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NON-LINEARITY BETWEEN INFLATION AND ECONOMIC GROWTH IN EMERGING ECONOMIES: A THRESHOLD REGRESSION APPROACH

NIELINIOWOŚĆ MIĘDZY INFLACJĄ A WZROSTEM GOSPODARCZYM W GOSPODARKACH WSCHODZĄCYCH: PODEJŚCIE REGRESJI PROGOWEJ

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Abstract

Purpose: This study examines the threshold effect of inflation on economic growth for 14 EMEs (Emerging Market Economies) from 1990 to 2022 using both panel and time series data.

Design/methodology/approach: We used Hansen's (1999; 2000) endogenous TAR method to estimate country-specific inflation thresholds for 14 EMEs and applied panel threshold regression to determine the collective inflation threshold for these economies.

Findings: Our findings suggest that inflation rates below 9.9977% benefit economic growth, while rates above this threshold are harmful. Time series analyses for the 14 EMEs consistently indicate a single threshold, with an average threshold rate of 6.79%. This closely aligns with the literature's average of 6%, supporting our results' robustness.

Originality: Our study differs from the earlier studies in four ways. Firstly, this study estimates the threshold impact of inflation with respect to economic growth in case of 14 EMEs as no such study has been done yet for these countries. Secondly, we have employed the latest TAR model suggested Hansen (1999, 2000) for empirical estimation of time series and panel threshold model for panel data respectively. Thirdly, we have used a large pool of data for the period of 1990-2022. Fourth, we have empirically determined the panel threshold inflation rate for 14 emerging market economies and also the country-specific threshold inflation rates for each of these nations individually.

Key Words*:* EMEs, Economic growth, Inflation, Threshold

Streszczenie

Cel: Niniejsze badanie analizuje progowy wpływ inflacji na wzrost gospodarczy 14 gospodarek rynków wschodzących (EME) w latach 1990-2022, wykorzystując dane panelowe i szeregi czasowe.

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Projekt/metodologia/podejście: Wykorzystaliśmy endogeniczną metodę TAR Hansena (1996; 2000) do oszacowania progów inflacji dla poszczególnych krajów dla 14 gospodarek rynków wschodzących oraz zastosowaliśmy panelową regresję progową do określenia zbiorczego progu inflacji dla tych gospodarek.

Wyniki: Nasze wyniki sugerują, że stopy inflacji poniżej 9,9977% sprzyjają wzrostowi gospodarczemu, podczas gdy stopy powyżej tego progu są szkodliwe. Analizy szeregów czasowych dla 14 gospodarek rynków wschodzących konsekwentnie wskazują na jeden próg, ze średnią wartością progową wynoszącą 6,79%. Jest to ściśle zgodne ze średnią literaturową wynoszącą 6%, co potwierdza solidność naszych wyników.

Oryginalność: Nasze badanie różni się od wcześniejszych badań pod czterema względami. Po pierwsze, w niniejszym badaniu oszacowano progowy wpływ inflacji na wzrost gospodarczy w przypadku 14 gospodarek wschodzących (EME), ponieważ nie przeprowadzono jeszcze takiego badania dla tych krajów. Po drugie, do empirycznej estymacji naszych danych panelowych wykorzystaliśmy najnowszy model TAR zaproponowany przez Hansena (2000). Po trzecie, wykorzystaliśmy dużą pulę danych z lat 1990-2022. Po czwarte, empirycznie określiliśmy progowy wskaźnik inflacji dla 14 gospodarek wschodzących, a także progowe wskaźniki inflacji dla każdego z tych krajów z osobna.

Słowa kluczowe: gospodarki wschodzące (EME), wzrost gospodarczy, inflacja, próg

1. Introduction

In Macroeconomics the relationship between rate of inflation[1] and economic growth[2] has long been a focus of intense study and debate. Inflation and its influence on the larger economic scenario, particularly the trajectory of economic growth, remain a primary concern for both economists and policymakers. This introduction looks into the various viewpoints on the dynamic connection between inflation and GDP (Gross Domestic Product) growth, focusing on major writings and recent research.

Historically, economists have deal with conflicting views regarding the implications of inflation for economic growth. Prior to the late 1960s, prevailing consensus often viewed inflation as either mild and favourable (benign) or even conducive to economic expansion. Many empirical studies like Lucas (1973), Mallik and Chowdhury (2001), Jung and Marshall (1986) also validate such a positive log run positive impact of inflation on economic growth with unidirectional causality. However, the turbulent experiences of the 1970s and 1980s, characterized by instances of high and sustained inflation across many countries, provoked a paradigm shift in economic thought. The convergence of high inflation and stagnating growth underscored the negative effects of inflationary pressures on macroeconomic performance, sparking a reassessment of its relationship with economic growth.

The seminal works of economists such as Rangarajan (1998) provide insight on the emerging insight of the inflation-growth nexus. The discourse turned towards recognizing inflation as a detrimental force that undermines economic growth, particularly in the long run. Kormendi and Meguire (1985), De Gregorio (1992), Singh and Kalirajan (2003), Low and Chan, (2017), Razia et al., (2023) in their empirical study found negative relation between the variables in their empirical studies.

This shift in perception was motivated by empirical evidence revealing the negative impact of inflation on numerous economic activities including savings, investment, exports, and income distribution. Such contradictory results raise significant doubt about the stability and uniformity of the inflation-growth relationship. So, Present-day research has contributed to further explaining the minute associations between inflation and economic growth. Scholars like Sarel (1997), Author et al., (1998), Bruno & Easterly (1996) Das and Loxley, (2015), Iqbal and Nawaz, (2009), Khan and Senhadji, (2001), Munir et al., (2009) and Kannan, (1999) investigated the existence of non-linear relations and threshold effects, in which the relationship between inflation and growth takes a structural shift at specified inflation rates. These studies highlight the necessity of defining crucial thresholds. Beyond this threshold, inflation has a disproportionately negative impact on the present state of the economy.

[1] A steady rise in the average price of goods and services over time is referred to as inflation. It is commonly quantified using indices like the CPI, Wholesale Price Index (WPI), and GDP Deflator.

[2] The gradual rise in an economy's output of goods and services over time is known as economic growth. It is often measured by the growth rate of GDP, which is the sum value of all products and services produced within the domestic territory during a given period.

Moreover, theoretical frameworks ranging from endogenous growth models[3] to structuralist[4] perspectives offer diverse insights into the mechanisms through which inflation affects economic dynamics. From the perspective of endogenous growth theory[5], inflation may impede capital accumulation and productivity growth, thus dampening overall economic performance. Conversely, structuralists argue that inflation may be conducive to growth by stimulating investment and capital formation.

