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Inflation Trend and Persistence in Bangladesh: An Empirical Analysis

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ABSTRACT

This paper tries to estimate the trend inflation and examines the degree of persistence in three inflation series (i.e. food, non-food, and headline) for Bangladesh. Our sample period starts in the first month of 2003 and ends in the last month of 2019. The paper uses a Multivariate Unobserved Component Model based on a state-space representation and estimates the model using maximum likelihood via Kalman filter. It identifies a high degree of persistence in all the three inflation series, which means that the effect of shocks on inflation is long-lasting. Consequently, it would take a longer time to bring inflation back to its long-run average path after a shock than if persistence were low. One explanation for this high persistence of inflation is that inflationary memory remains alive amongst the economic agents. Therefore, it requires relatively rigorous policy action to bring inflation back to its target level.

Keywords: Inflation; Inflation persistence; Monetary policy.

JEL Classification: E30, E31, E52

1. INTRODUCTION

Maintaining a reasonable degree of price stability while ensuring an adequate expansion of credit to assist economic growth have been the primary goals of monetary policy in Bangladesh. To achieve the goal variables monetary policy uses

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a quantity theory equation to back out an intermediate target for the growth of broad money based on projections for real GDP growth, numerical inflation goal, and expected velocity trends. Monetary targeting, far from being a rigid policy rule, is quite flexible in practice as there are no explicit numerical objectives for output and inflation. Bangladesh Bank (BB) demonstrated its flexibility by allowing its inflation goal to vary over time and to achieve other objectives, including output and exchange rates. For the last few years BB is increasingly emphasizing targeting an annual average CPI. By this shift of emphasis, BB has in effect adopting inflation targeting as a strategy for conducting monetary policy, albeit implicitly. In adopting such a framework, it is necessary to know the most useful information about inflation persistence to decide on the timing and magnitude of policy actions which are geared toward achieving price stability.

Understanding the inflation process is crucial for economic agents because they base many of their economic decisions on inflation pattern. It is also important for policymakers conducting monetary policy; for investors hedging the risk of nominal assets; for firms making investment decisions and setting prices, and for labor and management negotiating wage contracts. One of the most important characteristics of inflation is its degree of persistence, that is, how slowly it returns to its long-run path after a disturbance of some kind.

Nelson and Batini (2002), Marques (2004), and Dias & Marques (2010) interpret persistence with the idea of speed, i. e. the speed with which inflation converges to its equilibrium after a shock. Inflation is said to be more (less) persistent the slower (faster) it converges or returns to its equilibrium after the occurrence of a shock. An important implication of the inflation persistence is the fact that any estimate of inflation persistence is conditional on the assumed long-run inflation path. Putting it

slightly differently, to be able to tell whether inflation is moving slowly or quickly in response to a shock, we need information on the likely path inflation would have followed had the shock not occurred as well as on the level inflation is expected to be once the effect of the shock has died off.

In particular, the appropriate response to a random shock depends on the degree to which its effects on inflation will persist. If inflation is highly persistent, then bringing inflation back to its target level after a shock would require a more vigorous policy action than if persistence were low. Hence, in the case of low inflation persistence, a country can keep its output growth at a relatively high standard with the rate of inflation being at a low level. Therefore, the reduced inflation persistence in a country effectively helps maintain inflation at a relatively low level during the period of high economic growth. Policymakers need to know how rapidly their policy actions take effect: with less persistence, inflation can be established in a shorter time following a shock (Dossech and Evereart, 2005).

Persistent deviations of inflation from policymakers' inflation target can also affect the possible trade-off between stabilizing inflation and economic output: if inflation is more persistent, policymakers may be keener to avoid inflation that is too high or too low, which may require larger deviations of output from its normal level.

A more compelling argument for a continual focus on the characteristics of inflation is that it contains information that is important for changing the stance of monetary policy. There is a complex chain of events that links a change in the monetary policy actions with subsequent changes in inflation. Development anywhere along this chain can alter how much a policy action will affect inflation and when. So, it can take time for a monetary policy action to affect inflation. With the lags

associated with the monetary policy actions, BB needs to know in advance when inflation is likely to rise so that it can react in time and neutralize inflationary pressure that could appear in the future.

With this view in mind, the objective of our study is:

i) to measure the degree of persistence in the headline, food, and non-food inflation to identify long-run inflation expectation for Bangladesh; and
ii) to identify the implications of inflation persistence for decision making for both the public and private sectors.

