8. THE INFLATION-GROWTH NEXUS: A DYNAMIC PANEL THRESHOLD ANALYSIS FOR D-8 COUNTRIES

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Abstract

This study investigates the influence of inflation on economic growth in period 1971-2014 for the Organization of Islamic Cooperation (D-8 Countries: Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan and Turkey) through dynamic panel data analysis based on threshold. Results show the existence of a non-linear relationship between economic growth rate and inflation. They indicate that the threshold for the influence of inflation on economic growth is 12.88%, and an inflation rate exceeding this threshold level negatively influences economic growth whereas an inflation rate under this threshold positively influences economic growth. These results show that a high inflation rate will have a considerable influence on economic growth. In this respect, it is crucial to ensure sustainable growth, which plays a significant part in increasing the efficiency of the monetary policies implemented and assuring stability. Hence, while determining the target inflation rate in their attempts to deal with inflation, political and economic decision-makers in these economies should not disregard the concept of threshold within the framework of monetary policy.

Keyword: dynamic panel threshold, inflation, economic growth, D-8 countries
JEL Classification: E31, C23, O40

1. Introduction

The inflation-economic growth relationship, which is quite an important factor underlying economic approaches, is among the most debated and searched topics. No matter how developed countries are, price stability and economic growth performance are the primary performance criteria they attach importance to. Price stability is an important phase for macroeconomic stability and thus sustainable growth.

A sustainable economic balance and a sound economic structure depend on the regularity and stableness of the macroeconomic variables that make up the economic structure. Any imbalance in macroeconomic variables disrupts the general structure of economic life and prevents economic growth from being continuous and stable. Therefore, prerequisite for countries to enter into sustainable growth process and make it permanent is providing a

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stable macroeconomic structure (Ercan, 2002; Yıldırım, 2003). Achieving a stable structure and then sustainable economic growth performance mainly depends on price stability (Tarı and Kumcu, 2005: 156). The economy and political and social structure of any country that cannot establish price stability in its economy may be severely disrupted.

Inflationary process makes it difficult for economic decision-making units to make forward-looking investment, savings, consumption, and production decisions, which leads to an environment of uncertainty. The environment of uncertainty negatively affects economic growth. In this regard, when volatility in inflation (i.e. uncertainty concerning inflation) is high, savings turn to speculative areas that are expected to yield more return rather than real investments or production. This reduces real investments and thus negatively affects economic growth.

Inflation not only decreases real investments by negatively affecting the profits of producers but also adversely affects consumers' purchasing powers by influencing their real incomes. In addition, it both impairs consumption, investment, and growth by increasing uncertainty in the economy and makes the gap between income groups larger by disrupting income distribution (i.e. deterioration of income distribution to the detriment of fixed income groups) (Şiriner and Doğru, 2005). Therefore, price stability is an important factor that increases growth potential by improving economy, making it function more efficiently, and providing market functioning.

The effect of inflation on economic growth has been discussed in the economic literature for a long time. The content of discussions on this issue has changed depending on the period undergone by the world economy. Production and inflation increased as the state took an active part in economic life and policies for increasing total demand were implemented in the period following the Great Depression in 1929. At that period, increasing inflation rates were not considered to be a problem. It was even thought by some that inflation positively affected economic growth.

As the Bretton Woods system ended in the 1970s and money supply was left to the control of central banks, how to preserve the value of money became a current issue. At that period, a rapid monetary expansion took place in a lot of countries. As a result, inflation rates became double-digit. As economic growth rates fell due to debt crises and supply shocks stemming from high inflation in the 1970s and 1980s, the positive relationship between economic growth and inflation started to be questioned. In the course of time, price stability became the number one target as an economic policy in many developed and developing countries. At that period, it was accepted by all that a long-term strong and sustainable economic growth is only possible with price stability. As a matter of fact, today the central banks of a lot of countries target inflation directly or indirectly to achieve price stability and determine their policies accordingly.

Today's generally-accepted view is that inflation negatively affects growth in the medium and long term. Nobody argues that making prices stable is wrong or not a priority. However, questions such as what is the optimal inflation rate; whether there is a threshold value for every country group; and how long it will take for stability to be achieved after the general level of prices is reduced to the desired level always occupy the agenda.

Empirical research dealing with the relationship between inflation and growth depends on the assumption that such relationship is linear, and it is considered that inflation has the same absolute impact on growth in periods of rise and fall. In other words, it is assumed that the relationship is symmetrical. When a linear model is chosen, it is necessarily presupposed that the variables exhibit the same kind of movements regardless of the structure of the economic environment. However, both the behaviours of economic variables and the

relationships between them may have a non-linear character. This sort of an asymmetry is of a non-linear character and cannot be grasped by linear models. A non-linear model suggests that the response of inflation to economic growth and the response of economic growth to inflation level are asymmetrical; that is, inflation does not affect economic growth in the same way when it is high and when it is low.

Policy changes, economic crises, and the alterations that the institutional changes made for restructuring the economic environment cause in the individual movements of economic variables and in their relationships with one another can be listed among the reasons for the presence of a non-linear relationship between the variables. As a result, it is obvious that a linear structure will not be enough to make a sound analysis of these kinds of changes in the economic environment. Therefore, it is necessary to use a non-linear model for investigating the temporal changes of the variables and their mutual interactions in the relationship between inflation and economic growth.

