Economics Bulletin

Volume 29, Issue 3

Non-Linearity between Inflation Rate and GDP Growth in Malaysia

Qaiser Munir
Universiti Malaysia Sabah

Kasim Mansur
Universiti Malaysia Sabah

Abstract

This study analyses the relationship between inflation rate and economic growth rate in the period 1970-2005 in Malaysia. A specific question that is addressed in this study is what the threshold inflation rate for Malaysia. The findings suggest that there is one inflation threshold value exist for Malaysia. This evidence strongly supports the view that the relationship between inflation rate and economic growth is nonlinear. The estimated threshold regression model suggests 3.89% as the threshold value of inflation rate above which inflation significantly retards growth rate of GDP. In addition, below the threshold level, there is statistical significant positive relationship between inflation rate and growth. Bank Negara (central bank of Malaysia) should pay attention to inflation phenomena and substantial gain can be achieved in low-inflation environment while conducting the new monetary policy.

We thank Bruce E Hansen for making his Gauss codes available to us and for very helpful advice on the econometric issues. All remaining errors are our own.

Citation: Qaiser Munir and Kasim Mansur, (2009) "Non-Linearity between Inflation Rate and GDP Growth in Malaysia", *Economics Bulletin*, Vol. 29 no.3 pp. 1555-1569.

Submitted: Jul 01 2008. **Published:** July 01, 2009.

1. INTRODUCTION

A widely accepted view in macroeconomics is that low inflation is a necessary condition for fostering economic growth. Although the debate about the precise relationship between inflation and growth remains open, the question of the existence and nature of the link between inflation and economic growth has been the subject of considerable interest and debate. Different schools of thought offer different evidence on the relationship between inflation and growth. For example, *structuralists* believe that inflation is essential for economic growth, whereas the *monetarists* see inflation as detrimental to economic growth (Mallik and Chowdhury, 2001). Earlier empirical works, generally accepted the view that there exists a negative relationship between inflation and economic growth (Barro, 1991; Fischer, 1993; Bullard and Keating, 1995).

If inflation is indeed detrimental to economic activity and growth, it readily follows that policymakers should aim at a low rate of inflation. But how low should inflation be or should it be zero percent? In other words, at what level of inflation does the relationship between inflation and growth become negative? The answer to this question, obviously depends upon the nature and structure of the economy, and will vary from country to country. Recent studies specifically test for non-linearity in the relationship between inflation and economic growth. That is, at lower rates of inflation, the relationship is insignificant or positive, but at higher levels, inflation has a significantly negative effect on economic growth. If such a non-linear relationship exists between inflation and growth, then it should be possible to estimate the threshold level (structural break point), at which the sign of the relationship between the two variables would switches. This is mainly achieved either by defining *a priori* the thresholds for a different level of inflation rates in ad hoc manners (Fischer, 1993; Barro, 1995; Bruno and Easterly, 1998), or use a spline regression technique to directly estimate the threshold rate of inflation (Sarel, 1996; Ghosh and Phillips, 1998).

Fischer (1993) was among the first to examine the possibility of non-linearities in the relationship between inflation and economic growth in panel of 93 countries. Using both cross-section and panel data for a sample that includes both developing and industrialized countries, results from this study suggest a negative relationship between inflation and growth. Interestingly, by using break points of 15% and 40% in spline regression, Fisher showed not only the presence of non-linearities in the relationship between inflation and growth, but also that the strength of this relationship weakens for inflation rates above 40%.

Sarel (1996) used panel data of 87 countries during the period 1970-90 and tested a structural break in the relationship between inflation and growth and found evidence of a significant structural break at an annual inflation rate of 8% --implying below that rate, inflation does not have a significant effect on growth, or it may even show a marginally positive effect. Above that level, the effect is negative, statistically significant and extremely strong.

Bruno and Easterly (1998) examined the determinants of economic growth using annual CPI inflation of 26 countries which experienced inflation crises during the period between 1961 and 1992. In their empirical analysis, inflation rate of 40% and over is considered as the threshold level for an inflation crisis. They found inconsistent or somewhat inconclusive relationship between inflation and economic growth below this threshold level when countries with high inflation crises are excluded from the sample.

Khan and Senhadji (2001) used an unbalanced panel data with 140 countries covering the period 1960-1998 to estimate the threshold levels for industrial and developing countries. Using the nonlinear least squares (NNLS) estimation method, Khan and Senhadji (2001) estimated that the threshold levels for industrial countries and developing countries were at 1-3% and 11-12% respectively. The negative and significant relationship between inflation and growth, for inflation rates above the threshold level, is quite robust with respect to the estimation method.

There is, however, an implicit assumption in all the above panel studies that there is a unique and single structural break in the relationship between inflation economic growth for all countries in the sample beyond which inflation becomes detrimental to economic growth. Sepehri and Moshiri (2004) argued that it is not appropriate to impose a single 'inverted U' relationship across countries at various stages of development and with different institutions and social norms[1]. Most of the recent literature specifically focuses on the case studies of a particular country by employing time series data to test an existence of threshold effect in the relationship between inflation and growth.