In this study, we want to answer the following questions:

i) Is inflation persistence is high for Bangladesh?
ii) How inflation persistence has been deviating from their historical norms in recent years?

The remainder of the paper is structured as follows. Taking after the introduction, section 2 reviews some related studies regarding inflation persistence. Section 3 describes the data and methodology. Section 4 lays out the estimated results. The conclusion of the paper is specified in section 5.

2. LITERATURE REVIEW

Various factors can explain persistence. Persistence may be inherited from persistent fluctuations in the determinants of inflation, like marginal cost or output gap, called extrinsic persistence. The dependence of inflation on its past is called intrinsic persistence. Moreover, due to asymmetric information, sticky information or imperfect credibility, private agents' perceptions about the central bank's inflation target can differ from the true in the inflation target. The persistence of such deviations can be called expectations-based persistence (Angeloni et al., 2004).

Furthermore, Batini and Nelson (2002) and Batini (2002) distinguish three different types of persistence: (1) positive serial correlation in inflation (2) lags between systematic monetary policy actions and their (peak) effect on inflation and (3) lagged responses of inflation to non-systematic policy actions (i.e. policy shocks).

Given the important implication of inflation persistence on monetary policy analysis, a small but growing literature has flourished examining the nature of inflation persistence with the specific focus on industrial economies, notably Taylor (2000), Cogley and Sargent (2001), Cecchetti and Debelle (2006), Pivetta and Reis (2007), and Zhang, Osborn, and Kim (2008) studying the issue for the U.S., O'Reilly and Whelan (2005) for Europe, and Levin and Piger (2004) for twelve industrial countries. Surprisingly little research, however, has been conducted on the study of inflation persistence in Bangladesh.

Two kinds of theoretical discussion have been found on inflation persistence in the literature. First, the accelerationist hypothesis and the Fisher hypothesis suggest that inflation is a non-stationary process. The accelerationist view implies that inflation will remain on an ever-increasing level to maintain lower the natural rate of unemployment. Consequently, inflation would be characterized as a unit root where the unemployment rate is kept lower than the natural rate (Romero-Avila and Usabiaga, 2009). Moreover, the Fisher hypothesis claims that if the nominal interest rate contains a unit root, for the real interest rate to be stationary, it is necessary for the inflation rate to follow a unit root process and to be cointegrated with the nominal interest rate.

On the contrary, several theoretical models, for example, the rational expectations version of Cagan (1956), the sticky-price model (Taylor, 1979) and the 'higher-order' Phillips curve model (Calvo, 1983; Ball, 1993), assert that the inflation rate is a mean-reverting process. Traditionally, under the assumption of the stationary inflation process, the New Keynesian Phillips curve has been estimated (Gali and

Gertler, 1999; Gali et al., 2005; Nymoen et al., 2012). Moreover, the hypothesis of a "natural rate of inflation" assumes that inflation is a stationary process.

Cecchetti and Debelle (2006) in a study on US inflation found that allowing for changes in the mean inflation leads to a considerable decline in the measured inflation persistence. They also found that inflation expectations are directly related to changes in the mean of inflation in many developed countries. O'Reilly and Whelan (2005) use an annualized quarterly log difference of GDP deflator for the EURO area and document a very high degree of persistence.

For emerging markets, Mohanty and Klau (2001) document a high degree of inflation persistence for many countries in Asia as well as Latin America. This finding is consistent with Baum et al. (1999) who reports a high degree of persistence for both developed and developing economies for the period 1971-1995. Both of these studies find a high degree of inflation persistence in India. Mohanty (2011) finds that the persistence in non-food inflation remains high, whereas food inflation has increased in recent years.

As outlined in Russell (2011), inflation could also be a stationary process around shifting means. The rational expectations hypothesis proposes that the stable growth of the money supply implies stationary inflation (Yellen and Akerlof, 2006), Arize et al. (2005), and Arize and Malindretos (2012) also put emphasis on the stationarity of the inflation rate to estimate the money demand relations. Cecchetti and Debelle (2006) stressed that stationary inflation will incur a lower cost for the monetary authorities in conducting monetary policy.