This paper presents new evidence shedding light on the effect of inflation on economic growth. In this study, we investigated if there is a threshold level of inflation in the relationship between inflation and economic growth. This relationship may depend on the inflation level of a country. Inflation level has a reducing effect on economic growth after it goes beyond a specific threshold level. The findings obtained in this study may offer significant implications for policymakers. If it is clearly evidenced that a high inflation rate negatively affects economic growth or that a threshold level of inflation exists, policymakers should take such threshold level into consideration within the scope of their monetary policy when determining the target inflation rate in their efforts to fight inflation in order to enhance the efficiency of the monetary policies implemented and assure stability.

This study makes a contribution to the literature in two ways. Firstly, we employed the dynamic panel threshold model that was developed by Kremer et al. (2013) by expanding the static model for endogenous regressors of Hansen (1999). By its very nature, economic growth has a dynamic structure. Thus, establishing the dynamic panel threshold model is more suitable than establishing the static panel threshold model, which was proposed by Hansen (1999). Hansen (2000) and Caner and Hansen (2004) threshold models can tackle a dynamic problem, but both of them depend on cross-sectional analysis. Panel models can provide more benefits as they provide more information, reduce multicollinearity, and also control the country differences. In this sense, the dynamic panel threshold model developed by Kremer et al. (2013) fills this gap in the econometrics literature.

Secondly, in the literature, quadratic models are used for modelling the non-linear relationship between inflation and economic growth. This method bears a significant constraint. The use of the square of inflation in the quadratic model for determining the threshold effect of inflation rate in the relationship between inflation and economic growth brings a prior limitation that the effect of inflation on economic growth rises and falls monotonously and symmetrically depending on the level of inflation rate. However, reaching a specific inflation level may be required for inflation to have any effect on growth. Also, the relationship may have different negative ranges in terms of absolute impact in comparison to positive ranges. This is taken into consideration in a threshold model, but not considered in a quadratic model. In this regard, the present study employs a regression model based on the concept of threshold effect that will provide an insight into how inflation affects economic growth.

D-8, which stands as an example of cooperation among developing countries, is an organization for developing economic and commercial cooperation among member countries. Its aim is to liberate the financial systems in the member countries, reduce external

deficit, and achieve price stability, which serves as the building block of sustainable growth, by ensuring central bank independence. Little can be said about how inflation affects growth rate in the countries affiliated to D-8, which was founded to ensure price stability in order to achieve sustainable growth. Hence, determining whether inflation rate has a potential effect on economic growth performance in these countries is very important in theoretical and empirical terms.

The present study aims to empirically demonstrate how inflation rate influences economic growth in the case of D-8 countries. Literature contains a limited number of studies dealing with the relationship between inflation and economic growth in these economies. Thus, this study investigates the influence of inflation threshold on economic. In this way, a substantial contribution will be made to literature about the examination of economic development foundations of these economies. Another main aim of this study is to bring proper foundations to the discussions on inflation and growth in D-8 countries which are usually grounded on inaccurate theoretical and empirical bases.

2. Literature Review

The literature contains a lot of empirical and theoretical studies dealing with the relationship between inflation and growth, but they do not report a specific trend regarding the nature of this relationship. In applied research, the relationship between inflation and economic growth varies depending on the period and the country group examined, the inflation rate taken into consideration and the econometric method employed. Although many recent studies report that inflation is a constraint to growth and negatively influences economic growth, relatively older studies report that inflation promotes growth. Study results in this matter in the literature can be divided into four categories: inflation does not influence economic growth (Wai, 1959; Dorrance, 1966), inflation positively influences economic growth (Mallik and Chowdhury, 2001; Rapach, 2003; Benhabib and Spiegel, 2009), inflation negatively influences economic growth (Fischer, 1983; Barro, 1995) and inflation has an influence on economic growth within the framework of a specific threshold.

Recent studies demonstrate that new methods are employed with the thought that there exists a non-linear relationship between inflation and growth in order to indicate the relationship between them more clearly. In general, this new method states that after a specific threshold is exceeded, inflation may negatively influence economic growth. Though different results have been obtained in studies on this subject, all of these studies demonstrate that the use of inflation rates in models based on a threshold yields more clear results in the search of the influence of inflation on growth. Table 1 presents a summary of the literature, which is also treated below.

Mallik and Chowdhury (2001) examined the relationship between inflation and economic growth for Bangladesh, India, Pakistan and Sri Lanka. Unbalanced sample size was used for four countries in that study. They found evidence showing a positive relationship between inflation and economic growth rate in all four countries studied. The result indicates that while moderate inflation level supports economic growth, faster growth feedbacks into inflation. Thus, these countries are on a „knife-edge".

Khan and Senhadji (2001) explored where there existed a threshold effect in the relationship between inflation and growth in their study on 140 industrialized and developing countries in the period from 1960 to 1998. They predicted the threshold to be 1 to 3% for industrialized countries and to be 7 to 11% for developing countries. They found out that inflation rates over these values negatively influenced economic growth whereas inflation rates under

these values did not influence it. Gylfason and Herbertsson (2001) conducted a similar study on 170 countries for the period between 1960 and 1992, and determined that an inflation rate exceeding 10 to 20% on a yearly basis negatively affected economic growth.

Mubarik (2005) dealt with the relationship between inflation and economic growth for Pakistan economy based on the annual dataset from the 1973 to 2000 period through threshold analysis. The obtained analysis results demonstrated that an inflation rate over 9%, which was found to be threshold, negatively influenced economic growth.

