Inflation and Economic Growth in Zambia: A Threshold Autoregressive (TAR) Econometric Approach

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9 December 2013

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ABSTRACT: This study examines threshold effects of inflation on economic growth for the Zambian economy using quarterly data collected between 1998 and 2011. This objective is tackled through the use of a threshold autoregressive (TAR) model and the conditional least squares (CLS) estimation technique. As a by-product of utilizing this estimation technique, the paper is able to identify whether there could be an optimal inflation level at which the adverse effects of inflation on economic growth are subdued, or similarly, a level of inflation at which the positive effects of inflation on economic growth are maximized. In this respect, the paper estimates an inflation threshold level of 22.5% for the observed data. These results indicate that economic growth in Zambia can be stimulated even in a moderately high inflation environment. Particularly, the causality analysis identifies the credit sector and exchange rate developments as being crucial channels towards ensuring enhanced economic performance in the Zambian economy.

Keywords: Inflation, Economic Growth, Granger causality, TAR Models, Zambia.

JEL Classification Code: C22, E31.

1 INTRODUCTION

The study of inflation is essential for any economy whose monetary policy objectives are dependent on price stability. In Zambia, monetary authorities have been granted the exclusive responsibility of sustaining a low and stable inflation which has been reinforced in the constitution act of 1996 (Act No. 43). Deriving from this statutory mandate, the macroeconomic objectives set out for the Bank of Zambia are formally linked to the achievement of 'price stability'. The implementation of price stability-focused macroeconomic objectives is based on the popular presumption that low levels of inflation should instantaneously result in an economic environment that is conducive for the attainment of increased economic policy effectiveness and efficiency. Through the establishment of a low inflation environment, it is inexplicitly assumed that the Bank of Zambia can acquire better control and alignment of stabilization policies even in the presence of macroeconomic shocks. Henceforth, price stability is not deemed as being isolated in itself, as this policy objective stems from the consideration that the Bank of Zambia can best contribute to maximizing social welfare and promoting economic growth through the practical achievement of price stability (Juhasz, 2008). The concept of price stability indirectly prioritizes the Bank of Zambia's central role in ensuring that inflation is attained and maintained within a certain mean or targeted steady-state equilibrium level. Ideally, this equilibrium inflation level is supposed to be on par with an inflation target set by the Bank of Zambia. This article is primarily motivated by the lack of empirical evidence which defines the most efficient inflation rate at which the Bank of Zambia should maintain inflation at.

Generally, the available literature tends to, more often than not, support the intuition that inflation is detrimental to economic growth and that price stability, defined as a low and stable inflation rate, is at least an important condition for the attainment of higher economic growth. Examples of the adverse costs of inflation on economic growth are not difficult to find in the academic literature. For instance, high inflation can interfere with the price signaling mechanism, resulting in a misallocation of resources (Hodge, 2006). Inflation can reduce a country's international competitiveness by making exports expensive, hence impacting the balance of payments (Gokal and Hanif, 2004). Moreover, inflation can interact with the tax system to distort borrowing and lending decisions within the economy (Papapetrou, 2001). Despite a number of shortcomings associated with the empirical revelations, studies frequently provide support for a negative relationship between inflation and growth, which is consistent with predictions of the theoretical literature. Taking the above mentioned into consideration, it can be deduced that low inflation is considered a necessary condition for the attainment of increased economic growth and thus policymakers should direct their efforts at creating a low inflation environment. This statement in itself gives rise to a critical question; how low should policymakers keep inflation at within a particular economy? Ideally, policymakers would opt to choose the inflation rate that maximizes output growth gains, or similarly, minimizes output growth losses. In this regard the breakpoint or inflation threshold established for the data can be thought of as the optimal level of inflation, at which monetary policy should strive to keep inflation at, in order to attain the maximal possible economic growth (Mubarik, 2005).

Determining threshold effects in the inflation-growth correlation can be useful for policy analysis. They suggest that if monetary policy within an economy were to achieve maximum economic growth, or similarly, minimal growth loses, the implemented policy objectives should be concerned with keeping inflation at a specific threshold level. This ideology implies that the goal of monetary policy should not necessary be aimed at attaining and maintaining a low inflation but rather, monetary policy should focus on consistently holding inflation at a certain level. An important implication of the *threshold* level is that it represents the inflation level at which the economic welfare gains are maximized or, conversely, the inflation level at which welfare losses are minimized. It is via this implication that an established *threshold* level of inflation has direct relevance towards the conduct of monetary policy in an economy (Singh and Kalirajan, 2003). Even though the described investigations into the relationship between inflation and economic growth signify an important focus area of academic research for the conduct of monetary policy, no available research seems to exist for the exclusive case of the Zambian economy. This study aims at filling the void in the literature. The remainder of the study is organized as follows. The following section provides the literature review to the study. The third section of the paper outlines the empirical framework to be used in the paper whilst the fourth section presents the data and estimation results of the study. The paper is concluded in section five in the form of policy implications and recommendations of the study.