In the time series literature, Mubarik (2005) estimated the threshold level of inflation for Pakistan using an annual data from the period between 1973 and 2000. His estimation of the threshold model suggests that an inflation rate beyond 9% is detrimental for the economic growth of Pakistan. This in turn, suggests that an inflation rate below the estimated level of 9% is favorable for the economic growth. On the contrary, Hussain (2005) founds no threshold level of inflation for Pakistan by using the data set from the period 1973-2005. He suggests that targeting inflation exceeding a range of 4-6% will be a deterrent to economic growth. Previously, Singh and Kalirajan (2003) specifically addressed the issue of existence of the threshold effect by using annual data from India for the period of 1971-98. They also suggest that there is no threshold level of inflation for India; however, their findings clearly suggest that an increase in inflation from any level has negative effect on economic growth.

Lee and Wong (2005) estimated the threshold levels of inflation for Taiwan and Japan using quarterly data set from the period between 1965- 2002 for Taiwan and 1970-2001 for Japan. Their estimation of the threshold models suggest that an inflation rate beyond 7.25% detrimental for the economic growth of Taiwan. On the other hand, they found two threshold levels for Japan, which are 2.52% and 9.66%. This suggests that inflation rate below the estimated level of 9.66% is favorable to economic growth and beyond this threshold value it is harmful for the economic growth.

The purpose of this paper is to examine the relationship between inflation rate and economic growth and attempt to estimate precise threshold levels by using annual data for Malaysia over the period 1970-2005. Particularly, the questions that are addressed in this

[1] Temple (2000) warns against the risk of pooling together countries with very different inflation dynamics, as few extremely high values may well derive the overall results.

paper are: (1) whether there is any threshold level of inflation in the case of Malaysia above which inflation affects growth rate of GDP differently than at lower inflation rate? (2) Is such a structural break statistically significant? This paper employs relatively new econometric methods for threshold estimation and inference proposed by Hansen (1996, 2000). This enables us to estimate the number of thresholds, the threshold levels, and the marginal impact of inflation on growth in the various regimes.

The remainder of this paper proceeds as follows. Section 2 provides information about the historical trends of inflation and economic growth in Malaysia. Section 3 presents econometric techniques to find the precise threshold levels for inflation rate and describes the data and presents the summary statistics. Section 4 provides the estimation results and discussions. Lastly, section 5 offers some concluding remarks and proposes possible extensions for future research on the topic.

2. Inflation and Economic Growth in Malaysia

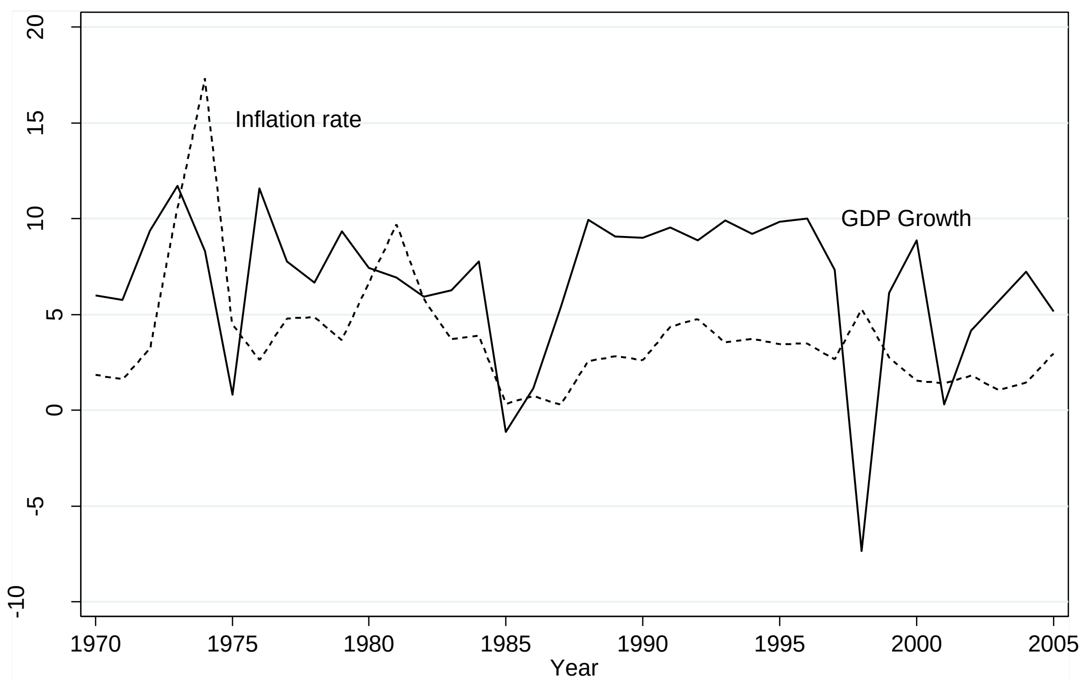
Low inflation and sustainable GDP growth has been one of the main features of the Malaysian economy in the last two decades. Despite its robust economic growth in 1980s and 1990s, Malaysia's inflation rate had been relatively low by international standards. Even after the severe Asian financial crisis (1997 and 1998) and sharp depreciation of the ringgit in 1997-98, Malaysia's inflation rate has been contained at a relatively low level (see Figure 1).

