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Inflation and Economic Growth:
A Dynamic Panel Threshold Analysis for Asian Economies

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Abstract: This paper investigates the existence of a threshold level for inflation and how any such level affects the growth of Asian economies. We used dynamic panel threshold growth regression, which allowed us to work with fixed effect and endogeneity issues. We observed a nonlinear relationship between inflation and economic growth for 32 Asian countries over the period 1980–2009. We detected an inflation threshold of approximately 5.43%, at a 1% level of significance. We found that inflation hurts growth when it exceeds 5.43% but has no effect below this level. Different estimation methods determined that the effect of inflation on growth is robust. Our findings may be useful to central banks as a guide for inflation targeting.

Keywords: Dynamic panel threshold model; economic growth; inflation; inflation thresholds.

JEL Classification: C23, O40, E31

1 Introduction

A sustained high growth rate of output and low inflation are the two main goals of the majority of macroeconomic policies. Price stability is a key factor in determining the growth rate of an economy. Many countries central Bank have adopted to maintain inflation in desirable rate through monetary policy transmission mechanism. Very high inflation affects the economy drastically, but there is some evidence that moderate inflation also slows down growth (Temple [36] cited from Little et al., 1993). In addition, Aiyagari [1], as well as Cooley and Hansen [12], suggest that the cost of lowering inflation toward zero is higher than the benefit.

In recent decades, there has been substantial theoretical and empirical research that investigates the inflation/growth trade-off. The results of existing research have been mixed and studies can be categorized as making one of four possible predictions, based on their findings. The first of these is that inflation has no effect on economic growth (e.g., Dorrance [14], Sidrauski [34], Cameron, Hum, and Simpson [10]). The second is that there is positive relationship between inflation and economic growth (e.g., Tobin [37], Shi [33], Mallik and Chowdhury [28]). The third is that inflation has a negative effect on growth (e.g., Friedman [18], Stockman [35], De Gregorio [13], Gylfason ([20], [21]), Barro [5], Andrés and Hernando [2], Saeed [31]). In addition, Feldstein [16] notes that "shifting the equilibrium rate of inflation from 2 to 0 percent would cause a perpetual welfare gain equal to about one percent of Gross Domestic Product (GDP) a year."

The last of the four types of studies suggests that the correlation between inflation and growth is nonlinear, and that interaction between these two variables is positive or nonexistent below some critical level, but affects the economy when it exceeds that level. Fischer [17] was one of the first authors to identify the possibility of such a non-linear relationship. He argued that inflation helps economic growth when it is below a threshold value, but has a negative influence if it is above that threshold level. Sarel [32] demonstrated the existence of point of inflection, which is equal to 8%. Ghosh and Phillips [19] identified a considerably lower threshold effect, at 2.5% inflation rate a year. In contrast, Bruno and Easterly [9] determined that 40% was the "natural" breakeven point between low and high inflation rate for 31 countries. Countries were examined based on their level of inflation crisis during a set period, and the authors demonstrated that high inflation crises lead to sharp decreases in growth rates, which recover when inflation falls.

Khan and Senhadji [25] calculated the threshold as being 1%–3% for industrialized countries and 11%–12% for developing countries. They claimed that inflation impedes economic growth significantly beyond this level but does not have any statistically significant effect below the threshold, even if it is positive. Drukker et al. [15] suggested that 19.16% is the critical threshold for 138 countries (full sample), but that there were two different threshold points, 2.57% and 12.61%, for industrialized countries. Bick [6] concluded that inclusion of difference in intercept regime decreases the threshold from 19% to 12% and doubles the magnitude and marginal effect of inflation on growth. Kremer, Bick, and Nautz [27] found that the threshold level is different for industrialized and developing countries, and stated that target inflation is 2% for developed countries and 17% for developing countries.

Most existing empirical work includes both industrialized and developing countries from different regions in samples. However, Temple [36] has noted that "One should probably be careful about extrapolating findings from one set of countries to another." He suggests that "In general, it would seem best to study inflation's effect within OECD or a sample of relatively similar developing countries and not mix the two." With this in mind, in this study, we consider only Asian countries.[1]

Moreover, most of the growth empirics, which seek to identify a threshold level of inflation, are found through approaches that explicitly ignore any potential endogeneity bias (Khan and Senhadji [25], Bick [6]). Some empirical literature, however, solves the problem of endogeneity bias by excluding initial income from growth regression (Drukker et al.

[1]Our sample does, however, consist of four OECD countries (Japan, Korea, Israel, and Turkey) and one developed country (Singapore). We have thus also dropped these five countries from our analysis and re-calculated the threshold point and its effect on economic growth to check the robustness of our result.

[15]). Hansen [22] has assumed that all variables are exogenous in his panel threshold model.[2] However, with regard to the panel data growth regression, we are uncertain about exogeneity restrictions, because some of the explanatory variables are endogenous by construction, such as initial income. Caselli, Esquivel, and Lefort [11] propose that estimates are inconsistent in cross-country growth regression for two reasons: (i) country-specific fixed effects and (ii) the inclusion of endogenous variables among explanatory regressor in the model. In our model setup, we have considered these two issues to obtain consistent estimates. Therefore, the issue of endogeneity bias has been reduced in this growth regression.

