ASEAN Economic Bulletin Vol. 26, No. 2 (2009), pp. 180–93 ISSN 0217-4472 print / ISSN 1793-2831 electronic

DOI: 10.1355/ae26-2d

Inflation and Economic Growth in Malaysia

A Threshold Regression Approach

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This paper examines the issue of the existence of threshold effects in the relationship between inflation rate and growth rate of GDP in the context of Malaysia, using new endogenous threshold autoregressive (TAR) models proposed by Hansen (2000) for estimation and inference. The empirical analysis uses annual data from Malaysia for the period 1970–2005. A specific question addressed in this study was: What is the threshold inflation rate for Malaysia? The findings clearly suggest that one inflation threshold value (i.e., structural break point) exists for Malaysia; and this implies a non-linear relationship between inflation and growth. The estimated threshold regression model suggests 3.89 per cent as the threshold value of inflation rate above which inflation significantly retards growth rate of GDP. In addition, below the threshold level, there is a statistically significant positive relationship between inflation rate and growth. If Bank Negara (Central Bank of Malaysia) pays more attention to the inflation phenomena, then substantial gains can be achieved in low-inflation environment while conducting the new monetary policy.

Keywords: Inflation rate, economic growth, threshold model, structural break, Malaysia.

I. Introduction

The conventional view in macroeconomics holds 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 this relationship. 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, p. 123). In a seminal paper, Tobin (1965) introduces money into a Solow-Swan model as an asset alternative to capital. In this context, inflation increases the opportunity cost of money holdings and thus favours capital accumulation and hence growth. Conversely, in endogenous growth models, the effects of inflation are explained in the works of Gomme (1993) and Jones and Manuelli (1995). For example, where money is introduced in the budget constraint in a model of human capital accumulation, an increase in the rate of inflation negatively affects both consumption and labour supply leading to a lower growth rate. De Gregorio (1993) shows that inflation may have relevant effects on accumulation of physical capital. In his model, money is a means of reducing transaction costs both for consumers and firms, a higher inflation rate induces agents to reduce their money holdings, thus increasing the transaction costs and generating negative effects on investment and growth. 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 policy-makers should aim at a low rate of inflation. But how low should inflation be or should it be 0 per cent? 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 switch. This is mainly achieved either by defining *a priori* the thresholds for different levels of inflation rate in *ad hoc* manners (Fischer 1993; Barro 1995; Bruno and Easterly 1998), or by using a spline regression technique to directly estimate the threshold rate of inflation (Sarel 1996; Ghosh and Phillips 1998).

For example, the seminal work by Fischer (1993) examined the possibility of non-linearities in the relationship between inflation and economic growth in panel of ninety-three 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 per cent and 40 per cent 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 per cent.

Sarel (1996) used a panel data of eighty-seven 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 per cent — 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 consumer price index (CPI) inflation of twenty-six countries which experienced inflation crises during the period 1961–92. In their empirical analysis, inflation rate of 40 per cent 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 were excluded from the sample.

Khan and Senhadji (2001) used an unbalanced panel data with 140 countries covering the period 1960–98 to estimate the threshold levels for industrial and developing countries. Using the non-linear least squares (NLLS) estimation method, Khan and Senhadji (2001) estimated that the threshold levels for industrial countries and developing countries were at 1–3 per cent and 11–12 per cent 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.

Most recent economists have chosen to analyse the relationship between inflation and growth by exploiting time series variation in the data. For instance, Mubarik (2005) estimated the threshold level of inflation for Pakistan using an annual data set from the period 1973–2000. His estimation of the threshold model suggests that an inflation rate beyond 9 per cent is detrimental for the economic growth of Pakistan. This, in turn, suggests that an inflation rate below the estimated level of 9 per cent is favourable for the economic growth. On the contrary, Hussain (2005) found 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 per cent 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 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 1965–2002 for Taiwan and 1970–2001 for Japan. Their estimation of the threshold models suggest that an inflation rate beyond 7.25 per cent is detrimental for the economic growth of Taiwan. On the other hand, they found two threshold levels for Japan, which are 2.52 per cent and 9.66 per cent. This suggests that inflation rate below the estimated level of 9.66 per cent is favourable to economic growth and beyond this threshold value it is harmful for the economic growth.