The quest to outline the optimal inflation-growth nexus has profound implications for policy formulation and institutional design. Policymakers deal with the challenge of regulating monetary and fiscal policies to maintain price stability while fostering sustainable economic growth. The adoption of inflation-targeting frameworks, as witnessed in countries like New Zealand and Canada, reflects a rigorous effort to anchor macroeconomic policies towards low and stable inflation.

Yet, among this newfound consensus, questions lingered, particularly for regions like South Asia. Here, the economic landscape is distinct, shaped by unique challenges and opportunities. Determining the optimal level of inflation became akin to finding the right balance in a delicate ecosystem, where too much or too little could upset the equilibrium. Recent studies offered hope, suggesting that while moderate inflation might not be harmful, crossing a certain threshold could spell trouble for economic growth. It was like identifying a tipping point where the path deviates from prosperity to peril. This revelation opened avenues for policymakers to chart a course toward stability, armed with insights assembled from the intersection of theory and practice.

In this study, we attempt to present an in-depth study of the relationship between inflation and economic growth, drawing on both theoretical concepts and empirical studies, particularly when calculating the inflation threshold rate. Our study differs from the earlier studies in four ways. Firstly, this study attempts to identify the threshold impact of inflation with respect to economic growth in case of EMEs as no such study has been done yet for the above mentioned countries. Secondly, we have employed the latest TAR model suggested by Hansen (1999, 2000) for empirical estimation of time series and panel threshold model for panel data respectively. Thirdly, we have used a large pool of data for the period of 1990-2022 which is extracted from World Bank Database (WDI). Fourth, we have empirically determined the panel threshold inflation rate for 14 emerging market economies and also the country-specific threshold inflation rates for each of these nations individually.

Inflation and Growth: Theoretical Foundations

The relationship between inflation and economic growth is multifaceted, with theoretical and empirical research offering varied insights. Traditionally, the Phillips Curve (Phillips, 1950s) proposed an inverse relationship between inflation and unemployment (growth), but this has been contested – particularly during episodes like stagflation, which demonstrated that high inflation and unemployment can coexist.

Economic theories often emphasize a growth-inflation trade-off, where policies aiming to boost output may trigger inflation, especially in the long run. The debate has shifted to examining threshold effects. Sarel (1997), Khan and Senhadji (2001), and Das and Loxley (2015) highlight that inflation's impact on growth is non-linear. At low levels, inflation may support growth, while beyond a certain threshold, it becomes detrimental. Threshold regression models help identify these critical inflection points.

[3] Endogenous growth theories explain how certain aspects of the production process, such as economies of scale, rising returns, or induced technical progress, lead to economic growth.

[4] School of thought that highlights the significance of economic structures, institutions, and historical context in shaping economic outcomes. Structuralist perspectives on inflation and economic growth stress the impact of underlying economic structures on inflation. They argue that inflation is not just monetary but also influenced by supply constraints, income distribution, and structural changes. Addressing these structural imbalances through policy interventions is crucial for managing inflation and fostering sustainable growth.

[5] According to endogenous growth theory, the capital return rate has been the sole variable that determines the growth rate. (Refer to Gillman et al. (2002). factors can lower that rate of return, such as inflation, which lowers capital accumulation and slows down the rate of expansion.

Under Classical economic thought, spearheaded by Adam Smith and David Ricardo, inflation is mainly a result of changes in the money supply (via the Quantity Theory of Money) and is assumed to have no long-run impact on real output. The theory promotes Say's Law and Saving-Investment equality, assuming full employment and flexible prices, with money playing a neutral role. Neoclassical thought, especially the Solow (1956) growth model, emphasizes capital, labour, and technology as drivers of growth, treating inflation as exogenous. However, extensions by Mundell (1963) and Tobin (1965) argue that inflation can affect real balances, encouraging investment over consumption, thereby promoting capital accumulation and growth.

Monetarist theory, led by Milton Friedman, strongly asserts that "inflation is always and everywhere a monetary phenomenon." Using the Quantity Theory of Money (MV = PT), monetarists argue that excessive money supply leads to inflation. While monetary changes can affect output and employment in the short run (due to adaptive expectations), in the long run, only real factors (not monetary ones) determine economic growth (Dornbusch et al., 1996). Thus, the inflation-growth nexus is context-dependent, influenced by inflation levels, policy regimes, and structural dynamics.

Below given Figure 1 and Figure 2 show the relation between GDPR and CPINF for 14 EMEs using data for the period of 1990 to 2022 through line graph and scatter plot.

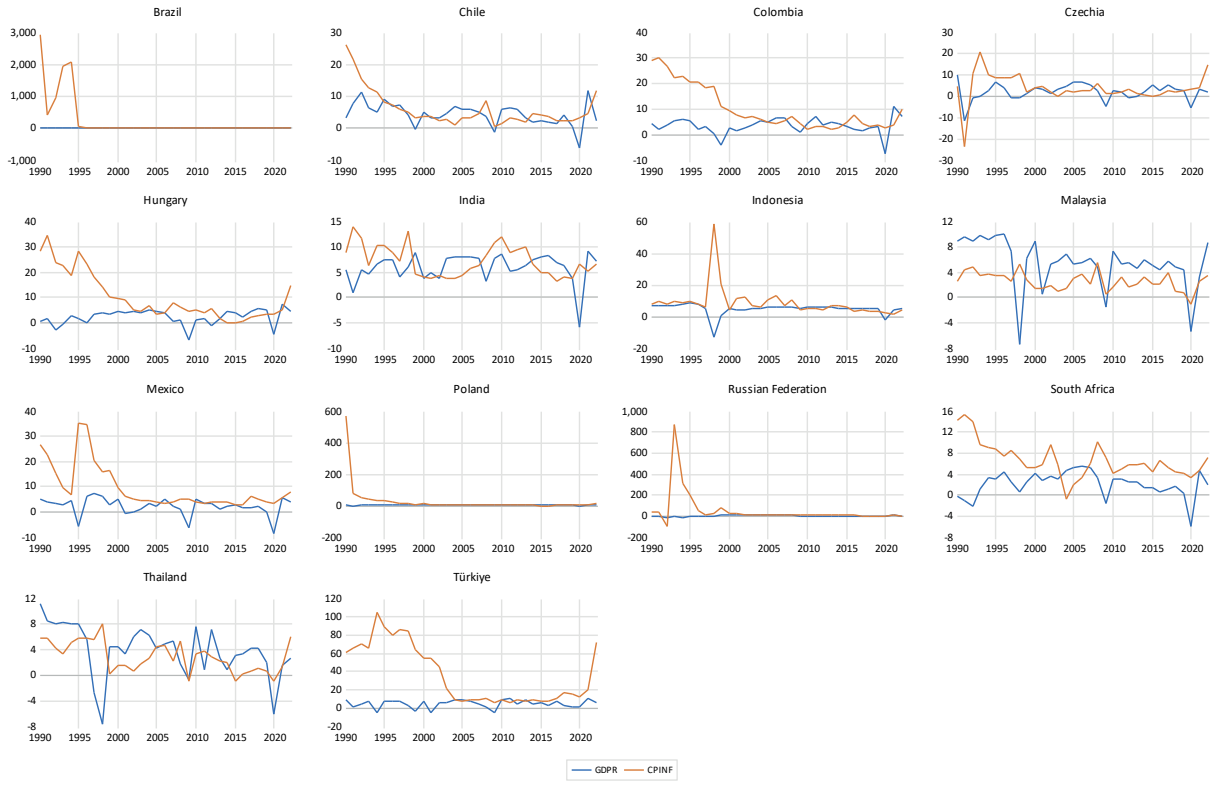

Figure 1: Line Graph representing GDPR and CPINF

Source: Prepared by the authors.