Less developed countries (LDCs) often suffer from macroeconomic instability and rely on international agencies such as the World Bank, International Monetary Fund, or Asian Development Bank in order to stabilize their economies. Different agencies have come up with different guidelines and suggestions, such as reducing or increasing prices, in many cases without proper coordination with each other. This makes it harder for policy-makers to determine the levels of inflation that Asian countries should maintain to stabilize their economies.

This article employs the dynamic panel threshold model to deal with country-specific heterogeneity and endogeneity issues. As suggested by Arellano and Bover [4], we apply the forward orthogonal deviation operator to eliminate the individual fixed effect, and use an entire set of lags of the initial income as instruments to deal with the issue of endogeneity, based on Roodmans' [30] "collapsed–form" generalized method of moment (GMM) style instruments. Our study estimates the potential threshold point, and investigates the effect of inflation on economic growth, for 32 Asian countries over the period 1980–2009. The sample size has been reduced by taking the average of the data for each two years in order to eliminate fluctuations in the business cycle.

[2] Kremer et al. [27] have considered initial income as an endogenous variable in their growth regression, but their sample includes both industrialized and developing countries.

Our empirical results support existing evidence of nonlinear correlation between inflation and growth. Our estimated threshold is 5.43%, which is statistically different from existing empirical research findings, which range from 8% to 40% for developing economies and 1% to 3% for industrialized economies (Bruno and Easterly [9], Khan and Senhadji [25], Bick [6], Kremer et al. [27]). We find that inflation impedes growth significantly when it exceeds 5.43%.

Below, section 2 explains the data and variables of our study. Section 3 describes the construction of the dynamic panel threshold model and our estimation method. Section 4 provides an estimation result for the model. Finally, our conclusion and the policy implications of this study are presented in section 5.

2 Data and Variables

To determine the potential threshold point and estimate the impact of inflation on the growth rate of output, using the dynamic panel threshold model, we use balanced panel data[3] from the World Development Indicator (WDI), Penn World Table (PWT) 6.3 and 7.0, and the Economy Watch (EW) database for 32 Asian countries (see Table 1 in appendix A1 for a list of countries and summary statistics). Our dataset covers the period from 1980 to 2009[4]. Table 2 in appendix A1 shows the variables that are used in our growth regression, definition, and data source. This article uses 2-year averages from the data to smooth out business cycle fluctuations, reducing the time dimension from 30 to 15 observations.

According to Table 2 (see appendix A1), the average value of the inflation rate over the sample period was 12.6%, which is much lower than that given in some previous growth empirics.[5] Figure 1a (see appendix A2) reveals that the distribution of inflation is asymmetric. Thus, following Sarel [32] and Ghosh and Phillips [19], we use the log of

[3] Khan and Senhadji [25], Drukker et al. [15], and Kremer et al. [27] have used unbalanced panel data to analyze the existence of threshold and nature and link between inflation and economic growth for 140, 138, and 124 countries (both industrialized and developing), respectively. Conversely, Bick [6] used balanced panel data for 40 developing countries.

[4] Since we want to have a balanced dataset and data in some countries is produced with a lag, we only cover the period until 2009.

[5] For example, Kremer et al. [27] computed an average value of inflation of 33.64% for 101 developing countries, while Khan and Senhadji [25] found an average inflation rate of 28.06 % among 140 countries.

inflation instead of a level. Those authors suggest that log transformation eliminates strong asymmetry in the initial distribution of inflation, at least partially, and provides the best fit among nonlinear models. Our sample includes some negative inflation observations, and we prohibit the use of log of inflation. To deal with negative inflation observations, we use a semi-log transformation, following Khan and Senhadji [25]. The transformation involved is

$$\tilde{\pi}_{it} = \begin{cases} (\pi_{it} - 1), if\ \pi_{it} \leq 1 \\ \log(\pi_{it}), if\ \pi_{it} > 1 \end{cases} \quad (1)$$

where $\tilde{\pi}_{it}$ denotes a continuous function that allows us to take into account both positive and negative inflation observations. Hence, $\tilde{\pi}_{it}$ is a hybrid function of inflation that is linear for inflation $\leq$ 1and logarithmic for inflation $>$ 1. Semi-logged transformation implies that the distributions of inflation rates are symmetrical and in line with the normal distribution (see Figure 1b in appendix A2).

3 Econometric Framework

In this empirical study, we work with a dynamic panel threshold model, which takes the following form:

$$y_{it} = \mu_i + \beta_1 \tilde{\pi}_{it} d(\tilde{\pi}_{it} \leq \gamma) + \beta_2 \tilde{\pi}_{it}(1 - d[\tilde{\pi}_{it} > \gamma]) + \theta' x_{it} + \varepsilon_{it} \quad (2)$$

where $\{y_{it}, x_{it}, \pi_{it}: 1 \leq i \leq N, 1 \leq t \leq T\}$, and ε_{it} is the error term with 0 mean and not serially correlated. The dependent variable y_{it} is the growth rate of real GDP per capita of country i at time t, μ_i is a country-specific fixed effect, $\tilde{\pi}_{it}$ is a threshold variable that is exogenous and a time variant, γ is the threshold level of inflation, and *d*(.) represents the indicator function, taking on a value of either 1 or 0, depending on whether the threshold variable is less or more than the threshold level. This effectively splits the sample observations into two groups, one with slope β_1 and another with slope β_2. X_{it} is the *k*-dimensional vector of explanatory variables, which can be divided into two parts: (i) predetermined variables,[6] where we assume initial income ($x_{it}^{1} = initial_{it} = gdppc_{it-1}$) to be a predetermined regressor, and (ii) exogenous variables, ($x_{it}^{2} = \{inv_{it},\ gpop_{it},\ open_{it}, tot_{it},\ sdopen_{it},\ sdtot_{it}\}$), which are uncorrelated with ε_{it}. We have chosen these control variables based on the existing empirical studies that use similar covariates (e.g., Kremer et al. [27], Bick [6], Drukker et al. [15], Khan and Senhadji [25]).