Fang Yao (2011) opined that when a central bank aggressively responds to inflation deviations, inflation persistence shifts from inherited persistence to intrinsic persistence, making inflation more stably anchored on its history, so that it is less affected by the extrinsic driving forces. On the other hand, when the central bank holds an easing policy stance on inflation, they would face a capricious inflation

dynamic even in the short- run. Erceg and Levin (2003) show that inflation will appear to be highly persistent if the central bank changes its inflation objective, but the public is uncertain about the change, even in a model where inflation displays very little persistence if the long-run inflation objective is constant.

Understanding persistence in macroeconomic variables is a well-established concern in the macroeconomic literature. Consequently, it is no surprise that considerable academic literature evaluates different inflation persistence measuring models. One common feature of the literature is the use of a scalar measure of persistence which is particularly useful in comparing the degree of persistence across the series. The most popular scalar indicator of persistence, in the inflation persistence literature, in particular, is the sum of autoregressive coefficients. Other commonly used measures of persistence include the largest autoregressive root, the spectrum at zero frequency, or the half-life decay[2].

Our approach differs from the current literature that we measure the degree of persistence using a multivariate unobserved component model to estimate the trend inflation for headline CPI inflation with the objectives of identifying long-run inflation expectations for Bangladesh economy. Our framework utilizes the information contained in the two components of Headline CPI inflation i.e. food inflation and non-food inflation. Using information from food and non-food inflation is valuable in the context of Bangladesh since persistent movements in food and non-food inflation can affect long-term inflation in a developing country like Bangladesh.

The decomposition of inflation into a trend and a cyclical component used in our study is motivated by Stock and Watson (2007). One of the advantages of this approach is that it provides us with a measure of the inflation gap (deviation of inflation from a time-varying trend) that can be used to measure its persistence.

[2] The persistence of an inflation response can be captured in a single number called the half-life, which states how long after a shock it takes for inflation to fall to half its initial value.

However, in their setting inflation innovations are serially uncorrelated, which makes the model unsuitable to investigate persistence in the inflation gap. This problem does not arise in our setup because we allow serial correlation in the inflation gap. The absence of any evidence about measuring the degree of persistence in inflation for Bangladesh is an important void in the literature that we tried to fill with this paper. This contribution enhances the current literature that exists on inflation persistence.

3. DATA AND METHODOLOGY

3.1 Data: Sources and Description

We use monthly data for the year-on-year rate of inflation for Bangladesh from January 2003 through December 2019. Data were obtained from the Bangladesh Bureau of Statistics (hereafter BBS). The monthly rate of inflation is measured using the overall Consumer Price Index (CPI) (headline inflation), two specific CPI indexes (food and non-food inflation). All variables are measured in percentages.

3.2 Unit Root Analysis

Almost all macroeconomic time series one typically uses have a unit root (Nelson and Plosser, 1982). The presence or absence of unit roots helps to identify some features of the underlying data generating process of a series. In the absence of unit root (stationary), the series fluctuates around a constant long-run mean and implies that the series has a finite variance which does not depend on time. On the other hand, in the presence of a unit root (non-stationary), the variance of the series is time-dependent. Non-stationary series suffer permanent effects from random shocks and thus the series follows a random walk.

The debate on unit root hypothesis underwent renewed interest following the important findings of Nelson and Plosser (1982). The traditional view of the unit

root hypothesis was that the current shocks only have a temporary effect and the long-run movement in the series is unaltered by such shocks. The most important implication under the unit root hypothesis sparked by Nelson and Plosser (1982) is that the random shocks have permanent effects on the long-run level of macroeconomics; that is the fluctuations are not transitory.

These findings were challenged by Perron (1989), who argues that most macroeconomic series are not characterized by a unit root, but rather that persistence arises only from large and infrequent shocks and that the economy returns to deterministic trend after small and frequent shocks. We test the unit root hypothesis for the three inflation series (headline, food and non-food inflation) using the Augmented Dickey-Fuller (ADF) test.

3.3 Random Walk Process of Persistence

We model the long-run inflation trend as a slow-moving random walk process to capture the degree of persistency of inflation in Bangladesh. Slow-moving random walk process can overcome the problem of varying local mean that has been much discussed in the literature on inflation dynamics (Cecchetti and Debelle 2006; Cogley et al. 2010). We outline our model using the three-variable unobserved component model where the three variables are Headline, Food and Non-food.