In the early 1970s, Malaysia experienced a single-digit episode of inflation only 2% while the growth rate of GDP was approximately 7%. The GDP growth rate remained the same during the second half of 1970s while inflation rate gradually increase to 4%. The sharp oil price increase in 1973 and 1974 was the principal reason for the escalation of world inflation in 1973-1974. Consequently, consumer prices in Malaysia began to rise and had reached to double-digit level of 10.56 % by the end of the year of 1973. In 1974, the surge in the oil price by over 230 per cent put strong fuel on inflation, and the inflation rate in Malaysia increased to its record high of 17.32%. A year later, the Malaysian economy slumped into its great recession, with a GDP growth rate of only 0.8% in 1975, compared to 8.3% and 11.7% in 1973 and 1974 respectively. On the other hand, inflation rate reduced to the level of 4.5% in 1975.

Malaysia experienced a second episode of high prices in 1980 and 1981, which were due mainly to external factors. Oil prices rose by 47% in 1979 and 66% in 1981. As a result, inflation in Malaysia accelerated from 3.6% in 1979 to 6.6% and 9.7% in 1980 and 1981 respectively. Consequently, the growth rate of GDP declined to 7.4% and 6.9% in 1980 and 1981 respectively, compared to 9.3% in 1979. However, since 1982 inflation rate kept decreasing and amounted to less than 1% in 1985 and 1986. The development of the Malaysian economy was at an important crossroad in 1985. The economic performance of the country had slumped into its greatest recession, with -1.1% and 1.1% growth rate recorded in 1985 and 1986 respectively. The severity of the international economic recession during the early 1980s imposed considerable constraints on the growth and development of the nation in 1985 and 1986.

After registering a significant growth with more than 9% for three consecutive years, with inflation rate as low at 2.6%, the economy in 1990 strengthened further despite some slowing down of growth in the industrial countries[2]. Although inflation rate increased, on average, to 3.9% during the period 1991-1996, the growth rate of GDP continued to increase and reached at 9.6%; However, with the outburst of the financial crisis in Asia in1997, interest rates, fuel prices and prices of goods and services have increased. Robust foreign demand as a result of the depreciation of the Malaysian Ringgit (RM) of over 40% has placed an extremely powerful inflationary pressure on Malaysia. As a result, inflation rate increased to 5.3% in 1998, compared to the 2.7% in 1997. Consequently, in 1998, Malaysian economy experienced a sharp decline in the growth rate of GDP from positive growth rate to negative at -7.4%, compared to 7.3% in 1997. Between 2000 to 2005, inflation rate stabilized and remained approximately 1.7% with relatively low growth rate of GDP of only 5.2%.

Figure 1: Relationship between Inflation Rate and GDP Growth



3. EMPIRICAL MODEL AND DATA

In this section, we describe briefly the econometric methodology of the threshold estimation proposed by Hansen (2000)[3]. Further, we present the data set used in this study with descriptive statistics and correlation matrix of the variables.

---

[2] The outbreak of Gulf War on 1990 has since set off a round of oil price increases, with prices rising from US$18 per barrel from its pre-Gulf crisis level to an average US$36 in October 1990 (Ministry of Finance Malaysia, 1990).

[3] Hansen (2000) presents a statistical estimation theory for threshold estimation in cross-section regression context; however, it can also be employed in time series analysis.

3.1. EMPIRICAL MODEL AND ESTIMATION TECHNIQUE

We consider the following linear regression equation:

$$GDPGR_t = \beta_0 + \beta_1 INFRATE_t + \beta_2 M2GR_t + \beta_3 GCFGR_t + \beta_4 FDI_t + \beta_5 EXPGR_t + u_t \qquad (1)$$

Where $GDPGR_t$ denotes real GDP growth rate; $INFRATE_t$ denotes inflation rate; $M2GR_t$ denotes growth rate of money supply as a proxy for financial sector depth; $GCFGR_t$ denotes growth rate of gross fixed capital formation as a proxy for investment rate, FDI and EXPGR denotes foreign direct investment and annual growth rate of exports of goods and services, respectively (see next section for detailed description of variables), u_t denotes the error term.

The regression equation (1) represents the standard linear growth model. However, as discussed above, some recent studies predict that threshold effects are associated with a rate of inflation exceeding some critical value or below some critical values (Boyd *et al*, 2001); implies the relationship between inflation rate and economic growth does not follow a single pattern. There is a particular econometric issue related to the estimation and inference in empirical models with threshold effects. It is important to develop suitable methods to conduct estimation. In the following section, we provide a brief and non-technical outline of the methodology used in this study.

Recent work by Hansen (1996; 2000) presents some new results on the threshold autoregressive (hereafter TAR) model introduce by Tong (1978). In particular, Hansen (2000) develops new tests for threshold effects, estimates the threshold parameter, and constructs asymptotic confidence intervals for the threshold parameter. The basic idea behind the Hansen (2000) threshold estimation is that an exogenously given variable, called "threshold variable", is used to split the sample in two groups or regime, which can or cannot be a regressor. This theory derives the asymptotic distribution of the Ordinary Least Squares (OLS) estimates of the threshold parameter.

