THRESHOLD EFFECT OF INFLATION ON ECONOMIC GROWTH IN SIERRA LEONE

BSL Special Studies

Research and Statistics Department

Bank of Sierra Leone

Abstract

The objective of the paper is to investigate the optimal inflation rate for Sierra Leone. With the use of annual data from 1980 to 2020, a model of growth is estimated accounting for the role of investment, terms of trade and inflation, using non-linear regression in the context of endogenous threshold was estimated. The model results show that there are two thresholds, which are 6.8% and 18.2%. Moreover, inflation has a negative effect on growth when inflation is below 6.8% and when it is between 6.8% and 18.2%. But above 18.2%, inflation has no impact on growth though the coefficient of inflation is positive. Moreover, the negative impact of inflation on growth is stronger when inflation is less than 6.8% than when it is between 6.8% and 18.2%. Thus, when inflation is below 6.8%, the growth lost when inflation increases further is higher than when inflation increases during periods when it is between 6.8% and 18.2%. Also, when inflation is above 18.2%, reduction of inflation to a rate higher than 18.2% brings no growth gain. The result therefore implies for policy that having inflation between 6.8% and 18.2% is optimal for Sierra Leone.

A paper presented at the 1st Annual Conference of the Bank of Sierra Leone at the Bank Complex, Kingtom, Freetown on May 9, 2023.

1. Introduction

There is a general consensus among Central Banks that price stability is the core objective of monetary policy, while they also care for economic growth. Price stability is however put at the forefront of this objective in order to avoid the inflation-unemployment trade-off. Among academics and policymakers, this has brought to light interest in studying the relationship between inflation and economic growth. The existence and nature of the nexus between inflation and growth has been at the center of the policy debate over the last three decades. The debate has been generally centered on identifying the effect of inflation on economic growth or investigating the rate of inflation at which the effect of inflation on growth changes in terms of sign or magnitude. Different schools of thought offer diverse views on the relationship between inflation and economic growth. One such set of these proponents are the structuralists, who are of the view that inflation is vital for economic growth, as opposed to the monetarists who posit that inflation is harmful to economic growth (Mallik and Chowdhury, 2001).

Earlier studies by Barro (1991) and Fischer (1993) posit that there exists an inverse relationship between inflation and economic growth. This inverse relationship is crucial for macroeconomic policy management. The effect of inflation on aggregate demand is exhibited mainly from different channels, such as higher interest rates, reducing purchasing power, increasing uncertainties, discouraging savings and investments, among others. Furthermore, inflation negatively impacts growth by decreasing investment as well as affecting the efficiency of government expenditure, thereby translating to a budget deficit which could shrink capital formation (Fischer 1993). Khan and Senhadji (2000; 2001) argued in favour of a nonlinear relationship in which at a low inflation rate, the relationship tends to be positive and negative at a certain higher rate. Many proponents agreed that inflation has distortional effects on long-term economic growth if it gets "too high". Yet how high is too high? For developing and industrialized countries, there has been an increasing consensus on inflation targets that center around 2% (Khan and Senhadji, 2001). Khan and Senhadji (2001) estimated the threshold effect in the relationship between inflation and economic growth for both developed and developing countries and found that the threshold level of inflation above which inflation significantly distorts economic growth for developed countries was 1-3% and 11-12% for developing countries. Azam and Khan (2020) identified 12.23% and 5.36% threshold that impede growth in developing and developed economies respectively.

In Sierra Leone, we are not aware of studies on this important issue. However, according to regional studies on the West African Monetary Zone, Tarawalie et al. (2012) used annual data for Sierra Leone from 1970 to 2010 using the exogenous threshold approach with one threshold assumed and found a threshold inflation rate of 9% beyond which inflation adversely affects economic growth in Sierra Leone. The paper investigates the non-linear effect of inflation on economic growth in Sierra Leone. We adopt an endogenous threshold framework, where the threshold is chosen within the historical series of inflation and test for the number of thresholds, as there could be more than one threshold in the relationship. The paper therefore extends the literature on Sierra Leone by (i) adopting a framework that provides a threshold that is within the country's inflationary trend and (ii) adopting a framework that accounts for more than one threshold.

The rest of the paper is organized as follows. Section two presents stylized facts on inflation and real GDP growth trends in Sierra Leone. Section three reviews the literature on inflation and growth nexus. Section four presents the methodology while Section five presents and discusses empirical findings. Section 6 is the conclusion.

2. Stylized Facts on Inflation and Real GDP Growth Trends in Sierra Leone

Using annual data for the period 1980 to 2022, the correlation between real GDP growth and inflation rate is -0.17 and the p-value is 0.298. Hence, there is a negative but insignificant correlation between real GDP growth and inflation rate in Sierra Leone. Though this correlation captures only linear correlation and correlation does not imply causality, it suggests that there is no significant relationship between real GDP growth and inflation in Sierra Leone. The correlation is shown at the bottom of Table 1.

Table 1: Inflation and Real GDP Growth in Sierra Leone

Period	Economy Description	Real GDP Growth	Inflation
1980-1990	The decade before the war	1.1	62.9
1991-2001	Decade of the war period	-2.2	38.4
2002-2012	1st Decade after War	8.6	8.6
2013	Iron Ore Boom	20.7	5.5
2014	1st Year of Iron Ore Price Collapse and Ebola Virus Disease	4.6	4.6
2015	2nd Year of Iron Ore Price Collapse and Ebola Virus Disease	-20.6	6.7
2016-2019	Pre-COVID-19 and Post Ebola	4.7	15.0
2020-2021	COVID-19 Pandemic	1.0	15.7
2022	Russian-Ukraine War	2.8	37.09
	Correlation Coefficient = -0.17 (0.298) Value in Parenthesis is probability of rejecting the null of no correlation		

Source: World Development Indicators and BSL

As observed in Table 1, time series data on inflation and real GDP growth in Sierra Leone shows that the 1980s was a decade of very high inflation rate, coupled with very slow growth rate of economic activities, with average inflation rate being 62.9% while average growth of real GDP was 1.1%. Though inflation rate reduced in the following decade, which was dominated by the war (which broke out in 1991), inflation rate moderated during the period 1990 to 2001, with real GDP growth contracting by an average of -2.2% while inflation reduced to 38.4%. In the first

decade after the end of the war (2002-2012), average real GDP growth was positive at 8.6%, from -2.2% in the previous decade. Inflation rate also declined, to a single digit average, coming from 38.4% in the previous decade to 8.6%. This suggests that if causality runs from inflation to growth, lower inflation brings higher growth. This observation is however different from the observation from the 1980-1990 and 1991- 2001, where inflation rate declined, and yet average real GDP growth went from a low growth of 1.1% to a negative growth of -2.2%. This suggests that the existence of war can break the inflation-growth positive linkage, which actually occurs through destruction of capital and growing macroeconomic uncertainty.