Ahmed and Mortaza (2005) detected a statistically significant long run negative relationship between inflation and economic growth in Bangladesh by employing co-integration and error correction models for the period covering 1980 to 2005. They estimated an inflation threshold level of 6%, above which inflation would have an adverse influence on economic growth.

Fabayo and Ajilore (2006) carried out a study on the Nigerian economy covering the period between 1970 and 2003 and investigated the relationship between inflation and economic growth. They determined a threshold inflation level of 6%. They pointed out that inflation impedes growth performance of the economy above this threshold whereas the inflation-growth relationship is significantly positive below it.

Munir et al. (2009) carried out a study on the Malaysian economy for the period between 1970 and 2005 and studied the relationship between inflation and economic growth via endogenous threshold autoregressive (TAR) model. They found the threshold for the influence of inflation on economic growth to be 3.89%. It was seen that an inflation rate over this threshold negatively influenced economic growth while an inflation rate under it positively influenced it.

Akgül and Özdemir (2012) carried out a study on Turkey for the period between 2003:01 and 2009:12 and investigated the non-linear relationship between inflation rate and economic growth via two-regime TAR model. They determined the inflation threshold as 1.26 for the entire analysis period. It was seen that an inflation rate exceeding the threshold negatively influenced economic growth while an inflation rate under the threshold positively influenced it.

Kremer et al. (2013) investigated the influence of inflation threshold on long-term economic growth by using the data from the period between 1950 and 2004 for 124 industrialized and non-industrialized countries. According to their predictions, the inflation threshold was 2% and 17% for industrialized countries and for non-industrialized countries, respectively. They concluded that while an inflation rate above the threshold negatively influenced economic growth, the influence of an inflation rate under the threshold on it was insignificant. These results support the view that inflation contributes to growth in developing countries.

Vinayagathasan (2013) investigated the relationship between inflation and economic growth for 32 Asian countries for the period between 1980 and 2009. Dynamic panel threshold model was employed in that study. The threshold value for the influence of inflation on economic growth was indicated to be 5.43%. It was determined that while an inflation rate exceeding this threshold negatively influenced economic growth, an inflation rate below this threshold did not influence it by any means.

Baglan and Yoldas (2014) investigated whether there exists a threshold effect in the relationship between inflation and growth by adopting a flexible semiparametric panel data model for developing countries. They found that that the inflation threshold to be 12% for the entire analysis period. Also, it was determined that an inflation rate over this threshold negatively influenced economic growth.

Thanh (2015) investigated inflation threshold effect on inflation–economic growth for ASEAN-5 countries over the period 1980–2011 using Panel Smooth Transition Regression (PSTR) model. He found that the inflation threshold to be 7.84% for the entire analysis period. It was seen that while an inflation rate over the threshold had a negative influence on economic growth.

Das and Loxley (2015) estimated the non-linear relationship between inflation and economic growth for 54 developing countries for the period from 1971 to 2010 by using quadratic model. For Asian countries, they estimated an inflation threshold level of 11% above which inflation would have an adverse effect on economic growth.

Esen et al. (2016) explored the role inflation threshold effect played in economic growth for Turkey in the 2002:Q1 – 2015:Q1 period. They identified a non-linear relationship between inflation and growth rate and found the threshold for the influence of inflation on economic growth to be 8.89%. It was seen that an inflation rate exceeding this threshold negatively influenced economic growth whereas an inflation rate under this threshold positively influenced it.

Saleem (2016) carried out a study on Pakistan for the period 1973-2013 and studied the non-linear relationship between inflation rate and economic growth via the non-linear regression model. He found that the inflation impact on the economic growth had a positive sign and it was statistically significant up to the threshold level of 7 percent. After 7 percent of threshold inflation, it showed a positive but insignificant impact on the economic growth.

Aydin et al. (2016) investigated inflation threshold effect on inflation–economic growth via dynamic panel threshold model for 24 emerging market countries in the period from 1980 to 2013. They detected a non-linear relationship between inflation and economic growth. They predicted the inflation threshold to be 13.68 % for emerging market countries. They concluded that an inflation rate exceeding the threshold negatively influenced economic growth whereas an inflation rate under the threshold positively influenced it.

Iyke and Odhiambo (2017) investigated inflation threshold effect on inflation–economic growth using threshold regression for Ghana and Nigeria over the period 1961–2011 and 1964–2011 respectively. They found that the inflationary threshold ranges for Ghana and Nigeria was 10.73%–29.83 and 10.07%–19.25% respectively.

3. Methodology and Data

In the current study, the relationship between inflation and economic growth was investigated for the period 1971-2014 for D-8 countries using dynamic panel data analysis which takes into account inflation threshold level. In line with the empirical studies about economic growth in the literature, the data set was created by calculating the five-year averages of the variables used in the study in order to make the use of the GMM estimator valid and ensure its consistence1 (i.e. 1971–1974, 1975–1979, 1980–1984, 1985–1989, 1990-1994, 1995-1999, 2000–2004, 2005–2009, 2010-2014). Moreover, averaging the data is likely to soothe the business cycle effect.