More specifically, consider a two-regime structural equation in threshold autoregression (TAR) model:

$$y_t = \theta_1' x_t + e_{1t} \qquad if \quad q_t \le \gamma, \qquad (2)$$

$$y_t = \theta_2' x_t + e_{2t} \qquad if \quad q_t > \gamma, \qquad (3)$$

Where q_t denotes the threshold variable, splitting all the observed values into two classes or regimes. Terms y_t and x_t are dependent variable and explanatory variable (m vector) respectively. e_{it} is the error term of property white-noise *iid* and γ denotes the threshold value. If we knew γ the model could be easily estimated by OLS. Since the threshold is unknown a *priori* so it should be estimated in addition to other parameters. Notice that when the threshold variable is smaller than the threshold parameter, the model estimates the equation (2). Similarly, when the threshold variable is larger than the threshold parameter, the model estimates the equation (3).

Defining a binary variable $d_t(\gamma) = \{q_t \le \gamma\}$ where $\{\cdot\}$ is the indicator function, with d = 1 if $q_t \le \gamma$ occurs or d = 0 otherwise, and setting $x_t(\gamma) = x_t d_t(\gamma)$, then equation (2) and (3) can be rewritten as a single equation:

$$y_t = \theta' x_t + \delta' x_t(\gamma) + e_t \qquad (4)$$

Where, $\theta = \theta_2$, $\delta = \theta_1 - \theta_2$, and $\theta, \delta,$ and γ are the regression parameters to be estimated. The residual sum of squares as a result of estimating the regression parameters can be written as follows:

$$S_1(\gamma) = \hat{e}_t(\gamma)' \hat{e}_t(\gamma) \tag{5}$$

Hansen (1996; 2000) recommends estimating γ by least squares technique. The easiest way to implement this procedure is through minimization of the sum of squared residuals as a function of expected threshold value. Hence, we can write the optimum threshold value as follows:

$$\hat{\gamma} = \arg\min S_1(\gamma) \tag{6}$$

Conditional on $\hat{\gamma}$, the regression equation is linear in θ $and\ \delta'$, yielding the conditional OLS estimates of $\widehat{\theta}(\gamma)$ and $\widehat{\delta}(\gamma)$ by regression of dependent variable on explanatory variables. Following the foregoing procedure, linear equation (1) can be expressed as a nonlinear equation under a two-regime threshold autoregression (TAR) model as follows:

$$\begin{aligned} GDPGR_t = {} & (\beta_{10} + \beta_{11} INFRATE_t + \beta_{12} M2GR_t + \beta_{13} GCFGR_t \\ & + \beta_{14} FDI_t + \beta_{15} EXPGR_t)\, d[q_t \le \gamma] \\ & + (\beta_{20} + \beta_{21} INFRATE_t + \beta_{22} M2GR_t + \beta_{23} GCFGR_t \\ & + \beta_{24} FDI_t + \beta_{25} EXPGR_t)\, d[q_t > \gamma] + e_t^* \end{aligned} \tag{7}$$

From equation (7), the optimal threshold value can be determined by obtaining the threshold value that minimizes the residual sum of squares (RSS). Since the main objective of this paper is to investigate the inflationary threshold effects in the relationship between inflation rate and economic growth in Malaysia, the annual growth rate of inflation is employed as the threshold variable in the analysis.

The main question in equation (7) is whether or not there is a threshold effect. This requires the examination between the linear model vis-à-vis the two-regime model (equation 7). The null hypothesis of no threshold effect ($H_0 : \beta_{1i} = \beta_{2i}$, where *i*= 0,…,5) is tested against an alternative hypothesis where threshold effect is present ($H_0 : \beta_{1i} \neq \beta_{2i}$). Traditional procedures of hypothesis testing cannot be applied, because under the null hypothesis of no threshold effect exits, the threshold parameter γ will be unidentified. Hansen (1996) therefore suggests a standard heteroscedasticity-consistent Lagrange Multiplier (*LM*) bootstrap method to calculate the asymptotic critical value and the *p*-value. To accomplish this, a test with near-optimal power against alternatives distant from H_0 is the standard *F*-statistics:

$$F_1 = \frac{S_0 - S_1(\hat{\gamma})}{\hat{\sigma}^2} \tag{8}$$

Where S_0 and S_1 be the residual sum of squares under the null hypothesis and the alternative of $H_0 : \beta_{1i} = \beta_{2i}$. Where $\hat{\sigma}^2$ is the residual variance defined as $= \frac{1}{T}\hat{e}_t \hat{e}_t = \frac{1}{T} S_1(\hat{\gamma})$. Hansen

(1996) shows that a bootstrap procedure achieves the first-order asymptotic distribution, so *p*-values constructed from the bootstrap are asymptotically valid.