2 LITERATURE REVIEW

Of recent, an escalating body of academic research has speculated that inflation and growth may be positively or insignificantly related up to some 'threshold' level, of which beyond, this relationship alters such that inflation begins to adversely affect economic growth. This ideology relates to the possibility of a nonlinear correlation between the two macroeconomic variables which in early studies was captured through the use of spline (continuous piecewise) regression functions. Fischer (1993) was among the first to econometrically acknowledge such nonlinearity by observing that the marginal effects of inflation on economic growth fluctuate across escalating bands of inflation ranges. Other studies which concluded similar observations include Bruno and Easterly (1995), who established that a number of economies can withstand moderate inflation rates of about 20 to 30 percent without suffering any undesirable consequences on growth, but once inflation reaches some critical high level (which the authors approximate to be 40 percent), then inflation may prove unfavourable for economic growth. Ghosh and Phillips (1998) ascertain that at low levels (which the authors establish to be in the region of 2-3 percent) inflation may be helpful for economic growth; while at higher levels the adverse effects of inflation begin to gradually emerge. However, a notable shortcoming with the studies of Fischer (1993), Bruno and Easterly (1995) and Ghosh and Phillips (1998) is that the suggested breakpoints are established by judgement rather than through an empirical search which makes it difficult to pinpoint the exact optimal inflation rate associated with these studies.

Nonetheless, seminal works by Sarel (1996) and Khan and Senhadji (2001) were the first to identify exact inflation breakpoints or thresholds in the inflation-growth correlation. These influential studies took into account the fact that the exact threshold level of inflation is unknown and conducted a search among a predetermined range of possible breakpoints for an optimal inflation level at which economic growth is maximized. This empirical 'breakthrough' set a trend for studies that were concerned with either establishing inflation thresholds in pragmatic data or incorporating inflation thresholds into theoretical frameworks. The literature identifies country specific and panel-data empirical approaches into investigating threshold effects in the inflation-growth nexus. Whilst country specific studies estimate thresholds for data pertaining to an individual economy, panel data studies opt to segregate the data into observations of industrialized and non-industrialized economies, before providing threshold estimates for each of the sample groups.

As more evidence emerges on inflation thresholds estimates for country-specific studies, certain biasness can be ascribed towards the relatively higher inflation thresholds estimated for grouped non-industrialized economies in panel data studies. For instance, Zambia, South Africa, Ghana, Nigeria, Jordan, Bangladesh, Pakistan and Malaysia have been categorized as non-industrialized economies in the panel data studies of Khan and Senhadji (2001), Drukker, Gomiss-Porqueras and Hernandez-Verme (2005), Mi (2005) and Kremer and Bick and Nautz (2009). In conducting empirical investigations for these specific economies (with the exception of Zambia for which no country-specific empirical evidence currently exists), the obtained thresholds are of a lower value in comparison to those obtained in the aforementioned panel data studies (see table 1 below for comparison). Possible attributes of this inconsistency include the grouping of economies with vast differences in ‘inflation experiences’ and the generalization of the estimated threshold for the entire group of observations, of which the result may well be driven by the high outliers (Temple, 2000). Hence, country-specific studies can be deemed as providing more reliable inflation threshold estimates in comparison to panel data studies due to the sufficiency of maintained homogeneity in the estimation process.

Table 1: SUMMARY OF REVIEWED STUDIES

type of study	*author(s)*	*sample period*	*no. of countries investigated*	*estimated inflation threshold*
	Sarel (1996)	1970-1990	87	8%
	Khan and Senhadji (2001)	1960-1998	140	11%
	Drukker et. al. (2005)	1950-2000	138	19%
	Mi (2006)	1961-2004	118	14%
	Kremer et. al. (2009)	1950-2004	124	17%
	Sweidan (2004)	1994-2002	*Jordan*	2%
	Ahmed and Mortaza (2005)	1981-2005	*Bangladesh*	6%
	Hussian (2005)	1973-2005	*Pakistan*	5%
country specific studies	*Munir and Mansur (2009)*	1970-2005	*Malaysia*	3.89%
	Frimpong and Oteng-Abayie (2010)	1960-2008	*Ghana*	11%
	Salami and Kelikume (2010)	1970-2008	*Nigeria*	8%
	Phiri (2010)	2000-2010	*South Africa*	8%