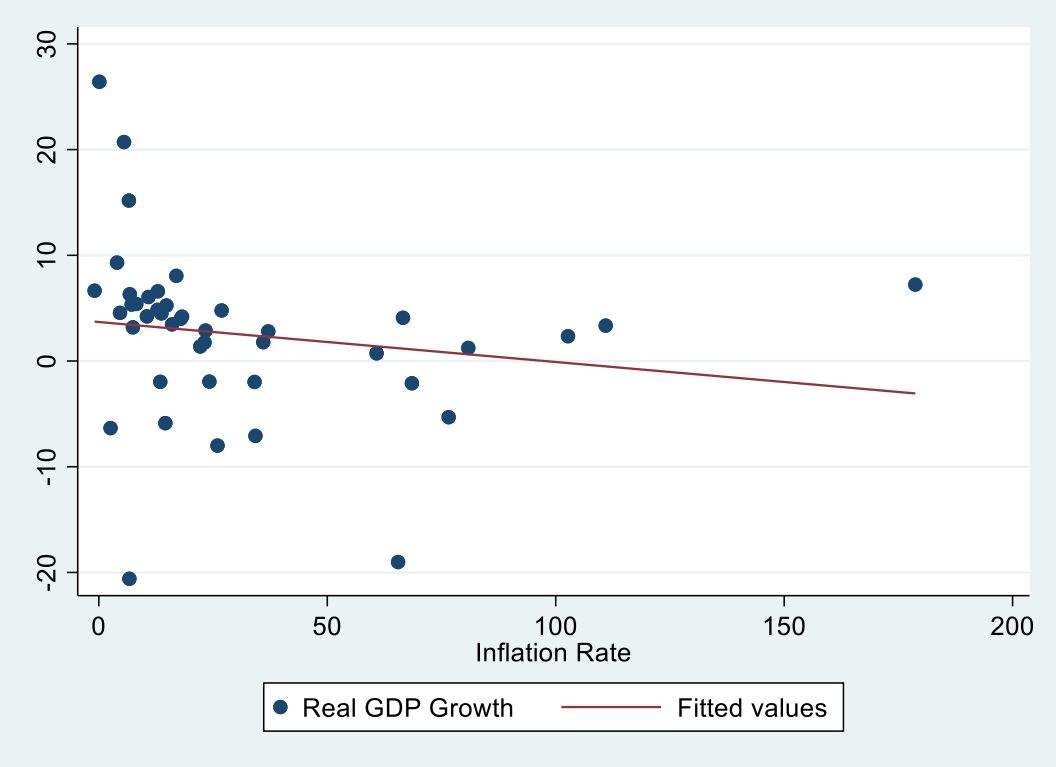
Following the end of the first decade after the war (after 2002-2012), Sierra Leone witnessed an iron ore boom. However, its contribution to growth was short-lived. In 2013, due to iron ore boom, Sierra Leone had its highest growth of real GDP since the 1980s, with the economy growing at 20.7% while inflation rate was 5.5%. This revealed a small reduction in inflation, from a low average of 8.6% during 2002-2012 and a value of 6.21% in 2012. However, this growth declined to 4.6% in 2014, while inflation rate declined from 5.5% to 4.6%. The emergence of the Ebola Virus Disease (EVD), which struck the country in the second quarter of 2014 and ran through 2015, and the fall in the price of iron ore were behind the fall in real GDP growth in 2014. Hence, while inflation declined moderately from 2013-2014, growth lost was very big. This also suggests a fall in inflation cannot necessarily bring higher growth, given the nature and size of external and domestic shocks. Commodity price shock and health crisis were the culprits. Also, while inflation rate increased moderately from 4.6% in 2014 to 6.7% in 2015, real GDP growth fell from 4.6% in 2014 to -20.6% in 2015. This was the result of the twin problems being in motion (commodity price shock and health crisis).

Considering the pre-Covid-19 period of 2016-2019 and the Covid-19 era of 2020-2021, average inflation rate increased moderately from 15.0% during the period 2016-2019, to 15.7% during the Covid-19 era of 2020-2021. However, due to supply-side disruptions created by the Covid-19 pandemic and the Russia-Ukraine war that emerged in February 2022, inflation rate in 2022 more than doubled the rate in 2020 and 2021, registering a rate of 37.09% in 2022, while real GDP growth was 2.8% in 2022. These observations imply that there is no linear relationship between inflation rate and real GDP growth in Sierra Leone. They, however, indicate that external

factors in the form of terms-of-trade shocks, health crisis and factors that disrupt supply chain are important in the nexus, which may lead to existence of a non-linear relationship or no relationship.

Figure 1 shows a scatter plot of inflation rate and real GDP growth, which shows a weak linear relationship between inflation and real GDP growth in Sierra Leone.

Figure 1: Inflation rate and real GDP growth in Sierra Leone



3. Literature review

3.1 Theoretical Literature

There are several theories on the effect of inflation on economic growth. This includes the classical model, the neoclassical view, and more recently, the endogenous growth theory. A brief discussion of the key channels of the theories is done here. The classical economists (e.g., Adam Smith, Karl Marx, David Ricardo, among others) theorize a growth model driven by supply-side factors, where supply is influenced by capital, land, and labour inputs. As a result, the growth of output is largely influenced by the growth of land, investment, and population. For instance, increased cultivation of land would lead to growth. Additionally, rise in the overall productivity necessitates growth. Particularly, Adam Smith postulated that savings lead to growth through investment creation, and that growth is self-reinforcing (referred to as increasing returns to scale). In addition, the classical economists predict that economic growth rate is determined by the income distribution, be it fast or slow and profit falls mainly as cost of inputs increases, for instance, increase in labour cost as a result of competition for labour increases profit. This underlying assumption therefore suggests a negative link between inflation and growth via higher wage cost.

The Keynesian proponents emphasize the concept of business cycle to explain the long run economic growth trajectory. The business cycle is further established within the Aggregate Supply (AS) and Aggregate Demand (AD) framework. A fundamental assumption of this framework is that the aggregate supply is upward sloping and fluctuations in the demand side of the economy influence prices and output, which can result from changes in expectations, fiscal and monetary policies and labour force. Thus, they postulated a positive link between inflation and output, to an extent that increasing prices of goods do not necessarily translate to a decline in output as the producers have to meet the consumers' demand.

The Neo-classical theorists, Swan (1956), Solow (1956), and Mundell (1963), posits a positive relationship on the inflation-growth nexus. For example, Mundell (1963) posited that a rise inflation lowers people's wealth, resulting from a reduction in the rate of return on real money balances. Thus, in order for people to accumulate wealth, they divert to financial assets so as to save more. Such a diversion increases asset prices, consequently reducing the real interest rate. Higher savings lead to higher capital accumulation which in turn speeds up output growth. The Tobin's (1965) framework also reveals a positive nexus between inflation and economic growth.