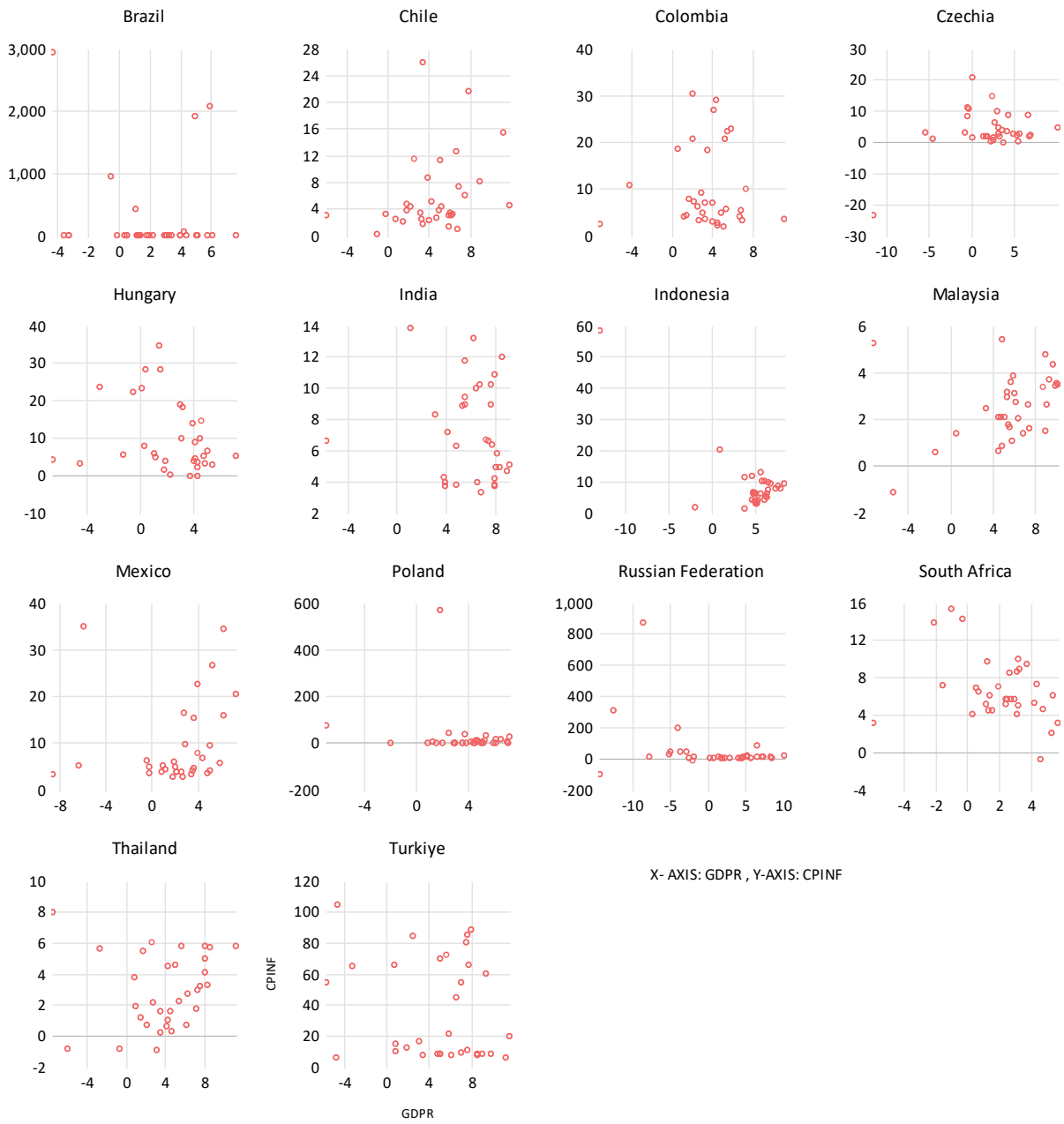

Figure 2: Scatter Plot representing GDPR and CPINF
Source: Prepared by the authors.

2. Review of Literature

Friedman (1994) famously claimed that "inflation is always and everywhere a monetary phenomenon." However, multiple empirical studies demonstrate that inflation is influenced by diverse factors beyond money supply. For instance, Sabade (2014) found that in India, although the Quantity Theory of Money (QTM) identity holds (MV = PT), price levels (P) are not solely determined by money supply (M). Similarly, Pandit (1978) highlighted agricultural output and monetary expansion as key inflation drivers in India (1950–1975).

Empirical evidence across countries shows varying inflation-growth dynamics. Khan and Senhadji (2001) and Sarel (1996) found a non-linear relationship where low inflation may foster growth, while high inflation hinders it. Munir et al. (2009), Iqbal and Nawaz (2009), and Author et al. (1998) confirmed threshold effects for Malaysia, Pakistan, and India respectively. Razia et al. (2023) noted inflation's long-term but not immediate impact on growth in Palestine.

Country-specific studies in emerging markets echo similar themes. For instance, Landerretche et al. (1999) and Bogdanski et al. (2000) supported inflation targeting in Chile and Brazil. Thresholds vary: Khadaroo (2005) found 3.4% for India, Morar (2011) 5.5-6.5% for South Africa, Esen et al. (2016) 8.89% for Türkiye, and Jiranyakul (2017) 3% for Thailand. Seraphin (2019), studying 13 African countries, identified 7.04% as a critical threshold.

Inflation's impact is double-edged-it may stimulate capital accumulation (Tobin effect), reduce real debt burden, and enhance wage flexibility, but high inflation can deter savings, investment, export competitiveness, and lead to capital flight. Kaldor (1959) emphasized profit stability and controlled inflation for sustainable growth.

Recent cross-country estimates by Azam and Khan (2022) suggest threshold levels of 12.23% for developing and 5.36% for developed economies. Makeeva and Sinelnikova-Muryleva (2020) and Kusumatrisna et al. (2022) further support this non-linear view, validating inflation targeting ranges like 3-4% used by central banks in Brazil, Colombia, and Russia as growth-conducive.