3.1 *Elimination of Fixed Effect*

In our first stage, we eliminate the country-specific fixed effects μ_i from the model to estimate the slope coefficients and potential threshold point. Nickell [29] and Bond [8] suggest that within-group transformation does not eliminate dynamic panel bias because the transformed lagged dependent variable ($x_{it}^{1^*}$) negatively correlates with the transformed error term(ε_{it}^{*})[7]. This motivated us to use another common transformation method called "forward orthogonal deviation," which was proposed by Arellano and Bover [4]. We have applied forward orthogonal deviation transformation to eliminate individual fixed effects. Therefore, for the error term, the required transformation is given by

$$\varepsilon_{it}^{*} = c_t \left[\varepsilon_{it} - \frac{1}{(T-t)}(\varepsilon_{i(t+1)} + \cdots + \varepsilon_{iT})\right] \tag{3}$$

where $c_t = \sqrt{\frac{T-t}{T-t+1}}$ and $Var(\varepsilon_{it}) = \sigma^2 I_T$ is not serially correlated and $Var(\varepsilon_{it}^{*}) = \sigma^2 I_{T-1}$ with also has no serial correlation. Applying this procedure to equation (2) yields:

$$y_{it}^{*} = \beta_0 + \beta_1 \tilde{\pi}_{it}^{*} d(\tilde{\pi}_{it} \leq \gamma) + \beta_2 \tilde{\pi}_{it}^{*}(1 - d[\tilde{\pi}_{it} > \gamma]) + \theta' x_{it}^{*} + \varepsilon_{it}^{*} \tag{4}$$

where $t = 1, \ldots, T-1$ and superscript * denotes data after the transformation.

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[6] Predetermined variables: The current error term is uncorrelated with the current and past values of the predetermined variable but may be correlated with future values, that is, $E(\varepsilon_{is}|x_{it}^{1})\begin{cases}\neq 0 & if \quad s < t \\ = 0 & otherwise\end{cases}$. For example, in our growth model with rational expectations, initial income is predetermined. As such, unpredictable income shock is uncorrelated with past (and potentially current) GDP per capita, but certainly correlated with future GDP per capita.

[7] Where $(x_{it}^{1^*}) = x_{it}^{1} - \frac{1}{T-1}(x_{i2}^{1} + \cdots + x_{iT}^{1})$ and $\varepsilon_{i,t}^{*} = \varepsilon_{i,t} - \frac{1}{T-1}(\varepsilon_{i,2} + \cdots + \varepsilon_{i,T})$

3.2 *Dealing with Endogeneity*

Structural equation (2) requires a set of suitable instruments to solve the problem of endogeneity. We use lags of initial income as instruments for the predetermined regressor. For transformed initial income, $(x_{it}^{1^*})$, we use the untransformed value x_{it}^1. As there are no clear guidelines regarding identification restrictions, by following Roodmans' [30] collapsed-form instrument method, we use the following $(T-1)$ moment condition, in other words employing the entire available set of lags as instruments:

$$E(x_{it}^1, \varepsilon_{it}^*) = 0 \quad \text{where } t = 2, \dots, T-1$$

We then estimate the instrumental variable parameter, or 2SLS estimator, through a two-step procedure. In the first step, we construct a reduced-form regression for the endogenous variable, $\left(x_{it}^{1^*}\right)$, as a function of the instruments z_{it} and all exogenous variables

$$x_{it}^{1^*} = \lambda_0 + \lambda_1^{'} \sum_{j=1}^{T} z_{i,t-j} + \lambda_2 \tilde{\pi}_{it}^* d(\tilde{\pi}_{it} \leq \gamma) + \lambda_3 \tilde{\pi}_{it}^* (1 - d[\tilde{\pi}_{it} > \gamma]) + \theta^{'} (x_{it}^2)^* + v_{it} \qquad (5)$$

where $E(v_{it}, z_{it}) = 0$. Then, we compute the reduced-form parameter, λ, by the least-square method, and the fitted value of endogenous variable, $\hat{x}_{it}^{1^*}$. Following that, we replace $x_{it}^{1^*}$ with its fitted value $\hat{x}_{it}^{1^*}$ in equation (4), which can be written as

$$y_{it}^* = \beta_0 + \rho \hat{x}_{it}^{1^*} + \beta_1 \tilde{\pi}_{it}^* d(\tilde{\pi}_{it} \leq \gamma) + \beta_2 \tilde{\pi}_{it}^* (1 - d[\tilde{\pi}_{it} > \gamma]) + \theta' x_{it}^{2*} + \varepsilon_{it}^* \qquad (6)$$

In the second step, we estimate the instrumental variable parameter, $\hat{\beta}_{iv}$, from equation (6) for any given threshold γ. Then, we find the residual sum of square (RSS) as a function of γ.

$$\hat{\varepsilon}_i = Y - X\hat{\beta}_{IV} \qquad (7)$$

$$S(\gamma) = \hat{\varepsilon}_i' * \hat{\varepsilon}_i \qquad (8)$$

where S is the residual sum of square.

