetarism has several essential features, with its focus on the long-run supply-side properties of the economy as opposed to short-run dynamics. Milton Friedman, who coined the term "Monetarism", emphasized several key long-run properties of the economy,

including the Quantity Theory of Money and the Neutrality of Money. The Quantity Theory of Money linked inflation and economic growth by simply equating the total amount of spending in the economy to the total amount of money in existence. Friedman proposed that inflation was the product of an increase in the supply or velocity of money at a rate greater than the rate of growth in the economy. Friedman also challenged the concept of the Phillips Curve. His argument was based on the premise of an economy where the cost of everything doubles. Individuals have to pay twice as much for goods and services, but they don't mind, because their wages are also twice as large. Individuals anticipate the rate of future inflation and incorporate its effects into their behaviour. As such, employment and output is not affected. Economists call this concept the *neutrality of money*. Neutrality holds if the equilibrium values of real variables -including the level of GDP – are independent of the level of the money supply in the long run. Super neutrality holds when real variables - including the rate of growth of GDP - are independent of the rate of growth in the money supply in the long run. If inflation worked this way, then it would be harmless. In reality however, inflation does have real consequences for other macroeconomic variables. Through its impact on capital accumulation, investment and exports, inflation can adversely impact a country's growth rate. In summary, Monetarism suggests that in the long-run, prices are mainly affected by the growth rate in money, while having no real effect on growth. If the growth in the money supply is higher than the economic growth rate, inflation will result.

Solow (1956) and Swan (1956) postulated one of the earliest neo-classical models. The model exhibited diminishing returns to labour and capital separately and constant returns to both factors jointly. Technological change replaced investment (growth of K) as the primary factor explaining long-term growth, and its level was assumed by Solow and other growth theorists to be determined exogenously, that is, independently of all other factors, including inflation (Todaro, 2000).

Mundell (1963) was one of the first to articulate a mechanism relating inflation and output growth separate from the excess demand for commodities. According to Mundell's model, an increase in inflation or inflation expectations immediately reduces people's wealth. This works on the premise that the rate of return on individual's real money balances falls. To accumulate the desired wealth, people save more by switching to assets, increasing their price, thus driving down the real interest rate. Greater savings means greater capital accumulation and thus faster output growth.

Tobin, (1965) another neoclassical economist, developed Mundell's model further by following Solow (1956) and Swan (1956) in making money a store of value in the economy. Individuals in this model substitute current consumption for future consumption by either holding money or acquiring capital. Under this setup, individuals maintain precautionary balances, in spite of capital offering a higher rate of return.

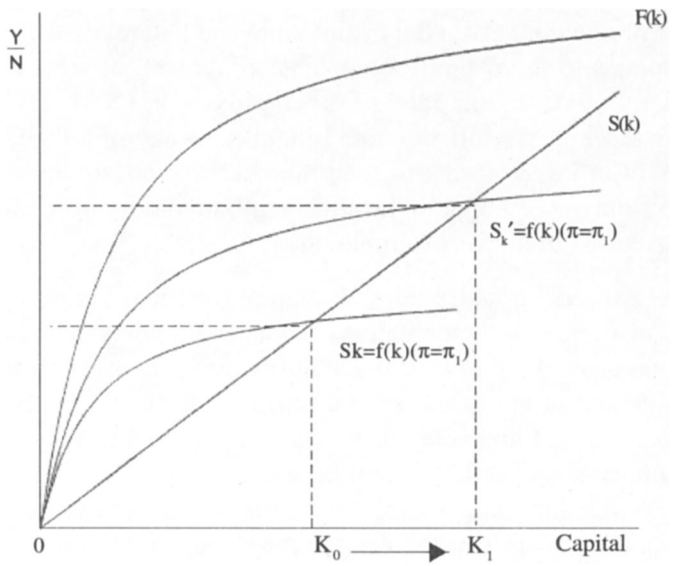

Figure 4

The above figure depicts the portfolio mechanism. If the inflation rate increases from π_0 to π_1 ($\pi_1 > \pi_0$), the return to money falls. According to Tobin's portfolio mechanism, people will substitute away from money, with its lower return, and move towards capital. In Figure 3, this substitution is depicted by a shift in the S_k line to S_k' The portfolio mechanism results in a higher steady state capital stock (from K_0 to K_1). Tobin's framework shows that a higher inflation rate permanently raises the level of output. However, the effect on output growth is temporary, occurring during the transition from steady state capital stock, K_0, to the new steady state capital stock, K_1. The impact of inflation can be classed as having a "lazy dog effect" where it induces greater capital accumulation and higher growth, only until the return to capital falls. Thereafter higher investment will cease and only steady state growth will result. Indeed, growth in the neoclassical economy is ultimately driven by exogenous technological advancement - upward shifts in the F(k) curve - not by a one-off change in the inflation rate.