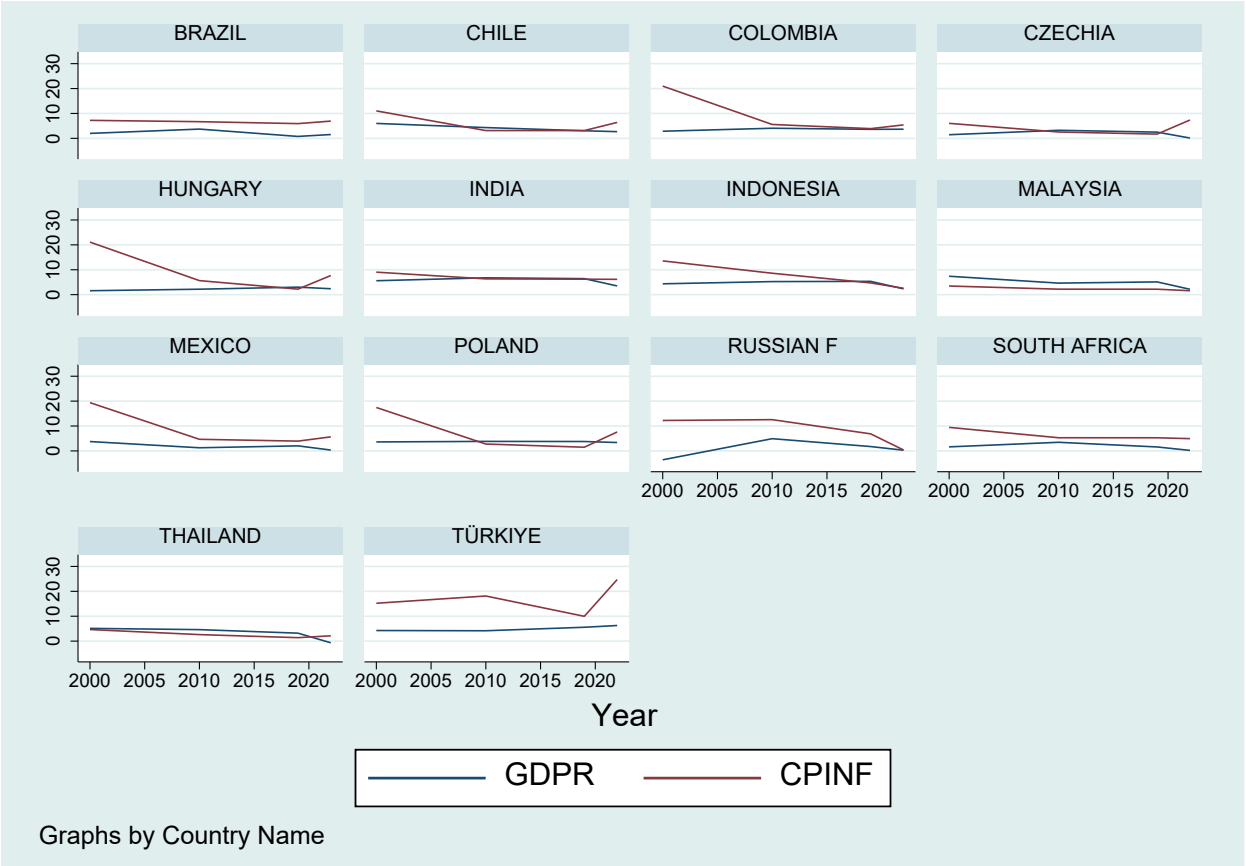

Figure 3: A trend analysis of GDPR and CPINF for all the 14 EMEs using decadal (10 years) average before and after COVID-19

Source: Prepared by the authors.

3. Data and methodology

3.1. Data and Model Specification

This section presents the correlation matrices, summary statistics, of the variables and the data set that was used in the analysis. Furthermore, we provide a brief description of the threshold estimation method as forward by Hansen (1999, 2000) and Munir et al., (2009). Further we divide our methodology in two parts for two different series namely time series estimation for individual nations and panel series estimation for EMEs.

3.2. Data Description and Source

A panel data framework consisting of 14 EMEs (Emerging market economies) considered in the analysis for the period from 1990 to 2022, one country is dropped due to lack of data availability. This study uses three variables: (1) GDPR, (2) CPIINF (3) GCFR. The variables are obtained from the World Bank Database (WDI).

Variables utilized in the estimations:

- **Growth of GDP at Constant Price (GDPR):** GDP is the aggregate value of countries goods and services produced during a financial period calculated on the base price. GDPR is the dependent variable.
- **Consumer Price Index (CPINF):** Inflation rate calculated from CPI considering 2010 as the base year. The threshold determining variable.
- **Gross Capital Formation (GCFR):** The annual growth value of Gross Capital Formation, used as a proxy of physical capital accumulation. It comprises of expenditures for increasing the economy's fixed assets as well as net adjustments to the number of inventories.

Table 1: Description of the variables and anticipated theoretical signs

Variable's	Description	Anticipated Theoretical sign
Dependent Variable		
RGDP	Real GDP Growth rate .	
Independent Variable		
CPINF	Inflation reflected by rise in CPI.	(+) / (-)
GCFR	Growth rate of Gross Capital Formation.	(+)

Source: Prepared by the authors.

4. Model Specification and Estimation Technique

We consider the linear regression equation utilized by Munir et al., (2009):

$$GDPR_t = \beta_0 + \beta_1 CPINF_t + \beta_2 GCFR_t + \varepsilon_t \quad \ldots(1)$$

Here $GDPR_t$ represents the growth rate of GDP; $CPINF_t$ represents inflation rate calculated from CPI; and $GCFR_t$ represents the gross capital formation growth rate serving as a substitution for rate of investment; and ε_t denotes the error term. The standard linear model is shown by Equation (1). Though, recent studies indicate threshold effects linked with inflation rates surpassing/falling under critical values. This suggests a non-uniform relationship between inflation and economic growth, requiring suitable methods for estimation.

4.1. Model Specification and Estimation Technique for Time Series Threshold Regression

Recent studies by Hansen(1999) introduce novel findings regarding the TAR model originally proposed by Tong (1978). New procedures for threshold effects, estimates threshold parameters, and derives asymptotic confidence intervals was developed by Hansen(1999). The basic idea underlying Hansen(1999) threshold calculation is to use an exogenous variable, known as the "threshold variable," in order to split the sample into two regimes. These regimes may or may not serve as regressors. This framework describes the asymptotic distribution of OLS estimates for the threshold parameter. Considering a TAR model with two-regime structural equation:

$$y_t = \theta`_1 x_1 + e_t \qquad if \;\; g_t \leq \gamma \quad \ldots(2)$$

$$y_t = \theta`_2 x_1 + e_t \qquad if \;\; g_t > \gamma \qquad ...(3)$$

Where g_t signifies threshold variable, break down all observed values into two separate regimes. Phrases y_t denote the response variable and x_t denotes the predictor variable (an m-dimensional vector). The error term, denoted by the character e_t, is believed to be white noise with independent and identically distributed (iid) characteristics, and γ represents the threshold value. If γ were known the model could be easily calculated using OLS. But the threshold needs to be calculated alongside with other variables because it is unknown earlier. It's crucial to remember that the model estimates Equation (2) when the threshold variable is lesser than the threshold parameter. On the other hand, the model estimates Equation (3) for the threshold variable above the threshold value.

