The Dynamics Relationship Between Inflation And Economic Growth In Indonesia: A Regional Thresholds Approach[1]

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Abstract

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 Indonesia. This analysis uses a dynamic panel threshold model to estimate inflation thresholds for long-term economic growth. Advancing on Hansen (1999) and Caner and Hansen (2004), this model allows the estimation of threshold effects with panel data even in case of endogenous regressors. The empirical analysis is based on annual panel-data set including 26 provinces in Indonesia for the period 2002–2012. A specific question addressed in this research was: What is the threshold inflation rate for Indonesia? The findings clearly suggest that one inflation threshold value (i.e., structural break point) exists for Indonesia; and this implies a non-linear relationship between inflation and growth. The estimated threshold regression model suggests 4.62 *percent 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 Indonesia (Central Bank of Indonesia) pays more attention to the inflation phenomena, then substantial gains can be achieved in low-inflation environment while conducting the policy mix.*

Keywords: Inflation Thresholds, Inflation and Growth, Dynamic Panel, structural break, provinces, Indonesia.

JEL classification: E31, C23, O40

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1. 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 favors 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 nonlinearities 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 percent 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 regional panel data for Indonesia over the period 2002–2012. Particularly, the questions that are addressed in this paper are: (1) Is there any threshold level of inflation in the case of Indonesia 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 a*dvancing on Hansen (1999) and Caner and Hansen (2004)*. The remainder of this paper proceeds as follows. Section 2 provides econometric techniques to find the precise threshold levels for inflation rate. Section 3 describes the data. Section 4 provides the estimation results and discussions. Last but not the least, section 5 offers some concluding remarks and proposes possible extensions for future research on the topic.

2. A Dynamic Panel Threshold Model

2.1 The Econometric Model

This section develops a dynamic panel threshold model that extends Hansen's (1999) original static set up by endogenous regressors. In our empirical application where we analyze the role of inflation thresholds in the relationship between inflation and economic growth (yit = dgpdit), the endogenous regressor will be initial income (gdpit−1). Our model extension builds on the cross-sectional threshold model of Caner and Hansen (2004) where GMM type estimators are used in order to allow for endogeneity. To that aim, consider the following panel threshold model:

$$\boldsymbol{y_{it} = \mu_i + \beta_1 z_{it} I\,(q_{it} \leq \gamma) + \beta_2 z_{it} I\,(q_{it} > \gamma) + \varepsilon_{it}} \text{..........}\mathbf{(1)}$$

where subscripts i = 1, . . . ,N represents the country and t = 1, . . . , T indexes time. μ_i is the country specific fixed effect and the error term is $\boldsymbol{\varepsilon_{it}}$ ~ (0, $\boldsymbol{\sigma}^2$). I(·) is the indicator function indicating the regime defined by the threshold variable qit and the threshold level γ . zit is a m-dimensional vector of explanatory regressors which may include lagged values of y and other endogenous variables. The vector of explanatory variables is partitioned into a subset z_{1it}, of exogenous variables uncorrelated with $\boldsymbol{\varepsilon_{it}}$, and a subset of endogenous variables $\mathbf{z_{2it}}$**,** correlated with $\boldsymbol{\varepsilon_{it}}$. In addition to the structural equation (1) the model requires a suitable set of **k ≥ m** instrumental variables x_{it} including z_{1it}.

2.2 Fixed-Effects Elimination

In the first step of the estimation procedure, one has to eliminate the individual effects $\boldsymbol{\mu_i}$ via a fixed-effects transformation. The main challenge is to transform the panel threshold model in a way that eliminates the country-specific fixed effects without violating the distributional assumptions underlying Hansen (1999) and Caner and Hansen (2004), compare Hansen (2000). In the dynamic model (1), the standard within transformation applied by Hansen (1999) leads to inconsistent estimates because the lagged dependent variable will always be correlated with the mean of the individual errors and thus all of the transformed individual errors. First-differencing of the dynamic equation (1) as usually done in the context of dynamic panels implies negative serial correlation of the error terms such that the distribution theory developed by Hansen (1999) is not applicable anymore to panel data.

In view of these problems, we consider the forward orthogonal deviations transformation suggested by Arellano and Bover (1995) to eliminate the fixed effects. The distinguishing feature of the forward orthogonal deviations transformation is that serial correlation of the transformed error terms is avoided. Instead of subtracting the previous observation from the contemporaneous one (first-differencing) or the mean from each observation (within transformation), it subtracts the average of all future available observations of a variable. Thus, for the error term, the forward orthogonal deviations transformation is given by:

$$\varepsilon_{it}^{*} = \sqrt{\frac{T-t}{T-t+1}}\left[\varepsilon_{it} - \frac{1}{T-t}(\varepsilon_{i(t+1)} + \ldots + \varepsilon_{iT})\right] \ldots\ldots\ldots (2)$$

Therefore, the forward orthogonal deviation transformation maintains the uncorrelatedness of the error terms, i.e.

$$Var(\varepsilon_i) = \sigma^2 I_T \rightarrow Var(\varepsilon_i^*) = \sigma^2 I_{T-1}$$

In accordance with Hansen (2000), this ensures that the estimation procedure derived by Caner and Hansen (2004) for a cross-sectional model can be applied to the dynamic panel equation (1).