Quite simply, the Tobin effect suggests that inflation causes individuals to substitute out of money and into interest earning assets, which leads to greater capital intensity and promotes economic growth. In effect, inflation exhibits a positive relationship to economic growth. Tobin (1972) also argued that because of the downward rigidity of prices (including wages), the adjustment in relative prices during economic growth could be better achieved by the upward price movement of some individual prices.

Neo-Keynesians initially emerged from the ideas of the Keynesians. One of the major developments under Neo-Keynesianism was the concept of 'potential output', which at times is referred to as natural output. This is a level of output where the economy is at

its optimal level of production, given the institutional and natural constraints. This level of output also corresponds to the natural rate of unemployment, or what is also referred to as the non-accelerating inflation rate of unemployment (NAIRU). NAIRU is the unemployment rate at which the inflation rate is neither rising nor falling. In this particular framework, the 'built-in inflation rate is determined endogenously, that is by the normal workings of the economy. According to this theory, inflation depends on the level of actual output (GDP) and the natural rate of employment.

Firstly, if GDP exceeds its potential and unemployment is below the natural rate of unemployment, all else equal, inflation will accelerate as suppliers increase their prices and built-in inflation worsens. This causes the Phillips curve to shift in the stagflationary direction; towards greater inflation and greater unemployment. Secondly, if the GDP falls below its potential level and unemployment is above the natural rate of unemployment, holding other factors constant, inflation will decelerate as suppliers attempt to fill excess capacity, reducing prices and undermining built-in inflation, leading to disinflation. This causes the Phillips curve to shift in the desired direction, towards less inflation and less unemployment.

Finally, if GDP is equal to its potential and the unemployment rate is equal to NAIRU, then the inflation rate will not change, as long as there are no supply shocks. In the long-run, the Neo Keynesians believe that the Phillips curve is vertical. That is, the unemployment rate is given and equal to the natural rate of unemployment, while there are a large number of possible inflation rates that can prevail at that unemployment rate. However, one problem with this theory is that, the exact level of potential output and natural rate of unemployment is generally unknown and tends to change over time. Inflation also seems to act in an asymmetric way, rising more quickly than it falls, mainly due to the downward rigidity in prices.

Endogenous growth theories describe economic growth which is generated by factors within the production process, for example; economies of scale, increasing returns or induced technological change; as opposed to outside (exogenous) factors such as the increases in population. In endogenous growth theory, the growth rate has depended on one variable: the rate of return on capital. Variables, like inflation, that decrease that rate of return, which in turn reduces capital accumulation and decreases the growth rate. One feature accounts for the foremost difference between the endogenous growth models and the neo-classical economies. In the neoclassical economies, the return on capital declines as more capital is accumulated.

In the simplest versions of the endogenous growth models, per capita output continues to increase because the return on capital does not fall below a positive lower bound. The basic intuition is that only if the return on capital is sufficiently high, will people be induced to continue accumulating it. Models of endogenous growth also permit increasing returns to scale in aggregate productions, and also focus on the role of externalities in determining

the rate of return on capital.

Endogenous models that explain growth further with human capital develop growth theory by implying that the growth rate also depends on the rate of return to human capital, as well as physical capital. The rate of return on all forms of capital must be equal in the balanced growth equilibrium. A tax on either form of capital induces a lower return. When such endogenous growth models are set within a monetary exchange framework, of Lucas (1980), Lucas and Stokey (1987), or McCallum and Goodfriend (1987), the inflation rate (tax) lowers both the return on all capital and the growth rate. A tax on capital income directly reduces the growth rate, while a tax on human capital would cause labour to leisure substitution that lowers the rate of return on human capital and can also lower the growth rate. Some versions of the endogenous growth economies find that the inflation rate effects on growth are small. Gomme (1993) studied an economy similar to the one specified by Cooley and Hansen; that is, an inflation rate increase results in a decline in employment. According to Gomme's research, efficient allocations satisfy the condition that the marginal value of the last unit of today's consumption equals the marginal cost of the last unit of work. A rise in inflation reduces the marginal value of today's last unit of consumption, thus inducing people to work less. With less labour, the marginal product of capital is permanently reduced, resulting in a slower rate of capital accumulation. Gomme found that in this economy, eliminating a moderate inflation rate (for example, 10 percent) results in only a very small (less than 0.01 percentage point) gain in the growth of output.

