# How Persistent is Indian Inflationary Process, Has it Changed?

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# *How Persistent is Indian Inflationary Process, Has it Changed?*

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Using monthly data for the period 1982:4 to 2008:3, the study analyses the inflation persistence in India in terms of autoregressive properties and lag response of inflation to systematic monetary policy. It finds inflation persistence to be on the lower side, particularly when allowed for the break in the mean of inflation observed around the second half of the 1990s. In general, with the decline in mean rate of inflation, persistence in most of the inflation measures also declined. The impact of money supply on various measures of inflation is mostly positive and had its maximum impact with a much longer lag during the higher inflationary period before the mid-1990s than during the succeeding lower inflationary environment. Interest rate have a negative impact on all the inflation series and, in general, had its maximum impact on inflation with a much longer lag than that of change in money supply.

JEL Classification : J31, J52

Keywords : Inflation Rate, Inflation Persistence,

## Introduction

Inflation has far-reaching economic implications in terms of economic efficiency and wealth distribution. In the past couple of decades, there has been a renewed emphasis by the monetary authorities in keeping the rate of inflation low and stable. For many monetary authorities, maintaining price stability is now a clear mandate under the inflation targeting framework, while for several others even without such a specific mandate, price stability is the prime objective. In achieving this objective, monetary authority needs to understand and monitor the properties of the inflation dynamics. One such characteristics of inflation dynamics is the degree of inflation persistence, which could be defined as the tendency

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of inflation to converge towards the monetary authority's inflation objective or the underlying trend following a shock. Broadly, the literature analyses three types of inflation persistence. First type is in terms of the positive serial correlation or the autoregressive properties of the inflation series. The second type refers to the number of periods it takes for the systematic component of monetary policy to have its maximum effect on the rate of inflation. Third type is the number of lags with which rate of inflation respond to a policy shock.

When inflation persistence is high, a positive shock to inflation would keep the inflation rate at an elevated level, while with a low inflation persistence, it will converge soon to its underlying trend.[1] It is also important to recognize the difference in the nature of persistence among the price disaggregates and also the difference between persistence at disaggregate and aggregate level. For the industrialised countries, it is found that the degree of persistence diverge significantly among the components and the level of persistence is higher at the aggregate level than at the disaggregate level [Clark (2003) and Lunnemann and Matha (2004)]. Thus, understanding the process of inflation persistence is relevant for the purpose of forecasting, as that would help the authority to predict the pattern of absorption to a shock in inflation process and also help understand how pre-emptive they should be to curb inflationary pressure with minimum output loss. As the response to monetary policy action could vary among disaggregates and the source of general inflationary trend could arise from one of the components, the persistence at the disaggregate level would further provide additional understanding to the monetary authority on the course of policy action.

While there is a growing volume of literature in this area for the industrialized countries, it is lacking for developing countries. This paper analyses two among the three of types of inflation persistence mentioned above for India *viz.,* i) the autoregressive property of the inflation series and ii) the maximum lag impact of systematic monetary policy on rate of inflation on monthly price series for the period 1982:4: to 2008:3, both at the aggregate and disaggregate level.[2] We consider various measures of prices in India *viz.,* WPI, consumer price index for industrial workers (CPI-IW), consumer price index for urban non-manual labour (CPI-UNML) and consumer price index for agricultural labour (CPI-

AL), along with the disaggregates of the WPI and food component of CPI-IW.

The rest of the paper is organized as in the following. Section II is a brief review of the literature. The stylised fact of the inflationary trend during the period under review is provided in Section III. The definitions of inflation persistence and the models estimated are discussed in Section IV. In Section V, the results and its interpretation are laid out. The final section contains the concluding remarks.

## Section II

## A Brief Review of Literature

Theories of aggregate inflation persistence postulate that inflation should exhibit low or even negative persistence. This follows as these theories are derived from the microeconomic models of price setting such as time-dependent models, limited information models and menu-cost or state-dependent models, which imply high persistence in the price level, and therefore, translate into low or even negative persistence in the rate of price change *i.e.*, inflation. In contrast to the above theorisation, a number of empirical estimates in the literature for the postwar US inflation and OECD countries found a high level of inflation persistence [Nelson and Plosser (1982), Fuhrer and Moore (1995), Nelson (1998) and Clarida *et al* (1999)]. Consequently, it was viewed that high inflation persistence is a stylised fact for the industrialised countries.