Nonlinearities in the relationship between inflation and growth have also emerged in the theoretical literature. Contributions include Gillman, Harris and Matyas (2001) who develop a model of endogenous growth in which money and capital are incorporated into a credit exchange technology. The model depicts that initial rates of inflation increases capital accumulation but as inflation continues rising, the adverse effects of inflation on capital accumulation begin to emerge[1]. However, these adverse effects diminish at high rates of inflation as a result of the optimizing agents' increasing reliance on the credit technology. The authors verify that the calibrations of the theoretical model comply with APEC and OECD data. In separate studies, Huybens and Smith (1999) and Bose (2002) proposes a dynamic general equilibrium model of endogenous growth in which credit market imperfections rise due to asymmetric information between lender and borrowers in the capital market. A rise in inflation reduces the funds available for lending while simultaneously altering the behaviour of lenders such that the adverse effects of inflation are magnified and a critical level or threshold effect is obtained. Hung (2005) expands on Bose (2002) by including non-productive consumption loans into a model of asymmetric information. These consumption loans allow for the concurrent existence of positive and negative effects of inflation on capital accumulation and economic growth resulting in two thresholds in the relationship. For inflation rates below the first threshold, either negative or positive effects may be dominant. Above the first threshold, the magnitude of the negative effect of inflation increases until a second threshold is attained of which beyond this level, the significance of the negative effect dampens.

The theoretical and empirical propositions associated with the existence of an exact threshold level of inflation integrates contradictory arguments advanced by structuralist and monetarist schools of thought[2]; by adhering to the idea that low inflation may initially be supportive of growth gains but once the economy achieves faster growth then inflation can be deemed as being detrimental towards the sustainability of such growth (Ahmed and Mortaza, 2005). From an empirical point of view, Sarel's (1996) model framework and estimation technique is commonly used for estimating thresholds for single-country case studies (i.e. Ahmed and Mortaza (2005); Mubarik (2005); Frimpong and Oteng-Abayie (2010); Salami and Kelikume

[1] Specifically, initial rates of inflation produce a Tobin (1965)-type positive effect on economic growth whereas higher rates result in a negative effect of inflation on economic growth similar to that realized in Stockman (1981).

[2] With respect to the inflation-growth nexus, structuralists believe that inflation is essential for economic growth, whereas this argument is countered by monetarists who view inflation as detrimental to economic growth.

(2010); and Phiri (2010)) whereas Hansen's (2000) TAR specification tends to be applied to panel data-sets (i.e. Khan and Senhadji (2001), Rousseau and Wachtel (2002), Barnes and Duquette (2002) and Mi (2006)). In view of drawing more precise comparisons with the obtained results from previous panel data studies, the paper opts to estimate an inflation threshold for South African data within Hansen's (2000) framework. Such an empirical exercise may be regarded as a more reliable attempt in "sifting the wheat from the chaff" with regards to making comparisons between threshold estimates for single-country evidence of Zambia against its panel data counterparts studies.

3 EMPIRICAL FRAMEWORK

It has become standardized practice in the literature to econometrically quantify inflation thresholds in the inflation-growth nexus by making use of Hansen's (2000) threshold autoregressive (TAR) econometric model. Although the TAR model is informed by the theoretical inflation threshold growth model, it does not exact correlates in functional form of the theoretical models and can be best thought of as a reliable representation of the theories predictions (Barnes, 2001). In its base form, the model framework assumes the following nonlinear inflation-growth regression function:

$$Y_t = \beta_{i1}X_tI.\{\tau \leq \pi^*\} + \beta_{i2}X_tI.\{\tau > \pi^*\} + \varepsilon_t \quad (1)$$

Where Y_t represents a vector measuring the growth rate of GDP, X_t is the vector of control variables containing the inflation threshold variable τ with π^* denoting its threshold estimate. Regime-switching of the data is facilitated by the indicator function, I(.) with the 'β_1' parameters denoting the autoregressive slopes when $\tau \leq \pi^*$ which switches to 'β_2' when $\tau > \pi^*$. The error term ε_t is assumed to be an i.i.d. N(0, σ^2) process. Since the inflation threshold is unknown a-prior, regression equation (1) is estimated for different values of π^* which are chosen from an ascending range of possible threshold values and the optimal value of π^* is obtained by finding the value that maximizes the explanatory power of the regression (Sweidan, 2005). Based on the resulting vector of residuals obtained in equation (1), $\varepsilon_t(\gamma)=Y_t - \beta_{i1}X_t(\pi^*)$; the residual sum of squares is computed as, $RSS(\pi^*) = \varepsilon_t(\pi^*)'\varepsilon_t(\pi^*)$; and the least squares (LS) estimator of π^* is attained by minimizing the following objective function:

$$\pi^* = \text{argmin}_{(\pi^*_1 \in \Gamma_1)} RSS(\tau) \qquad (2)$$

Where $\Gamma = [\pi^*_{min}, \pi^*_{max}]$. Once π^* is obtained, the vector of slope coefficients is estimated as $\alpha(\pi_t) = (\Sigma x_t(\pi^*)x_t(\pi^*)')^{-1}(\Sigma x_t(\pi^*)\pi_t)$; the vector of residuals as $\varepsilon_t = \varepsilon_t(\pi^*)$ and the residual variance is given by $\sigma^2 = (n(T-1))^{-1} RSS(\pi^*)$. A particular econometric issue is associated with the estimation of threshold models. Inference methods need to be developed as to determine whether the threshold effect is statistically significant. Conventional tests of the null hypothesis of a linear model against the alternative of a threshold model have nonstandard distributions as the threshold parameter is not identified under the null hypothesis of linearity (Chan and Tsay, 1998). This results in the asymptotic distribution of the standard f-statistic used in the inference testing not being chi-square. Hansen (2000) suggests the circumvention of this problem via an estimation technique known as the conditional least squares (CLS) method. As a prior step to the estimation procedure, it must be determined whether an inflation threshold actually exists, that is, if the parameter coefficients are different from each other i.e. $\beta_{i1} \neq \beta_{i2}$. This hypothesis can be tested by a conventional F-test statistic. By denoting RSS_0 as the residual sum of squares for the linear model, an F-test of the null hypothesis of a linear model is based on:

$$F = [RSS_0 - RSS(\tau)] / RSS(\tau) \qquad (3)$$

Hansen (2000) has shown that the conventional F-test has a nonstandard asymptotic distribution since the threshold parameter is not identified under the null hypothesis of linearity i.e. $\beta_{i1} = \beta_{i2}$. Hansen (2000) utilizes a bootstrap method to approximate the asymptotic distribution of the F-statistic. In view of existing threshold effects, a second consideration deals with whether the inflation threshold is statistically significant i.e. $\pi^* \neq \tau$. A likelihood ratio (LR) statistic is used to test the null hypothesis of $\pi^* = \tau$ and the resulting statistic is computed as follows:

$$LR(\tau) = [RSS(\tau) - RSS(\tau^*)] / RSS(\tau) \qquad (4)$$

To construct asymptotic valid confidence intervals for the threshold parameter, Hansen (2000) suggests the inverting of the likelihood ratio (LR) statistic associated with the threshold parameter. A bootstrap method is used to simulate the asymptotic distribution of the likelihood ratio (LR) test by attaining the first-order asymptotic distribution, so that the p-values constructed from the bootstrap are asymptotically valid. The asymptotic distribution of the likelihood ratio (LR) is used to form valid asymptotic confidence intervals about the estimated threshold values (Lee and Wong, 2005). Hence, construction of confidence intervals is a natural by-product of the estimation method (Hansen, 2000).

One of the most important tasks for empirical analysts is to find evidence that any specified relationship discovered between inflation and economic growth is more than a correlation, and there is indeed a causal relationship in the background (Juhasz, 2008). Granger's (1969) theorem of causality is used as a means of examining the direction of causality between paired combinations of the time-series variables employed in the study. Granger (1969) starts from the premise that the future cannot cause the present nor the past. If a series Y_t contains information in past terms that help in the prediction of another time series X_t and if this information is contained in no other time series used in the predictor, then Y_t is said to cause X_t (Granger 1969). The vector autoregressive (VAR) model provides a natural framework to test Granger causality. Consider the following pair-wise VAR regressions:

$$Y = \sum_{i=1}^{k} \alpha_1 Y + \sum_{i=1}^{k} \alpha_2 X + \mu_1 \qquad (5.1)$$

$$X = \sum_{i=1}^{k} \beta_1 X + \sum_{i=1}^{k} \beta_2 Y + \mu_2 \qquad (5.2)$$

From the above regression equations, the time series Y fails to granger-cause X if in the regression of Y on the lagged Y's and lagged X's, the coefficients of the lagged X's are zero. Otherwise, Y is said to granger cause X. Granger causality is concerned with whether lagged values of X do or do not improve on the explanation of Y obtainable from only lagged values of Y itself. The null hypothesis is defined as:

$$H_0: \alpha_2 = 0 \text{ or } \beta_2=0 \qquad (6)$$

The above described null hypothesis of no granger causality is tested via a χ^2–test statistic. Granger causality tests, as Toda and Phillips (1993) note, are valid asymptotically as χ^2 criteria only when there is sufficient cointegration with respect to the variables whose causal effects are being tested. The cointegration aspects of the employed data are addressed in the following section of the paper.