Alternative models examine how inflation might directly affect capital accumulation and hence output growth. Marquis and Reffert (1995) and Haslag (1995) specify economies in which capital and money are complementary goods. Marquis and Reffert examine inflation rate effects in a Stockman economy: there is a cash-in-advance constraint on capital. In Haslag's research, banks pool small savers but are required to hold money as deposits to satisfy a reserve requirement. Thus, an inflation rate increase drives down the return to deposits, resulting in deposits being accumulated at a slower rate. Since capital is a fraction of deposits, capital accumulation and output growth are slow. In both the Marquis and Reffert, and Haslag studies, the inflation rate effects on growth are substantially greater than those calculated in Gomme.

2.2 Empirical Evidence

While there seems to be consensus on the fact that very high inflation is bad for growth, there have been mixed results from empirical studies, as to their precise relationship. Among the first authors to analyze the inflation-growth relationship included Kormendi & Meguire (1985) who helped to shift the conventional empirical wisdom about the effects of inflation on economic growth: from a positive one, as some interpret the Tobin (1965) effect, to a negative one, as Stockman's (1981) cash-in-advance economy with capital,

has been interpreted. They found a significant negative effect of inflation on growth. In pooled cross-section time series regressions for a large set of countries, Fischer (1993) and De Gregorio (1993) found evidence for a negative link between inflation and growth. This was also confirmed by Barro (1995, 1996). Barro's studies also found that the relationship may not be linear. Studies by Levine & Zervos (1993) and Sala-i-Martin (1997) suggested that inflation was not a robust determinant of economic growth..

A number of studies have focussed on the nonlinearities and threshold effects of inflation on growth. These studies included Sarel (1996), Andres & Hernando (1997), Ghosh and Phillips (1998), Khan and Senhadji (2001), Singh and Kalirajan (2003) and Yasir (2005). In what follows we review the recent work done on the inflation-growth relationships that are considered most relevant to the present research interest.

Khan and Senhadji (2001) work is seminal in that it actually estimates the threshold level of inflation for both developing and developed countries. The study re-examine the issue of the existence of "threshold" effects in the relationship between inflation and growth, using econometric techniques initially developed by Chan and Tsay (1998), and Hansen (1999, 2000). The study used panel data for 140 developing and industrialized countries for the period 1960 -1998. The empirical results presented in the paper, strongly suggest the existence of a threshold beyond which inflation exerts a negative effect on growth. Inflation levels below the threshold levels of inflation have no effect on growth, while inflation rates above the threshold have a significant negative effect on growth. In particular, the threshold estimates are 1-3 per cent and 7-11 per cent for industrial and developing countries, respectively.

Given the growing concern, particularly in the EMU area that excessively low inflation threshold may hurt economic growth, Singh and Kalirajan (2003) examine whether a developing countries perspective is different. Their empirical analysis was done using the annual data from India for the period of 1971–1998. A specific question that is addressed in this paper is what the threshold inflation rate for India is. The findings clearly suggest that the increase in inflation from any level has negative effect on economic growth and substantial gains can be obtained by focusing the monetary policy towards maintaining price stability.

Yasir (2005) estimates the threshold level of inflation for Pakistan. Following the methodology of Khan and Senhadji (2001), the study estimates the threshold model for the period 1973-2000, and suggests 9 percent as the threshold inflation level for economic growth at which inflation is inimical for economic growth.