It reveals that higher inflation raises output growth albeit for short periods. Tobin's model posits that during inflationary period, people switch to and keep their interest earning assets, which leads to greater capital intensity and boosts economic growth. According to Stockman (1981), a variant of the neo-classical theory, there is a negative link between inflation and economic growth. The Stockman model posits that a rise in inflation rate leads to lower steady-state level of output as it lowers the purchasing power of money, which in turn lowers people's ability to purchase both goods and capital, leading to decreases in the steady-state level of output.

The Endogenous Growth theorists postulated that economic growth hinges on the rate of return on capital, which is negatively related to inflation. Inflation reduces growth rate through lowering the rate of return, which in turn, decreases capital accumulation. Alternative models assess the effects of inflation on capital accumulation and consequently on output. High inflation lowers the return to deposits, leading to slower rate of deposits accumulations. Given that capital is a constituent of deposits, fall in deposit rates reduces capital accumulation and consequently output growth reduces.

3.2 Empirical Literature

In this paper, we review several empirical studies to ascertain the nexus between inflation and economic growth. We found out four strands of literature covering the relationship between inflation and economic growth so far.

The first strand of the literature reveals an inconclusive result on the connection between inflation and economic growth. For example, Wai (1959) investigated the link between inflation and economic growth for thirty-one (31) countries and found no conclusive result for the less developed countries generally; but for some individual countries with considerable data, the growth rate was observed to be higher in times of lower inflation. Bhatia (1960) studied the long-run relationship between inflation and economic growth in five (5) developed nations – Japan, United Kingdom, Sweden, Germany, and Canada. He found that the relationship varied across the countries - Germany and Japan recorded a negative relationship between inflation and economic growth, while Canada and Sweden recorded a positive relationship between inflation and economic growth. However, based on the low correlation coefficients obtained from the study, coupled with some data shortages, the author emphasized that no sufficient conclusion on the connection between inflation rate and economic growth can be drawn. Dorrance (1966) studied

the link between inflation and economic growth in forty-eight (48) countries in the world and found no conclusive result based on the given data, even though low inflation rate appears to lead to low growth rates. This was because, other key determinants of the rate of progress like natural resources, education, population pressures, etc., were not included in the study. Malla (1997) investigated the connection between inflation and economic growth using a sample of countries drawn across Asia and the OECD regions. By disaggregating the countries and controlling for inputs of capital and labour, a statistically significant inverse link between inflation and economic growth was found for the OECD nations, while inflation was found to have no statistically significant connection with economic growth for the Asian nations. These findings thus suggest an inconclusive nexus between inflation and economic growth for regressions involving different regions and time periods.

The second strand of the literature reported an inverse relationship between inflation and economic growth. Fischer (1993) applied cross-sectional and panel data regressions to evaluate the effect of inflation on economic growth and found that inflation has adverse effects on economic growth. In investigating the relationship between inflation and real output in Brazil using Bi-variate Auto regression, Faria and Carneiro (2001) found that inflation has no impact on real output in the long run, however, it adversely affects real output in the short run, consistent with the phenomenon of neutrality of money, which postulates that in the long run, inflation does not significantly affect output and productivity. Dewan and Hussein (2001) utilized 41 middle income developing nations to build an empirical growth model and found that inflation is adversely related to growth. In investigating the effect of inflation on economic growth in Tanzania, Shitundu and Luvanda (2000) employed the Least Trimmed Squares (LTS) technique, which identifies outliers in regression and leads to a robust regression. Their findings revealed that inflation is inimical to economic growth. Gokal and Hanif (2004) used correlation matrix and Granger Causality tests to investigate the relationship between inflation and economic growth in Fiji. They found a weak negative correlation between the two variables. However, a unidirectional causality between the variables, running from economic growth to inflation was found.

Ahmed and Mortaza (2005) employed the cointegration and error correction techniques to investigate the effect of inflation on economic growth in Bangladesh for the period 1980 to 2005 and found a statistically significant negative effect of inflation on economic growth in the long

run. Saaed (2007) utilized the cointegration and error correction model to study the connection between inflation and economic growth from 1985 to 2005 in the case of Kuwait. The result confirmed a statistically significant adverse effect of inflation on economic growth in Kuwait. Tan (2008) employed the Philips curve framework to investigate the relationship between inflation and economic growth in the Association of South-East Asian Nations. The countries in the sample were: Singapore, the Philipines, South Korea, Indonesia, Japan, Thailand, and Malaysia. The study used quarterly data covering the period 1991 to 2007. The result confirmed a statistically significant negative effect of inflation on economic growth in the post 1997/98 Asian Financial Crisis period in South Korea, Thailand, and Singapore, but no statistically significant effect was found in the other nations. Erbaykal and Okuyan (2008) used the Bound Test cointegration and Toda Yamamoto techniques to study the link between inflation and economic growth in Turkey using the data coverage 1987:1 – 2006:2. They found that there exists no statistically significant connection between inflation and economic growth in the long run, whereas a statistically significant inverse relationship was found between the two variables. Furthermore, the results revealed that there is causality running from inflation to economic growth, whereas no causality exists from economic growth to inflation.

The third strand of the literature suggests a positive nexus between inflation and economic growth. Mallik and Chowdhury (2001) employed the cointegration and error correction mechanism techniques to investigate the short-run and long-run effects of inflation on economic growth in four Asian nations – India, Pakistan, Sri Lanka, and Bangladesh. They found a statistically significant positive effect of inflation on economic growth in all the four countries. Hussain and Malik (2011) used Error Correction Model and Granger Causality test to investigate the effect of inflation on economic growth in Pakistan using annual data coverage 1960 to 2006 and found a positive effect of inflation on economic growth, and a uni-directional causality running from inflation to economic growth was found.

The final strand of literature suggests a non-linear relationship between inflation and economic growth. Fischer (1993) was one of the first proponents of a non-linear relationship between inflation and economic growth. Fisher (1993) found that below an inflation threshold, the economy grows favorably, and beyond it, inflation negatively affects economic growth. Ghosh and Phillips (1998) studied the relationship between inflation and economic growth in IMF member countries

within the period 1960-96. They found that growth is positively related to inflation at low inflation rates (2-3 percent annually) and beyond this threshold, inflation is inversely related with growth. This result implies that within the lower inflation region, efforts to further reduce inflation rate would lead to a decline in growth. Fabayo and Ajilore (2006) studied the threshold effects in inflation-growth nexus in Nigeria, utilizing annual data for 1970-2003. They found that below an inflation rate of 6% inflation threshold, inflation positively affects economic growth, and above it, inflation negatively affects economic growth.