The binary variable $d_t\,\gamma = \{q_t \le \gamma\}$ is defined with $\{\cdot\}$ serving as the indicator function, with

$$d_t(\gamma) = \begin{cases} 1 & if \;\; q_t \le \gamma \\ 0 & if \;\; q_t > \gamma \end{cases} \qquad ...(4)$$

and establishing $x_t\,\gamma = x_t\,d_t(\gamma)$, then equation (2) and (3) can be rephrased as a unique single equation:

$$y_t = \theta`_1 x_1 + \delta` x_1(\gamma) + e_t \qquad ...(5)$$

In which, $\theta = \theta_1$, $\delta = \theta_1 - \theta_2$ and the regression parameters to be estimated are β, δ, γ . $S_1(\gamma) = \hat{e}_t(\gamma)\;\hat{e}_t(\gamma)$ is the residual sum of squares (RSS) that remain after the regression parameters are estimated. Hansen(1999) suggests utilizing the least squares method to estimate γ . This can be done easily by minimizing the RSS as a function of the estimated threshold value. Consequently, the optimal threshold value can be expressed as $\hat{\gamma} = arg\;min\;S_1(\gamma)$. Regressing the response variable on independent variables yields conditional OLS estimates of $\hat{\theta}(\gamma)$ and $\hat{\sigma}(\gamma)$ since the regression equation becomes linear in θ and $\delta`$ biased on $\hat{\gamma}$. After this process, linear equation (1) can be transformed into a non-linear equation with a two-regime TAR model as follows:

$$GDPR_t = (\beta_0 + \beta_1 CPINF_t + \beta_2 GCFR_t)\; d[q_t \le \gamma] + (\beta_0 + \beta_1 CPINF_t + \beta_2 GCFR_t)\; d[q_t > \gamma] + \varepsilon^*_t \qquad ...(6)$$

Determining the threshold value that minimizes the RSS allows us to find the ideal threshold value in the estimate of model (6). The yearly inflation growth rate is used as the threshold variable in the study because our primary goal is to examine the threshold effect in the association of economic growth and inflation in EMEs and the inflation rate. As we are calculating it for each country so, we are using the same model specification in every country case.

The primary inquiry in Equation (6) revolves around the presence of a threshold effect This involves comparing the two-regime model Equation (6) with the linear model. An alternative hypothesis ($H_1 : \beta_{1i} \neq \beta_{2i}$) is evaluate against the null hypothesis ($H_0 : \beta_{1i} = \beta_{2i}$, $of\;no\;threshold\;effect$, $where\;i = (0,\ldots,5)$ is tested against. Because γ the threshold parameter is unknown under the null hypothesis of no threshold effect, conventional hypothesis testing techniques are insufficient. Therefore, Hansen (1996) suggests computing the asymptotic critical value and the p-value using a typical heteroscedasticity-consistent likelihood ratio (LR) bootstrap approach.

4.2. Model Specification and Estimation Technique for Panel Threshold Regression

Hansen (2000) developed the threshold, which was employed by Khan and Senhadji (2001), and Mubarik (2005) in a cross-country analysis and individual country study respectively. The structural equation of inflation propounded by Hansen (2000) is

$$y_{it} = \mu_i + \beta_1 x_{it} I(q_{it} \leq \gamma) + \beta_2 x_{it} I(q_{it} > \gamma) + \varepsilon_{it} \quad \text{.....(7)}$$

The data observed are from a balanced panel[6] denoted as $\{y_{it}, q_{it}, x_{it}: 1 \leq i \leq n, 1 \leq t \leq T\}$. Here, the subscript i denotes the individuals, whereas the subscript t represents time. The explained variable y_{it} and the threshold variable q_{it} are scalars, and the regressor x_{it} it is a k vector where $I(\cdot)$ is the indicator function. In this paper we employed the following model for the empirical estimation in calculating panel threshold level for the EMEs:

$$GDPR_{it} = \theta GCFR_{it} + \beta_1 (CPINF_{it} \leq \gamma) + \beta_2 (CPINF_{it} > \gamma) + e_{it} \quad \text{...(8)}$$

Another intuitive style of writing equation (8) is

$$GDPR_{it} = \begin{cases} \theta GC F_{it} + \beta_1 CPINF + e_{it}, & \leq \gamma \\ \theta GC F_{it} + \beta_1 CPINF + e_{it}, & > \gamma \end{cases}$$

Conditional on whether the threshold variable $CPIN F_{it}$ is above or below the threshold level γ, we divide the data into two regimes. The variations in regression slopes, β_1 and β_2, set these regimes apart. The elements of $CPIN F_{it}$ must not be time-invariant in order to identify β_1 and β_2, and we further assume that the threshold variable, $CPIN F_{it}$, is not time-invariant. Assumed to have a mean of zero ($\overline{X}=0$), finite variance σ^2, and independent and identically distributed (iid) error term e_{it}. The inclusion of lagged explained variables from $CPIN F_{it}$ is prohibited by this iid assumption. It is unclear, nevertheless, how to expand the findings to take into account dynamic models and /or heteroskedastic errors. With a fixed T as $n \rightarrow \infty$, the analysis is asymptotically sound.

In order to achieve this, standard F-statistics are used to run a test with near-optimal power against options that are far from H_0:

$$F_1 = \frac{S_0 - S_1}{\sigma^2} \quad \text{...(9)}$$

The RSS S_0 and S_1 under the null hypothesis $H_0 : \beta_{1i} = \beta_{2i}$ and the alternative hypothesis $H_1 : \gamma \neq \gamma_0$ indicated below. The $\hat{\sigma}^2$ represents the estimate of error variance, defined as $\hat{\sigma}^2 = \frac{1}{T} \hat{e}_t$, $\hat{e}_t = \frac{1}{T} S_1(\gamma)$. According to Hansen (1996) illustration, a bootstrap approach could achieve the 1st order asymptotic distribution. Consequently, p-values derived from the bootstrap procedure have asymptotic validity.