3.4 A Multivariate Unobserved Component Model of Trend Inflation

We used the information from the CPI headline, food and non-food inflation in our model. We argue that using information from food inflation is valuable in the context of Bangladesh since persistent movements in food inflation can affect long-term inflation in a developing country like Bangladesh.

Formally, at a given time t, we assume that inflation for each component of CPI headline inflation can be decomposed into a stochastic trend and an idiosyncratic

transitory component. We also assume that these variables share a common trend because of having a significant association.

$$\pi^{CPIHead} = \phi_t + C_t^{CPIHead} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\pi^{Food} = \gamma_1 + \lambda_1 \phi_t + C_t^{Food} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\pi^{NonFood} = \gamma_2 + \lambda_2 \phi_t + C_t^{NonFood} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Trend Dynamics (τ_t):

Trend inflation has been modelled as a slow-moving random walk process

$$\phi_t = \phi_{t-1} + \varepsilon_t \qquad \varepsilon_t \sim \text{iidN}\ (0,\ \sigma_\varepsilon^2) \quad \ldots\ldots\ldots\ldots (4)$$

Cycle Dynamics (c_t):

Each inflation series is allowed to have an idiosyncratic cycle. The idiosyncratic cycles c_t are assumed to follow an AR (1) process.

$$C_{it} = \theta_i C_{t-1} + \upsilon_{it} \qquad \upsilon_{it} \sim \text{iidN}\left(0,\ \sigma_{vi}^2\right) \quad \ldots\ldots\ldots\ldots (5)$$

Trend inflation has been estimated using CPI headline inflation by employing univariate decomposition which is a special case of the three-variable model presented above. The multivariate model has the following structure:

$$\pi_t = \phi_t + C_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$\phi_t = \phi_{t-1} + \varepsilon_t \qquad \varepsilon_t \sim \text{iidN}\ (0,\ \sigma_\varepsilon^2) \quad \ldots\ldots\ldots\ldots (7)$$

$$C_{it} = \theta_i C_{t-1} + \upsilon_{it} \qquad \upsilon_{it} \sim \text{iidN}\left(0, \sigma_{vi}^2\right) \quad \ldots\ldots\ldots\ldots (8)$$

The model is presented with the state-space form and estimated using maximum likelihood via the Kalman filter. Representing a dynamic system in state-space form has two main benefits. First, the state-space form allows unobserved variables to be

incorporated into and estimated along with the observable model. Second, state-space models can be analyzed using the powerful recursive Kalman filter. The state-space representation of the three-variable unobserved component model is presented below.

The measurement or signal equation can be written as:

$$Z_t = \alpha + L_t \psi_t$$

The unobserved state variables ψ_t are generated by a first-order Markov process defined by the transition or state equation:

$$\psi_t = F\psi_{t-1} + u_t \qquad u_t \sim \mathrm{N}(0, Q)$$

Where Z_t is an (n*1) vector of observable variables, L_t is an (n*m) matrix, βt is an (m × 1) vector of (possibly) unobservable state variables.

The prediction equations and updating equations for the Kalman filter model are as follows:

Prediction Equations:

$$\psi_{t/t-1} = F\psi_{t-1/t-1}$$

$$\rho_{t/t-1} = F\rho_{t-1/t-1}F' + Q$$

$$\Omega_{t/t-1} = Z_t - L_t\psi_{t/t-1}$$

$$y_{t/t-1} = L_t\rho_{t/t-1}L_t'$$

Updating Equations:

$$\psi_{t/t} = \psi_{t/t-1} + K_t\Omega_{t/t-1}$$

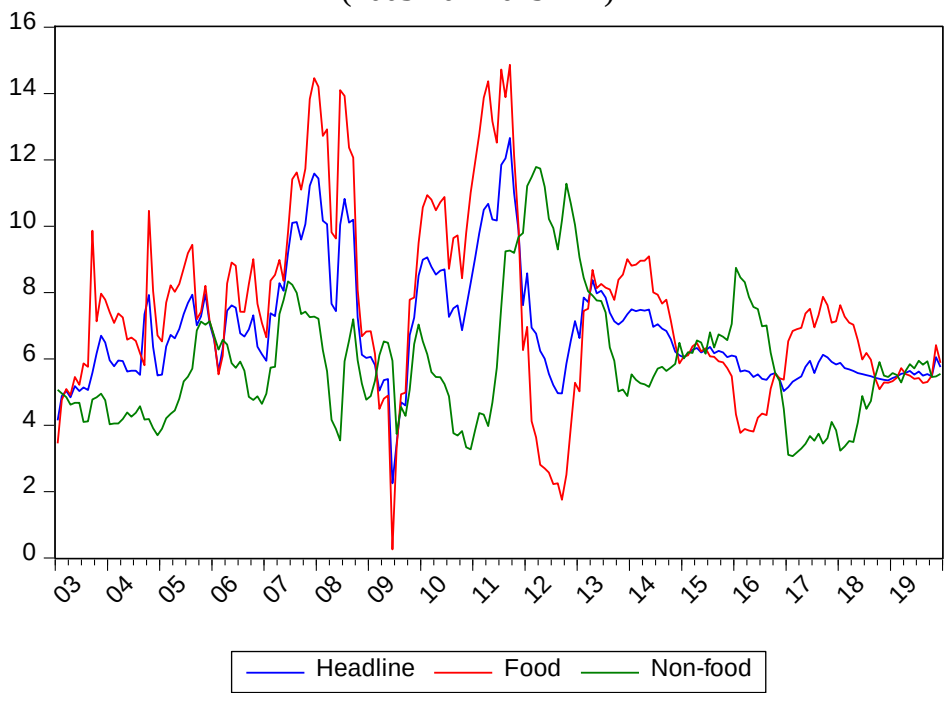
$$\rho_{t/t} = \rho_{t/t-1} - K_tL_t\rho_{t/t-1}$$

$$K_t = \rho_{t/t-1}L_t'y_{t/t-1}^{-1}$$

4. EMPIRICAL RESULTS

Figure 1 plots the monthly rate of inflation for the three inflation series and Table 1 presents some summary statistics, where μ stands for the mean, σ stands for the standard deviation and σ/μ stands for the coefficient of variation. The coefficient of variation shows the extent of variability to the mean. The variability of food inflation is higher than the non-food inflation. Despite the impact of food inflation on the cost of living, the high variability of food inflation makes it more difficult for BB to address it without the risk of exacerbating output variability. Correlation coefficients of the three inflation series, presented in table 2, depict statistically significant association among the series.

Figure 1: Monthly rate of inflation for the headline, food and non-food.
(2003m01-2019m12)



Source: Bangladesh Bureau of Statistics.

Table 1: Summary Statistics of Inflation
(2003m01-2019m12)

Headline			Food			Non-food		
μ	σ	μ/σ	μ	σ	μ/σ	μ	σ	μ/σ
6.3	2.3	2.7	6.7	3.3	2.9	5.6	2.0	2.8

Source: Authors' calculation based on the Bangladesh Bureau of Statistics (BBS) data.

Table 2: Correlation Coefficients of Headline, Food and Non-food Inflation
(2003m01-2019m12)

	Headline	Food	Non-food
Headline	1		
Food	0.90	1	
Non-food	0.24	- 0.18	1

Source: Authors' calculation based on the Bangladesh Bureau of Statistics (BBS) data.

We test the unit root hypothesis for the three inflation series using the Augmented Dickey-Fuller *t*-test. The *t*-test for the whole sample series strongly suggests that the null hypothesis of a unit root can be rejected for all variables (Table 3).

Table 3: Unit Root Tests
(2003m01-2019m12)

Variables	DET	ADF *t*-statistics	P-value
Headline Inflation	Intercept	-3.08	0.03**
Food Inflation	Intercept	-3.25	0.02**
Non-food Inflation	Intercept	-2.65	0.08*

Note: DET stands for Deterministic Component, SIC stands for Schwartz Information Criteria. Critical values for unit root test with intercept and trend:1%: (-5.719131);
*5%: (-5.175710); and 10%: (-4.893950). ***p<0.01, **p< 0.05, *p<0.10*
Source: Authors' calculation based on the Bangladesh Bureau of Statistics (BBS) data.

Table 4: Parameter estimates of the model
(2003m01-2019m12)

Parameter	Estimate	Standard Error	P-value
σ_{Trend}	0.698	0.040	0.00
$\sigma_{CPIhead}$	0.006	3.841	0.99
σ_{Food}	0.574	0.080	0.00
$\sigma_{Nonfood}$	0.547	0.023	0.00
$\theta_{CPIhead}$	0.917	0.025	0.00
θ_{Food}	0.874	0.051	0.00
$\theta_{Nonfood}$	0.955	0.026	0.00
γ_{Food}	-2.496	1.965	0.20
$\gamma_{Nonfood}$	4.437	2.545	0.08
λ_{Food}	1.439	0.164	0.00
$\lambda_{Nonfood}$	0.222	0.071	0.00

Source: Authors' calculation based on the Bangladesh Bureau of Statistics (BBS) data.