Ghosh and Phillips (1998) argue that if a relationship exists between inflation and growth, it is not likely to be a simple one. The bivariate relationship may not be linear; and the correlation between inflation/disinflation and growth maybe quite different from the steady-state inflation-growth relationship. Using data set that consists of 3,603 annual

observations on real per capita GDP growth, and period average consumer price inflation, corresponding to 145 countries, over the 1960-96 period in a panel regression, their findings reveal that there is a negative relationship between inflation and growth that is statistically significant and of an economically interesting magnitude. At very low rates of inflation (around 2 -3 percent a year or lower), inflation and growth are positively correlated. Otherwise, inflation and growth are negatively correlated, but the relationship is convex, so that the decline in growth associated with an increase from 10 percent to 20 percent inflation is much larger than that associated with moving from 40 percent to 50 percent. They also found a threshold at 2.5 percent, and a significant negative effect above this level.

Christoffersen and Doyle (1998) focus on the role of export market growth and structural reforms and tries to ascertain the relationship between output and inflation as well as the impact of disinflation. The study adopted a similar approach to Sarel (1995), modeling the linked relationship between inflation and output. Findings from the study suggest that there is no evidence that disinflation necessarily incurs significant output costs, even at moderate inflation rates. Losses only appear to arise when moderate inflation is stabilized in the presence of exchange rate pegs. They also found no evidence of countries closer to the inflation-output threshold simply aiming to stay there without proceeding further towards industrial country inflation rates. The authors suggest that, for countries now well below the estimated inflation-output threshold, no evidence is found that raising inflation will boost output. Thus, such countries should aim to lock in their low rates of inflation.

Sarel (1995) examines the possibility of non-linear effects on economic growth; it finds evidence of a significant structural break in the function that relates economic growth to inflation. The study was conducted to confirm the changing view, from the 1970s and 80s, that inflation had a negative effect on growth. It finds that there is evidence of a structural break that is significant. The break is estimated to occur when the inflation rate is 8 percent. Below that rate, inflation does not have any effect on growth or it may even have a slightly positive effect. When the inflation rate is above 8 percent, however, the estimated effect of inflation on growth rates is negative, significant, robust and extremely powerful. This study also demonstrated that when structural break is taken into account, the estimated effect of inflation on economic growth increases by a factor of three. The results suggest that the existence of a structural break also suggests a specific numerical target for policy, which is to keep inflation below the structural break.

Faria and Carneiro (2001) investigate the relationship between inflation and output in the context of an economy facing persistently high inflation and inflation shocks. By analyzing data on the monthly inflation rate and real output for the period January 1980 to July 1995 for Brazil, the study found that inflation does not impact growth in the long-run, but in the short-run there exists a significant negative effect from inflation on output.

Bruno and Easterly (1995) study examine the determinants of economic growth. The study proposes a nonparametric definition of high inflation crises as "periods when annual inflation is above 40 percent". Their aim is to make progress on stylized facts that can be used for further theorising. The data series contained annual CPI inflation of 26 countries that had inflation crises at some point in time over the 1961- 1992 period. Bruno and Easterly found a negative relationship between inflation and growth, which is firmly established when looking at the temporal association of growth with discrete high inflation crises. However, they found the case for growth effects of low to moderate rates of inflation very much ambiguous. According to the results obtained, causality remained problematic, but their results are consistent with the view that costs of inflation only become significant at relatively high rates of inflation. At lower rates of inflation, growth and inflation may simply be jointly troubled by various demand and supply shocks and hence shows no consistent pattern.

Barro (1995), attempts to find from empirical analysis, the estimated effects of inflation on growth. The paper considers the effect on growth of inflation, and of "other determinants" such as fertility, education etc. Once the effects of the other determinants are removed, the residual growth is plotted against inflation. The data set covers over 100 countries from 1960 to 1990. The results in this paper show that if a number of the country characteristics are held constant, then regression results indicate that the impact effects from an increase in average inflation by 10 percentage points per year are a reduction of the growth rate of real per capita GDP by 0.2-0.3 percentage points per year, and a decrease in the ratio of investment to GDP by 0.4-0.6 percentage points..

Fischer (1993) established a framework to identify possible channels from macroeconomic policy to growth. The author, in the process, identifies growth's responsiveness with inflation, large budget deficits and distorted foreign exchange markets, and scrutinizes the causal relationship and the channels through which it operates. Examination of exceptional cases illustrated that while low inflation was not necessary for high growth even over long periods, high inflation was not consistent with sustained growth.

