Special Feature A

# Is Higher Inflation also More Persistent Inflation? Threshold Effects on Inflation Persistence

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## 1 Introduction

The recent surge in global inflation has disrupted decades of price stability enjoyed by advanced economies. The conventional wisdom states that inflation stemming from supply shocks may occasionally be accommodated as those shocks may be temporary, and the cost of reducing such inflationary pressures could be significant. However, it is essential to be mindful of the potential risks that come with accommodating supply shocks. Past experiences in countries with extended periods of high inflation have shown that inflation can become self-perpetuating if it reaches a sufficiently high level. This occurs as domestic factors attempt to recover their real purchasing power by indexing wages and contracts to inflation, while economic agents adjust their expectations of inflation upward.

The likelihood that inflation dynamics shift as inflation reaches higher levels highlights the importance of conducting thorough empirical analysis that appropriately considers non-linearities and the possibility of regime shifts in inflation dynamics.

This study examines if there is a shift in inflation persistence at higher levels of inflation. A standard definition of inflation persistence is the "speed with which inflation converges to equilibrium after a shock" (Marques, 2004). If inflation becomes more persistent when it overshoots its target level, it becomes more costly to bring it back to the target level. While there are various alternative measures of inflation persistence in the literature, the one that is most easily adaptable for allowing changes in persistence related to inflation levels is an autoregressive model for inflation. This framework can be integrated into the Self-Exciting Threshold Autoregression (SETAR) model proposed by Hansen (1997). The model setup allows for estimation and inference, including testing for the existence of threshold effects against a null hypothesis of no threshold effects, and constructing confidence intervals around threshold values.

This study departs from previous literature that mainly concentrates on analysing how inflation persistence changes over time or across monetary policy regimes in one or a few advanced economies. Instead, this study broadens the scope by including all countries with suitable data, estimating how inflation persistence changes with inflation levels. Moreover, this paper estimates country-specific threshold values for annual inflation that identify high and low inflation regimes for inflation persistence, along with confidence intervals for these values. The results reveal substantial differences in these threshold values, with advanced economies having significantly lower threshold values than emerging markets and

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developing economies (EMDEs). This is likely because the latter have more recent experiences with higher inflation.

# 2 Literature Review

## Stylised Facts

Fuhrer (2011) is a useful review of the literature on inflation persistence. It was written more than a decade ago, but remains relevant. Up to the recent inflation surge, few researchers dealt with this issue. One of the results highlighted in the review is that there is some evidence that inflation persistence has decreased over time in the US, but this finding is not entirely conclusive because the results on inflation persistence are often not robust. The literature also indicates that countries that adopt explicit inflation targeting frameworks (such as Canada and the UK) have experienced a decline in inflation persistence.

The literature also examines whether inflation persistence is inherited or intrinsic. Inherited inflation persistence may arise because shocks to the economy may be long lasting (e.g., real or fiscal shocks), with inflation inheriting its persistence from these drivers. Intrinsic persistence implies that inflation's own dynamics are persistent regardless of the persistence of its drivers (e.g., due to backward-looking price or wage setting rules). According to Fuhrer's (2011) review of the literature, the majority of studies assign a central role to intrinsic persistence, largely because inflation persistence has declined in many countries since the 1980s without a corresponding reduction in the persistence of inflation drivers.

Beechey and Osterholm (2012) argue that inflation persistence is higher the more the central bank prioritises output stabilisation over inflation stabilisation in its objective function. They apply the Kalman filter to US data and find that their estimates support a decrease in inflation persistence since the tenure of Paul Volcker at the Federal Reserve. Arguably, this reduction in inflation persistence could be at least partly attributed to central bankers adopting a more hawkish tone on inflation since the Volcker disinflation period.

Benati (2008) examines inflation persistence across monetary policy regimes and finds that inflation targeting countries experience little to no inflation persistence. His results challenge the notion that there is an intrinsic component to inflation persistence when the monetary regime is consistent with price stability. It also suggests that macroeconomic models with built-in inflation persistence may be misleading. However, given that his results were obtained during the "Great Moderation", when economic conditions were particularly favourable, it may be necessary to revisit this conclusion in light of recent developments.