4 DATA ANAD ANALYSIS

4.1 DATA DESCRIPTION AND COMPATIBILITY

The data utilized in the study was retrieved from the World Bank database as well as from various publications from the BoZ annual reports and comprised of quarterly data for the periods ranging from 1998-2010. The data was collected in the spirit of Mutoti (2006), who encourages the use of data which corresponds to the monetary targeting and post liberalization era. The dataset consists of the annual percentage change in the gross domestic product (*Δgdp*); the inflation in total consumer prices (π); the real interest rate (*interest*); the ratio of foreign direct investment to GDP (*fdi*); the ratio of exports to GDP (*exp*); domestic credit as a ratio of GDP (*credit*) and the real effective exchange rate (*reer*). Referring back to the TAR regression (1), the independent variable (Y_t) is represented by *Δgdp*, the threshold variable is given by inflation (i.e. $\tau = \pi$) and the vector of explanatory variables in the growth regression is specified as:

$$X_t \sim [\pi, \textit{interest}, \textit{fdi}, \textit{credit}, \textit{reer}] \quad (7)$$

The paper's choices of dependent and explanatory variables are guided by conventional economic growth theory (see Salai-I-Martin (1997) for a comprehensive review of appropriate explanatory variables suitable for an economic growth regression. It is a well acknowledged fact that most economic time-series variables are non-stationary and tend to exhibit processes with a long memory of past errors. Based on economic theory, we can expect a set of economic variables to be related to each other, such that these variables don't drift away from each other. However, economic time series variables tend to contain unit roots which are subject to fluctuations, such that random shocks to these time series variables usually have permanent effects (Cheung and Tan, 2000). Hence, the error terms produced by non-stationary time-series are not white noise processes and the statistical properties of regression analysis becomes 'spurious' or 'nonsense' (Malik and Chowdury, 2001). To ensure the compatibility of the analyzed data in view of what could otherwise be spuriously correlated regressions, two statistical conditions must be satisfied. Firstly, all observed time series must be integrated of similar order I(1). Secondly, there should exist at least one cointegration vector which is representative of a combination of the observed macroeconomic variables. The integration properties of the variables are examined through the use of the Augmented Dickey-Fuller (ADF) and Phillip and Perron (PP) unit root tests. The ADF unit root test is designed to accommodate autoregressive moving-average (ARMA) models with unspecified autoregressive (AR) or moving-average (MA) orders. For a given a time series variable Y_t, the ADF test is based on the following test regression:

$$\Delta Y_t = \mu + \beta\, t + \alpha Y_{t-1} + \sum\nolimits_{j=1}^{k} \gamma_j\, \Delta Y_{t-j} + \varepsilon_t \quad (8)$$

Since it is widely believed that the ADF test does not consider the case of heteroskedasticity and non-normality frequently revealed in raw data of economic time-series variables, the PP test for unit root test has been also used in the empirical analysis. Moreover, ADF tests are unable to discriminate between non-stationary and stationary series with a high degree of autocorrelation and are sensitive to structural breaks which the PP test accounts for. In particular, where the ADF tests use a parametric autoregression to approximate the autoregressive moving-average (ARMA) structure of the errors in the test regression, the PP tests ignore any serial correlation in the test regression. Therefore, the PP test provides robust estimates over the ADF test and is based on the following test equation:

$$\Delta Y_t = \mu + \beta(t - ½T) + \alpha Y_{t-1} + \varepsilon_t \quad (9)$$

The results of the unit root tests are presented in Table 2 below and the test statistics are compared to the critical values derived in Mackinnon (1996). With both a drift and a trend inclusive of a drift, the implemented Augmented Dicker-Fuller (ADF) and the Phillips and Person (PP) unit root tests confirm that all time series are integrated of order I(1) whilst retaining complete stationarity in their first differences.