Having estimated the threshold effect, the next step is to determine whether the estimate is statistically significant, i.e $H_0 : \beta_{1i} \neq \beta_{2i}$. In this case the estimate $\hat{\gamma}$ is consistent for the true value of γ, say γ_0. Since the asymptotic distribution of the threshold estimate $\hat{\gamma}$ is highly non-standard, Hansen (2000) uses the likelihood ratio statistic for the tests on γ to form confidence intervals for γ. The null hypothesis of the threshold value is $H_0: \gamma = \gamma_0$ and the likelihood ratio statistic is given by:

$$LR_1(\gamma) = \frac{S_1(\gamma) - S_1(\hat{\gamma})}{\hat{\sigma}^2} \tag{9}$$

Where $S_1(\gamma)$ and $S_1(\hat{\gamma})$ are the sums of the squared residuals from equation (5) given the true and estimated value, respectively. The null hypothesis is rejected for large values of $LR_1(\gamma_0)$. Hansen (2000) showed that there is an asymptotic distribution of $LR_1(\gamma_0)$ to form valid asymptotic confidence intervals for γ. Hansen (2000) demonstrates that the distribution function has the inverse $c(\alpha) = -2\ln(1 - \sqrt{1 - \alpha})$ from which it is easy to calculate critical values[4]. Where α is a given asymptotic level; and the no-rejection region of the confidence level is 1-α. i.e, if $LR_1(\gamma_0) \leq c(\alpha)$ than the null hypothesis of $H_0: \gamma = \gamma_0$ cannot be rejected. In order to examine more than one threshold value, foregoing procedures are applied until the null hypothesis can no longer be rejected.

3.2. DATA DESCRIPTION AND SOURCE

To carry out an estimation procedure of the relationship between inflation and economic growth we employ annual data covering the period 1970 to 2005. The data is extracted from the World Bank's *World Development Indicators* (2007 CD-ROM). In order to maintain an acceptable degree of freedom and avoid potential Multicollinearity problem, we include only those variables which are frequently used in the growth regression[5]. The variables used in the estimations are the following:

- ***GDP Growth Rate (GDPGR)***. This is the dependent variable used in the regressions. The economic growth rate represented by the annual percentage growth rate of gross domestic product (GDP) at market prices based on constant local currency.
- ***Inflation Rate (INFRATE)***. Inflation rate represented by the annual percentage growth rate of Consumer Price Index (CPI) with 2000 as the base year. This is the main explanatory and threshold variable used in the regressions.
- ***Financial Depth (M2GR)***. This explanatory variable is used as the index of financial depth in a country. This is constructed as an average annual percentage growth rate

[4] E.g. the 5% critical value is 7.35 and 1% critical value is 10.59 Hansen (2000, page 582, table 1).

[5] Other potential explanatory variables, for instant, Government size, population growth, human capital, etc, are important explanatory variables in the growth model. However, Government size and population growth variables were not significant in regressions; whereas human capital variable is not available for annual basis from 1970 to 2005. Therefore, we restrict to few variables in the sample dataset.

in money and quasi money. Money and quasi money comprise the sum of currency outside banks, demand deposits other than those of the central government, and the time, savings, and foreign currency deposits of resident sectors other than the central government. This definition is frequently called broad money (M2).

- ***Gross Capital Formation (GCFGR)***. This variable used as a proxy of physical capital accumulation. This is the annual percentage growth rate of Gross capital formation (formerly gross domestic investment). It consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories.
- ***Foreign Direct Investment (FDI)***. This variable is measured as the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows in the reporting economy and is percentage of GDP.
- ***Exports of Goods and Services (EXPGR)***. Export variable represented by annual growth rate of Export of goods and services. Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude labor and property income (formerly called factor services) as well as transfer payments.
- ***Financial Crises Dummy (DCRISES)***. Due to the financial crises in the region, the economic growth in Malaysia was declined sharply. Therefore the effect of this unprecedented change in the growth trend controlled with dummy variable that takes a value of 1 for financial crises period and 0 otherwise[6].

Table 1 provides the some summary statistics of the variables used in the paper. Malaysia's average inflation rate is approximately 3.84% from 1970 to 2005, whereas; in the same period Malaysia had maximum and minimum inflation rate 17.33% and 0.290% respectively. Malaysia's average GDP growth during same period was around 6.66% ranging from maximum of 11.71% and minimum of -7.36%.

Table 1: Summary Statistics of Variables

Variables	Mean	Standard Deviation	Maximum	Minimum	Skewness	Kurtosis
GDPGR	6.6639	3.8708	11.7100	-7.3600	-1.6779	6.3016
INFRATE	3.8439	3.2111	17.3300	0.2900	2.4283	10.2269
M2GR	16.1944	16.6877	71.9100	-43.7400	0.0082	9.2898
GCFGR	9.2717	17.0129	36.4600	-43.0400	-0.8896	3.9367
FDI	3.8131	1.8629	8.7600	0.6300	0.8245	3.4054
EXPGR	9.5839	7.0419	21.9100	-7.5000	-0.4530	2.3947

[6] We are grateful to an anonymous referee for suggesting this particular issue. However, this variable is not shown in the model.