Following the estimation of the threshold impact, what comes next is to analyse its statistical significance. Hansen (2000) proposes using a bootstrap approach to recreate the empirical distribution of the LR test:

$$LR_1(\gamma) = \frac{S_1(\gamma) - S_1(\hat{\gamma})}{\sigma^2} \quad \text{...(10)}$$

[6] It is ambiguous if the results apply to imbalanced panels.

where $S_1(\gamma)$ and $S_1(\hat{\gamma})$ represent the RSS under $H_0 : \gamma = \gamma_0$, and $H_1 : \gamma \neq \gamma_0$ respectively; and the estimated error variance $\hat{\sigma}^2$, stated as $\hat{\sigma}^2 = \frac{1}{T}\ \hat{e}_t\ \hat{e}_t = \frac{1}{T} S_1(\gamma)$.

For values of $LR_1(\hat{\gamma})$ the likelihood ratio statistics is employed to reject the null hypothesis. Furthermore, the asymptotic distribution of the LR statistic (γ_0) is not normally distributed as Hansen (2000,p.584) shows $1-\alpha$ is the no-rejection region of the confidence level, that is, if $LR_1(\gamma) \leq c(\alpha)$ then the null hypothesis of $H_0 : \gamma = \gamma_0$ cann't be rejected. Valid asymptotic confidence intervals around the predicted threshold values are estimated using their no-rejection region, $c(\alpha) = -2\ln\left(1-\sqrt{1-\alpha}\right)$, where α is a given asymptotic level. Until the null hypothesis can no longer be rejected, the previously described processes are repeated in order to examine multiple threshold values.

5. Country Specific Time Series Empirical Results (14 EMEs)

It is essential to ponder about if the variables in analysis are stationary or not before presenting the results. To make sure that there is no erroneous association among the variables utilized in the regressions, we test for stationarity. Each variable's stationary status is examined using the Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) units root tests. The level variables are subjected to these tests. Table 6 presents the findings. According to the estimate findings, the null hypothesis i.e., "unit root is present" is rejected in both tests at the 1%, 5%, and 10% significance levels. Consequently, the findings often suggest that the underlying variables exhibit a stationary process.

Table 2: ADF and PP Unit Root Test Results for GDPR

COUNTRY	ADF		PP		Decision
	Level	1st Diff.	Level	1st Diff.	
Brazil	-4.77***	-	-4.77***	-	I(0)
Chile	-5.00***	-	-5.06***	-	I(0)
Colombia	-5.14***	-	-5.14***	-	I(0)
Czechia	-5.92***	-	-5.89***	-	I(0)
Hungary	-4.52***	-	-4.52***	-	I(0)
India	-5.26***	-	-5.26***	-	I(0)
Indonesia	-3.74***	-	-4.09***	-	I(0)
Malaysia	-4.05***	-	-4.71***	-	I(0)
Mexico	-4.29***	-	-5.95***	-	I(0)
Poland	-5.35***	-	-4.24***	-	I(0)
Russian Federation	-2.79*	-	-2.69*	-	I(0)
South Africa	-3.11**	-	-4.04***	-	I(0)
Thailand	-2.28**	-	-3.82***	-	I(0)
Türkiye	-5.71***	-	-6.79***	-	I(0)

Note: Significant at the 1%, 5%, and 10% levels are indicated by ***, **, and *, respectively

Source: Prepared by the authors.

Table 3: ADF and PP Unit Root Test Results for CPINF

COUNTRY	ADF		PP		Decision
	Level	1st Diff.	Level	1st Diff.	
Brazil	-5.28***	-	-5.82***	-	I(0)
Chile	-4.25***	-	-4.65***	-	I(0)
Colombia	-2.71***	-	-2.93***	-	I(0)

COUNTRY	ADF		PP		Decision
	Level	1st Diff.	Level	1st Diff.	
Czechia	-4.63***	-	-4.65***	-	I(0)
Hungary	-3.14**	-	-1.97**	-	I(0)
India	-7.79***	-	-2.73*	-	I(0)
Indonesia	-3.53**	-	-4.38***	-	I(0)
Malaysia	-3.09**	-	-4.28***	-	I(0)
Mexico	-2.70*	-	-2.64*	-	I(0)
Poland	-4.65***	-	-29.76***	-	I(0)
Russian Federation	-3.03**	-	-4.46***	-	I(0)
South Africa	-3.77***	-	-3.19**	-	I(0)
Thailand	-3.42**	-	-3.38**	-	I(0)
Türkiye	-5.01***	-	-2.26*	-	I(0)

Note: Significant at the 1%, 5%, and 10% levels are indicated by ***, **, and *, respectively.

Source: Prepared by the authors.

Table 4: ADF and PP Unit Root Test Results for GCFR

COUNTRY	ADF		PP		Decision
	Level	1st Diff.	Level	1st Diff.	
Brazil	-5.18***	-	-5.18***	-	I(0)
Chile	-6.08***	-	-6.13***	-	I(0)
Colombia	-4.42***	-	-4.19***	-	I(0)
Czechia	-4.46***	-	-5.45***	-	I(0)
Hungary	-8.77***	-	-8.76***	-	I(0)
India	-4.38***	-	-7.45***	-	I(0)
Indonesia	-4.88***	-	-5.27***	-	I(0)
Malaysia	-4.61***	-	-6.58***	-	I(0)
Mexico	-5.08***	-	4.28***	-	I(0)
Poland	-3.89***	-	-5.37***	-	I(0)
Russian Federation	-4.83***	-	-5.83***	-	I(0)
South Africa	-3.80***	-	-5.74***	-	I(0)
Thailand	-5.56***	-	-5.56***	-	I(0)
Türkiye	-3.79***	-	-3.28***	-	I(0)

Note: Significant at the 1%, 5%, and 10% levels are indicated by ***, **, and *, respectively.

Source: Prepared by the authors.

5.1. Test Statistics for Threshold Effects

Using the yearly inflation growth as the threshold variable, Table 6 shows the test results for threshold effects. Our endogenous threshold analysis yields asymptotic p-values and threshold test results by using 1,000 bootstrap replications to correct the standard errors. By showing that there is at least one threshold in each of the 14 nations, the test conclusively disproves the null hypothesis of no threshold. Based on this criterion, our sample splits into classes exhibiting low and high inflation rates. The estimated ideal threshold value averages at 6.79% among the 14 nations. Additionally, at a significance level of 5%, the LR test rejects the null hypothesis of no threshold.

Table 5: LM Test Results

Country	LM-test	Bootstrap P-Value	Trimming (%)
BZL	6.06	0.00	0.15
CHL	6.07	0.00	0.15
COL	6.64	0.00	0.15
CZE	8.27	0.00	0.15
HNG	6.95	0.00	0.15
IND	3.21	0.00	0.15
INO	3.95	0.00	0.15
MLY	13.48	0.00	0.15
MEX	11.16	0.00	0.15
POL	2.68	0.00	0.15
RUF	6.94	0.00	0.15
SA	6.45	0.00	0.15
THI	8.03	0.00	0.15
TKY	4.56	0.00	0.15

Source: Prepared by the authors.