Pivetta and Reis (2007) find no evidence of a reduction in inflation persistence in the US. However, more recent data analysed by Fuhrer (2011) suggests a reduction in persistence in recent years. Fuhrer also argues that results by Pivetta and Reis (2007) may differ from those of other papers because they use the GDP deflator instead of CPI, and studies that use the GDP deflator tend to find weaker evidence of a decline in persistence compared to those using CPI.

## Measurement

There are many alternative measures of inflation persistence adopted in the literature, each one with its strengths and drawbacks.

- O'Reilly and Whalen (2005) estimate inflation persistence as the parameter $\rho$ in the following equation:

$$\pi_t = \alpha + \rho\pi_{t-1} + \sum_{k=1}^{p} \psi_k \Delta\, \pi_{t-k} + \varepsilon_t$$

  That is numerically equivalent to the sum of autoregressive terms (SUM) in the AR(p) representation: $\pi_t = \alpha + \sum_{k=1}^{p} \beta_k\, \pi_{t-k} + \varepsilon_t$.

- Pivetta and Reis (2007) estimate inflation persistence using rolling-sample estimates of the first-order autocorrelation coefficient, derived using a Bayesian non-linear model of inflation dynamics.

- Stock (1991) estimates persistence in macroeconomic variables as the largest autoregressive root. This measure has a limitation: it only considers information from the largest root and disregards the information from other roots. For instance, an AR(2) process with roots 0.9 and 0.8 would be more persistent than an AR(2) process with roots 0.9 and 0.1, but the measure would not illustrate this. The advantage of this measure is having an asymptotic theory for conducting inference (Stock, 1991).

- Dias and Marques (2004) use mean reversion as a measure of persistence. They propose a nonparametric statistic that measures mean reversion:

$$\hat{\gamma} = 1 - \frac{n}{T}$$

  where $n$ is the number of times the series crosses the mean during a time interval with $T + 1$ observations.

This paper proposes a straightforward empirical model for persistence that is well-suited for analysing the question of whether inflation persistence is affected by the level of inflation. Specifically, we use a threshold first-order autoregressive model to estimate inflation. This model allows us to identify any relevant thresholds where the relationship between inflation and persistence may change.[2]

More specifically, a SETAR model is used, which is an AR(1) model for inflation ($\pi$), where the autoregressive parameter is dependent on whether a function of lagged values of inflation is below or above some threshold value $A$. In particular, the working hypothesis in this study is that persistence depends on whether annual inflation ($\bar{\pi}_{t-2}$) is below or above a threshold value:

$$\pi_t = \begin{cases} \alpha + \rho_L \pi_{t-1} + \varepsilon_t & \text{if } \bar{\pi}_{t-2} < A \\ \alpha + \rho_H \pi_{t-1} + \varepsilon_t & \text{if } \bar{\pi}_{t-2} \geq A \end{cases}$$

Estimating the SETAR model proposed by Hansen (1997) is relatively straightforward as it involves running a series of OLS regressions, each assuming a different threshold level, and selecting the estimate with the lowest mean square error. Estimation and inference of the

[2] According to Fischer, Sahay and Vegh (2002), there is no straightforward relationship between inflation persistence and inflation levels during high-inflation episodes. Specifically, persistence actually decreases at very high inflation levels. This stylised fact presents a challenge to the empirical strategy in this paper because it implies that there may be two relevant thresholds, the lower one above which persistence increases and a higher one above which persistence is reduced. However, it is worth noting that the high inflation episodes studied by Fischer *et al.* (2002) have not been observed in any advanced economy in our estimation sample, and only a few of the EMDEs have experienced them.