Salami and Kelikume (2010) used the non-linear inflation-growth model to investigate the inflation thresholds in Nigeria utilizing annual data spanning two periods 1970-2008 and 1980-2008. The study controlled for terms of trade growth and broad money to GDP ratio. They found an inflation threshold of 8% for Nigeria for the period 1970-2008, below which the effect on growth is positive and above which the effect is negative. López-Villavicencio and Mignon (2011) used the panel smooth transition (PSTR) and dynamic Generalized Method of Moment (GMM) techniques to study the relationship between inflation and economic growth for forty-four (44) countries, including emerging and industrialized economies. The results revealed a non-linear relationship between inflation and economic growth. Particularly, a threshold of 15% was found below which economic growth takes place and above it inflation negatively affects economic growth. Kremer et al. (2013) studied the impact of inflation on economic growth for 124 countries using a dynamic panel threshold technique covering the period 1950 to 2004. They found that the inflation thresholds for the industrialized and developing countries were 2% and 17% respectively. Beyond these thresholds, inflation undermines growth, while below the threshold for developing countries, inflation was found to have no growth-enhancing impacts. Nell (2000) used Vector Auto Regressive (VAR) method to study the link between inflation and economic growth in South Africa within the period 1960-1999. The study result reveals that growth is enhanced in single-digit zone but slows down within the double-digit zone.

Sweidan (2004) investigated the potential existence of structural breakpoint effect in Jordan within the period 1970-2003. The result revealed the existence of structural breakpoint at 2%, below which inflation positively impact growth, and exceeding it, inflation adversely affect economic growth. Khan and Senhadji (2001) employed the Non-Linear Least Squares (NLLS) and Conditional Least Squares technique to study inflation threshold effects on economic growth for

140 countries, including industrial and developing nations. The results revealed two inflation threshold levels, 1-3 percent for developed countries and 11-12 percent in developing countries. Beyond these threshold levels, inflation negatively affect growth. Mubarik (2005) used the Granger Causality test and Sensitivity Analysis to examine the threshold effect of inflation on economic growth in Pakistan using annual data for the period 1973 and 2000. The study found that the inflation threshold level is 9 percent, below which inflation favourable impacts economic growth, and beyond it, inflation is inimical to economic growth. Munir et al. (2009) employed the new endogenous threshold autoregressive (TAR) models to investigate the non-linear nexus between inflation and economic growth in Malaysia, utilizing annual data for the period 1970-2005. The study revealed that below inflation of 3.9%, inflation positively affects economic growth, and below it, inflation negatively affects economic growth.

In Sierra Leone, we are not aware of studies on this important issue. However, according to regional studies on the West African Monetary Zone, Tarawalie et al. (2012) used annual data for Sierra Leone from 1970 to 2010 using the exogenous threshold approach with one threshold assumed and found a threshold inflation rate of 9% beyond which inflation adversely affects economic growth in Sierra Leone. We adopt an endogenous threshold framework, where the threshold is chosen within the historical series of inflation and test for the number of thresholds, as there could be more than one threshold in the relationship.

4. Methodology

4.1 Model Specification

A model of growth is estimated in order to investigate the effect of inflation on economic growth. In light of this, we specify a model of real GDP growth based on the Neo-classical growth model which emphasizes the role of capital accumulation in growth and accounts for the effect of inflation and terms of trade (as an external shock) on economic growth in Sierra Leone. Terms of trade is used because Sierra Leone is a net importer. In addition, it does not influence the price of its exports, which are dominated by primary products. In addition, both energy and food account for a large proportion of its imports and they are necessary goods in Sierra Leone. Thus, unfavorable changes in their prices at the international market can have growth repercussions as domestic production can be affected.

Thus, in linear form, the real GDP growth model estimated is given as in equation (1).

$$RGDPg_t = \alpha_0 + \alpha_1 INF_t + \alpha_2 INVg_t + \alpha_3 TOT_t + \varepsilon_t \quad (1)$$

$$\alpha_1 < 0, \alpha_{2,}\alpha_3 > 0$$

Where RGDPg is real GDP growth, INF is inflation rate, INVg is investment and TOT is terms of trade and ε is the error term. Equation (1) can be augmented to incorporate a number of variables, including for example the real exchange rate to determine how the allocation of resources between tradable goods and non-tradable goods affect growth or a measure of financial debt to capture the effect of the financial system on economic growth. However, as our focus is on the estimation of threshold effect of inflation on growth, we keep the number of explanatory variables simple as the threshold regression involves trimming the data at selected thresholds which involves great loss of degrees of freedom when there are large number of variables.

In linear form, as in equation (1), investment is expected to have a positive effect on growth as it measures capital. Also, terms of trade are expected to have a positive effect on real GDP growth because when price of imports increases relative to price of exports, the resulting decline in terms of trade reduces imports. Some of the imports may be intermediate goods that act as inputs into domestic production which therefore hinders growth. For inflation, if the relationship is strictly linear as in equation (1), increase in inflation is interpreted as increase in macroeconomic uncertainty and the uncertainty reduces the efficiency of investment, which retards growth. The

motivation for exploring a non-linear impact of inflation is that the strength and effect of the negative effect of inflation may actually depend on the history of inflation or the level of inflation. The result has important implication for monetary policy authorities as low and stable inflation remains a core mandate of central banks and they also care for growth, where the latter objective does not have the same weight as the former in the objective function of monetary authorities. This is the case also for the Bank of Sierra Leone.

4.2 Estimation Technique

Consider a two-regime structural model in the form of the threshold autoregression model with only inflation as the regressor, as in equations (2) to (3)

$$RGDPG_t = \gamma_1 INF_t + \mu_{1t} \qquad if\ z_t \leq \theta, \tag{2}$$

$$RGDPG_t = \gamma_2 INF_t + \mu_{2t} \qquad if\ z_t > \theta, \tag{3}$$

Where z_t is the threshold variable, $RGDPG_t$ and INF_t are vectors of dependent and independent variables respectively, while θ is the threshold parameter. $\mu_{1t}\ and\ \mu_{2t}$ are white-noise terms which are assumed to be identically and independently distributed with zero mean and constant variance.

In equations (2) and (3), if θ is unknown, we estimate the model using OLS. Given that the threshold is unknown, we estimate the model with other parameters. If this threshold variable is less than the threshold parameter, we estimate equation (2). However, when the threshold variable is greater than the threshold parameter, we estimate equation (3).