5.2. Relationship between Inflation Rate and Economic Growth

Table 6 displays the estimated results of the non-linear relationship between GDP growth and inflation rates in EMEs from 1990 to 2022. The threshold model reveals that inflation's impact on growth varies significantly, depending upon the inflation rate level. The marginal effect of inflation on growth is notably positive under the low-inflation regime, especially at inflation rates below the threshold. Specifically, under the rate of 2.95, 5.56, 3.91, 2.97, 2.36, 6.38, 5.04, 5.69, 4.03, 3.97, -19.61, 2.64, 6.81, and 5.53 for BZL, CHL, COL, CZE, HNG, IND, INO, MLY, MEX, POL, RUF, SA, THI, and TKY respectively.

A 1% increase in inflation during the low-inflation regime causes an average jump in economic growth of 2.73% across these nations, as column (3) illustrates. However, Inflation has a major negative impact on economic growth if it rises over the threshold, as evidenced by substantially diminished and even negative coefficient values in shown in column (4). Remarkably, a unique threshold rate is identified for all 14 EMEs. Moreover, the consistency with existing literature regarding similar threshold rates and inflation targets further supports the validity of these results. Overall, these findings suggest that during high-inflation periods, Economic growth declines in response to rising inflation rates.

Table 6: Country wise Results of Threshold Regression

Country	γ	GCFR	(Inf_reg1)	(Inf_reg2)
BZL	6.93	0.22	2.95	1.25
CHL	4.35	0.15	5.56	3.40
COL	5.90	0.20	3.91	2.86
CZE	8.76	0.34	2.97	-2.68
HNG	9.80	0.18	2.36	0.71
IND	6.62	0.06	6.38	5.90
INO	9.42	0.24	5.04	3.05
MLY	3.54	0.22	5.69	4.19
MEX	6.97	0.40	4.03	1.58
POL	2.46	0.15	3.97	3.49
RUF	11.65	1.05	-19.61	-25.71
SA	6.57	0.19	2.64	1.48

Country	γ	GCFR	(Inf_reg1)	(Inf_reg2)
THI	3.25	0.09	6.81	2.96
TKY	8.89	0.27	5.53	3.60
Average	**6.79**	**0.27**	**2.73**	**1.15**

Source: Prepared by the authors.

The projected nonlinear relation between economic growth and inflation, as well as the fact that every nation has a different threshold rate i.e., 6.93, 4.35, 5.90, 8.76, 9.80, 6.62, 9.42, 3.54, 6.97, 2.46, 11.65, 6.57, 3.25 and 8.89 for BZL, CHL, COL, CZE, HNG, IND, INO, MLY, MEX, POL, RUF, SA, THI, and TKY respectively. The findings are consistent with the theoretical and empirical conclusions from earlier research, as shown in Table 7. In particular, it validates that inflation has a detrimental impact on economic growth during times of high inflation. Furthermore, it's important to highlight that investment (GCFR), irrespective of inflation regimes, exhibits a positive and considerable influence on economic growth. This finding underscores the profound dependence of EMEs on trade.

Table 7: Existing literature's results of Threshold Regression

Area of Study	Inflation Rate	Description	Citation/ Source
Brazil	3%	IT	Banco Central do Brasil.
Chile	2% – 4%	IT	Landerretche et al., (1999)
Colombia	3% with ± 1%	IT	Banco de la República.
Czechia	2% with ± 1%	IT	Czech National Bank
Hungary	3.2%	TR	Kiss and Krekó, (2004)
India	5.5%	TR	Mohanty et al., (2011)
Indonesia	9.59%	TR	Kusumatrisna et al., (2022)
Malaysia	3.89%	TR	Munir and Mansur, (2009)
Mexico	9.0%	TR	Adrián Risso and Sánchez Carrera, (2009)
Poland	2.5% with ±1%	IT	Stawska, (2016)
Russian Federation	4.0%	TR	Makeeva and Sinelnikova-Muryleva, (2020)
South Africa (EMEs)	5.5% – 6.5%	TR	Morar, (2011)
Thailand	3.0%	TR	Jiranyakul, (2017)
Türkiye	8.89%	TR	Esen et al., (2016)
Developing World	12.23%	TR	Azam and Khan, (2022)
BRICS	7.04%	TR	Seraphin, (2019)
Average	6%		

Note: IT means Inflation Targeting and TR means Threshold Rate.

Source: Prepared by the authors.

6. Panel Threshold regression results

Summary statistics for the panel series are given and shown by Table 8. The average inflation rate for EMEs stands at around 31.79% between 1980 and 2022. During the same period, EMEs witnessed a maximum inflation rate equal to 2947.73 % (Brazil – 1990) and a minimum of-98.54% (Russian Federation-1992). The average GDP growth for EMEs during this timeframe was approximately 3.43 percent, with a maximum of 11.73 percent and a minimum of -14.53 percent.

Table 9 illustrates the correlation matrix for the variables. The correlation coefficients for all explanatory variables vary from 0.101 to 0.013, which is believed to be satisfactory in preventing multicollinearity in the basic regression.

Table 8: Summary Statistics of Variables

Statistics	GDPR	CPINF	GCFR
Mean	3.435	31.790	44.424
Std. Dev.	3.958	201.485	295.411
Kurtosis	2.544	135.664	67.465
Skewness	-1.216	11.123	6.893
Minimum	-14.531	-98.543	-1254.266
Maximum	11.737	2947.733	3358.757

Source: Prepared by the authors.

Table 9: Correlation Matrix

Variables	GDPR	CPINF	GCFR
GDPR	1		
CPINF	-0.10	1	
GCFR	0.039	-0.01	1

Source: Prepared by the authors.

6.1. Empirical Result- Panel Series

Before proceeding with the outcomes, it is necessary to assess if the variables using for analysis are stationary. Checking for stationarity is necessary to guarantee that the variables included in the estimation are not prone to spuriousness. The LLC, Breitung, and IPS Unit Root Tests are used to determine the stationary position of the variables. These tests are performed using the level variables. Table 10 shows the outcomes. The estimated results of all three tests demonstrate that null hypothesis i.e., "unit root is present" is rejected at 1% significance level. As a result, the findings indicate that the underlying variables exhibit a stagnant process.

Table: 10 Panel Unit Root Test of the variables

Tests	Variables	GDPR	CPINF	GCFR
Levin–Lin–Chu Unit Root Test.	*t-value*	-13.80	-20.18	-17.54
	P-value	0.00	0.00	0.00
	level	I(0)	I(0)	I(0)
Breitung Unit Root Test.	*lambda*	-8.25	-3.96	-9.92
	P -value	0.00	0.00	0.00
	level	I(0)	I(0)	I(0)
Im–Pesaran–Shin Unit Root Test.	*t-bar*	-4.73	-8.45	-6.04
	P -value	0.00	0.00	0.00
	level	I(0)	I(0)	I(0)

Source: Prepared by the authors.