3.3 *Computation of Threshold Value and its Impact on Growth*

In the third step, the threshold level of inflation is calculated by using the conditional least-square method. To estimate the threshold γ, we repeat the procedure described above by changing the threshold level of inflation ranging from $\underline{\gamma}\ to\ \overline{\gamma},$ with a decimal value of increment. Finally, the threshold value γ is selected as the value associated with the smallest RSS. The minimization search takes form as

$$\hat{\gamma} = \underset{\gamma}{argmin}\, S_n(\gamma) \tag{9}$$

In practice, the length of inflation may be an unusually large number. If we consider the full length of inflation to search for the optimum threshold level, the optimization search method described above may lead to a numerically intensive process. Hansen [23] suggests narrowing the range of values of inflation by searching for the optimal threshold, which is the region where we expect value to be. In addition, Hansen [22] proposes that this search should be restricted to a smaller set of values of threshold, instead of to the overall values of π_{it}, using a set increment that can be integer-valued. With this in mind, we employ a graphical analysis to determine the range of inflation (see Figure 1b in appendix A2) and optimum threshold level, before minimizing the RSS.

Once the threshold value of $\hat{\gamma}$ is determined, in the second stage, we estimate the slope coefficients ($\beta_1$and β_2), and the impact of other control variables on growth from structural equation (2) in levels using GMM.[8] In this case, we apply the previously used instruments and previous estimated threshold $\hat{\gamma}$. We can test whether the threshold level is significant by testing $\beta_1 = \beta_2$, which is the same as testing the following null hypothesis:

[8] Arellano and Bond [3] suggest that differenced GMM is more efficient than the Anderson-Hsiao estimator. In contrast, Kiviet [26] finds that there is no appropriate estimator for all circumstances. Blundell and Bond [7] propose that a system GMM estimator is more efficient than first-differenced IV or GMM estimators, which may suffer from severe small sample bias, because they are weak instruments applied to highly persistent data. Judson and Owen [24] support the LSDVC estimator, based on a Monte Carlo analysis, when N is small or moderately large and $T \leq 30$ for a balanced panel data set. In this study, we apply system GMM procedures to estimate slope coefficient and fixed effect estimator, as well as LSDVC for robustness.

$$H_0: \beta_1 = \beta_2$$

4 Threshold and Inflation-Growth Trade-off

We use the conditional least-square method for equation (6) to evaluate the potential threshold point. In this stage, we assume that only initial income is a predetermined regressor, regard the remaining control variables as exogenous, and choose all valid sets of lags as instruments, following Roodman's [30] collapsed-form instruments matrix. In the second stage, we investigate the impact of inflation on economic growth from equation (2), using the GMM method. At this stage, we assume that initial income is a predetermined variable, and that the remaining control variables are exogenous.[9] For the instruments, we consider all available lags of the predetermined variable as instruments for increasing efficiency (see Table 3). However, for robustness and to avoid over-fitting instrumented variables, we also considered the current lag of the predetermined variable as an instrument. Our choices of instruments did not have any significant impact on our main results (see Table 4, column 3 in appendix A1).

4.1 *Estimation Results of Threshold Inflation*

We employ the conditional least-square method to calculate the threshold level of inflation, with the goal of minimizing RSS in equation (6), as conditional on any given threshold level. We repeat the procedure for different threshold values from 0.1% to 1.25% (inflation rates are in natural logarithms), with an increment of 0.005%. Figure 2 (see appendix A2) illustrates how RSS changes with increases in inflation rates. The minimum is reached at 0.735% (converting a log 0.735% to level value we will get 5.43%).

[9] The above model can be extended by allowing further explanatory variables to be endogenous. For this reason, in the second stage of our empirical application, we have considered two benchmarks. First, initial income is a predetermined variable, while any remaining regressors are strictly exogenous. Second, all regressors are predetermined. However, the choice of endogeneity has almost the same impact on this empirical result (see Table 3, column 1 & 3).

The empirical results indicate that the threshold level of inflation is approximately 5.43%,[10] which is statistically significant at the 1% level. The estimated threshold value is statistically different from that found in previous empirical works focused on developing countries. For example, Bruno and Easterly [9] calculated a 40% threshold, Khan and Senhadji [25] estimated 11%–12%, Bick [6] calculated 19.16% and Kremer et al. [27] identified the threshold as 17.2%. Moreover, we arrived at the same threshold value of about 5.43% (see, Figure 3 in appendix A2) when we extracted the data of four OECD countries (Japan, Israel, Korea, and Turkey),[11] as well as Singapore, from the sample, in order to incorporate motivation one. The effects of inflation on growth were also found to be the same as for the full sample (see Table 3, column 2 in appendix A1), meaning that inflation impedes GDP growth significantly when it exceeds 5.43%.

4.2 *Estimation Results for Inflation and Control Variables*

Once we had determined the threshold level, we estimated equation (2) to analyze the impact of inflation on growth. Table 3 (see appendix A1) presents the results obtained from equation (2) for Asian countries by applying GMM.[12] The upper panel of the table shows the estimated threshold level of inflation. The effect of inflation on growth is presented in the middle section of the table. In particular, $\hat{\beta}_1$ and $\hat{\beta}_2$ indicate the marginal impact of inflation on growth when inflation is below or above the estimated threshold value, respectively. Finally, the lower part of the table displays the coefficients of control variables. When we reduce the instrument count to 1, the estimation results from equation (2) are similar to those obtained using all available lags of initial income (see Table 4, column 3 in appendix A1).