Table-4 presents the estimated parameters and their respective standard errors. We found that the cyclical components of CPI Headline, food, and non-food inflation are highly persistent with respective persistency value of 0.92, 0.87, and 0.96 which are very close to 1, recommended as fully persistent.

Again, persistency of the cyclical component of food inflation is comparatively lower than that of non-food inflation. This may be because shock in food inflation is somewhat offset by different government initiatives to keep food price lower such as subsidy in the agriculture sector, open market sales etc. Also, seasonal bumper production of main crops might be an important component of lower persistency of food inflation.

We also find that food and non-food inflation have significant loadings on the common trend where food inflation loading is 1.44 and non-food inflation loading is 0.22 implying that trend inflation is affected by the long-run movements of food

and non-food inflation. Again, it is apparent that food inflation has a much larger impact on trend inflation. Hence plays a greater role in long-run inflation dynamics of Bangladesh.

We plot the estimated trend inflation from the model in Fig.2 and also cycles for CPI headline, food and non-food inflation in Fig. 3, Fig. 4, and Fig. 5 respectively. It can be pointed out that our estimated trend inflation measure is smoother than the CPI inflation. During our sample period, 2003-2019, the standard deviation of CPI inflation is 1.73 whereas the corresponding value for our estimated trend inflation is 0.17. This is expected as the trend inflation is a long-term forecast of inflation that filters out the short-term noises and cyclical component in the data. Our results also suggest that the trend inflation started declining in the middle of 2012.