Such relationship was examined based on the neoclassical production function used by Khan and Senhadji (2001) and Kremer et al. (2013) in Equation (1).

$$\dot{Y}_{it} = \alpha_0 + \alpha_1 initial_{it} + \alpha_2 \pi_{it} + \beta x_{it} + \varepsilon_{it} \quad (1)$$

1 In dynamic panel threshold model, estimator is consistent when T/N → c for 0<c≤2" (Alvarez and Arellano, 2003).

where: $\dot{Y}$ indicates the real GDP per capita growth at time *t* in the country i; $initial$ indicates the initial level of income; π is the inflation rate; x represents other macroeconomic variables that might have an impact on economic growth and ε denotes the white noise error term.

We included the lagged value of GDP per capita into the model as the explanatory variable based on the assumption that production level and structure of an economy are not entirely independent of the previous periods, and thus production levels at the previous period are also reflected in the subsequent periods (Ramirez and Rondán, 2013).

The literature review shows that, the real GDP is taken as a basis in the international comparisons as it gives important information about the growth performances of economies; however, in comparing the living standards of different countries or examining the changes in the welfare level of a country over time, the real GDP per capita is preferred as it takes into account the number of people living in a country. In this sense, we used the annual growth rate of real GDP per capita *(dgdp)* as an indicator of living standards. We also used inflation rate (π) as the independent variable of the model. The inflation rate was calculated as the annual percentage change occurring in the consumer price index (CPI). To control the effects of other macroeconomic variables related to inflation on economic growth, we used the following control variables based on the studies of Khan and Senhadji (2001), Drukker *et al*. (2005), and Kremer *et al*. (2013): the gross capital formation as a share of GDP (*investment*), population growth (*dpop*), initial income level (*initial*) measured as the log of GDP per capita of the previous period, openness (*openess*) measured as the annual growth rate of export and the annual percentage change in the terms of trade (*dtot*), where the terms of trade are measured as exports divided by imports. We obtained gross capital formation as a share of GDP, population, export and import data from the United Nations Statistics Division (UNSTATS). The real GDP per capita and the consumer price index data were obtained from the International Financial Statistics (IFS). Table 2 and 3 show the descriptive statistics and correlation matrix about the variables respectively.

For the period between 1971 and 2014, average annual inflation growth rates are approximately 14.68%, 10.96%, and 20.89% in full sample, lower and upper middle-income countries, respectively. For all set of countries, the dispersion of inflation rates is considerable, see Figures 1. The dataset about inflation rates shows that there are some extreme inflation rate values. Ghosh and Phillips (1998) recommend using the log of inflation rate in models in order to avoid the negative influences of extreme inflation rate values on regression results. Since the dataset regarding inflation rates involved negative values, semi-logarithmic transformation was administered to the inflation rate variable based on Khan and Senhadji (2001), Drukker *et al*. (2005), and Kremer *et al*. (2013). Such transformation took place as follows:

$$\overline{\pi}_{it} = \begin{cases} \pi_{it} - 1 & \text{if} \quad \pi_{it} \leq \%1 \\ \ln(\pi_{it}) & \text{if} \quad \pi_{it} > \%1 \end{cases}$$

Use of the lagged values of dependent variable as the explanatory variable in the fixed effects and random effects models used in the static panel data analysis causes the emergence of a relationship between the lagged values of the dependent variable and the error terms. Such relationship causes the estimation made by fixed and random effects models and the estimators to be inconsistent (Green, 2000). In such cases, use of dynamic panel data method eliminates such relationship between the lagged values of the dependent variable and the error terms, increasing the reliability of the estimation and the consistency of the estimators.

In this study, we used dynamic panel threshold model developed by Kremer *et al*. (2013) through extending Hansen's (1999) static model for endogenous regressors. We chose the

initial level of income as the endogenous regressor ($initial = gdp_{t-1}$) Our panel threshold model was built on the cross-sectional threshold model of Caner and Hansen (2004) where GMM type estimators are used for allowing for endogeneity. Equation (2) shows the model.

$$y_{it} = \mu_i + \beta_1' z_{it} I(q_{it} \leq \gamma) + \beta_2' z_{it} I(q_{it} > \gamma) + \varepsilon_{it} \quad (2)$$

where: *i* represents the units within the scope of the cross-section *(i = 1,…,n)*; *t* indicates the dimension of the time series for each unit *(t = 1,…, T)*. y_{it} is the dependent variable, μ_i is the country specific fixed effect and $\varepsilon_{it} \approx (0,\sigma^2)$ is the independently and identically distributed error term. *I(.)* is the indicator function indicating the regime, q_{it} is the threshold variable, and *Y* is the threshold value. Besides, z_{it}, indicates a m-dimensional vector of explanatory regressors which may include lagged values of the dependent variable and other endogenous variables. The vector of explanatory variables is partitioned into a subset z_{1it} of exogenous variables uncorrelated with ε_{it} and a subset of endogenous variables z_{2it}, correlated with ε_{it}. Additionally, in equation (2) requires a suitable set of $k \geq m$ instrumental variables x_{it} including z_{1it} (Kremer et al., 2013).

In the first step of the estimation of the model in Equation (2), the individual effects (μ_i) have to be eliminated via a fixed-effects transformation. Therefore, we apply the forward orthogonal deviation method suggested by Arellano and Bover (1995). This method is showed in equation (3).