[10] If we use only the current lag ($m = 1$) of the initial income as an instrument, we find that the threshold level of inflation is approximately 3.63%. These estimation results are not presented here, but are available on request.

[11] We also arrived at the same threshold level, 5.43% when we included Turkey in our sample (making a total of 28 developing countries) since it is currently going through the developing process. However, the threshold value and co-efficient are insignificant in that case, except investment ratio. The results are not presented here but are available on request.

[12] In order to control for time effects, we included time dummies in equation (2). Inclusion of time dummies in the growth regression (2) did not change our main results, which are not presented here but are available on request.

The results that were obtained for Asian countries in this study differ from existing empirical studies in three important respects. First, the estimated inflation threshold is statistically different and much lower than those found in existing empirical studies investigating non-industrialized countries. We found a threshold level of 5.43%, whereas existing literature offers figures that vary from 8% to 40%. Our low inflation threshold could be explained by our use of the indexation system, which shows that most Asian countries have a moderate or less-than-moderate history of inflation.

Second, the coefficient of inflation above the threshold ($\hat{\beta}_2 = -1.627$) has a plausible sign and is statistically significant at the 1% level. An increase of 1% in the inflation rate reduces the growth rate of GDP per-capita by 1.63%. In contrast, other existing studies, such as that of Drukker et al. [15], find that while inflation thresholds are statistically significant, the effect of inflation on growth is not significant in any regime.

Finally, in this study, inflation below the threshold was not found to have any significant effect on growth, although it reveals a positive sign($\hat{\beta}_1 = 0.043$). However, Kremer et al. [27] have detected the negative sign, which is not statistically significant, when inflation is less than the threshold value. Meanwhile, Bick [6] has identified a plausible sign that is significant when inflation below its threshold.

This study also arrived at other interesting findings. First of all, the coefficient of initial income is negative and significant at the 5% level, indicating that rich countries grow slowly, while poor countries grow quickly. Therefore, our results strongly support the concept of conditional convergence. Secondly, coefficient of investment has a plausible sign that is significant at the 1% level. The standard growth model predicts that investment has a positive impact on growth, and suggests that governments of Asian countries can promote economic growth by motivating investment. Thirdly, we found that a positive relationship exists between level of openness and the growth rate of GDP per capita. As such, we recommend that the governments of Asian countries reduce trade barriers in order to increase the health of their economies. Many existing empirical studies have also found an inverse correlation between level of openness and economic growth.

To ensure consistency in our results, we applied different estimation methods to equation (2), such as the bias-corrected least-square dummy variable (LSDVC) method and the fixed effect (FE) estimation technique (see Table 4 in appendix A1). We found that the impact of inflation on growth was quite similar across different estimation procedures when the inflation rate was above its threshold value. Column 1 of Table 3 and columns 1 and 2 of Table 4 show that the effect of inflation on growth is negative and statistically significant when the rate of inflation exceeds 5.43%. In contrast, inflation does not have any significant effect on growth below its threshold level of 5.43%, which is consistent with our main finding. In addition, the impact of control variables on economic growth changed our results slightly when we used the LSDVC and FE estimation methods (see Table 4).

5 Conclusion and Discussions

In this empirical study, we have examined inflation growth nexus by considering a threshold level of inflation. We used panel data from 32 Asian countries, covering the period from 1980 to 2009. We estimated the potential threshold point and slope co-efficient through the use of the dynamic panel threshold model, which allowed us to include endogenous regressors, in our model's setup, as proposed by Kremer et al. [27]. The sample size was reduced by using the averages of the data for each two years, which smoothed out business cycle fluctuations. Forward orthogonal deviation transformation was applied to remove individual-specific characteristics from the panel setup, as suggested by Arellano and Bover [4]. We applied a conditional least-square technique to estimate the potential threshold point. Once we had determined the threshold for inflation, we estimated covariates by using a GMM procedure for equation (2).

We observed a nonlinear relationship between inflation and economic growth, implying that when inflation exceeds our detected threshold level of inflation (5.43%, over the long run), that eliminated positive effects and growth is hampered. We also found that higher initial income affects economic growth. In addition, we determined that investment ratio stimulates economic growth. Finally, we found evidence that maintaining a greater level of openness promotes economic growth.

Our results, with regard to the effect of the threshold level of inflation on growth, are consistent with existing empirical studies.[13] Inflation was not found to have any significant effect on growth until it reached 5.43%, but after that point, it was found to slow down growth significantly. However, we found that the threshold level of inflation for Asian countries was lower than values found in previous empirical studies of developing countries, which range from 8% to 40%.

The results of this study, with regard to the impact of inflation on economic growth over the long run, are consistent with those arrived at through other estimation methods when inflation is above the threshold. The effect of investment on growth is robust in all cases, whereas the impact of other control variables on growth differs based on the estimation methods involved.

This study is not without its limitations. First, the exclusion of some relevant control variables and inclusion of other less relevant variables in the growth equation may have led to a specification bias, and relevant control variables should have been chosen through the application of an appropriate econometric technique (e.g., Bayesian modeling average). Second, owing to the exogeneity restriction, under which not only initial income is predetermined, but other control variables may also be endogenous, our estimated coefficient may be biased. Third, our estimate does not imply the causality relationship but only reveals a correlation. Finally, it should be kept in mind that as every country has a different geographic and economic environment, optimum inflation targets may be country-specific. We regard these limitations as providing direction for further studies.