The purpose of this paper is to re-examine the relationship between inflation rate and economic growth, and it attempts to estimate precise threshold levels by using annual data for Malaysia over the period 1970–2005. Particularly, the questions that are addressed in this paper are: (1) Is there any threshold level of inflation in the case of Malaysia above which inflation affects growth rate of GDP differently? (2) Is such a structural break statistically significant? This paper employs relatively new econometric methods for threshold estimation and inference, as proposed by Hansen (1996; 2000).

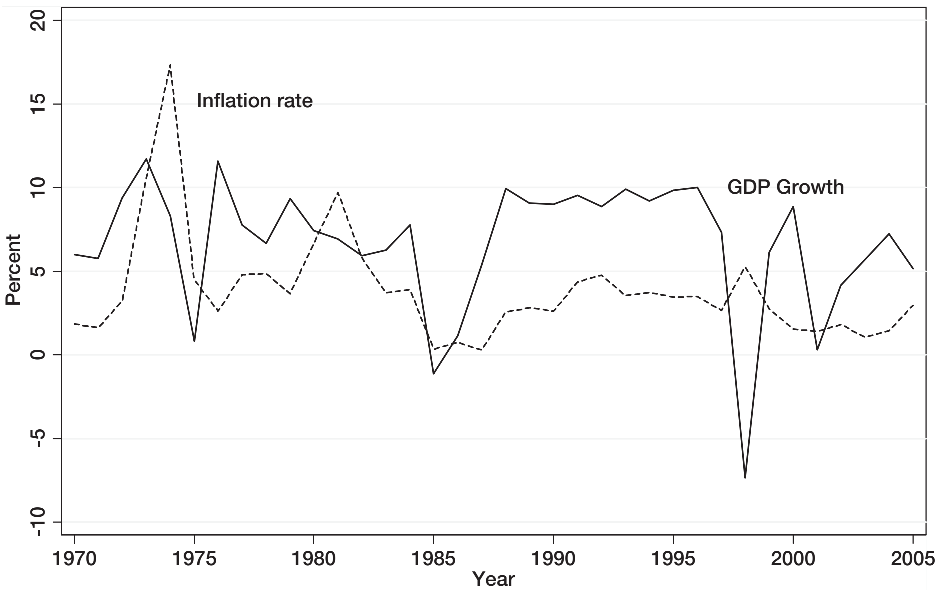
The remainder of this paper proceeds as follows. Section II provides information about the historical trends of inflation and economic growth in Malaysia. Section III presents econometric techniques to find the precise threshold levels for inflation rate, describes the data, and presents the summary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

II. Historical Trends of 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 the 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 at only 2 per cent while the growth rate of GDP was approximately 7 per cent. The GDP growth rate remained the same during the second half of the 1970s while inflation rate gradually increased to 4 per cent. The sharp oil price increase in 1973 and 1974 was the principal reason for the escalation of world inflation in 1973–74. Consequently, consumer prices in Malaysia began to rise and inflation had reached a double-digit level of 10.56 per cent by the end of 1973. In 1974, the surge in oil price by over 230 per cent added strong fuel to inflation, and the inflation rate in Malaysia increased to its record high of 17.32 per cent. A year later, the Malaysian economy slumped into its great