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

The error terms ε_{it} and ε_{it}^* are not serially correlated, i.e. $Var(\varepsilon_{it}) = \sigma^2 I_T$ and $Var(\varepsilon_{it}^*) = \sigma^2 I_{T-1}$. Applying this procedure to Equation (2) yields;

$$y_{it}^* = \beta_1' z_{it}^* I(q_{it} \leq \gamma) + \beta_2' z_{it}^* I(q_{it} > \gamma) + \varepsilon_{it}^* \quad (4)$$

where: *t=1, ..., T-1* and * denotes post transformation data.

The most distinguishing feature of this method is that it allows for avoiding serial correlation of the transformed error terms. According to Kremer *et al*. (2013), this feature of the method allows for applying the estimation procedure derived by Caner and Hansen (2004) for a cross-sectional model to the dynamic panel data models.

The following step in the prediction of the model included in the equation (4) is the use of two-stage least squares method (*2SLS*) to determine inflation threshold. To this end, firstly reduced form regression in equation (5) is constructed for endogenous variables (z_{2it}^*) which are a function of the instrumental variables following Caner and Hansen (2004).

$$z_{2it}^* = \lambda_1' x_{it} I(q_{it} \leq \gamma) + \lambda_2' x_{it} I(q_{it} > \gamma) + v_{it} \quad (5)$$

where: x_{it} are the instruments that includes z_{1it} and $E(v_{it}, x_{it}) = 0$.

Then the predicted values ($\hat{z}_{it}^*$) of the endogenous variables ($\hat{z}_{2it}^*$) and exogenous variables (z_{1it}^*) obtained from the equation (4) in the structural equation (6).

$$y_{it}^* = \beta_1' \hat{z}_{it}^* I(q_{it} \leq \gamma) + \beta_2' \hat{z}_{it}^* I(q_{it} > \gamma) + \varepsilon_{it}^* \quad (6)$$

Where $\hat{z}_{it}^* = (z_{1it}^*, \hat{z}_{2it}^*)$.. The model included in equation (6) is predicted via least squares method for a fixed threshold γ. This operation is repeated for the subsets of the threshold variable q. Among the obtained thresholds, the appropriate threshold having the lowest error terms sum of squares (S(γ)) is chosen as (γ). This constraint is expressed as in equation (7) (Hansen, 2000).

$$\hat{\gamma} = \operatorname{argmin} S_n(\gamma) \quad (7)$$

Based on Hansen (1999), Caner and Hansen (2004), and Kremer *et al*. (2013), critical values concerning the confidence interval at 95% confidence level are calculated for the inflation threshold. In calculating the critical values, the constraint in equation (8) is used.

$$\Gamma = \{\gamma : LR(\gamma) \leq C(\alpha)\} \quad (8)$$

In equation (8), *C(α)* shows the 95% percentile of the asymptotic distribution of the likelihood ratio statistic *LR(γ)*. According to Hansen (1999), likelihood ratio takes into account the time used in each cross-sectional data. After the appropriate threshold *(γ')* is determined, slope coefficients in the dynamic panel threshold model are predicted via the generalized method of moments for the predetermined instrumental variables and predicted threshold. Equation (9) shows the dynamic panel threshold model established via the generalized method of moments in order to investigate the influence of inflation on economic growth.

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$$dgdp_{it} = \mu_i + \beta_1 \overline{\pi}_{it} I(\overline{\pi}_{it} \leq \gamma) + \delta_1 I(\overline{\pi}_{it} \leq \gamma) + \beta_2 \overline{\pi}_{it} I(\overline{\pi}_{it} > \gamma) + \emptyset z_{it} + \varepsilon_{it} \quad (9)$$

In equation (9), $\overline{\pi}_{it}$ variable represents inflation rate for two regime types while z_{it} represents the control variables vector. β_1 and β_2 coefficients indicate regime slope coefficients while δ_1 indicates the regime fixed coefficient. Based on Kremer *et al*. (2013), initial income level (z_{2it}) was used as endogenous variable in the model.

When dynamic panel data analysis is being made, a sample having a small cross-section dimension, just like in this study, may cause biased standard errors and biased estimated parameters as well as a weakened over-identification test (Bowsher, 2002; Windmeijer, 2005). According to Roodman (2009), this results from the use of too many instrumental variables in the model. For that reason, we decreased the instrumental variables and used only one lag of the dependent variable as instrumental variable in order to avoid an overfit of instrumental variables which may lead to biased coefficient estimates.

4. Findings

Table 4 reports the results of estimating Equation (9) using inflation rate as a threshold variable. The upper part of Table 4 shows the estimated inflation threshold level and the corresponding 95% confidence interval. The middle part of the table shows the effect of inflation on economic growth for both regime types. $\hat{\beta}_1$ denotes the marginal effect of inflation on economic growth in the low inflation regime, while $\hat{\beta}_2$ indicates the marginal effect of inflation on economic growth in the high inflation regime. Low inflation regime indicates the case in which inflation rate is below the estimated threshold value, whereas high inflation regime indicates the case in which inflation rate level is above the estimated threshold value.