4. THE EMPIRICAL RESULTS

Prior to presenting the results, it is important to consider whether the variables under consideration are stationary. We test for stationarity to ensure that the variables used in the regressions are not subject to spurious correlation. The Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) units root tests are used to investigate the stationary status of each variable. These tests are applied to the level variables. The results are presented in Table 2. The estimation results show that the null hypothesis of unit root is rejected at the 1% level of significance in both tests, except *INFRATE and FDI*. In ADF test *INFRATE* only significant at 10% when time trend not included. However, when PP test is applied *INFRATE* become significant at 5% levels. Whereas, *FDI* variable is only significant at 10% level in ADF and PP tests when time trend in not included. Therefore, generally results imply that the underlying variables show stationary process.

Table 2: Results of Unit Root tests with ADF and PP

Variables	**Augmented Dickey-Fuller (ADF)**		**Phillips-Perron (PP)**	
	Constant without linear trend	Constant with linear trend	Constant without linear trend	Constant with linear trend
GDPGR	-4.8255*** (0)	-4.9291*** (0)	-4.8381*** (1)	-4.9373*** (1)
INFRATE	-2.9096* (8)	-3.1010 (8)	-3.2877** (3)	-3.6829** (12)
M2GR	-4.6277*** (1)	-5.4196*** (1)	-4.8861*** (0)	-5.2862*** (5)
GCFGR	-5.4663*** (0)	-5.5278*** (0)	-5.4664*** (2)	-5.5223*** (3)
FDI	-2.7091* (0)	-2.5227 (0)	-2.6782* (2)	-2.6054 (2)
EXPGR	-5.4340*** (0)	-5.3812*** (0)	-5.4340*** (0)	-5.3812*** (0)

Notes: figures within parentheses indicate lag lengths. Lag length for ADF tests have been decided on the basis of *Akaike Information Criterion* (AIC) (Akaike, 1974). Maximum Bandwidth for PP tests have been decided on the basis of *Newey-West* (1994). The ADF and PP tests are based on the null hypothesis of unit roots. ***, **, and * indicate significant at 1%, 5%, and 10% levels respectively, based on the critical t statistics as computed by MacKinnon (1996).

4.1. TEST STATISTICS FOR EXISTENCE OF THRESHOLD EFFECTS

The results of the threshold test and asymptotic *p*-values in our endogenous threshold analysis obtained through 1000 bootstrap replications are reported in Table 3. In a first step, we applied Hansen's (2000) testing procedure for determining the number of inflation thresholds. The statistics of F_1 is 44.56, which is significant at the 5% level in one threshold testing, and the bootstrap *p*-value is 0.048, which indicates that the threshold exits. The threshold value is 3.89%, and this suggests that one threshold exits. However, when we go a step further to test two thresholds, we find that the F_2 statistic indicates that the null hypothesis of one threshold is not rejected significantly. Therefore, the test procedure implies one threshold and, thus, two inflation regimes in the inflation-growth relation for the Malaysia.

Table 3: Summary of the Test Results of Threshold Effects

Test Hypothesis	F_1 test	Bootstrap *P*-Value	Threshold Estimates (%)	95% Confidence Interval
H_0 : no threshold	44.56**	0.048	3.89%	[2.74%, 3.95%]
H_0 : one threshold	6.19	0.516		

Notes: Test of Null of no Threshold against Alternative of Threshold. The threshold is found by the minimized sum of the squared residual. ** represents significant at 5% levels.

The estimation results are quite similar to the results reported in the studies of Sarel (1996), Khan and Senhadji (2001), Sepehri and Moshiri (2004), and Lee and Wong (2005), that is, structural break exists in the data. However, our estimated threshold value is quite different to these studies.

Once the threshold is found, now the next step is to determine how precise this is. For this, we employ *LR* test to examine the confidence interval around the threshold estimate. The 95% asymptotic confidence region is as [2.74%, 3.95%]. Figure 2 presents the normalized likelihood ratio sequence $LR_n^*(\gamma)$ statistics as a function of the inflation rate (*INFRATE*) threshold. As mentioned in section 3, the least squares estimate of the threshold (γ) is the value that minimizes the function $LR_n^*(\gamma)$ and occurs at $\hat{\gamma}$ = 3.89%. The asymptotic 95% critical value 7.35, which is significant at 5% levels, is shown by the dotted line and where it crosses $LR_n^*(\gamma)$ displays the confidence interval [2.74%, 3.95%]. This result implies that the threshold estimates are very precise. Thus, there is significant evidence supporting one threshold in the relationship between inflation rate and real GDP growth.