Now, let us define a binary variable as $\Delta_t(\theta)=(z_t \leq \theta)$, where $(z_t \leq \theta)$ is an indicative function with the following notations:

$\Delta(t) = 1$ if $z_t \leq \theta$

$\Delta(t) = 0$ if $z_t > \theta$

Setting $INF_t(\theta) = INF_t\Delta_t(\theta)$, implies equations (2) and (3) are compressed as a single model.

$$RGDPG_t = \gamma' INF_t + \varphi' INF_t(\theta) + \varepsilon_t \tag{4}$$

Where $\gamma = \gamma_2, \varphi = \gamma_1 - \gamma_2$. $\gamma, \varphi \; and \; \theta$ in equation (4) are the regression parameters to be estimated. Accordingly, the residual sum of squares (RSS) derived from estimating the parameters of the model is denoted by equation (5) as.

$$RSS_1(\theta) = \hat{e}\,(\theta)'\hat{e}\,(\theta) \tag{5}$$

We then use the OLS technique to estimate θ by minimizing the sum of squared residuals as a function of the estimated threshold value (Hansen, 2000). This threshold value is given as.

$$\hat{\theta}=\text{argmin } RSS_1(\theta) \tag{6}$$

Depending on the value of $\hat{\theta}$, the regression model is linear in $\gamma \; and \; \varphi'$, which gives rise to the conditional OLS value of $\hat{\gamma}\;(\theta) \; and \; \hat{\varphi}\;(\theta)$ when we regress the dependent variable on the explanatory variables. On the basis of the foregoing, equation (1) can now be converted to a non-linear model under a two-regime threshold autoregressive model as.

$$RGDPG_t = (\alpha_{10} + \alpha_{11}INF_t + \alpha_{12}INVG_t + \alpha_{13}TOT_t)\Delta[z_t \leq \theta] + (\alpha_{20} + \alpha_{21}INF_t + \alpha_{22}INVG_t + \alpha_{23}TOT_t)\Delta[z_t > \theta] + \epsilon_t^* \tag{7}$$

Minimizing the residual sum of squares (RSS) of equation (7) yields the optimal threshold value. To ascertain the existence of a threshold, we examine equation (7). Hence, the null hypothesis of the absence of threshold effect is tested against the alternative hypothesis of the presence of threshold effect as.

$$H_0: \alpha_{11} = \alpha_{12} = \alpha_{13} = 0$$

$$H_0: \alpha_{11} \neq \alpha_{12} \neq \alpha_{13} \neq 0$$

We then compute a standard heteroscedasticity-consistent LM bootstrap method to get the asymptotic critical and probability values, since the threshold parameter θ will be unidentified if we use the traditional approach to hypothesis testing (Hansen, 1996). In this regard, a test that contains linear optimal power against alternative distant from the null hypothesis is computed. This test is the standard F-statistics denoted by.

$$F_{stat} = \frac{RSS_0 - RSS_1\,(\widehat{\theta})}{\rho^2} \tag{8}$$

Where RSS_0 and RSS_1represent residual sum of squares under the null and alternative hypotheses respectively. The residual variance in this case is denoted $\hat{\rho}^2$ and is computed as $\frac{1}{T}=\epsilon_t^*\epsilon_t^*=\frac{1}{T}RSS_1(\widehat{\theta})$.

We now ascertain whether the estimated threshold effect is statistically significant. Under this circumstance, we assume the estimated threshold is consistent and that its asymptotic distribution is highly non-standard so that the likelihood ratio statistic for this test (θ) form a confidence interval for θ. Hence, the null hypothesis of the threshold value to be to tested is given as$H_0: \theta = \theta_0$, while the likelihood ratio test statistic is denoted as:

$$LR_1(\theta) = \frac{RSS_1(\theta) - RSS_1(\widehat{\theta})}{\rho^{*2}} \quad (9)$$

Where $RSS_1(\theta)$ and $RSS_1(\widehat{\theta})$ are the residual sum of squares true and estimated threshold value respectively.

4.3 Data Type and Sources

The study employed annual data from 1980 to 2020 on inflation rate, terms of trade, investment and real GDP growth. The dataset was obtained from the International Financial Statistics, World Development Indicators and the Bank of Sierra Leone database. Inflation is measured as the percentage change in the consumer price index. Real GDP growth is measured as percentage change in gross domestic product at constant prices while investment is measured as gross fixed capital formation at constant prices.

5. Empirical Results

5.1 Descriptive Statistics for Model Variables

Table 2 shows descriptive statistics of model variables. The Table shows that mean terms of trade was 52.54, mean investment as share of GDP was 12.00%, mean real GDP growth was 2.48% and mean inflation was 36.90% during the period 1980 to 2020.

Table 1: Descriptive Statistics of Model Variables

Variable	Observation	Mean	Std. Dev.	Minimum	Maximum
Terms of Trade	41	52.540	25.770	15.625	100
Investment as Share of GDP	41	12.000	7.528	-2.424	41.538
Real GDP Growth	41	2.479	8.329	-20.599	26.417
Inflation	41	31.101	36.900	-0.918	178.70

Source: Authors' estimation

5.2 Test for Variable Stationarity

Table 3 presents summary of the conclusion from the various unit root tests while Appendix 1 shows the various unit root test results. The variables were tested for stationarity because the application of OLS with nonstationary variables leads to spurious regression. The Dickey-Fuller GLS unit root test was applied as it has better size and power over the original Dickey-Fuller tests and other first generation tests. The (Perron and Vogelsang (PV) 1998) unit root test for single structural break (immediate and gradual breaks) and the (Clemente-Montanes-Reyes (CMR) 1998) unit root tests for double structural breaks (immediate and gradual breaks) were applied. The use of these structural break tests is to account for the fact that when a series has structural break(s), the Dickey-Fuller GLS tends to fail to reject the null hypothesis that there is unit root (the variable is nonstationary) even when the variable is stationary. The use of the CMR in conjunction with the PV is to account for the fact that when there is a double break, the PV tends to fail to reject the null hypothesis that there is unit root because it accounts for only one structural break in the data while the CMR accounts for double breaks. The combined test results show that all the variables are stationary.

Table 3: Unit Root Results

Variable	DF-GLS	PV	CMR	Conclusion
Terms of Trade	I(K)	I(0)	I(K)	I(0)
Investment as Share of GDP	I(1)	I(0)	I(K)	I(0)
Real GDP Growth	I(0)	I(0)	I(K)	I(0)
Inflation Rate	I(0)	I(K)	I(K)	I(0)

1. **Note: 1. I (K) means series is not stationary after second differencing. 2. DF_GLS means Dickey-Fuller GLS; PV means Perron-Vogelsang and CMR means Clemente-Montanes-Reyes.**

Table 3 shows the inflation-growth threshold regression model result for Sierra Leone. The result shows that testing the existence of 0, 1, or 2 thresholds (using the Bayesian Information Criterion (BIC) reveals two thresholds. These are inflation rate of 6.8% and inflation rate of 18.2%.