As shown in Table 4 (Model 1a), estimated optimal threshold value for inflation is found to be 12.88% with the corresponding 95% confidence interval [7.31–14.55] for the full sample (via two-stage least squares). This is consistent with the range indicated in the related literature. For instance, Khan and Senhadji (2001), studying 110 developing countries, find the optimal threshold level of inflation rate to be equal to 11%, whereas Kremer et al. (2013), studying 101 non-industrialized countries, report the threshold to be 17.2%. In developing economies, Baglan and Yoldas (2014) determine the optimal threshold level of inflation rate as 12%, while Das and Loxley (2013) report a threshold of 11%. Thanh (2015), focusing on ASEAN-5 countries, estimates the threshold level for inflation as 7.84%, while Aydin *et al*. (2016), examining 24 emerging countries, find a threshold of 13.68%. In various studies dealing with individual countries, Ahmed and Mortaza (2005), Mubarik (2005), Munir *et al*. (2009), Bawa and Abdullahi (2012), and Akgül and Özdemir (2012), Saleem (2016), Esen *et al*. (2016), and Iyke and Odhiambo (2017) report threshold estimation in the range of 3% to 15%. The highness of the threshold level of inflation rate in D-8 countries can be attributed to a couple of factors. Firstly, these economies widely use wage and interest indexation systems because of their long hyperinflation experience. These indexation systems may have partly reduced the negative effect of inflation (Kremer *et al*., 2013). Another reason may be convergence process and the Balassa-Samuelson effect (Khan and Senhadji, 2001:14). According to this effect, the growth differences between the sectors in which the goods subject to foreign trade are produced and the sectors in which the goods not subject to foreign trade are produced affect the changes occurring in the real exchange rate and influence the threshold level of inflation in these economies (Altunöz, 2014: 109).

Regarding the results for full sample provided in Table 4, the regime-dependent coefficients are statistically significant ($\hat{\beta}_1$= 2.23 and $\hat{\beta}_2$= -1.45). This means that inflation has a positive marginal effect on economic growth in the low inflation regime, whereas it has a negative marginal effect in the high inflation regime. That is to say, the rate of inflation below the threshold level affects economic growth positively. If the rate is above the threshold value, then it affects economic growth negatively. In particular, if inflation rate of the average country is under the threshold, a 1% rise in inflation rate will lead to an increase by 2.23% in economic growth. However, when the average country has an inflation rate exceeding the threshold estimation, a 1% rise in government size will lead to a decrease by 1.45% in growth. Hence, the effect of inflation on growth is larger quantitatively when it is under the estimated threshold.

All the estimated coefficients of initial income, investment, and population growth in the model are in line with theory. The variable of initial income, showing the conditional convergence hypothesis of neoclassical growth theory, is significant. This indicates that the convergence hypothesis is strongly supported. The coefficient of population growth is negative, and it stands as a crucial determinant of growth at conventional levels. Such negativity of the variable of population growth indicates the burden overpopulation has on long-term growth, which is also supported by the Solow growth model (Eggoh and Khan, 2014). Contrary to this, the coefficient of investment is positive. However, it is an insignificant determinant of economic growth.

According to the obtained findings, the relationship between inflation and economic growth is not linear and follows a single-threshold and two-regime process, and that there is a difference between high inflation and low inflation periods in terms of effect. When inflation is high, it negatively and significantly affects growth, but when inflation is low, it has a positive and significant effect on growth. That is to say, we have strong evidence showing the existence of an inverted "U-shaped" relationship between the inflation and economic growth

values for D-8 countries. This may be explained by the fact that when setting their targets, countries have to make a choice between growth and low inflation targets (Akgül and Özdemir, 2012). The countries choosing growth and those choosing low inflation depend on different assumptions. While those giving prominence to growth depend on the assumption that a positive relationship exists between inflation and growth, the other group of countries argue that inflation harms economic growth. To put it another way, while the former advocates the structuralist approach, the latter is in favour of monetarism. In the recent economic literature, it is the latter view (i.e. low inflation is positively correlated with economic growth) that is generally accepted. Fischer's study published in 1993 is considered as a pioneer in this matter. After Fischer (1993) highlighted that the relationship existing between inflation and growth is not linear and there exists a positive relationship between growth and inflation at a low rate, the studies conducted on various countries based on this thesis found out that the relationship is not linear. Some later studies determined that inflation positively affects economic growth until a specific level (threshold), but it negatively affects it economic growth when such level is exceeded.

The model in Equation (9) was re-estimated through dynamic panel threshold model by using all the possible lagged values of the dependent variable as instrumental variable ($dgdp_{it-1}, dgdp_{it-2}, \dots, dgdp_{i0}$). The results are shown in Table 5 (Model 1b). The findings indicate that the choice of instrumental variables has no significant effect on the results. The results in Model 1a and 1b appeared to be rather similar except rather minor differences. In both models, the estimated inflation threshold levels and their confidence intervals were found to be the same. No change was detected in terms of the statistical significance of the coefficients and the sign of the coefficients. However, increasing the number of instruments only affects estimates for control variables where standard errors are slightly reduced.

A lot of robustness checks were conducted in order to investigate the sensitivity of the results to additional explanatory variables. Robustness check involves estimating the model by adding variables such as government expenditure, openness, and terms of trade, which are the determinants of economic growth, to the model. Firstly, the variables were added to the model one by one, and the model was estimated. Then all the additional variables were included in the model, and the analysis was repeated. The obtained empirical findings are presented in Table 6. The results are similar, in quantitative terms, to the ones reported in Table 4, where the inflation threshold value is still located at 12.88 with no change at all. The regime-dependent coefficients ($\hat{\beta}_1$ and $\hat{\beta}_2$) are seen to be statistically significant at the conventional level. As Table 6 shows, all the additional explanatory variables stand as statistically significant determinants of growth, and the signs are in line with theory. The variable of openness is positively correlated with economic growth, while the variables of terms of trade and government expenditure are negatively correlated with it. It suggests that D-8 countries should reduce trade barriers and government expenditure further to increase the health of their economies. The findings of the above-mentioned robustness checks reveal that the results are qualitatively robust.