Overall, our empirical solution could be of use in providing policy guidance to policy-makers. Policy-makers in Asian countries need to consider a maximum rate of 5.43% as an inflation target for maintaining economic stability. Economic growth can also be enhanced by reducing trade barriers and motivating investment.

[13] See Khan and Senhadji [25], Drukker et al. [15], Bick [6] and Kremer et al. [27]

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Appendix A1

Table 1: ***List of Countries and Summary Statistics***

Country	T	π Mean	$\log(\pi)$ Mean	Y Mean
Bahrain	15	1.6606	-0.4590	-0.4694
Bangladesh	15	7.7788	0.8427	2.2714
Bhutan	15	8.0705	0.8604	6.0256
China	15	5.6970	0.3576	8.6139
Cyprus	15	4.0649	0.5462	2.7504
Hong Kong	15	4.7142	-0.0729	3.6324
India	15	8.0781	0.8815	4.0835
Indonesia	15	9.4723	0.4983	3.4329
Iran	15	19.5005	1.2608	1.1946
Israel	15	43.0075	1.0103	1.7084
Japan	15	1.1617	-0.4144	1.6066
Jordan	15	5.2615	0.5256	0.6974
Korea	15	5.7518	0.6618	5.1772
Kuwait	15	3.5280	0.3407	0.0476
Laos	15	33.1098	0.7396	4.5376
Macao	15	42.4727	0.9462	4.8905
Malaysia	15	3.1782	0.4157	3.6154
Maldives	15	6.5742	0.0992	5.8760
Nepal	15	8.7303	0.8971	1.7144
Oman	15	2.0234	-0.6340	2.1256
Pakistan	15	8.1793	0.8687	1.8409
Papua New Guinea	15	7.5712	0.8097	0.9967
Philippines	15	9.6841	0.8765	1.1287
Qatar	15	4.2107	0.5139	3.1552
Saudi Arabia	15	1.1183	-0.7172	-1.6388
Singapore	15	2.0654	0.0409	4.4564
Sri Lanka	15	11.7156	1.0495	3.6325
Syria	15	12.0104	0.5872	1.3081
Thailand	15	3.8986	0.3103	4.1716
Turkey	15	50.5111	1.5966	2.0600
United Arab Emirates	15	4.7466	0.6279	-0.6579
Vietnam	15	65.2895	1.1733	4.8919

Note: This table describes the average annual inflation rates in levels [π] and in semi-log [$\log(\pi)$] and growth rate of GDP per capita (Y) over the period 1980–2009. Source: WDI, PWT 6.3 and 7.0, and EW.

Table 2: ***Variable, Definitions, Sources, and Summary Statistics***

Variables	Description and Source	Mean	Std. Dev.	Min	Max
Growth rate of GDP per capita (Y)	GDP per capita growth rate in purchasing power parity (PPP) 2005 constant prices From Penn World Table (PWT) 7.0	2.78	4.97	–22.3	23.1
Initial income ($initial$)	GDP per capita from previous period In PPP 2005 constant prices (in log) From PWT 7.0	3.79	0.57	2.81	5.18
Investment Ratio (inv)	Annual percentage change of the GDP per capita dedicated to investment in PPP 2005 constant prices From PWT 7.0	28.1	10.8	5.60	67.9
Inflation rate (π)	Average percentage change of CPI for the year, from Economy Watch (EW)	12.6	32.7	–6.44	406.9
$\tilde{\pi}$	Semi-log transformation of π	0.53	1.08	–7.44	2.61
Population growth rate ($gpop$)	Annual growth rate of population, from World Development Indicator (WDI)	2.41	2.06	–5.97	18.1
Trade openness ($open$)	Share of export plus import in percentage of GDP in 2005 constant prices, PWT 7.0	1.86	0.31	0.89	2.64
Terms of Trade (tot)	Export value divided by import value (2000=100), from WDI	1.92	0.14	1.41	2.33
$sdopen$	Standard deviation of trade openness	4.04	5.12	.003	42.9
$sdtot$	Standard deviation of terms of trade	6.58	7.11	0.01	51.1

Note: All variables are in 2-year arithmetic averages. Total number of observations is 480.

Table 3: ***Results of inflation threshold and its impact on growth***

Threshold estimates	(1)	(2)	(3)
$\hat{\gamma}$	5.433%	5.433%	5.433%
Testing significance of threshold			
$p - value$	0.010	0.037	0.005
Impact of inflation on growth			
$\hat{\beta}_1$	0.043	0.030	0.120
	(0.10)	(0.07)	(0.31)
$\hat{\beta}_2$	-1.627***	-1.482**	-1.481***
	(-3.25)	(-2.64)	(-3.68)
Impact of control variables			
$linitial$	-12.10**	-8.425*	5.624*
	(-2.53)	(-1.85)	(-1.75)
inv	0.143***	0.157***	0.147***
	(2.95)	(3.38)	(2.82)
$gpop$	0.042	-0.044	-0.008
	(0.11)	(-0.12)	(-0.03)
$lopen$	12.60**	9.875	4.041
	(2.04)	(1.65)	(1.18)
$ltot$	3.581	4.008	-0.412
	(0.79)	(0.89)	(-0.11)
$sdopen$	-0.070	-0.097	-0.072*
	(-1.45)	(-1.60)	(-1.66)
$sdtot$	0.019	0.050	0.022
	(0.41)	(1.08)	(0.54)
Observation	448	378	448
ID	32	27	32

Note: This table describes the system GMM results of equation (2), using all available lags of the predetermined variable as instruments. Results 1, and 2 were obtained by assuming that only initial income is predetermined and all other regressors are exogenous variables for the full sample (32 Asian countries), and sample of 27 countries (the full sample minus four OECD countries and Singapore) respectively. Result 3 was estimated by assuming that all explanatory variables are predetermined regressors for the full sample. Robust *t*-statistics are given in the parenthesis, and ***/**/* denotes that the variables are statistically significant at 1%, 5%, and 10%, respectively.