FIGURE 1
Relationship between Inflation Rate and GDP Growth



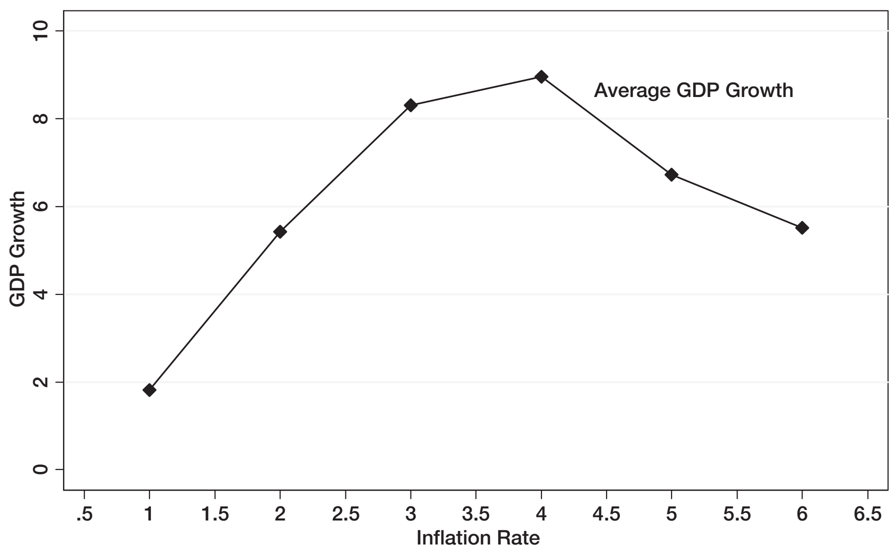
recession, with a GDP growth rate of only 0.8 per cent in 1975, compared with 8.3 per cent and 11.7 per cent in 1973 and 1974 respectively. On the other hand, inflation rate reduced to the level of 4.5 per cent in 1975.

Malaysia experienced a second episode of high prices in 1980 and 1981, which were due mainly to external factors. Oil prices rose by 47 per cent in 1979 and 66 per cent in 1981. As a result, inflation in Malaysia accelerated from 3.6 per cent in 1979 to 6.6 per cent and 9.7 per cent in 1980 and 1981 respectively. Consequently, GDP declined to 7.4 per cent and 6.9 per cent in 1980 and 1981 respectively, compared with 9.3 per cent in 1979. However, since 1982 inflation rate kept decreasing, and it amounted to less than 1 per cent in 1985 and 1986. The development of the Malaysian economy was at an important crossroad in 1985. The economic performance of the country slumped into its greatest recession: –1.1 per cent and 1.1 per cent growth rates were 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 of more than 9 per cent for three consecutive years, with inflation rate as low at 2.6 per cent, the economy in 1990 strengthened further in the country despite some slowing down of growth in the industrial countries.[1] Although inflation rate increased, on average, to 3.9 per cent during the period 1991–96, the growth rate of GDP continued to increase and reached 9.6 per cent. However, with the outburst of the financial crisis in Asia in 1997, 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 per cent placed an extremely powerful inflationary pressure on Malaysia. As a result, inflation rate increased to 5.3 per cent in 1998, compared with 2.7 per cent 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 per cent, compared with 7.3 per cent in 1997. Between 2000 and 2005, inflation rate stabilized and remained approximately around 1.7 per cent with relatively low growth rate of GDP of only 5.2 per cent.

Generally, Malaysian inflation rate is controlled by the government. Malaysia exhibits an exceptional feature in terms of inflationary experiences; the economy had experienced high (1973–74, 1980–81) and low (1985–87) regimes of inflation, and was able to contain a low and stable inflation during the high economic growth period of 1988–96. The achievement of this relatively low inflation during the high economic growth regime was attributed to the effective and consistent policy mix adopted by the Malaysian government (Cheng and Tan 2003, p. 423). Cheng and Tan (2003, p. 423) indicate that, besides domestic factors, which include private consumption, government expenditure, interest rate and money supply, external factors, such as increased fuel prices, also have a significant influence on Malaysian inflation resulting in a negative impact on growth. In order to test the threshold effect of inflation, Figure 2 provides a more direct view of the inflation–growth association by plotting the average GDP growth rate against average inflation rate. This analysis is done by reducing the whole sample of observations into six observations, according to the degree of inflation rate; by calculating average inflation rate and corresponding average growth rate of GDP within each range of inflation rate (i.e., inflation rate ≤ 1 per cent, 1 per cent < inflation rate ≤ 2 per cent, and so on). This data-reductioning procedure makes two key features of the data immediately apparent. First, it is clearly evident from Figure 2, that there is a non-linear relationship between inflation rate and growth rate of GDP. Second, this non-linearity shows positive relationship between inflation and growth up to 4 per cent level (approximately); and beyond that level there is negative relationship. The initial conclusion drawn from this analysis is that the threshold value is around 4 per cent. However, in the subsequent section, we employ new