5. Conclusion

The present study explored the role of the inflation threshold in the non-linear relationship between inflation and economic growth in the case of D-8 countries (for D-8 Countries) (Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan and Turkey) for the period between 1971 and 2014. To this end, dynamic panel threshold model, which is the extended

version (Kremer *et al*., 2013) of the static model administered for the endogenous predictors by Hansen (1999), was used in the present study.

The obtained findings present new evidences concerning the presence of a non-linear relationship between inflation and economic growth in D-8 countries in the long term. In addition, these findings show that when inflation rate is above a specific critical value in these countries, inflation will negatively influence the economic growth. The predicted critical value was found to be 12.88% for the examined in D-8 countries. This result supports the view that a moderate inflation rate under the threshold positively influences economic growth. This finding does not indicate any causality relationship between inflation and economic growth. It just shows the existence of a relationship. On the other hand, the present study indicates the importance of inflation threshold in the relationship between inflation and economic growth.

The highness of the threshold level of inflation obtained for D-8 countries having a chronic inflation problem may be resulting from that these countries heavily use the indexation system, which they resort to frequently. The fact that the indexation system can reduce the negative effects of inflation, though partly, makes this system critical for rising economies. The importance of the system becomes clear when it is considered that inflation may negatively affect the sustainable growth process when the threshold is exceeded, as can be understood from the analysis results. On the other hand, given the fact that moderate inflation rates positively affect the production process, growth will certainly be triggered in such conditions. However, it should be noted here that when central banks turn to other policy targets instead of policies for assuring price stability, which is one of their primary objectives, inflation may have a reducing effect on economic growth, rather than a boosting one. At this point, it becomes clear again that maximum attention should be paid to inflation targeting, which is conducted in many countries. Under this perspective, it can be said that central banks, which are supposed to be free from political authority and thus populist concerns, should stand firm, before all, in their policies aimed at restraining inflation by assuring price stability.

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Annexes

Table 1

Summary of the Nonlinear Studies of Economic Growth and Inflation

Authors	Sample countries	Type of data and sample period	Methods	Findings
Mallik and Chowdhury (2001)	Bangladesh, India, Pakistan and Sri Lanka	Time Series Data (Bangladesh 1974-1997; India 1961-1997; Pakistan 1957-1997; Sri Lanka 1966-1997)	The Cointegration and Error Correction Models	Moderate inflation rate helps economic growth but faster growth feedbacks into inflation.
Khan and Senhadji (2001)	140 industrialized and developing countries	Panel Data (1960-1998)	Threshold Regression	Inflation threshold is 1 to 3% for industrialized countries and to be 7 to 11% for developing countries.
Mubarik (2005)	Pakistan	Time Series Data (1973-200)	Threshold Regression	An inflation rate over 9%, which was found to be threshold, had a negative influence on economic growth.
Ahmed and Mortaza (2005)	Bangladesh	Time Series Data (1980-2005)	Threshold Regression	An inflation threshold level of 6% above which inflation will adversely affect economic growth.
Fabayo and Ajilore (2006)	Nigeria	Time Series Data (1970-2003)	Threshold Regression	The threshold inflation level was 6%
Munir *et al*. (2009)	Malaysia	Time Series Data (1970-2005)	Threshold Autoregressive Model	The threshold for the influence of inflation on economic growth was 3.89%.
Akgül and Özdemir (2012)	Turkey	Time Series Data (2003:01-2009:12)	Threshold Autoregressive Model	The monthly inflation threshold was 1.26.
Kremer *et al.* (2013)	124 Industrialized and Non-Industrialized Countries	Panel Data (1950-2004 five years average)	Dynamic Panel Threshold Model	The inflation threshold was 2% for industrialized countries and 17% for non-industrialized countries.
Vinayagathasan (2013)	32 Asian Countries	Panel Data (1980-2009 five years average)	Dynamic Panel Threshold Model	The inflation threshold value was 5.43%.
Baglan and Yoldas (2014)	Developing Economies	Panel Data	A Flexible Semiparametric Panel Data Model	Inflation threshold level was 12%
Das and Loxley (2015)	54 Developing countries	Panel Data (1971-2010)	Quadratic Model	Inflation threshold level was 11% for Asian countries.
Thanh (2015)	ASEAN-5	Panel Data (1980-2011)	PTSR	The inflation threshold to be 7.84% for the entire analysis period.
Saleem (2016)	Pakistan	Time series Data (1973-2013)	The Non-Linear Regression Model	The threshold level for inflation 7%.
Esen *et al*. (2016)	Turkey	Time Series Data (2002:Q1 – 2015:Q1)	Threshold Autoregressive	The threshold for the influence of inflation on

Authors	Sample countries	Type of data and sample period	Methods	Findings
			Model	economic growth is 8.89%.
Aydin *et al.* (2016)	24 Emerging Market Countries	Panel Data (1980-2013)	Dynamic Panel Threshold Model	Inflation threshold level was 13.68%.
Iyke and Odhiambo (2017)	Ghana and Nigeria	Time series Data (1961-2011)	Threshold Regression	The inflationary threshold ranges for Ghana and Nigeria was 10.73% – 29.83 and 10.07%–19.25 % respectively.