Table 2: UNIT ROOT TESTS

	adf test statistics		*pp test statistics*		*decision*
	drift	*trend*	*drift*	*trend*	
Δgdp	1.34	-3.11*	-1.13	-3.11	I(1)
	(-8.05)***	(-7.93)***	(-8.05)***	(-7.93)***	
π	-0.52	2.59	-0.52	-2.59	I(1)
	(-8.01)***	(-7.96)***	(-8.01)***	(-8.67)***	
interest	-2.39	-2.74	2.14	-2.42	I(1)
	(-4.04)***	(-4.00)***	(-7.19)***	(-7.11)***	
credit	0.77	-1.98	0.61	-1.71	I(1)
	(-3.56)***	(-3.52)**	(-5.17)***	(-5.11)***	
fdi	-2.44	-2.51	-2.44	-2.51	I(1)
	(-7.91)***	(-7.81)***	(-7.91)***	(-7.81)***	
reer	-0.89	-2.46	-0.89	-2.46	I(1)
	(-7.68)***	(-7.61)***	(-7.68)***	(-7.61)***	

*Significance Level Codes:"***", "**' and '*' denote the 1%, 5% and 10% significance levels respectively. P-values are reported in (). The lag length for the time series associated with the ADF test is selected through the minimization of the AIC and BIC.*

The next step, into ensuring compatibility of the data is achieved via cointegration analysis. The existing number of cointegration vectors (r) within the system of the data is examined by two likelihood ratio tests as proposed by Johansen (1991):

- The lambda-maximum test

This test is based on the log-likelihood ratio In[L_{max}(r) / L_{max}(r+1)] and is conducted for sequentially for r = 0,1,...,k-1. The test statistic involved is a maximum generalized eigenvalue. The test tests the null hypothesis that the cointegration rank is equal to r against the alternative that the cointegration rank is equal to r+1.

- The trace test

The test is based on the log-likelihood ratio In[L_{max}(r) / L_{max}(k)], and is conducted sequentially for r = k-1,...,1,0.The involved test statistic is the trace of a diagonal matrix of generalized eigenvalues and is designed to test the null hypothesis that the cointegration rank is equal to r against an alternative of the cointegration rank being equal to k.

As shown below in Table 3, the computed Eigen and trace test statistics are able to reject the null hypothesis of less than two cointegration relations up to 5 percent significance level. Therefore, we can conclude that the cointegration exists amoung the observed and estimation of the econometric models described in the previous section of the paper can be conducted without concern for spurious results.

Table 3: Johansen's Tests for Cointegration Vectors

h_0	h_1	*eigen statistic*	*99% CV*	*95% cv*	*trace Statistic*	*99% cv*	*95% cv*
$r \le 5$	$r=5$ $(r \ge 6)$	0.24	11.65	8.18	0.24	11.65	8.18
$r \le 4$	$r=4$ $(r \ge 5)$	6.33	19.19	14.90	6.57	23.52	17.95
$r \le 3$	$r=3$ $(r \ge 4)$	9.34	25.75	21.07	15.91	37.22	31.52
$r \le 2$	$r=2$ $(r \ge 3)$	23.30	32.14	27.14	39.20	55.43	48.28
$r \le 1$	$r=1$ $(r \ge 2)$	35.76***	33.78	33.32	76.96**	78.87	70.60
$r \le 0$	$r=0$ $(r \ge 1)$	52.56***	44.59	39.43	119.52***	104.20	85.18

*Significance Level Codes:"***",and "**' denote the 1% and 5% significance levels respectively. The alternative hypotheses of the trace tests are stated in parentheses.*

4.2 Threshold Regression Estimates

The econometric analysis was conducted using the "tsDyn" package under the econometric software "R". Hansen (2000) suggests eliminating the smallest and largest 5 percent of the data to allow for computation ease in searching for the optimum threshold point. By setting the search range for selecting a threshold between π^*_{min}=7 percent and π^*_{max}=28 percent, the optimal inflation threshold is established at 22.5 percent. As a preliminary step to the estimation procedure, the LR test for significant threshold effects, as described in Section 3, was conducted. Owing to the relatively small sample size, the asymptotic p-values for the employed threshold tests are obtained by using 1000 bootstrapped replications. The null hypothesis of linear framework is rejected at all significance levels and the results are reported at the bottom of Table 4.

Table 4: CLS Estimation Of Threshold Regression

	dependent variable: Δgdp	
explanatory variable	β_{1i}	β_{2i}
π	-0.02	0.10
	(0.03)	(0.11)
interest	-0.01	0.05
	(0.02)	(0.04)
fdi	0.05	-1.30
	(0.04)	(0.39)
credit	0.08	0.15
	(0.03)*	(0.23)
reer	0.48	0.69
	(0.11)**	(0.07)*
% of observations	41	51
threshold value	22.5%	
LR(λ)	94.04[0.00]***	
j-b test statistic	p = 0.196	

*Significance Level Codes: '***', "**' and '*' denote the 1%, 5% and 10% significance levels respectively. t-statistics which are based on errors corrected for heteroscedasticity are reported in () and the asymptotic bootstrapped p-values of the LR statistic is reported in []. The critical values for the LR(λ) test statistic are: 1%(78.20), 5%(76.48); and 10%(74.33).*