A more recent alternative view, however, argues that inflation persistence may not be a structural characteristic of industrialised countries, but would vary with the monetary policy regimes [Taylor (1998, 2000) and Sargent (1999)]. They argue that with the increasing focus of monetary policy on achieving low inflation and less on exploiting short-run output gains, the credibility of monetary policy has increased leading to anchoring inflation expectations at a low rate of inflation. Consequently, inflation expectation of economic agents is unlikely to adjust to temporary increases in inflation rate thereby reducing the persistence to shocks to both the price level and the inflation rate.

Another view, which is more of a technical in nature pertaining to

the estimation procedure of the persistence parameter, is that neglecting the structural break in the mean of inflation would exaggerate the persistence parameter (Perron, 1989). Therefore, the high inflation persistence observed in earlier studies could be due to neglect of shift in the mean of inflation. However, the empirical findings of the ensuing studies addressing this issue remained varied and inconclusive.

Batini (2002) finds that despite a sizeable downward shift in the mean inflation, the inflation persistence at the aggregate Euro area level and at the country level, except German, remained high and varied only marginally since the 1970s. Thus, it was concluded that Euro area inflation persistence could well be an intrinsic phenomenon rather than a statistical fluke due to aggregation. O'Reilly and Whelan (2004) also find that for the Euro area there appears to be no structural break in the mean of inflation since 1970 and the stability of high inflation persistence cannot be rejected. Hondroyiannis and Lazaretou (2004) for Greece during 1975 to 2003 find that while the mean inflation declined significantly since the beginning of the 1990s, persistence remained high with only a small shift.

On the other hand, Batini and Nelson (2001) show that inflation persistence in the US declined sharply after 1984 under the Volker-Greenspan monetary policy regime, while for the UK the decline was dramatic after the adoption of explicit inflation targeting in 1992. Gadzinski and Orlandi (2004) taking account of intercept dummies in the underlying inflation models on 79 inflation series find that inflation persistence in the EU countries, the Euro area and the US was moderate across the board. Similarly, Levin and Piger (2004) for twelve industrial countries find that allowing for break in intercept, the inflation measures generally exhibit relatively low inflation persistence and concludes that high inflation persistence is not an inherent characteristic of industrial economies. Cecchetti and Debelle (2004) for 16 industrialised countries since the 1990 find that the conventional wisdom of high level of inflation persistence is not robust, as controlling for break in mean of inflation considerably lowers the measure of inflation persistence. However, change in monetary policy frameworks contributed in lowering the mean of inflation, but have little impact on the already low inflation persistence.

There is also a growing volume of literature on analysing inflation persistence at the disaggregate level in order to identify the key drivers of aggregate inflation persistence. This interest to analyse inflation persistence at the disaggregate level followed from the theoretical finding that aggregate inflation persistence is predominantly driven by the most persistence disaggregate inflation components. In the US, for the period 1959 to 2002, Clark (2003) found that the average persistence in disaggregate inflation rates was consistently lower than the aggregate persistence, with virtually the persistence in all the disaggregate series lower than the aggregate. Among the disaggregates, those which account for larger shares of the consumer spending viz., durable goods, non-durable goods and services have higher persistence, without any significant difference between them. Further, while many of the disaggregate components display sizable reductions in persistence, the declines were larger in those components receiving relatively smaller weights. Similarly, for the EU15 countries using 1400 price indices during January 1995 to December 2003, Lunnemann and Matha (2004) could reject the notion of disaggregate inflation exhibiting a high degree of persistence. Thus, they also found the aggregate inflation exhibiting a larger degree of persistence than the weighted average of the disaggregate series. Among the individual indices, indices affected by sales (seasonal food) and some services exhibited low degrees of persistence, while 'gas', 'energy' and 'telephone equipments' showed higher persistence. Category-wise, 'durables' and indices affected by sales as well as services showed less inflation persistence than processed 'food' and 'alcohol'.