Table 2

Descriptive Statistics

Variables	*Explanation*	Mean	Std. dev.	Min	Max
dgdp	Five-year average of the annual growth rate of real GDP per capita (2005 Constant $)	2.61	2.82	-5.20	10.36
Gov	Five-year average of the government final consumption expenditure as a share of GDP	11.59	6.49	1.36	36.90
π	Five-year average of the annual percent changes in the Consumer Price Index (CPI)	2.18	0.93	-0.13	4.39
investment	Five-year average of the gross capital formation as a share of GDP	23.13	8.09	5.22	41.00
dpop	Five-year average of the annual growth rate of population	2.23	0.63	1.14	4.05
initial	Five-year average of GDP per capita of the previous period	7.13	0.99	5.43	9.00
openness	Five-year average of the annual growth rate of export	6.96	5.95	-11.30	26.31
dtot	Five-year average of the annual percentage change in the terms of trade	2.74	10.77	-15.29	64.15

Table 3

Correlations

	dgdp	*Gov*	π	*investment*	*dpop*	*initial*	*openness*	*dtot*
dgdp	1.00							
Gov	-0.13	1.00						
π	-0.06	0.19	1.00					
investment	0.16	0.30	0.05	1.00				
dpop	-0.29	0.28	-0.04	-0.09	1.00			
initial	0.00	0.20	0.31	0.44	-0.23	1.00		
openness	0.43	-0.18	-0.11	-0.07	0.03	-0.06	1.00	
dtot	-0.36	-0.10	-0.22	-0.30	0.03	-0.22	0.19	1.00

Table 4

Results of Dynamic Panel Threshold Model

Estimated Threshold Value (π)	**Model 1a**
$\hat{\gamma}$	12.88
95% CI	[7.31%-14.55%]
Effect of Inflation (π)	
$\hat{\beta}_1$	2.23*** (0.60)
$\hat{\beta}_2$	-1.45* (0.85)
Effect of Control Variables	
$initial_{it}$	-2.88** (1.41)
$investment_{it}$	0.10 (0.07)
$dpop_{it}$	-1.73*** (0.58)
$\hat{\delta}_1$	-3.28 (3.23)
Number of Observations	
$\pi \leq \hat{\gamma}$	46
$\pi > \hat{\gamma}$	26
Number of Countries	**8**

*Note: One lag of the dependent variable were used as instruments in the analysis i.e. ($dgdp_{it-1}$). Standard errors are given in parentheses. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively.*

Table 5

Results of Dynamic Panel Threshold Model

Estimated Threshold Value (π)	**Model 1b**
$\hat{\gamma}$	12.88
95% CI	[7.31%-14.55%]
Effect of Inflation (π)	
$\hat{\beta}_1$	2.25*** (0.58)
$\hat{\beta}_2$	-1.50** (0.73)
Effect of Control Variables	
$initial_{it}$	-2.65** (1.20)
$investment_{it}$	0.09 (0.06)
$dpop_{it}$	-1.66*** (0.55)
$\hat{\delta}_1$	-2.68 (2.86)
Number of Observations	
$\pi \leq \hat{\gamma}$	46
$\pi > \hat{\gamma}$	26
Number of Countries	**8**

Note: All possible lags of the dependent variable were used as instruments in the analysis i.e. ($dgdp_{it-1}, dgdp_{it-2}, \ldots, dgdp_{i0}$).

Table 6

Results of Dynamic Panel Threshold Model with Additional Explanatory Variable

Estimated Threshold Value (π)	**Model 2a**	**Model 2b**	**Model 2c**	**Model 2d**
$\hat{\gamma}$	12.88	12.88	12.88	12.88
95% CI	[4.29%-15.69%]	[7.31%-15.69%]	[3.38%-15.69%]	[3.63%-14.59%]
Effect of Inflation				
$\hat{\beta}_1$	2.01*** (0.52)	2.01*** (0.48)	1.85*** (0.62)	1.24** (0.43)
$\hat{\beta}_2$	-0.84* (0.50)	-0.83 (0.69)	-0.40 (0.76)	-1.30** (0.45)
Effect of Control Variables				
$initial_{it}$	-3.62*** (1.36)	-2.62** (1.23)	-2.92** (1.35)	-3.21*** (1.05)
$investment_{it}$	0.17*** (0.07)	0.09 (0.06)	0.08 (0.07)	0.12** (0.06)
$dpop_{it}$	-1.69*** (0.45)	-1.99*** (0.50)	-1.79*** (0.53)	-2.07*** (0.38)
Gov_{it}	-0.16** (0.07)	-	-	-0.12** (0.06)
$openess_{it}$	-	0.18*** (0.04)	-	0.19*** (0.04)
$dtot_{it}$	-	-	-0.05* (0.03)	-0.07** (0.03)
$\hat{\delta}_1$	-4.22 (2.88)	-4.77 * (2.60)	-2.78 (3.16)	-4.79** (2.22)
Number of Observations				
$\pi \leq \hat{\gamma}$	46	46	46	46
$\pi > \hat{\gamma}$	26	26	26	26
Number of Countries	8	8	8	8

Figure 1

Distribution of Inflation Rate for Full Sample (In Levels and Log)