Model (1) was utilized for a single threshold to determine the no. of threshold. Table 9 displays the test statistics for threshold regression, F-value, and associated bootstrap p-values. With a bootstrap p-value of 0.001, we found the test for a single threshold is very significant, leading us to draw the inference that there is strong evidence of a unique threshold in the regression relationship.

Table: 11 LR Test for Panel Threshold Regression

Statistics	Test for Threshold Effect
F Value	45.49***
P-Value	0.001
Critical Values	10.12(10%), 24.02 (5%), 35.81 (1%)

Source: Prepared by the authors.

The next step is to determine the level of precision of the identified threshold level. To assess the confidence interval surrounding the threshold estimate, we use the LR test. [9.99 - 15.76] is the 95% asymptotic confidence area. The sequence statistics of the normalized LR of $LRn*(\gamma)$ as a function of CPINF, threshold is shown in Figure 4. As previously stated, the value which minimizes the function $LRn*(\gamma)$ and occurs at γ = 9.997 % is the least squares estimate of the threshold (γ). The dotted line represents the asymptotic 95% critical value 7.35, which is significant at 5% levels. The confidence interval [9.99, 15.76] is displayed when the line crosses $LRn*(\gamma)$. The threshold estimations appear to be quite accurate based on this outcome. As a result, there is substantial evidence in support of one threshold.

According to the threshold model, inflation affects growth in a unique and significant way.

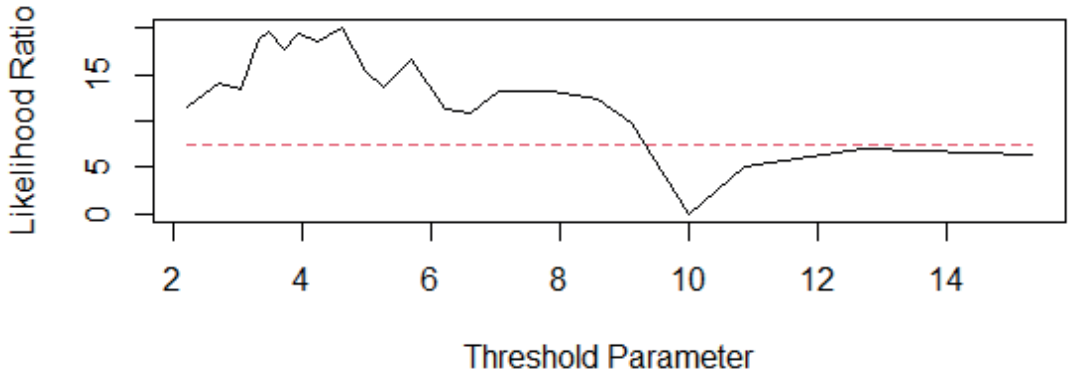

Figure 4: Confidence Interval Construction in Single Threshold Model

Source: Prepared by the authors.

Yet, the inflation rate determines the inflation coefficient's sign and value. The marginal effect of inflation on growth is notably positive (0.167) under the low-inflation regime, that is, when inflation is under 9.997%. Table 11 shows that, in EMEs, a 1% increase in inflation corresponds to an average 0.167% increase in economic growth within a low-inflation regime. Similarly, as the coefficient is -0.0003, inflation implies a strong negative impact on economic growth when it exceeds the threshold level of 9.997%. This suggests that, in a high-inflation environment, there is an average 1% reduction in economic growth for every 1% increase in the inflation rate. In the case of two- regime models, the computed coefficients of CPINF show a substantial statistical difference from zero at p<0.05.

Table: 12 Panel Threshold Regression Estimates

Parameter	Estimate	OLS SE	White SE	T stat
θ	0.20**	0.014	0.018	11. 15
β_1	0.167**	0.025	0.023	7. 39
β_2	-0.0003***	0.0007	0.0005	-0.52

Estimated Threshold (γ), $\hat{\gamma} = 9.9977$, Confidence interval: (9.998, 15.758).

Source: Prepared by the authors.

The estimated non-linear association between inflation and economic growth-which is that inflation has a negative impact on economic growth in high inflation regimes – is supported by the empirical and theoretical findings derived from earlier research, as indicated in Table 7. Investment (GCFR), independent of inflation regimes, has a positive, significant impact on economic growth. The effect shows how important it is to invest in EMEs. Now we can re-write our equation we can call that the Fitted regression model as;

$$\widehat{GDPR}_{it} = 0.20 \;\; GCFR_{it} + 0.167 \;\; \left(CPINF_{it} \leq 9.997\right) - 0.00032 \;\; \left(CPINF_{it} > 9.997\right)$$

7. Conclusion

This paper probes into the intricate relationship of inflation and economic growth, exploring its non-linear nature using the TAR model. Following the econometric approach suggested by Hansen (1996; 2000), we analyse annual data from 14 EMEs spanning from 1990 to 2022. Our empirical findings strongly indicate the presence of a structural break, signifying a threshold beyond which the relationship between inflation rate and economic growth changes, with inflation exerting a negative impact on growth.

Our results underscore a non-linear association between inflation and economic growth in EMEs. Specifically, we find that economic growth may benefit from inflation rates below 9.9977%, while inflation above this threshold level becomes detrimental to economic growth. Additionally, conducting individual time series analyses for each of the 14 EMEs consistently reveals the presence of a single threshold. The average threshold rate across all countries is 6.79%, closely aligns with the existing literature's average of 6%, reinforcing the robustness of our findings.

By employing the structural break approach, we demonstrate that the effect of inflation on economic growth is not solely detrimental under high inflation scenarios; rather, inflation has a beneficial and significant impact on economic growth in low inflation settings. In conclusion, our study underscores the importance of maintaining inflation rates below the collective threshold level of 9.9977% and individual threshold levels for each country specifically, for BZL, CHL, COL, CZE, HNG, IND, INO, MLY, MEX, POL, RUF, SA, THI, and TKY with the respective threshold levels of 6.93%, 4.35%, 5.90%, 8.76%, 9.80%, 6.62%, 9.42%, 3.54%, 6.97%, 2.46%, 11.65%, 6.57%, 3.25%, and 8.89%. Following these thresholds facilitates sustainable economic growth.

The empirical evidence of the current study will be helpful for Central Banks in shaping monetary policy, as inflation targeting has become one of the most widely adopted strategies globally to promote sustainable economic growth and reduce inflation volatility.

Declarations

Data Availability Statement: Data will be made available on reasonable request.

Ethics approval: This paper is original and has not been submitted elsewhere for publication. We have not received any fund for writing this article.

Consent to participate: Not applicable

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Conflicts of interest/Competing interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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