The estimation results of the TAR model presented in Table 4 provide evidence of regime switching behaviour between inflation, economic growth and other growth determinants. Only at very high levels of inflation (above inflation rates of 22.5 percent) are inflation and real interest rates found to be positively correlated with economic growth. However, this is accompanied with a negative effect of foreign direct investment on economic growth as is indicated by the negative coefficient on *fdi* in the lower regime of the TAR regression estimates. At moderate and low inflation rates (below inflation rates of 22.5 percent) the adverse effects of inflation and real interest rates begin to manifest on economic growth and *fdi* is positively correlated with economic growth. Overall, is should be noted that the coefficient signs of the variables in the lower regime are in alignment with conventional growth theory. The opposite is also true as the coefficient signs of the variables in the lower regime seem to contradict growth theory, that is, with the exception of *credit* and *reer* which remain positively correlated with economic growth in either regime. Robustness of the results is ensured through computed errors corrected for heteroscedasticity as well as on a test for normally distributed errors via the jarque-bera (j-b) test.

4.3 Granger Causality Analysis

Beyond correlation analysis, it would prove useful to examine causality between inflation, economic growth and the other included control variables. Taking into consideration the number of macroeconomic variables under consideration, 21 pair-wise regressions can be derived for Granger (1969) causality analysis which is investigated in a bi-causal sense. Since it is well-known that the Granger (1969) causality tests are sensitive to the number of employed lags, two-system VAR specifications are initially run for the 21 pair-wise regressions of variables as to determine the appropriate number of lags to be used in each system. The Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC) are used to determine the optimal lag lengths of the VAR systems in which the minimized values of the information criterion are preferred and selected. As discussed by Nguyen and Wang (2010), causality analysis of inflation, economic growth and other growth determinants is sensitive to structural breaks. This study ensures robustness of the causality tests to structural breaks by limiting the analysis over a singular monetary regime period. A standard F-distribution test is used to evaluate the significance of granger causality against a derived χ^2 critical statistic. Table 5 presents the results of the performed Granger (1969) tests and a flow diagram of the obtained results is sketched in Figure 1.

Table 5: GRANGER CAUSALITY TESTS

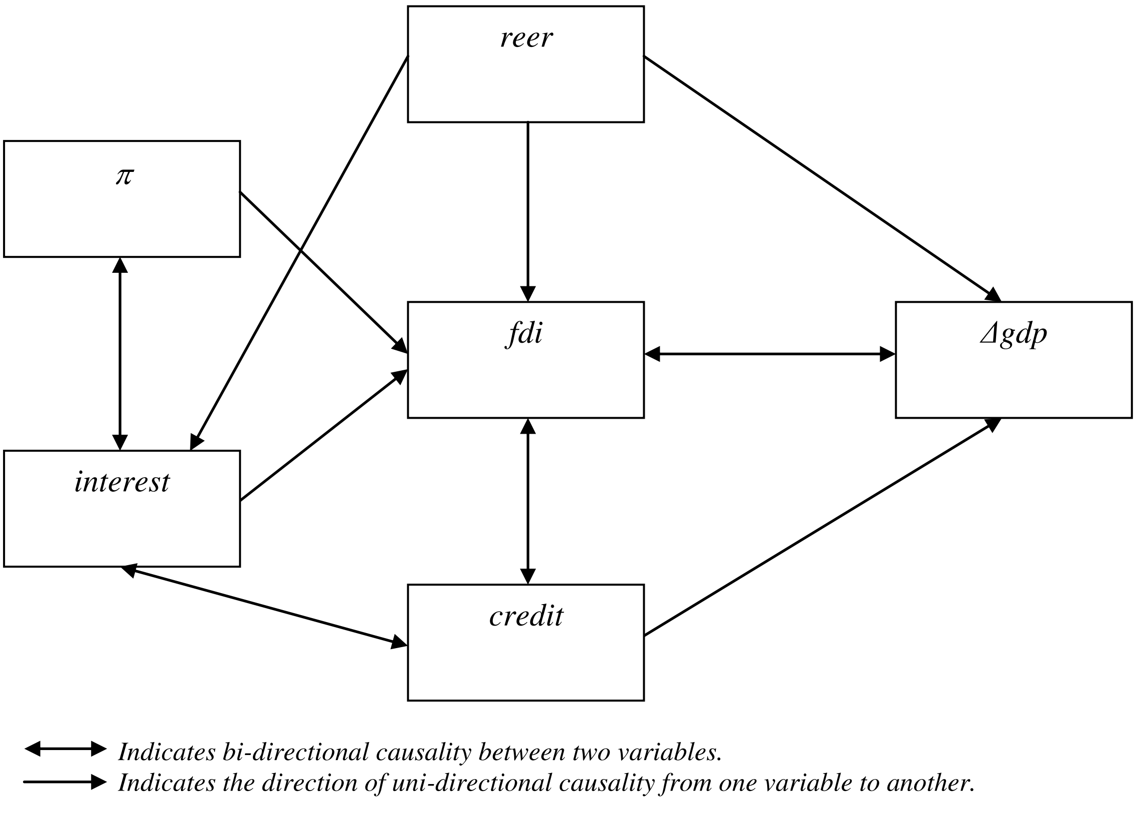
Y	*x*	*causality [y->x]*		*causality [x->y]*	
		f-stat	χ^2 *critical value*	*f-stat*	χ^2 *critical value*
Δgdp	π	0.26	1.57	1.11	1.57
	interest	0.40	2.32	0.38	2.32
	fdi	1.38*	0.36	0.641*	0.36
	credit	0.02	2.62	10.42*	2.62
	reer	0.65	1.88	3.59*	1.88
π	*interest*	4.86*	0.04	0.41*	0.04
	fdi	1.15*	0.26	0.17	0.26
	credit	0.82*	0.38	0.12	0.38
	reer	0.58	15.95	0.06	15.95
interest	*fdi*	5.19*	0.33	0.30	0.33
	credit	1.94*	0.52	1.13*	0.52
	reer	0.07	0.75	1.69*	0.75
fdi	*credit*	2.14*	0.32	2.30*	0.32
	reer	0.92	3.38	6.89*	3.38
credit	*reer*	0.44	2.08	5.79*	2.08