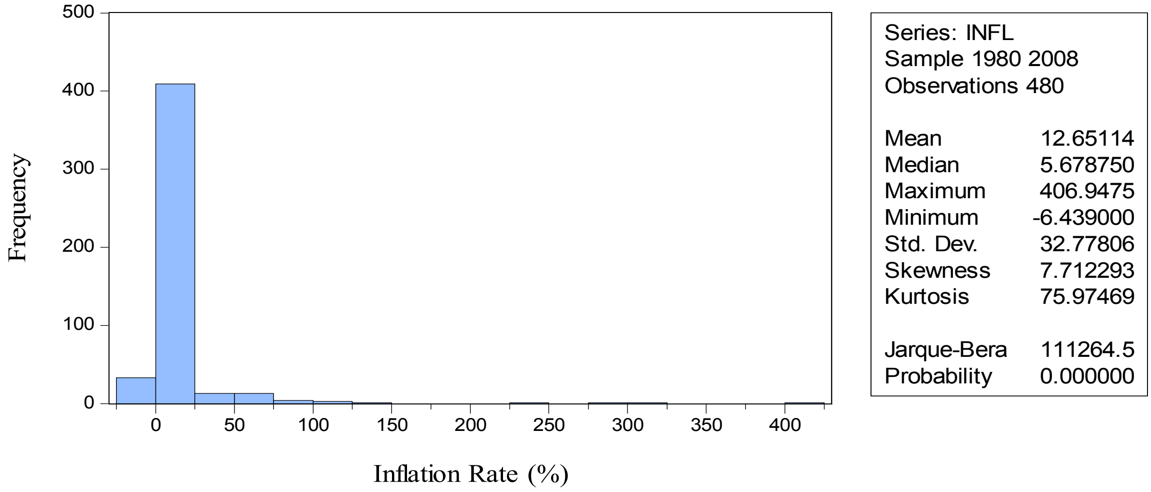
Table 4: ***Estimation Results of equation (2), Using FE and LSDVC***

Threshold estimates	(4)	(5)	(6)
$\hat{\gamma}$	5.433%	5.433%	5.433%
Testing significance of threshold			
$p - value$	0.032	0.000	0.010
Impact of inflation on growth			
$\hat{\beta}_1$	0.133	0.029	0.043
	(0.50)	(0.12)	(0.10)
$\hat{\beta}_2$	-1.294**	-1.256***	-1.626***
	(2.64)	(-2.46)	(-3.25)
Impact of control variables			
$l.grgdppc$		0.226***	
		(4.65)	
$linitial$	-2.934	-5.986***	-12.10**
	(-1.49)	(-2.74)	(-2.53)
inv	0.153***	0.114***	0.143***
	(4.59)	(3.21)	(2.95)
$gpop$	-0.073	0.039	0.042
	(-0.53)	(0.28)	(0.11)
$lopen$	1.219	4.116*	12.60**
	(0.55)	(1.76)	(2.04)
$ltot$	-0.219	0.226	3.581
	(-0.10)	(0.10)	(0.79)
$sdopen$	-0.082*	-0.057	-0.070
	(-1.71)	(-1.21)	(-1.45)
$sdtot$	0.026	0.021	0.019
	(0.76)	(0.60)	(0.41)
Observation	480	416	448
N	32	32	32

Note: These results have been obtained by using the FE, LSDVC, and system GMM methods. For GMM estimation, we used only the current lag of the initial income as an instrument. Robust t (for results 4 & 6) and z (for results 5) statistics are in parenthesis and ***/**/* denotes that the variables are statistically significant at 1%, 5%, and 10%, respectively.