SETAR model was proposed by Hansen (1997). However, statistical inference presents some challenges. Testing for differences in the autoregressive coefficient across regimes is difficult because, under the null hypothesis that $\rho_L = \rho_H$, the value of the threshold is not identified so the typical F-statistic for hypothesis testing does not have a chi-squared distribution. To address this issue, Hansen (1997) proposes a bootstrap procedure to approximate the asymptotic distribution, which this paper replicates.

# 3 Results

The baseline results in this study are based on the full sample, which covers the period from January 1970 to September 2022, and is subject to data availability on a country-by-country basis.[3] The analysis is conducted using monthly, seasonally adjusted, headline CPI data, with the dependent variable being the annualised monthly inflation. The threshold variable is the annual inflation for the period ending two months before, which is motivated by the idea that the dynamics of inflation are less likely to change in response to short-term fluctuations in inflation, while the lagged annual inflation may capture the effects of more persistent changes in inflation. This approach also helps to address the issue of endogeneity.

The study finds evidence of threshold effects in 61.3% of the countries (49 out of 80) at the 90 per cent confidence level, indicating that the null hypothesis of no threshold effects can be rejected for these countries **(Table 1)**.

**Table 1** Countries that Experience Threshold Effects vs. Countries that Do Not

| No Threshold Effects (31 Countries) | | | Threshold Effects (49 Countries) | | |
|---|---|---|---|---|---|
| Albania | Georgia | Palestine | Austria | Guatemala | Portugal |
| Armenia | Ireland | Paraguay | Belgium | Honduras | Romania |
| Bangladesh | Jamaica | Peru | Bolivia | Hungary | Singapore |
| Belarus | Japan | Philippines | Chile | Iceland | Slovenia |
| Brazil | Kazakhstan | Poland | China | Indonesia | South Africa |
| Bulgaria | Kenya | Saudi Arabia | Colombia | Israel | Spain |
| Canada | Latvia | Slovakia | Costa Rica | Italy | Sweden |
| Croatia | Lithuania | Trinidad & Tobago | Denmark | Jordan | Switzerland |
| Cyprus | Mauritius | Uganda | Dominican Republic | South Korea | Taiwan |
| Czechia | Pakistan | Ukraine | Ecuador | Luxembourg | Thailand |
| Egypt | | | El Salvador | Mexico | Tunisia |
| | | | Estonia | Netherlands | Turkey |
| | | | Eurozone | Nigeria | United Kingdom |
| | | | Finland | North Macedonia | United States |
| | | | France | Norway | Uruguay |
| | | | Germany | Panama | Zambia |
| | | | Greece | | |

[3] Only countries with at least 300 observations for the headline consumer price index (CPI) on a monthly basis are included.

The econometric exercise reveals a pattern of high inflation persistence following periods of higher inflation for the countries where the AR(1) model is rejected in favour of the model with threshold effects **(Table 2)**. Specifically, the mean persistence after higher inflation is 0.54 (with a median 0.57), while after lower inflation it is significantly lower at 0.08 (with a median 0.07). Moreover, the persistence during periods of inflation higher than the estimated threshold is higher than that implied by the OLS estimates, with a mean of 0.42 (median 0.43). Those findings imply that assuming a constant persistence model for inflation underestimates inflation persistence when inflation is high, and overestimates it when inflation is low.

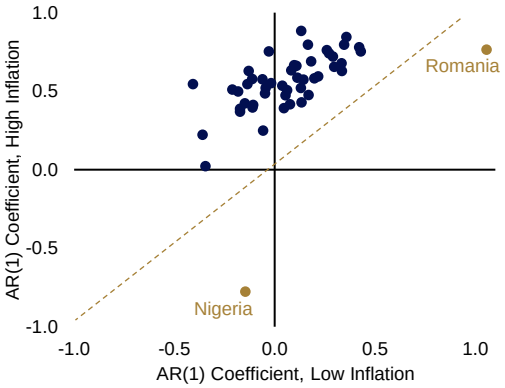
**Table 2** Regression Results of AR(1) Model and Threshold Model

| Model and Coefficient | Mean | Median |
|---|---|---|
| **AR(1) Model, estimated by OLS** | | |
| AR(1) Coefficient | 0.42 | 0.43 |
| **Threshold Model** | | |
| AR(1) coefficient, low inflation | 0.08 | 0.07 |
| AR(1) coefficient, high inflation | 0.54 | 0.57 |

Note: The analysis was based on 49 countries for which the AR(1) model was rejected in favour of the model with threshold effects.