2.3 Estimation

Following Caner and Hansen (2004), we estimate a reduced form regression for the endogeneous variables, $\mathbf{z_{2it}}$, as a function of the instruments $\mathbf{x_{it}}$. The endogenous variables, z_{2it}, are then replaced in the structural equation by the predicted values $\hat{Z}_{2it}$. In step two, equation (1) is estimated via least squares for a fixed threshold γ where the z_{2it}'s are replaced by their predicted values from the first step regression. Denote the resulting sum of squared residuals by $S(\gamma)$. This step is repeated for a strict subset of the support of the threshold variable q from which in a third step the estimator of the threshold value γ is selected as the one associated with the smallest sum of squared residuals, that is $\hat{\gamma}$ = argmin $S_n(\gamma)$.

In accordance with Hansen (1999) and Caner and Hansen (2004), the critical values for determining the 95% confidence interval of the threshold value are given by

$$\Gamma = \{\gamma : LR(\gamma) \leq C(\alpha)\},$$

where C(α) is the 95% percentile of the asymptotic distribution of the likelihood ratio statistic LR(γ). The underlying likelihood ratio has been adjusted to account for the number of time periods used for each cross section, see Hansen (1999). Once $\hat{\gamma}$ is determined, the slope coefficients can be estimated by the generalized method of moments (GMM) for the previously used instruments and the previous estimated threshold $\hat{\gamma}$.

3. Data and Variables

Our empirical application of the dynamic panel threshold model to the inflation-growth nexus is based on a balanced panel-data set of 26 provinces in Indonesia. The data of provinces are identified in accordance with the Indonesia's National Statistical Office (BPS) and shown in Table 3 in the Appendix A.1. This research uses annual panel data from 2002 to 2012 and obtained from BPS. For each province, annual growth rates of real GDP are in constant 2000 prices (dgdp). Inflation is computed as the annual percentage change of the Consumer Price Index (π).

3.1 Control Variables

Any empirical analysis of inflation's impact on economic growth has to control for the influence of other economic variables that are correlated with the rate of inflation. Following Khan and Senhadji (2001) and Drukker et al. (2005), we consider the population growth rate (dpop), the initial income level (initial) measured as GDP per capita from the previous period and openness (open) measured as the share of exports plus imports in GDP. The annual percentage change in the terms of trade (dtot) is measured as prices of exports divided by prices of imports. These variables are obtained from BPS. However, instead of the percentage of GDP dedicated to investment (igdp) we use the loan growth rate (dloan), and this variable taken from Bank Indonesia data. More information about the control variables is contained in Table 2 in the Appendix. All these variables passed the robustness tests of Levine and Renelt (1992) and Sala-i-Martin (1997).

3.2 Inflation

In the case of inflation, Ghosh and Phillips (1998) strongly suggest the use of logged inflation rates to avoid that regression results are distorted by a few extreme inflation observations. Moreover, using logged inflation rates has the plausible implication that multiplicative, not additive, inflation shocks will have identical growth effects. Since our sample contains negative inflation rates, we follow Drukker et al.(2005) and Khan and Senhadji (2001) by employing a semi-log transformation of the inflation rate π_{it} .

$$\tilde{\pi}_{it} = \begin{cases} \pi_{it} - 1, & if\ \pi_{it} \le 1 \\ \ln(\pi_{it}), & if\ \pi_{it} > 1 \end{cases}$$

where inflation rates below one are re-scaled for sake of continuity.

4. Inflation Thresholds and Growth

Let us now apply the dynamic panel threshold model to the analysis of the impact of inflation on long-term economic growth in provinces of Indonesia. To that aim, consider the following threshold model of the inflation-growth nexus:

$$dgdp_{it} = \mu_i + \beta_1 \tilde{\pi}_{it} I\ (\tilde{\pi}_{it} \le\ \gamma) + \delta_1 I\ (\tilde{\pi}_{it} \le\ \gamma) + \beta_2 \tilde{\pi}_{it} I\ (\tilde{\pi}_{it} >\ \gamma) + \emptyset z_{it} + \varepsilon_{it} \text{....(3)}$$

In our application, inflation $\tilde{\pi}_{it}$ is both, the threshold variable and the regime dependent regressor. z_{it} denotes the vector of partly endogenous control variables, where slope coefficients are assumed to be regime independent. Following Bick (2010), we allow for differences in the regime intercepts (δ_1). Initial income is considered as endogenous variable, i.e. z2it = initialit = gdpit−1, while z1it contains the remaining control variables.
Following Arellano and Bover (1995), we use lags of the dependent variable (dgdpit−1, . . . , dgdpit−p) as instruments. Empirical results may depend on the number (p) of instruments, Roodman (2009). In particular, there is a bias/efficiency trade-off in finite samples. Therefore, we considered two empirical benchmark specifications. On the one hand, we use all available lags of the instrument variable (p = t) to increase efficiency, see Table 1. On the other hand, we reduced the instrument count to one (p = 1) to avoid an overfit of instrumented variables that might lead to biased coefficient estimates. According to Table 5 in the Appendix, the choice of instruments has no important impact on our results.