FIGURE 2
Average GDP Growth and Inflation Rate



econometric techniques that provide appropriate procedures for estimation and inference for threshold effects.

III. Model Specification and Data

In this section, we present the data set used in this study with the descriptive statistics and correlation matrix of the variables. Further, we describe briefly the econometric methodology of the threshold estimation proposed by Hansen (2000).[2]

III.1 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 1970–2005. 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 to avoid potential multicollinearity problem, we include only those variables which are frequently used in the growth regression.[3] 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 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 (M2/GR)*. Following King and Levine (1993*a*, *b*), we used this explanatory variable as the index of financial depth in a country. This is constructed as an average annual percentage growth rate in money and quasi money to the GDP. 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 is 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.

Table 1 provides some summary statistics of the variables used in the paper. Malaysia's average inflation rate is approximately 3.84 per cent from 1970 to 2005, whereas in the same period Malaysia had maximum and minimum inflation rates of 17.33 per cent and 0.29 per cent respectively. Malaysia's average GDP growth during the same period was around 6.64 per cent, ranging from a maximum of 11.71 per cent and a minimum of –7.36 per cent. Table 2 reports the

TABLE 1
Summary Statistics of Variables

Variables	*Mean*	*Standard Deviation*	*Maximum*	*Minimum*	*Skewness*	*Kurtosis*
GDPGR	6.6411	3.8711	11.7142	–7.3594	–1.6773	6.2996
INFRATE	3.8442	3.2111	17.3289	0.29	2.4277	10.2247
M2GR	16.1948	16.6881	71.9121	–43.7382	0.0084	9.2894
GCFGR	9.2711	17.0137	36.4574	–43.0443	–0.8897	3.9368

TABLE 2
Correlation Matrix

	GDPGR	*INFRATE*	*M2GR*	*GCFGR*
GDPGR	1.0000			
INFRATE	0.2028			
M2GR	0.2831	0.4946	1.0000	
GCFGR	0.8281	0.3147	0.1841	1.0000

correlation matrix of the variables. All the explanatory variables, correlation coefficients range from 0.184 to 0.495, which are acceptable to avoid *multicollinearity* in the base regression.

III.2 Model Specification and Estimation Technique

We consider the following linear regression equation:

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

Where $GDPGR_t$ denotes real GDP growth rate; $INFRATE_t$ denotes inflation rate calculated from CPI; $M2GR_t$ denotes growth rate of money supply percentage of GDP as a proxy for financial sector depth; $GCFGR_t$ denotes growth rate of gross fixed capital formation as a proxy for investment rate; and u_t denotes the error term.

The regression equation (1) represents the standard linear 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, Levine and Smith 2001, p. 222). In other words, 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 studies by Hansen (1996; 2000) present some new results on the threshold autoregressive (TAR) model introduced 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 regimes, 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 TAR model:

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

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

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 equation (2). Similarly, when the threshold variable is larger than the threshold parameter, the model estimates equation (3).

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

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

Where, $\theta = \theta_2$, $\delta = \theta_1 - \theta_2$, and θ, δ, 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 $S_1(\gamma) = \hat{e}_t(\gamma)\hat{e}_t(\gamma)$. Hansen (2000, p. 577) recommend 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 $\hat{\gamma}$ = arg min $S_1(\gamma)$. Conditional on $\hat{\gamma}$, the regression equation is linear in θ and δ', yielding the conditional OLS estimates of $\hat{\theta}(\gamma)$ and $\hat{\sigma}(\gamma)$ by regression of dependent variable on explanatory variables.