Rousseau and Wachtel (2002) examined the robustness of the cross-sectional relationship between the size of a country's financial sector and its rate of economic growth. Specifically, the study tests whether the strength of this relationship varies with the inflation rate. Using five-year averages of standard measures of financial development, inflation, and growth for 84 countries from 1960 to 1995, a series of rolling panel regressions show that there is an inflation threshold for the finance-growth relationship that lies between 13 and 25 percent. When inflation exceeds the threshold, finance ceases to increase economic growth. The study also finds that the level of inflation is associated with a positive effect of financial depth on growth.

3. DATA AND MODEL SPECIFICATION

The study utilized annual data series sourced from the International Financial Statistics CD-ROM (2004) database on Consumer Price Index, real GDP, Population and Total investment, proxy by Gross Capital Formation. The dataset spans the period 1970 -2003. The growth rate of all variables of the model is constructed as the first difference of logarithmic transformation of the variable. This serves to eliminate, as suggested by Sarel (1996), at least partially, the strong asymmetry that is usually associated with inflation distributions. Khan and Senhadji (2001) and Yasir (2005) similarly calculated growth rates of macroeconomic variables using log transformation which Ghosh and Phillips (1998) show to provide best fits in the class of non-linear models. This study is focused at estimating the threshold level of inflation for Nigeria. The work of Khan and Senhadji (2001) is seminal in inflation threshold estimation. The authors developed a model for the analysis of threshold level of inflation for industrialized and developing countries. The present study adopts the model of the aforementioned. The estimated model is of the form:

$$d\log(Y_t) = \beta_0 + \beta_1 \log(\pi_t) + \beta_2 D_t^{\pi^*} \left[\log(\pi_t) - \log(\pi^*)\right] + \eta X_t + \varepsilon_t$$
$$D_t^{\pi^*} = \begin{cases} 1: \pi_t > \pi^* \\ 0: \pi_t < \pi^* \end{cases} \quad (1)$$

where $d\log(Y_t)$ is the growth rate of real GDP, π_t is inflation rate based on the CPI indepx, π^* is the threshold level of inflation, $D_t^{\pi^*}$ is a dummy variable defined as value one for inflation levels greater than the threshold level of inflation and zero otherwise. X_t is a vector of control variables that consists of population growth rate and investment growth rate. We are guided by empirical literature in the choice of these variables in the growth regression. Solow (1956) and Swan (1956) who developed first neo-classical models of growth, took the rate of growth of population as one of exogenous variables in their model to show that the faster the rate of population growth, the poorer the country. Fischer (1993) included investment in his model to show that inflation reduces growth by reducing investment and productivity growth. Mankiw, et al. (1992) also includes investment and population growth in their growth model. Khan and Sendhadji (2001) include growth rate of term of trade in their inflation threshold estimation, while it is also one of the few variables that passed the robustness tests in Levine and Renelt (1992) and Sala-i-Martin (1997). Continuity of the relationship given by equation (1) is necessary in order that small changes in the inflation rate around the threshold level will not yield different impacts on growth depending on whether inflation is increasing or decreasing. The term $\left[\log(\pi_t) - \log(\pi^*)\right]$ in equation (1) makes the relationship between growth and inflation, described by the equation continuous at the threshold level π^*. Parameter π^* has the

property that the effect of inflation on GDP growth is given by β_1 when inflation is less or equal to π^* percent, and $(\beta_1+\beta_2)$ when inflation rates are higher than π^* percent. For estimation, the value of π^* is given arbitrarily for the estimation, the optimal k is obtained by finding that value which minimizes the residual sum of squares (RSS). Stacking the observations in equation (1) in vectors yields the compact notation:

$$d\log(Y_t) = X\beta_\pi + e \quad . \pi = \pi_{l,} \ldots\ldots, \pi^h \tag{2}$$

where $\beta_\pi = (\beta_0\, \beta_1\, \beta_2\, \eta)$ is the vector of parameters and X is the corresponding matrix of observations on the explanatory variables. The coefficient vector β is indexed by π to show its dependence on the threshold level of inflation, the range of which is given by π_1 and π^h. Define $S_1(\pi)$ as the residual sum of squares with the threshold level of inflation fixed at π. The optimal threshold level π^* is chosen so as to minimize $S_1(\pi)$.