Table 1: Inflation Thresholds and Growth

	INDONESIA
Threshold estimates	
$\tilde{y}$	4.616
95% confidence interval	[4.61 - 4.71]
Impact of inflation	
$\hat{\beta}_1$	1.429

$\hat{\beta}_2$	-0.105
Impact of covariates	
$initial_{it}$	2.227
$dloan_{it}$	0.143
$dpop_{it}$	0.00041
$dopen_{it}$	1.319
$dtot_{it}$	-0.0063
$\hat{\delta}_1$	-3.448
Observations	286
N	26

Notes: This Table reports results for the dynamic panel threshold estimation as described in Section 2 using all available lags of the instrument variable, i.e. {dgdpit−1, dgdpit−2, . . . , dgdpi0}. Following Hansen (1999), each regime contains at least 5% of all observations. For Indonesia, feasible inflation thresholds are, therefore, between 4.61 and 4.71. Standard errors are given in parentheses.

Table 1 shows the results obtained for Indonesia provinces. The upper part of the table displays the estimated inflation threshold and the corresponding 95% confidence interval. The middle part shows the regime-dependent coefficients of inflation on growth. Particularly, $\hat{\beta}_1$ denotes the marginal effect of inflation on growth in the low inflation regime, i.e. when inflation is below the estimated threshold value. $\hat{\beta}_2$ denotes the marginal effect of inflation on growth in the high inflation regime, i.e. when inflation is above the estimated threshold value. The coefficients of the control variables are presented in the lower part of the table.

4.1 The Inflation-Growth Nexus in Indonesia

The results for the empirical relation between inflation and economic growth in Indonesia based on the first benchmark specification are presented in the Table 1. The estimated inflation threshold of 4.616% as well as the marginal effects of inflation on growth strongly support the prevailing inflation targets of Bank Indonesia. First, the 95% confidence interval ([4.61, 4.71]) indicates that the critical value of inflation for Indonesia is clearly lower than the 40% proposed by Bruno and Easterly (1998). Second, both regime-dependent coefficients of inflation are significant and plausibly signed. Inflation is positively correlated with economic growth in Indonesia if below the threshold ($\hat{\beta}_1$=1.429), while the opposite is true for higher inflation ($\hat{\beta}_2$ = -0.105). The absolute size of the inflation coefficients suggest that correlation between inflation and economic growth of Indonesia is stronger when inflation is low. According to the 95% confidence intervals, this conclusion holds at least for inflation rates ”below but close to 5%”. It is worth emphasizing that our results are robust with respect to the choice of instruments, see Table 5 in the Appendix. The only notable exception refers to the confidence interval of the inflation threshold. If the instrument count is reduced to one, estimation is less efficient and the 95% confidence interval of the inflation threshold widens to [1.38, 5.50]. As a consequence, the evidence on the long-run growth effects of inflation rates around 5% must be viewed with caution.

5. Concluding Remarks

This paper provided new evidence on the non-linear relationship between inflation and long-term economic growth. To that aim, we built on Hansen (1999) and Caner and Hansen (2004) and developed a dynamic threshold model that allows for endogeneous regressors in a panel setup. Applying the forward orthogonal deviations transformation suggested by Arellano and Bover (1995) ensured that the original distribution theory of the threshold model applied to static panels as in Hansen (1999) is still valid in a dynamic context.

Applying the dynamic regional panel threshold model to the analysis of thresholds in the inflation-growth nexus of Indonesia, confirmed the general consensus among economists. In particular, our empirical results suggest that inflation distorts economic growth provided it exceeds a certain critical value. For the case of Indonesia, our results support the inflation targets of about 5% which are more or less explicitly announced by Bank Indonesia. Contributing to the recent discussion on the appropriate level of inflation targets stirred by Blanchard et al. (2010), we estimated that inflation rates exceeding a critical value of 5% are negatively correlated with economic growth. Inflation rates above this threshold come along with significantly lower growth rates.

However, policy conclusions based on reduced form estimates have to be viewed with caution. In particular, the estimated inflation-growth nexus does not necessarily reflect causality but rather correlation. Yet, significant inflation thresholds in the empirical relationship between inflation and growth may provide a useful guideline for further research on the impact of inflation on growth. Lin and Ye (2009), for example, show that the performance of inflation targeting in developing countries can be affected by further country characteristics. Accordingly, inflation thresholds in developing countries and, thus, the appropriate level of the inflation target might be also country-specific. The identification of country-specific inflation thresholds in the inflation-growth nexus might provide useful information about the appropriate location and width of an inflation targeting band.