## Section III

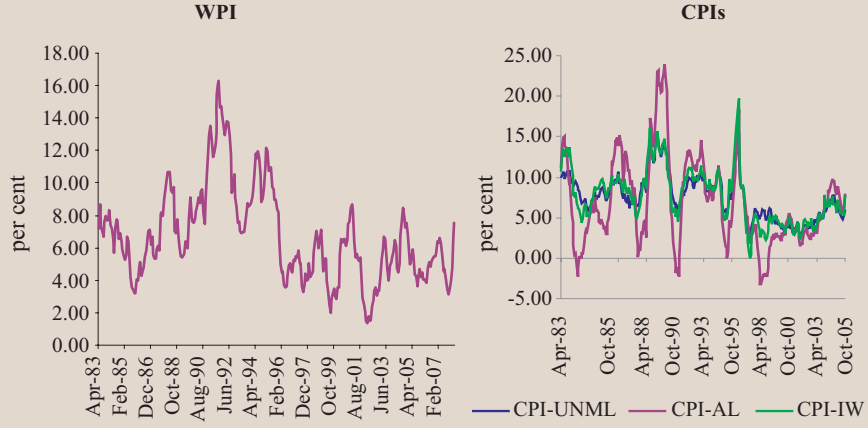
## Inflationary Trend-Some Stylised Facts

In the developing country context, inflation on year-on-year basis in India had been on the lower side. Chart 1 plots the year-on-year inflation rate of WPI and CPI measures on monthly frequency since 1983:4. It can be seen that there has been different phases of inflation for different measures of inflation. Broadly, inflation rate declined during the first half of the 1980s, but started picking up in the second half to a peak in the early 1990s, when the country faced an external payment crisis. Since

then the mean WPI inflation rate followed a declining trend up to the mid-1990s. From around the mid-1990s, inflation rate has fluctuated around a lower trend despite intermittent shocks emanating from both domestic and external front. While a similar picture can be discerned in the various CPI measures of inflation, due to food price shock around the end of 1998, there was spurt in CPIs inflations. Among the alternative measures of CPIs, CPI-IW and CPI-UNML inflation broadly overlaped, while CPI-AL inflation was more volatile due larger food component and diverged from the other two measures on number of occasions, particularly during 1991-92, when it recorded the highest increase during the period under review.

Testing for a break in the mean rate of inflation employing Quandt-Andrews unknown break point test, table-1 presents the mean and volatility of inflation rate in WPI, CPIs and their components during the pre-break and post-break sample as well as for the full sample period. First, it is found that a statistically significant break in the inflation rate had taken place in all the aggregate measures of WPI and CPIs. At the disaggregate level also mean break is observed in all, except for 'fuel' components of WPI. It is, however, observed that there are divergences in the break date among the components, though, expectedly, the divergence is much less between the major component and the aggregate. Second, the mean inflation rate declined in the post-break period, barring

**Chart 1: 12-Month Inflation Rate of WPI and CPI Measures**



that of 'metal' component of WPI. Thus, inflation rates in the components of WPI which ranged between 6.4 to 9.5 percent during the pre-break period averaged less than 5.0 percent in the post-break period, with many of the components averaging less than 4.0 percent. Third, while the inflation rate of WPI was lower than the CPI measures of inflation during the pre-break period, the reverse was the case in the post-break period. Fourth, volatility in inflation rate also declined along with the decline in the mean inflation rate, barring the case of 'metal' components of WPI.

This trending down in the rate of inflation which has been associated with significant reduction in volatility, despite episodes of intermittent domestic and external shocks, is indicative of well-anchored inflation expectation in India (Reddy, 2007). The questions are: How persistent had been the inflationary process in India and has there been a decline? What had been the behavior at the disaggregated level and how have they contributed to the persistence at the aggregate level?

**Table 1: Mean and Volatility of WPI, CPIs and Components**

(In percent)