Table 4: The Non-Linear Growth-Inflation Model for Sierra Leone

VARIABLES	(All Regions)	(Region1) **inf <6.8**	(Region2) **6.79<inf<18.2**	(Region3) **inf>18.2**
Investment_Lag1	0.765***			
	(0.000)			
Investment_Lag2	0.414**			
	(0.015)			
Terms-of-Trade	0.174**			
	(0.031)			
Terms-of-Trade_Lag2	0.164**			
	(0.026)			
Inflation Rate		-3.237***	-0.543**	0.0512
		(0.000)	(0.013)	(0.148)
Constant	-25.80***			
	(0.000)			
Observations	39			

P-values in parentheses
*** p<0.01, ** p<0.05

Note: inf=inflation rate

Source: Authors' estimation

The result of the threshold model shows that at an inflation rate that is less than 6.8%, inflation has a negative effect on growth. That is, when inflation rate is less 6.8%, reducing it comes with increased growth while an increase in the inflation rate comes with reduced growth.

This threshold effect is significant at 1% level. Moreover, a one percentage point reduction in inflation rate increases growth by 3.2 percentage points.

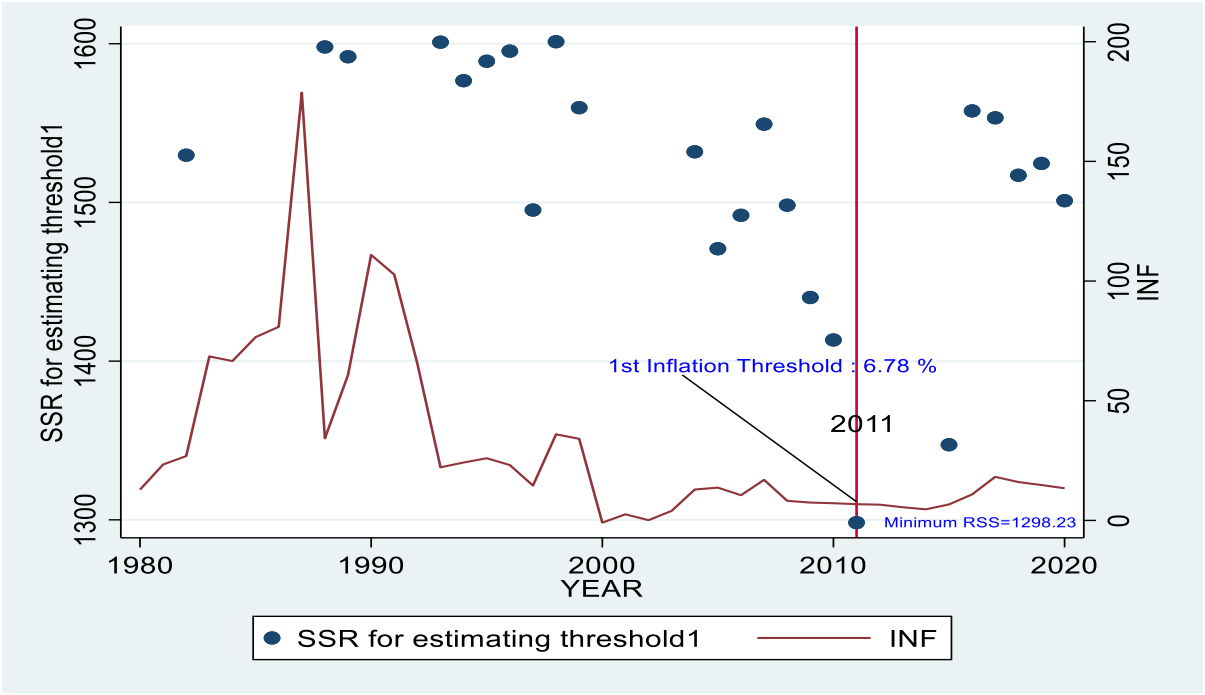
The model results show that for the second region of the threshold effect, inflation also has a negative effect on growth of real GDP and the inflation rate is significant at the 5% level of significance. However, the growth benefit of reducing inflation when inflation is between 6.8% and 18.2% is lower than when the inflation rate is lower than 6.8%. Real GDP growth increases by 0.54 percentage point when inflation reduces by 1 percentage point when inflation rate is more than 6.8% and less than 18.2%.

In the third range of the two threshold, where inflation rate is more than 18.2%, inflation does not have a significant effect on growth even though the effect is positive. The results of the effect of inflation on growth therefore suggest that policymakers keep inflation rate in Sierra Leone below 18.2% when actual inflation is above 6.8% because in this range, a one percentage point reduction in inflation rate increases growth by 0.54 percentage point and when it increases by 1 percentage point, the growth loss is 0.54% compared to a loss of 3.24% when actual inflation is less than 6.8%.

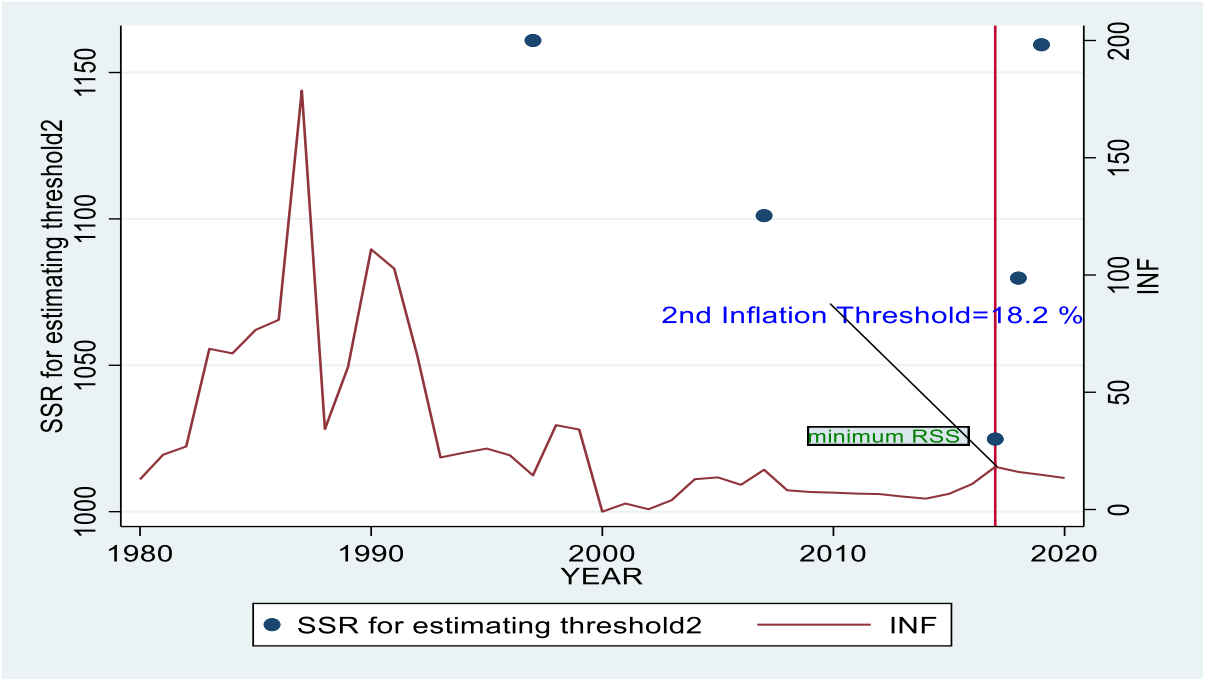
Other results of the model are the effects of investment and terms of trade on growth. The model result shows that both the first and second lags of investment have significant positive effects on growth, suggesting the importance of capital for growth. Terms of trade also has a significant positive effect on growth, though the first lag is not significant. Thus, it was dropped in the modelling process to save the degrees of freedom and allow for model parsimony. This is the case also for contemporaneous investment. In the modelling process, replacing the current or second lag of terms of trade (tot) with the first lag led to lower Bayesian Information Criterion (BIC). Also, the replacement of the first lag and second lag of investment with current investment led to a linear BIC. Hence, both current investment and first lag of terms of trade were not maintained in the model. Figure 2 shows the sum of squared residuals of the competing models that led to the determination of the optimal inflation rates, with 20 % trimming percentage to ensure model estimation. Given the specification, the endogenous (in sample) assumed optimal inflation rate that minimizes the sum of squared residuals is the preferred model.