Fig. 2: Estimated Trend Inflation

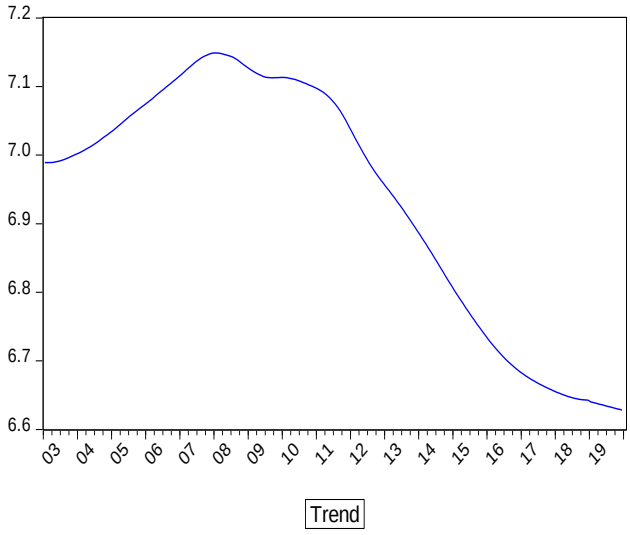


Fig. 3: CPI headline inflation and estimated cycle headline inflation

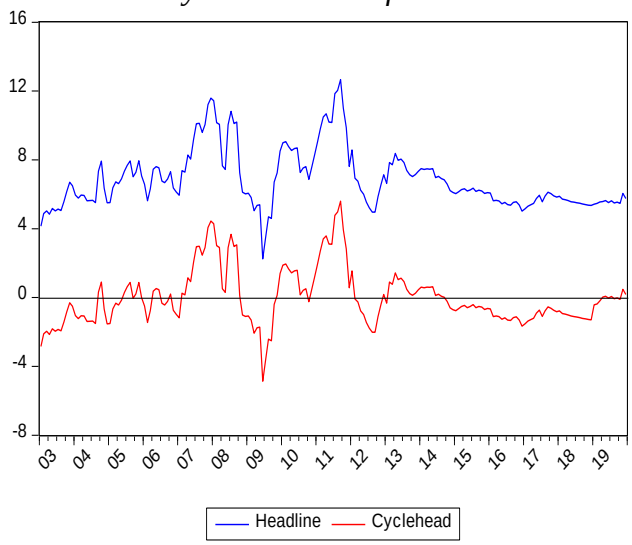


Fig. 4: Food inflation and estimated cycle of food inflation

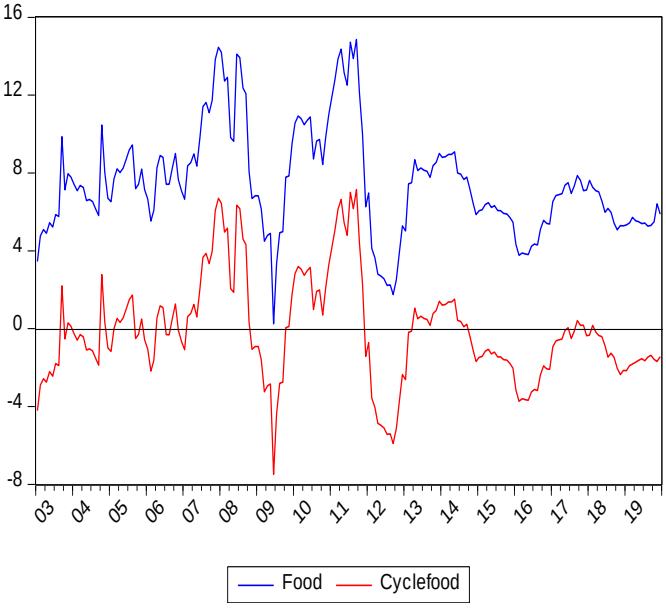
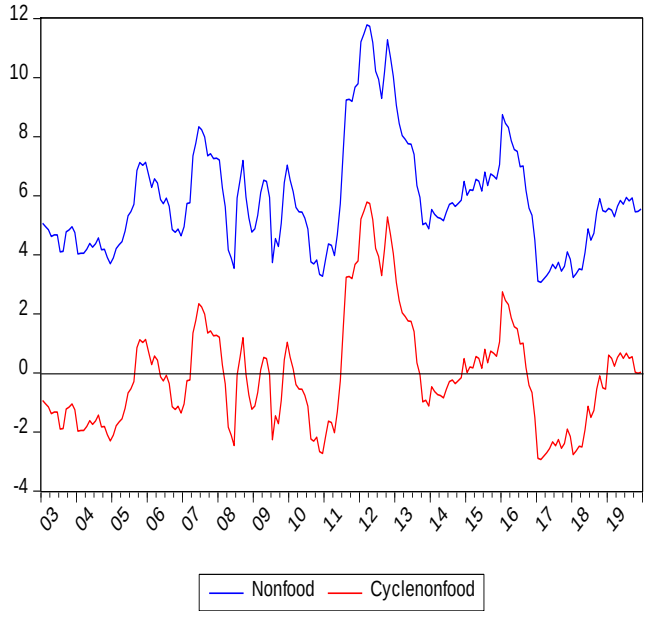


Fig. 5: Non-food inflation and estimated cycle Non-food inflation



6. CONCLUSION

In this paper, we attempt to provide a measure of trend inflation that aids the understanding of price dynamics. Using CPI inflation, we use a multivariate unobserved component model that decomposes the CPI headline inflation into trend inflation and a transitory inflation gap. The overtime evolution of this inflation gap measure provides a natural measure of inflation persistence that captures how quickly a shock to the inflation disappears and brings inflation back to its trend. We find that trend inflation from our unobserved component model captures the long-run dynamics of inflation in Bangladesh. We found that the cyclical components of CPI Headline, food, and non-food inflation are highly persistent.

The implications of high inflation persistence for the monetary policy are the follows; i) public perception about the inflation objective of the central bank is not

well anchored. As a result, inflation expectations are much more dependent on past inflation i.e. more backwards-looking than forward-looking; ii) a high degree of persistence means that inflation will not be stabilized in a short period following a shock. This suggests that to bring inflation back to its target level, BB should react more vigorously than if persistence were low; iii) similar levels of persistence across the different types of inflation indicators (headline, food, and non-food) suggests that extracting the most volatile components of the headline inflation indicator does not generate a new inflation indicator that is less persistent than the original. Therefore, contrary to common belief, a more volatile variable is not necessarily less persistent.

By conducting monetary policies such that Bangladesh Bank can ensure that actual inflation does not deviate for too long from its target inflation, expectations of economic agents can be anchored. A key benefit of establishing a strong nominal anchor is that the monetary authorities may find they have less need to induce large swings in economic activity to control inflation.

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