4. ESTIMATION AND INTERPRETATION OF RESULTS

The task of identifying a precise value of threshold inflation level and its impact on growth performance involves estimating equation (1) and computing the residual sum of squares (RSS) for threshold level of inflation ranging from π_1 to π^h. The optimal threshold level is the one that minimizes the sequence of RSSs. The search for the optimal threshold effect is conducted for π_1 = 1percent and π^h = 55 percent, the upper bound has been set to 55 percent as all observations lie below that inflation level. The increment is 1 percent; this exercise yields 55 linear regressions of equation (1).

Table 1 presents the results of estimation of non-linear model at π^* = 1 to 10 percent to search for a precise value of threshold inflation level. The optimal threshold level is the one that minimizes the sequence of RSS, and from the table, 6 percent inflation level is the threshold level for Nigeria. The estimated equation at this inflation level is as follows:

$$d\log(Y_t) = 51.06 + 4.36(\pi_t) - 3.43D_t^{\pi^*}\left[(\pi_t) - (6)\right] + 0.22(INVST_t)$$

Adjusted R-squared 0.632516 $\quad RSS_{min}$ 0.5312

The results in Table 1 indicate a significant positive effect of inflation on economic growth rate at low levels of inflation ($\pi^* \leq 6$). While at higher inflation levels ($\pi^* \geq 6$), the signs of the relationship switches to a significant negative one. If inflation increases above threshold level, growth is estimated to decline by 3.43 percent, while if maintained at or below 6 percent; growth rate increases by 4.36 percent. This result is in line with findings of Ghosh and Phillips (1998), while it slightly differs from Khan and Sendhadji (2001) and Yasir (2005) whose results indicated a statistically insignificant relationship between inflation and growth rates below the inflation threshold level. Our results also support the findings of Fischer (1993), which is that the negative effect of inflation on growth weakens

somewhat at higher levels of inflation. This is evident from the consistent reduction in the magnitude of the negative coefficient of inflation rate at levels above the threshold level.

As expected, investment growth rates have a significant positive effect on growth, conforming to previous results of growth regressions (e.g; Khan and Sendhadji, 2001; Fischer, 1993; Mankiw, et. al., 1992; Solow, 1956; and Swan, 1956). Empirical estimation of the model equation consistently indicates the variable POP to be statistically insignificant at any level of inflation rate. This prompted a re-estimation of the model without the variable to see what significant effect it could have on the estimated relationships. It was however found out that the results and conclusions of the study are not significantly altered by this re-specification. Thus the variable POP has been dropped from the estimated model reported above, albeit, we note its authenticity in empirical literature on growth regressions (See Solow, 1956; Swan, 1956; Fischer, 1993; and Mankiw, et. al 1992, amongst others).

TABLE 1

THRESHOLD MODEL ESTIMATION RESULTS.

π^*	Variable	Coefficient	Std. Error	t-Statistic	Prob.	RSS
1	INF	2.750513	0.934485	2.943346	0.0159	0.5573
	DINF- 1	-1.876097	0.792016	-2.368761	0.0765	
	INVST	0.209762	0.085626	2.449746	0.0423	
	C	53.79602	39.09689	1.375966	0.2572	
2	INF	3.011737	1.011527	2.977416	0.0147	0.5514
	DINF- 2	-1.953416	0.877831	-2.225275	0.0643	
	INVST	0.211735	0.085176	2.485852	0.0395	
	C	53.97400	38.86845	1.388632	0.2525	
3	INF	3.324953	1.100199	3.022137	0.0134	0.5447
	DINF- 3	-2.278615	0.978383	-2.328960	0.0532	
	INVST	0.214350	0.084689	2.531025	0.0362	
	C	53.99311	38.60661	1.398545	0.2490	
4	INF	3.685509	1.200856	3.069068	0.0122	0.5380
	DINF- 4	-2.662043	1.094411	-2.432397	0.0438	
	INVST	0.217769	0.084213	2.585930	0.0325	
	C	53.69455	38.32598	1.400996	0.2481	
5	INF	4.060633	1.309745	3.100323	0.0114	0.5326
	DINF- 5	-3.076816	1.223365	-2.515043	0.0373	
	INVST	0.222042	0.083871	2.647422	0.0289	
	C	52.82407	38.07188	1.387482	0.2275	
6	INF	4.361178	1.416033	3.079856	0.0107	0.5312
	DINF- 6	-3.439127	1.355585	-2.537005	0.0322	
	INVST	0.226821	0.083892	2.703726	0.0232	
	C	51.06716	37.94166	1.345939	0.2684	