Asterisk denotes that the null hypothesis of no causality is significantly rejected.

Contrary to popular economic belief, the results presented in Table 5 above establish no direct causal effects between inflation and economic growth. Given that conventional growth theory further identifies investment as the intermediary channel in transmitting effects between inflation and economic growth, it is not surprising to find causality running from π and *fdi*, on one hand, and bi-directional causality between *fdi* and *Δgdp*, on the other. An additional identified channel through which inflation may affect GDP growth is via the credit channel. The bi-directional causal effects established between inflation and interest rates concur with the results presented in Odihambo (2009) and may be considered equivalent to confirming the fundamental monetarist's view of inflation dynamics within the Zambian macroeconomy. Both inflation and interest rates are also found to be indirectly linked with *Δgdp* via univariate causality running through the channels of *credit* and *fdi*.

Another observation worth highlighting from Table 5 concerns the unidirectional causality which *reer* exerts upon *interest*, *fdi* and *Δgdp*. These interactions emphasize the importance of exchange rate developments relative to financial sector stability (as proxied by the real interest rate) as well as to stability in the real economy (as proxied by the GDP growth rate). Even though no direct causality effects exist between π and *reer*, the aforementioned variables are linked through the real interest rate. The remaining causality results can be summarized as follows. Univariate causality runs from *credit* to *Δgdp* and thus depicts that the availability of credit to the private sector is instrumental in enhancing economic growth and exports of goods and services to foreign economies. In turn, developments in the credit sector are enhanced by developments in inflation, interest rate and foreign direct investment as is implied by the uni-directional causality from the latter variables to the former.

Figure 1: FLOW DIAGRAM OF CAUSALITY ANALYSIS



5 CONCLUSION

Motivated by the lack of empirical evidence assessing the correlation between inflation and economic growth in Zambia, this study undertook an analysis of inflation threshold effects in a growth regression for the Zambian economy. An inflation threshold estimate of 22.5% is estimated for the data and is relatively higher than those obtained for developing countries in previous panel data studies. Generally, the results imply that moderate inflation may not be harmful towards economic growth in Zambia and supports the notion that monetary policy efforts should be more directed towards credit sector and exchange rate developments instead of actively targeting a predetermined inflation level. In light of the above mentioned, the granger-causality analysis presented in the study may further reveal some important policy considerations. For instance, the overriding goal of disinflation could be accomplished through exchange rate stabilization and credit sector developments which were found to be directly related with foreign direct investment and GDP growth. This opinion is derived based on the strong causal effects observed from exchange rate movements and credit towards real interest rates which, in turn, are found to be strongly correlated with the inflation rate. Besides, the inflation rate in Zambian economy is only established to be directly influential in creating a positive climate for foreign direct investment and yet exerts no direct influence on both the credit sector and the exchange rate.

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