Following the foregoing procedure, linear equation (1) can be expressed as a non-linear equation under a two-regime TAR model as follows:

$$\begin{aligned} GDPGR_t = {} & (\beta_{10} + \beta_{11}INFRATE_t + \beta_{12}M2GR_t \\ & + \beta_{13}GCFGR_t)\ d[q_t \leq \gamma] + \\ & (\beta_{20} + \beta_{21}INFRATE_t + \beta_{22}M2GR_t \\ & + \beta_{23}GCFGR_t)\ d[q_t > \gamma] + e_t^* \end{aligned} \quad (5)$$

In the estimation of model (5), the optimal threshold value is 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 (5) 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 5). The null hypothesis of no threshold effect ($H_0 : \beta_{1i} = \beta_{2i}$, where $i = 0,\ldots,5$) 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, p. 422) 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:

$$F_1 = \frac{S_0 - S_1(\gamma)}{\sigma^2} \quad (6)$$

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. Hansen (2000, p. 582) suggests a bootstrap technique to simulate the empirical distribution of the following likelihood ratio test:

$$LR_1(\gamma) = \frac{S_1(\gamma) - S_1(\hat{\gamma})}{\hat{\sigma}^2} \quad (7)$$

Where $S_1(\gamma)$ and $S_1(\hat{\gamma})$ are the sums of the squared residuals (SSR) under $H_0{:}\gamma = \gamma_0$, and $H_1{:}\gamma \neq \gamma_0$ respectively; and $\hat{\sigma}^2$ is the residual variance, expressed as $= \frac{1}{T}\hat{e}_t\hat{e}_t = \frac{1}{T}S_1(\hat{\gamma})$. The likelihood ratio statistics under the null is to reject for large values of $LR_1(\gamma_0)$.

In addition, Hansen (2000, p. 584) showed that the asymptotic distribution of the likelihood ratio statistics $LR_1(\gamma_0)$ is not normally distributed. The author computed valid asymptotic confidence intervals about the estimated threshold values by using their no-rejection region, $c(\alpha) = -2\ln(1-\sqrt{1-\alpha})$, where α is a given asymptotic level; and the no-rejection region of the confidence level is $1 - \alpha$. i.e., if $LR_1(\gamma_0) \leq c(\alpha)$ then 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.

IV. 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 3. The estimation results show that the null hypothesis of unit root is rejected at the 1 per cent level of significance in both tests, except *INFRATE*. In the ADF test, *INFRATE* is only significant at 10 per cent when the time trend not included. However, when PP test is applied, INFRATE become significant at 5 per cent levels. Therefore, generally results imply that the underlying variables show stationary process.

IV.1 Test Statistics for Existence of Threshold Effects

Table 4 presents the test results for the threshold effects with the annual growth rate of inflation employed as the threshold variable. The results of the threshold test and asymptotic *p-values* in our endogenous threshold analysis are obtained through 1,000 bootstrap replications to correct the standard errors of the estimates.

We first need to examine the existence of a threshold effect. The value of F_1 statistics is 25.74 with bootstrap p-value 0.02. Therefore, F_1 test strongly rejects the null hypothesis that there is no threshold at the 5 per cent significant level, suggesting one threshold at least. The estimated optimal threshold value is equal to 3.897 per cent which divides our sample in two groups (low inflation and high inflation groups) according to this variable. We further employ the F test to

TABLE 3
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)

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 per cent, 5 per cent, and 10 per cent levels respectively, based on the critical t statistics as computed by MacKinnon (1996).