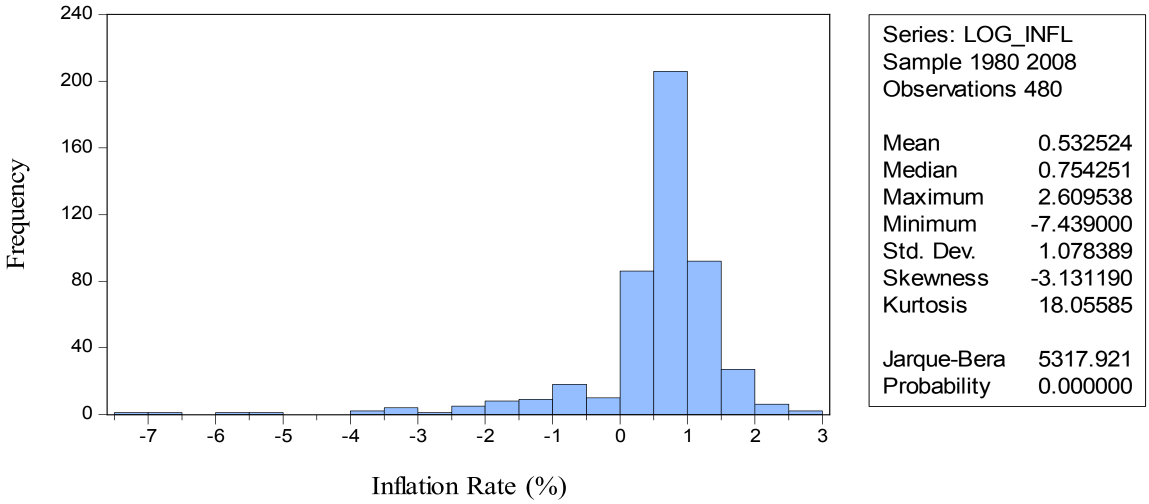
Appendix A2: Figures

Figure 1a: ***Distribution of Inflation Rate (In Levels)***



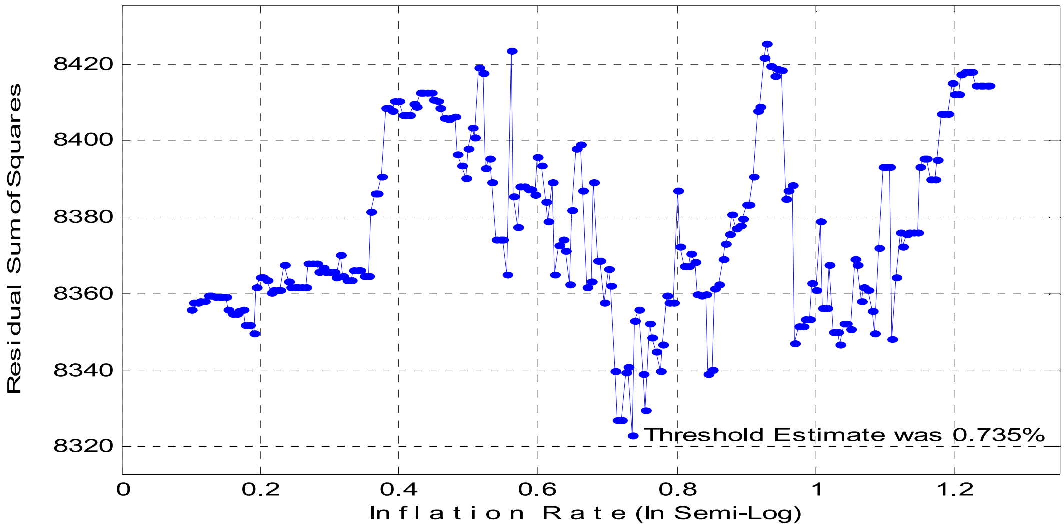
Note: The figure shows the distribution of 2-year averages of annual inflation rates (%), in level value, for Asian countries over the period of 1980–2009. Source: EW

Figure 1b: ***Distribution of Inflation Rate (In Semi-Log)***



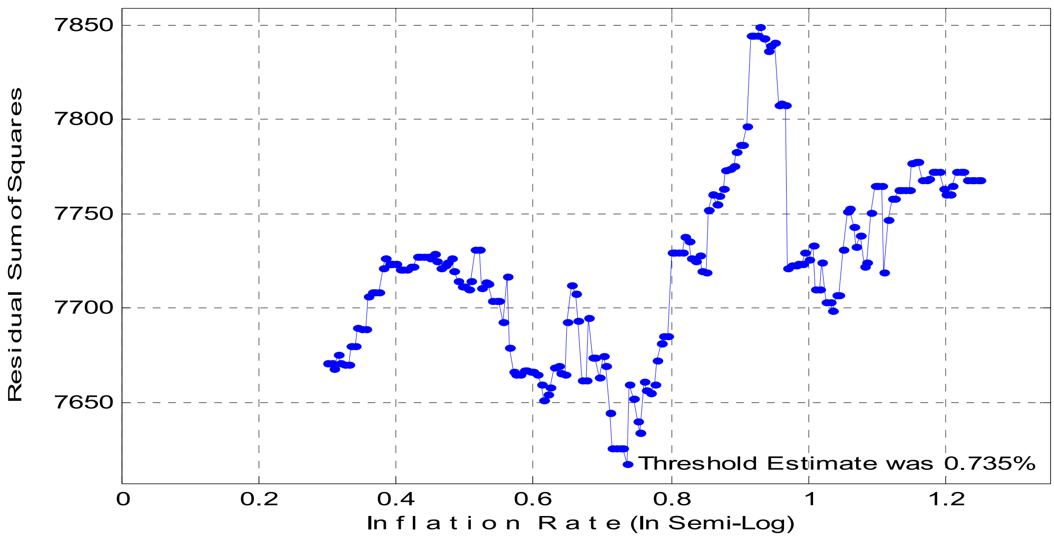
Note: The figure shows the distribution of 2-year averages of annual inflation rates (%), in semi-logged transformation, for Asian countries over the period 1980 –2009. Source: EW

Figure 2: Residual Sum of Squares as a function of the threshold level of Inflation
(Using all available lags as instruments)



Note: The figure 2 indicates threshold level of inflation for full sample (32 Asian economies).

Figure 3: Residual Sum of Squares as a function of the threshold level of Inflation
(Using all available lags as instruments)



Note: The figure 3 indicates threshold level of inflation for 27 developing Asian economies (four OECD countries [Japan, Israel, Korea, and Turkey] and Singapore were dropped from the sample).