Figure 3: Confidence Interval Constructions for Threshold

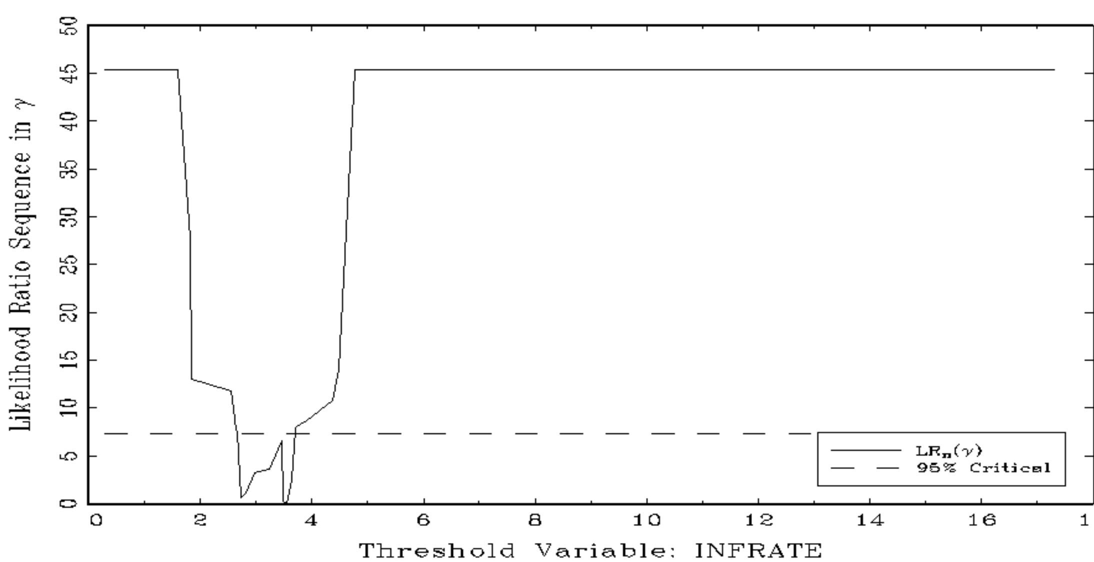


Table 4 provides the estimation results of the relationship between inflation rate and growth rate of GDP for Malaysia from 1970 to 2005. For comparison purposes, the first column presents estimates for a linear regression equation (1) that ignore the threshold effect. Column two and three provide estimates of the two-regime TAR model (7).

Table 4: Regression Results of Inflation rate and GDP Growth (1970-2005)

Variables	Linear Model	Threshold Model	
	(OLS without threshold)	Regime1 $\leq 3.54\%$	Regime 2 $> 3.54\%$
Constant	3.7342***	1.2211	5.7433***
	(0.8992)	(0.8873)	(0.6893)
INFRATE	- 0.1619*	1.7709***	- 0.2692**
	(0.0878)	(0.4581)	(0.0993)
M2GR	0.0443**	0.0201	0.0650***
	(0.0186)	(0.0136)	(0.0168)
GCFGR	0.1526***	0.0771**	0.1506***
	(0.0329)	(0.0305)	(0.0166)
FDI	0.0471	- 0.2219	- 0.2994*
	(0.1663)	(0.2222)	(0.1435)
EXPGR	0.1395**	0.1751**	0.1163**
	(0.0527)	(0.0656)	(0.0432)
DCRISIS	- 0.8828	- 0.6989	- 4.3754***
	(0.9821)	(0.6939)	(0.8498)
Observations	36	21	15
R^2	0.78	0.83	0.96

NOTES: The dependent variable is growth rate of real GDP from 1970 to 2005. Standard errors in parentheses are White corrected for heteroskedasticity. The estimation results correspond to trimming percentage of 15%. ***, **, and * represent significant at 1%, 5%, and 10% levels respectively.

The empirical results obtained from the estimation of the linear model show that inflation rate has significant negative impact on growth rate of GDP, as the significant coefficient is -0.162. In contrast to the results obtained for the linear specification, the threshold model reveals that inflation has a different significant impact on growth. However, both magnitude and sign of the inflation coefficient depends on the level of inflation rate. In the low-inflation regime--i.e., when inflation is below 3.89%--the marginal impact of inflation on growth is significantly positive (1.77). Column (2) illustrates that under low-inflation regime, on average, a 1% increase in inflation in Malaysia leads to increase in the economic growth by 1.77%. However, in column (3), when inflation is higher than threshold level, 3.89%, inflation has a significant negative effect on economic growth, as the coefficient is -0.269. This Suggests that under high-inflation regime, on average, a 1% increase in inflation rate leads to a decline in the economic growth by 0.269%. The estimated coefficients, in two-regime models, of *INFRATE* not only differ statistically from zero but also highly significant at $p<0.05$. The estimated non-linear relationship between inflation and economic growth is consistent with the empirical and theoretical conclusion derived in previous studies (Sarel, 1996; Bose, 2002; Lee and Wong, 2005); that is, under high inflation regime, inflation has a negative effect on economic growth. Note that investment (*GCFGR*) and export (*EXPGR*) variables indicating positive and significant impact on economic growth regardless of the inflation regimes. This finding reinforces the fact that Malaysia's economy indeed heavily depends on trade. Furthermore, financial depth have a positive and significant impact on economic growth in linear model as well as in high inflation regime. Financial crises variable (*DCRISES*) indicating negative impact on economic growth in linear regression as well as in low-inflation regime, however, it is not statistically significant. Note that when inflation exceeds threshold value, *DCRISES* showing significant negative impact on growth. This finding supports the evidence that the economic growth in Malaysia was declined sharply from 7.3% to -7.4% in 1997.