Figure 2: The Sum of Squared residuals of the competing models and the Thresholds

Panel A: First Inflation Threshold and the Sum of Squared Residuals (SSR)



Panel B: Second Inflation Threshold and the Sum of Squared Residuals (SSR)



Note: INF = Inflation Rate and RSS= Residual Sum of Squares

Source: Authors' estimation

6. Conclusion

Price stability is the core objective of monetary policy in central banks. While some central banks have dual mandate of price stability and growth (or employment), those that have price stability as the objective of monetary policy also care for growth, though price stability is put at the forefront when price stability and growth are in conflict. Inflation has recently been a challenge to monetary policy implementation in Sierra Leone while economic growth has also been slow. Recent weak world and Sub-Sahara African growth performance has been widely considered by policymakers and researchers to be driven by the supply side disruptions linked to Covid-19 pandemic and the Russia-Ukraine war. The same reason is at the forefront for recent hikes in inflation rates.

It has been argued theoretically that inflation deters growth and there is huge empirical literature supporting this. However, there is also theoretical literature supporting that some level of inflation is useful for growth. Thus, the effect of inflation on growth has also been considered to be non-linear. Given the joint interest of the Bank of Sierra Leone in price stability and growth, while price stability is explicit in the Bank of Sierra Leone Act 2019, the objective of the paper was to investigate the optimal inflation rate for Sierra Leone. Annual data from 1980 to 2020 was used to estimate a model of growth using endogenous threshold regression that tested for the optimal number of thresholds and estimated the threshold values. This was preceded by testing the model variables for stationarity using the ADF-GLS test and tests that accommodate the existence of structural break in a series, the Perron-Vogelsang test, which accounts for one structural break and the Clement-Montannes-Reyes test, which accounts for two structural breaks.

The results show that there are two inflation thresholds for Sierra Leone, which are 6.8% and 18.2%. At inflation rate below 6.8%, the effect of inflation on growth is negative and significant, and at inflation rate between 6.8% and 18.2%, the effect is also negative and significant. However, above 18.2%, the effect is not significant, though positive. Moreover, the negative effect of inflation on growth is stronger in magnitude at rate below 6.8% than at rate between 6.8% and 18.2%. Thus, when inflation is below 6.8%, the growth lost when inflation increases further is higher than when inflation increases during periods when it is between 6.8% and 18.2%. Also, when inflation is above 18.2%, reduction of inflation to a rate

higher than 18.2% brings no growth gain. The result therefore implies for policy that having inflation between 6.8% and 18.2% is optimal for Sierra Leone.

References

Ahmed, S., & Mortaza, G. (2005). Inflation and Economic Growth in Bangladesh: 1981-2005, Bangladesh Bank Working Paper Series, WP 0604.

Azam, M., & Khan, S. (2020). Threshold effects in the relationship between inflation and economic growth: Further empirical evidence from the developed and developing world. *International Journal of Finance & Economics*, *27*(4), 4224-4243.

Barro, R. J. (1991). Economic growth in a cross section of countries. *The quarterly journal of economics*, *106*(2), 407-443.

Bhatia, R. J. (1960). Inflation, deflation, and economic development. *Staff Papers (International Monetary Fund)*, *8*(1), 101-114.

Dewan, E., & Hussein, S. (2001). Determinants of economic growth (Panel data approach*)*. Suva Fiji: Economics Department, Reserve Bank of Fiji.

Dorrance, G. (1966). Inflation and Economic Growth: The Statistical Evidence. *IMF Staff Papers Vol*, *13*.

Erbaykal, E., & Okuyan, H. A. (2008). Does inflation depress economic growth? Evidence from Turkey. *International Journal of Finance End Economics*, *13*(17).

Fabayo, J. A., & Ajilore, O. T. (2006). Inflation: How much is too much for economic growth in Nigeria. *Indian Economic Review*, 129-147.

Faria, J. R., & Carneiro, F. G. (2001). Does high inflation affect growth in the long and short run? *Journal of applied economics*, *4*(1), 89-105.

Fischer, S. (1993). The role of macroeconomic factors in growth. *Journal of monetary economics*, *32*(3), 485-512.

Ghosh, A., & Phillips, S. (1998). Warning: Inflation may be harmful to your growth. *Staff Papers*, *45*(4), 672-710.

Gokal, V., & Hanif, S. (2004). Relationship between inflation and economic growth (Vol. 4). Suva: Economics Department, Reserve Bank of Fiji.

Hussain, S., & Malik, S. (2011). Inflation and economic growth: Evidence from Pakistan. *International Journal of Economics and Finance*, *3*(5), 262-276.

Khan, M. S., & Senhadji, A. S. (2001). Threshold effects in the relationship between inflation

and growth. *IMF Staff papers*, *48*(1), 1-21.

Kremer, S., Bick, A., & Nautz, D. (2013). Inflation and growth: new evidence from a dynamic panel threshold analysis. *Empirical Economics*, *44*, 861-878.

López-Villavicencio, A., & Mignon, V. (2011). On the impact of inflation on output growth: Does the level of inflation matter? *Journal of macroeconomics*, *33*(3), 455-464.