**Chart 1** provides a visual representation of the joint distribution of inflation persistence in high and low inflation states, while **Chart 2** shows the density function of persistence estimates in high and low inflation states. Notably, only two countries (Nigeria and Romania) exhibit lower estimates of inflation persistence when inflation is above its threshold value compared to when it is below. This suggests that for the majority of countries in the sample, higher inflation is associated with greater persistence, consistent with the findings of previous studies.

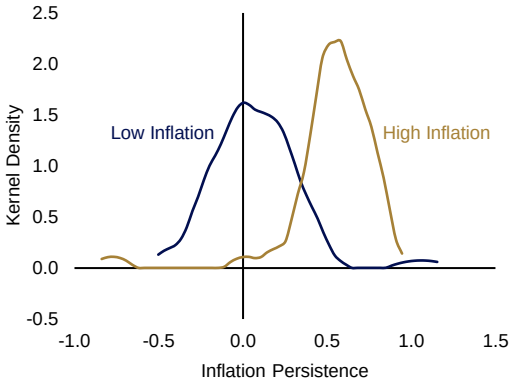
**Chart 1** Joint Distribution of Inflation Persistence in High and Low Inflation States




Source: Author's estimates

Note: Countries that fall on the dotted line have the same inflation persistence in both high and low inflation states.

**Chart 2** Density Functions of Persistence Estimates




Source: Author's estimates

The estimated threshold values that separate low and high inflation persistence states vary across countries. Among advanced economies (with 24 observations), the mean and median threshold values for annual inflation are 4.9%. The median threshold value for emerging and developing economies is 9.8%, while the mean, which is more influenced by outliers, is considerably higher at 17.6%. These imply that advanced economies typically experience higher inflation persistence at lower inflation threshold values compared to EMDEs.

**Table 3** Mean and Median Threshold Values for Different Types of Economies

| | Mean | 25th Percentile | Median | 75th Percentile | Number of Observations |
|---|---|---|---|---|---|
| Advanced Economies | 4.9 | 3.6 | 4.9 | 5.9 | 24 |
| Emerging and Developing Economies | 17.6 | 6.4 | 9.8 | 21.0 | 25 |
| All Countries | 11.4 | 4.4 | 6.2 | 10.2 | 49 |

Source: Author's estimates

Finally, in order to test the robustness of our findings, we estimated the model on two limited samples, from 1970 through 1990 and from 1990 onwards. The main results of this paper remained robust to the restricted samples, indicating that our findings are not influenced by features specific to either the Volcker disinflation or the Great Moderation periods.

# 4 Conclusion

This paper provides empirical evidence that inflation persistence is positively related to the level of inflation. Specifically, our results show that higher inflation is generally more persistent, while persistence is negligible at low levels of inflation. This finding is consistent with previous research, such as Benati (2008), which suggests that inflation persistence may behave differently under stable monetary policy regimes.

The study also finds that inflation processes become more persistent at significantly lower levels in advanced economies than in EMDEs. Arguably, this could be explained by differences in wage-setting institutions across countries triggering second-round effects at lower levels of inflation in advanced economies than in EMDEs. It is important to be cautious when interpreting the results of this study, given the wide confidence bands around threshold estimates. Nonetheless, it is worth noting that for most advanced economies, current inflation levels fall within the estimated high persistence territory.

These results have important implications for the conduct of monetary policy. Central banks may need to take more pre-emptive actions to control inflation while it is still low, in order to avoid triggering increases in inflation persistence. Additionally, central banks may be able to reduce inflation persistence by maintaining low and stable inflation rates. Understanding the dynamics of inflation persistence is therefore essential for effective monetary policy.

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