TABLE 4
Summary of the Test Results of Threshold Effects

Test Hypothesis	*F test*	*Bootstrap P-Value*	*Threshold Estimates (%)*	*95% Confidence Interval*
Null of no threshold	25.74**	0.028	3.89727%	[1.844%, 4.358%]
Null of 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 per cent levels.

investigate the possibility of the existence of more than one threshold. The split produces insignificant bootstrap *p*-values, 0.516 (i.e., cannot reject the one threshold's null hypothesis). Therefore, the test procedure implies one threshold, which is 3.89 per cent, and, thus, two inflation regimes in the inflation-growth relation for Malaysia.

For comparison purposes, the estimation results are quite similar to the results reported in the studies of Sarel (1996), Khan and Senhadji (2001), Sepehri and Moshiri (2004), that is, structural break exists in the data. However, using time series data and endogenous TAR model, our estimated threshold value is quite different to these panel data studies. There is, however, an implicit assumption in these 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, p. 192) 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.[4]

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 per cent asymptotic confidence region is as [1.844 per cent, 4.358 per cent]. Figure 3 presents the normalized likelihood ratio sequence $LR^*_n(\gamma)$ statistics as a function of the inflation rate (*INFRATE*) threshold. As mentioned in section III, the least squares estimate of the threshold (γ) is the value that minimizes the function $LR^*_n(\gamma)$ and occurs at $\hat{\gamma}$ = 3.89727 per cent. The asymptotic 95 per cent critical value 7.35 (which is significant at 5 per cent levels) is shown by the dotted line and where it crosses $LR^*_n(\gamma)$ displays the confidence interval [1.844 per cent, 4.348 per cent]. This result implies that the threshold estimates are very precise. Thus, there is significant evidence supporting one threshold in the model.

These results show that there is strong evidence for a two-regime specification. Thus, the results confirm that there is a threshold at inflation rate for Malaysia, suggesting the data can be divided into two regimes.

IV.2 The Relationship between Inflation and Economic Growth

Table 5 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 linear regression equation (1) that ignores the threshold effect. Columns (2) and (3) provide estimates of the two-regime TAR model (7).

The empirical results obtained from the estimation of the linear model show that inflation rate has no significant negative impact on growth

FIGURE 3
First Sample Split: Confidence Interval Constructions for Threshold

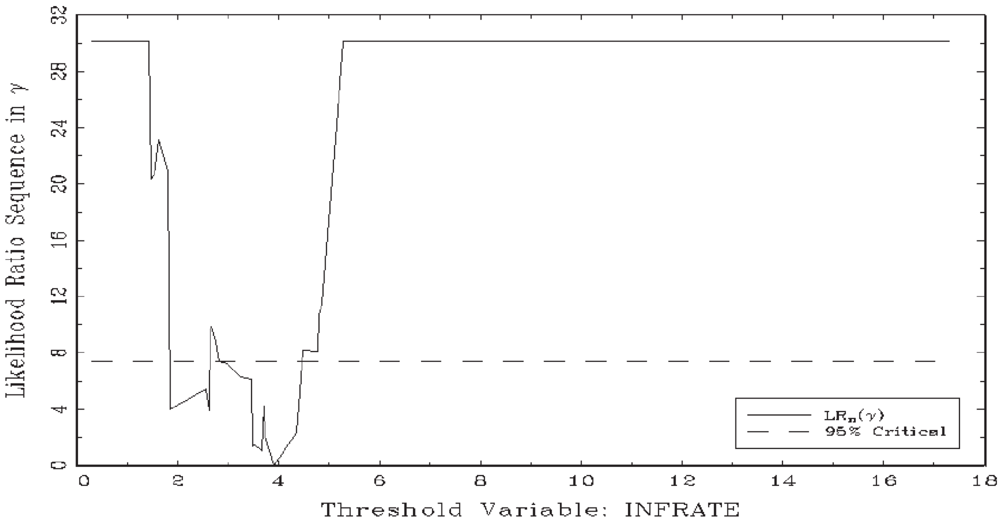


TABLE 5
Regression Results of Inflation Rate and GDP Growth (1970–2005)