5. CONCLUSIONS

This paper re-examines the issue of the existence of threshold effects in the relationship between inflation and growth using new econometric methods (Hansen 1996; 2000) that provide appropriate procedures for estimation and inference. Estimates were obtained with yearly data for the period 1970-2005.

The empirical results strongly suggest the existence of one threshold value beyond which inflation exerts a negative effect on economic growth. This implies there is non-linear relationship between inflation and economic growth for Malaysia. Our results point to the fact that inflation may promote economic growth when it is below 3.89%. However, inflation is detrimental to economic growth when it is above the threshold level i.e. 3.89%.

In conclusion, the policy implication derived from this study is that it is desirable to keep inflation rate below threshold level in Malaysia, as it may be help sustainable growth. Using the structural break technique, this study show that the effect of inflation rate on economic growth is not only negative in high inflation environment, but in low inflation environment, it can also be positive and more significant.

REFERENCES

Barro, R. J. (1991) “Economic Growth in a Cross Section of Countries”. *Quarterly Journal of Economics*, **104**, pp. 407-433.

Barro, R. J. (995) “Inflation and Economic Growth”. National Bureau of Economic Research (NBER) Working Paper No. 5326.

Boyd, J., R. Levine. and B. Smith (2001) “The impact of inflation on financial sector performance”. *Journal of monetary Economics*, **47**, pp. 221-248.

Bruno, M. and Easterly, W. (1998) “Inflation Crises and Long-Run Growth”. *Journal of Monetary Economics*, **41**, pp. 3-26.

Bullard, J. and Keating, D. (1995) “The Long-Run Relationship between Inflation and Output in Postwar Economies”. *Journal of Monetary Economics*, **36**, pp. 477-496.

Dickey, D. and Fuller, W. (1979) “Distribution of the Estimators for Autoregressive Time Series with a Unit Root”. *Journal of the American Statistical Association*, **74**, pp. 427-431

Dickey, D. and Fuller, W. (1981) “Likelihood Ratio Tests for Autoregressive Time series With a Unit Root. *Econometrica*, **49**, pp. 1057-1072.

Fischer, S. (1993) “The Role of Macroeconomic Factors in Growth”. *Journal of Monetary Economics*, **32**, pp. 485-512.

Ghosh, A. and Phillips, S. (1998) “Warning: Inflation May Be Harmful to Your Growth”. *IMF Staff Papers*, International Monetary Fund, **45**, pp. 672-710.

Hansen, B. (1996) “Inference When a Nuisance Parameters Is Not Identified Under the Null Hypothesis”. *Econometrica*, **64**, pp. 413-430.

Hansen, B. (2000) “Sample Splitting and Threshold Estimation”. *Econometrica*, **68**, pp. 575-603.

Hussain, M. (2005) “Inflation and Growth: Estimation of Threshold Point for Pakistan”. *Pakistan Business Review*, October, pp. 1-15.

Khan, M.S. and Senhadji, A.S. (2001) “Threshold Effects in the Relationship Between Inflation and Growth”. *IMF Staff Papers*, International monetary Fund, **48**, pp. 1-21.

Lee, C.C. and Wong, S, Y. (2005) “Inflationary Threshold Effects in the Relationship Between Financial Development and Economic Growth: Evidence from Taiwan and Japan”. *Journal of Economic Development*. **30**. Pp. 49-69.

MacKinnon, J.G. (1996) “Numerical Distribution Functions for Unit Root and Cointegration tests. *Journal of Applied Econometrics*, **11**, pp. 601-618

Mallik, G. and Chowdhury, A. (2001) “Inflation and Economic Growth: Evidence from South Asian Countries”. *Asian Pacific Development Journal*. **8**, pp. 123-135.

Phillips, P.C.B. and Perron, P. (1988) “Testing for a Unit Root in Time Series Regression”. *Biometrika*, **75**, pp.335-346.

Mubarik, Y.A. (2005) “Inflation and Growth: An Estimate of the Threshold Level of Inflation in Pakistan”. *State Bank of Pakistan-research Bulletin*, **1**, pp. 35-44.

Sarel, M. (1996) Nonlinear Effects of Inflation on Economic Growth. *IMF Staff Papers*, International Monetary Fund, **43**, pp. 199-215.

Sepehri, A. and Moshiri, S. (2004) “Inflation-Growth Profiles Across Countries: Evidence from Developing and Developed Countries”. *International Review of Applied Economics*, **18**, pp. 191-207.

Singh, K. and Kaliappa, K. (2003) “The Inflation-Growth Nexus in India: An Empirical Analysis”. *Journal of Policy Modeling*, **25**, pp. 377-396.

Temple, J. (2000) “Inflation and Growth: Stories Short and Tall”. *Journal of Economic Surveys*, **14**, pp. 395-426.
Tong, H (1978) “On the threshold model: Pattern recognition and signal processing,” *Amsterdan: Sijthoff and Noordhoff*, pp. 101-41.