7	INF	-4.430895	1.498123	-2.956267	0.0154	0.5374
	DINF- 7	-3.590798	1.469814	-2.443028	0.0429	
	INVST	0.230985	0.084565	2.731412	0.0244	
	C	48.27129	38.07583	1.267767	0.2993	
8	INF	-4.127370	1.526095	-2.704530	0.0258	0.5531
	DINF- 8	-3.372052	1.534275	-2.197814	0.0677	
	INVST	0.232804	0.085992	2.707275	0.0256	
	C	44.84856	38.55756	1.163160	0.3444	
9	INF	-3.485781	1.479048	-2.356773	0.0504	0.5749
	DINF- 9	-2.791304	1.523425	-1.832255	0.1274	
	INVST	0.231306	0.087818	2.633924	0.0296	
	C	41.79379	39.28025	1.063989	0.3916	
10	INF	2.729044	1.365931	1.997936	0.0963	0.5969
	DINF- 10	-2.057786	1.440968	-1.428058	0.2386	
	INVST	0.227345	0.089473	2.540934	0.0355	
	C	39.90503	40.00803	0.997425	0.4254	

5. SENSITIVITY ANALYSES

A fundamental assumption of regression analysis is that the right hand side variables are uncorrelated with the disturbance term. This assumption is violated, for instance, when there are endogenously determined variables on the right hand side of the equation, in this situation, both OLS and weighted LS are biased and inconsistent. In our specification, inflation rate and investment growth may not be an exogenous variable in the growth-inflation regressions above. The standard approach in cases where right hand side variables are correlated with the residuals is to estimate the equation using instrumental variables regression. The idea behind instrumental variables is to find a set of variables, termed instruments, which are both (1) correlated with the explanatory variables in the equation, and (2) uncorrelated with the disturbances. These instruments are used to eliminate the correlation between right hand side variables and the disturbances. Two stage least squares (2SLS) is a special case of instrumental variables regression and it is an appropriate technique when right hand side variables are correlated with the error terms, and there is both heteroskedasticity and contemporaneous correlation in the residuals.

To control for this problem, the model has also been estimated using Two Stage Least Squares (2SLS) in which inflation rate and investment growth rate are treated potentially endogenous to growth. The set of instruments in the regression include the lag of inflation, the lag of investment, the lag of real GDP growth, the growth rate of terms of trade and a time trend. The lagged variables are valid instruments only if the error term in equation (1) is not autocorelated. Autocorrelation test rejects the null hypothesis at 10 percent. The results from 2SLS estimation remain largely similar[1]. The results still suggest 6 percent

1 Details of 2SLS estimation results are obtainable from authors.

threshold level of inflation and the values of estimated coefficients also remain largely similar.

A test of causality between inflation and growth is also important in validating the choice of dependent and independent variable for the threshold model specification. Also the endogeneity problem may be benign, if causality runs mainly from inflation to growth, while it will be more severe, if other way round. The Granger Causality test was applied to measure linear causation between inflation and economic growth. The Test statistics presented in Table 2 rejects the null hypothesis, indicating that inflation is causing GDP growth. The causality between the variables is uni-directed, with no feedback from output growth to inflation.

TABLE 2

PAIRWISE GRANGER CAUSALITY TESTS

Sample: 1970 2003 Null Hypothesis:	Obs	F-Statistic	Probability
GROWTH does not Granger Cause INF	30	0.48395	0.62200
INF does not Granger Cause GROWTH	3.86877	0.03175	

6. SUMMARY AND CONCLUDING REMARKS

This study follows the methodology of Khan and Sendhadji (2001) to examine the existence of threshold effects in the inflation-growth relationship, using Nigeria data for the period 1970 to 2003. The results suggest the existence of inflation threshold level of 6 percent. Below this level, there exists significantly positive relationship between inflation and economic growth, while above this threshold level, inflation retards growth performance. Sensitivity analyses conducted confirmed the robustness of these results. This finding suggests that bringing inflation down to single digits should be the goal of macroeconomic management in Nigeria, while the optimal inflation target for policy in Nigeria is 6 percent.

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