Variables	*Linear Model*	*Threshold Model*	
	(OLS without threshold)	*Regime 1 ≤ 3.89727%*	*Regime 2 > 3.89727%*
Constant	4.8681^{***}	2.5966^{**}	4.1971^{***}
	–0.5751	–0.9507	–0.7046
INFRATE	–0.2001	1.2896^{***}	-0.3129^{**}
	–0.1354	–0.3813	–0.1029
M2GR	0.0488^{*}	0.0104	0.0787^{***}
	–0.0244	–0.0194	–0.0076
GCFGR	0.1915^{***}	0.1249^{***}	0.2076^{***}
	–0.0296	–0.0336	–0.0157
Observations	36	25	11
R^2	0.723	0.716	0.947

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

rate of GDP. Under low inflation regime, inflation rate below 3.897 per cent, inflation has significant positive impact on economic growth, where the significant coefficient is 1.289. Column (2) illustrates that, on average, a 1 per cent increase in inflation rate (*INFRATE*) in Malaysia leads to increase in the economic growth (*GDPGR*) by 1.3 per cent. However, in column (3), when inflation rate is higher than threshold level, 3.897 per cent, inflation has a significant negative effect on economic growth, as the coefficient is –0.312. Suggesting that, on average, a 1 per cent increase in inflation rate leads to a decline in the economic growth by 0.312 per cent. The estimated coefficients, in two-regime models, of *INFRATE* not only differ statistically from zero but are also highly significant at p < 10. The estimated non-linear relationship between inflation and economic growth is quite 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. In addition, the estimated coefficients on *GCFGR* (investment rate) show a positive and statistically significant relationship with *GDPGR* (growth rate of GDP) in the linear model as well as the TAR mode. Furthermore, financial depth (*M2GR*) has a positive and significant effect on economic growth (except in low inflation regime for which *M2GR* is statistically insignificant) in linear model as well as in high inflation regime.

V. Conclusions

This paper re-examines the issue of the existence of threshold effects in the relationship between inflation and growth using new econometric methods 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 per cent. However, inflation is detrimental to economic growth when it is above the threshold level, i.e., 3.89 per cent.

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 help in maintaining sustainable growth. Using the structural break technique, this study show that the effect of inflation rate on economic growth is not only negative in a high-inflation environment, but in a low-inflation environment, it can also be positive and more significant. Thus, a substantial increase in growth can be achieved by focusing the monetary policy towards maintaining price stability. A low and stable price environment in Malaysia may enable the economy to further recover and take off. The stable price environment provides a great deal of flexibility for the Government to continue to implement stimulating and expansionary macroeconomic policies without worrying too much about price pressure.

Finally, in the current scenario of the Malaysian economy, the results derived from this study are very important for policy-makers; soaring oil costs are forcing Malaysia to raise fuel prices by reducing the subsidies on fuel consumption up to 40 per cent, a move that is expected to lift the inflation rate to 5 per cent. In this case, as our results suggest, inflation rate beyond 3.89 per cent may adversely affect economic growth, resulting in weaker consumer spending and business investment.

NOTES

The authors would like to thank the referees and co-editors of the bulletin for their constructive comments on the early versions of the paper. All remaining errors are ours.

1. The outbreak of hostilities in the Gulf on 1990 as a result of the Iraqi invasion of Kuwait 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. The immediate impact of the third oil crisis in 1990 has been an increase of inflationary pressure in both the industrial and developing countries (Ministry of Finance Malaysia 1990).
2. 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. Other potential explanatory variables, population growth, foreign direct investment, trade openness, and exports of goods and services, etc., are found insignificant in the regression. Furthermore, the proxies for human capital variables, secondary school enrollment rate, the average years of secondary schooling of the total population, etc., are important explanatory variables in the growth model. However, in the existing datasets for education, such as World Development Indicators, Barro-Lee, such variable is not available for annual basis from 1970 to 2005. Therefore, we restrict to very few variables in the sample dataset.
4. 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.

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