Malla, S. (1997). Inflation and economic growth: Evidence from a growth equation. *Department of Economics, University of Hawaiâ™ I at Monoa, Honoulu, USA*.

Mallik, G., & Chowdhury, A. (2001). Inflation and economic growth: evidence from four south Asian countries. *Asia-Pacific development journal*, *8*(1), 123-135.

Mubarik, Y. A., & Riazuddin, R. (2005). Inflation and growth: An estimate of the threshold level of inflation in Pakistan. Karachi: State Bank of Pakistan.

Mundell, R. A. (1963). Growth, stability, and inflationary finance. *Journal of Political Economy*, *73*(2), 97-109.

Munir, Q., Mansur, K., & Furuoka, F. (2009). Inflation and economic growth in Malaysia: A threshold regression approach. *ASEAN Economic Bulletin*, 180-193.

Nell, K. S. (2000). Is low inflation and precondition for faster growth? The case of South Africa (No. 00, 11). Department of Economics Discussion Paper.

Saaed, A. A. (2007). Inflation and economic growth in Kuwait: 1985-2005-Evidence from co-integration and error correction model. *Applied Econometrics and International Development*, *7*(1).

Salami, D., & Kelikume, I. (2010). An estimation of inflation threshold for Nigeria (1970-2008). *International review of Business Research papers*, *6*(5), 375-385.

Shitundu, J. L., & Luvanda, E. G. (2000). The effect of inflation on economic growth in Tanzania. *African Journal of Finance and Management*, *9*(1), 70-77.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The quarterly journal of economics*, *70*(1), 65-94.

Stockman, A. C. (1981). Anticipated inflation and the capital stock in a cash in-advance economy. *Journal of monetary economics*, *8*(3), 387-393.

Swan, T. W. (1956). Economic growth and capital accumulation. *Economic record*, *32*(2), 334-361.

Sweidan, O. D. (2004). Does inflation harm economic growth in Jordan? An econometric analysis for the period 1970-2000. *International Journal of Applied Econometrics and Quantitative Studies*, *1*(2), 41-66.

Tan, E. C. (2008). Inflation and economic growth in ASEAN-5, *Japan and South Korea*.

Tobin, J. (1965). Money and economic growth. *Econometrica: Journal of the Econometric Society*, 671-684.

Tarawalie et al. (2012). Inflation and Growth in the WAMZ: Evidence from a Threshold Analysis. West African Monetary Zone Occasional Paper Series No. 1.

Wai, U. T. (1959). The relation between inflation and economic development: a statistical inductive study. *Staff Papers (International Monetary Fund)*, *7*(2), 302-317.

Appendix 1

Table 4: Dickey-Fuller Generalized Least Squares Unit Root Test Results

Variable		Deterministic Component	Lag	Test Statistics	Conclusion
Inflation Rate	L	Constant	2	-3.561	I (0)
Investment	L	Constant	1	-2.918	I (1)
	1D	Constant	1	-4.835	
Terms of Trade	L	Constant	2	-1.626	I (K)
	1D	Constant	1	-3.265	
	2D	Constant	1	-6.372	
Real GDP-Growth	L	Constant	1	-3.594	I (0)
Critical Values					
Constant			**Constant and Trend**		
1%:	-2.634		**1%:**	-3.770	
5%:	-2.384		**5%:**	-3.314	

Table 5: Perron-Vogelsang Single Break Unit Root Test Results

Additive Outlier (Immediate Break)					Innovative Outlier (Gradual Break)			
Variable		**Break Point**	**P-Value**	**Test Statistics**	**Break Point**	**P-Value**	**Test Statistics**	**Conclusion**
Inflation Rate	L	1993	0.000	-3.251	1990	-	-3.140	I (K)
	1D	1985	0.362	-2.794	1986	-	-3.242	
	2D	1986	0.968	-6.238	1987	-	-6.877	
Investment	L	2007	0.000	-3.625	2008	0.002	-4.792	I (0)
Terms of Trade	L	1995	0.000	-2.223	1996	0.007	-4.754	I (0)
Real GDP Growth	L	1999	0.081	-1.188	2000	0.001	-5.637	I (0)
5% Critical Values								
Additive Outlier:				**-3.560**	**Innovative Outlier:**			**-4.270**

Note: 1. L=Level, 1D=1st Difference and 2D=2nd Difference; 2. I (K)=Series not Stationary after 2nd Difference

Table 6: Clemente-Montanes-Reyes Double Breaks Unit Root Test Results

Panel A: Additive Outlier (Immediate Break) Results							
	First Break			Second Break			
Variable		**Breakpoint**	**P-Value**	**Breakpoint**	**P-Value**	**Test-Statistics**	**Conclusion**
Inflation Rate	L	1985	0.000	1992	0.000	-0.629	I (K)
	1D	1985	0.327	1994	0.677	-3.239	
	2D	1986	0.739	1990	0.664	-1.144	
Investment	L	1997	0.531	2007	0.001	-3.465	I (K)
	1D	1995	0.717	2008	0.935	-5.285	
	2D	2008	0.652	2013	0.561	-5.031	
Terms of Trade	L	1995	0.000	2008	0.002	-5.094	I (K)
	1D	1995	0.021	1998	0.009	-5.163	
	2D	1996	0.443	1999	0.475	-8.580	
Real GDP Growth	L	1999	0.016	2011	0.468	-3.428	I (K)
	1D	1990	0.839	2013	0.432	-9.354	
	2D	1990	0.962	2013	0.827	-6.317	
Additive Outlier 5% Critical Value:						**-5.490**	

Note: 1. L=Level, 1D=1st Difference and 2D=2nd Difference; 2. I (K)=Series not Stationary after 2nd Difference

Table 7: Clemente-Montanes-Reyes Double Breaks Unit Root Test Results

Panel B: Innovative Outlier (Gradual Break) Results							
	First Break			Second Break			
Variable		**Breakpoint**	**P-Value**	**Breakpoint**	**P-Value**	**Test-Statistics**	**Conclusion**
Inflation Rate	L	1986	-	1991	-	-3.140	I (K)
	1D	1986	-	1992	-	-2.183	
	2D	1985	-	1987	-	-6.877	
Investment	L	2008	0.000	2013	0.001	-6.477	I (0)
Terms of Trade	L	1996	0.000	2005	0.000	-3.509	I (K)
	1D	1987	0.407	1997	0.864	-11.431	
	2D	1989	0.402	1999	0.039	-8.721	
Real GDP Growth	L	2000	0.000	2012	0.002	-5.726	I (0)
Innovative Outlier 5% Critical Value:						**-5.490**	

Note: 1. L=Level, 1D=1st Difference and 2D=2nd Difference; 2. I (K)=Series not Stationary after 2nd Difference