| Variable | Mean Inflation | | | Volatility | | | Break |
|---|---|---|---|---|---|---|---|
| | Full Period | Before Break | After Break | Full Period | Before Break | After Break | Date |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **I. WPI** | 6.54* | 8.08* | 4.97* | 5.77 | 5.9 | 5.19 | 1995:6 |
| **II. Primary** | 6.79* | 8.26* | 4.16* | 12.36 | 12.93 | 10.83 | 1998:12 |
| Food | 7.03* | 9.05* | 3.46** | 15.77 | 17.1 | 12.36 | 1998:12 |
| Non-food | 6.68* | 9.54* | 3.8* | 18.32 | 20.16 | 15.8 | 1995:5 |
| **III. Fuel** | 8.31* | – | – | 15.4 | – | – | – |
| **IV. Manufacturing** | 5.95* | 7.98* | 3.82* | 5.49 | 5.49 | 4.63 | 1995:8 |
| Food | 6.29* | 8.12* | 3.08* | 13.3 | 14.0 | 11.33 | 1998:11 |
| Textile | 3.80* | 7.60* | -0.17 | 11.4 | 10.84 | 10.71 | 1995:8 |
| Chemical | 5.5* | 6.43* | 3.1* | 7.94 | 8.7 | 4.78 | 2001:1 |
| Metal | 7.95* | 6.67* | 12.5* | 14.48 | 9.54 | 24.8 | 2002:8 |
| Machine | 5.31* | 7.83* | 3.60* | 7.06 | 8.53 | 5.21 | 1992:11 |
| **V. CPI-IW** | 7.4* | 9.2* | 4.24* | 7.1 | 7.23 | 5.62 | 1998:12 |
| Food | 7.25* | 9.5* | 2.91** | 11.1 | 11.3 | 9.43 | 1998:12 |
| **VI. CPI-AL** | 6.64* | 8.36* | 3.58* | 9.78 | 11.1 | 5.84 | 1998:12 |
| **VII. CPI-UNML** | 7.28* | 8.81* | 4.58* | 5.26 | 5.30 | 3.96 | 1998:12 |

* and ** denote significance at 1% and 5%, respectively.

## Section IV

## Definitions of Inflation Persistence

In the literature, inflation persistence is interpreted in different ways. Batini and Nelson (2001) and Batini (2002), however, distinguish between three types of persistence. First type is the positive serial correlation in the price series, as the underlying pricing process, the conduct of monetary policy and the expectations' formation process of price-setting agents would influence the autocorrelation properties of inflation. Thus, this type of inflation persistence is considered as a reduced-form property of inflation.

The second type of inflation persistence, pioneered by Friedman (1972), refers to the number of periods it takes for the systematic component of monetary policy to have its maximum effect on the rate of inflation. Batini and Nelson (2001) point out that this type of persistence is the most relevant for monetary policy making as it determines the costs of disinflation. When the policy makers know the lag in the peak effect of policy action they can have pre-emptive response to private sector shocks and minimise the variability in output gap.

The third type of inflation persistence relate to the number of lags it takes for inflation rate to respond to a policy shock such as in the analysis of VAR evidence on the effect of monetary policy shocks.

Here we consider only the first two types of inflation persistence. For the first type (type-I) of inflation persistence, in the classical formulation, the autocorrelation properties of inflation is considered by an AR (k) process for the price series of the following type,

$$\Delta p_t = C + \sum_{j=1}^{k} \alpha_j \Delta p_{t-j} + u_t \qquad (1)$$

where $\Delta p_t$ is rate of inflation[3], $\alpha_j$ is the autoregressive coefficient and $u_t$ is a serially uncorrelated, but possibly heteroskedastic random error term. Andrews and Chen (1994) advocate that the best scalar measure of persistence is the sum of the AR coefficients, $\rho \equiv \sum \alpha_j$. To measure persistence in terms of the sum of AR coefficients, equation (1) can be re-written as

$$\Delta p_t = C + \rho \Delta p_{t-1} + \sum_{j=1}^{k-1} \beta_j \Delta\Delta p_{t-j} + u_t \qquad (2)$$

where $\rho$ is the persistence parameter, while $\beta_t$ parameters are transformations of AR coefficients in equation (1), $\beta_{k-1} = -\alpha_k$. If $\rho$ takes a value close to unity, the inflation process has a unit root or behaves like a random walk so that when inflation goes up it stays up. On the other hand, if $\rho$ is significantly lower than unity, a shock on inflation has only a temporary effect on inflation and will soon revert back to its trend level. The lag lengths are selected on the basis of Schwarz Bayesian Criterion (SBC) or Akaike Information Criterion (AIC).

As mentioned above, Perron (1989), however, had demonstrated that the persistence as measured by the above autocorrelation properties of inflation series will be exaggerated if the presence of structural breaks in the mean in not considered. Therefore, we conduct tests for the presence of structural break in the mean using Quandt-Andrews unknown break point test. If we find a structural break, the persistence parameter allowing for a break in the mean at the identified point is estimated by using the following equation,

$$\Delta p_t = c_0 + c_1 D_t + \rho \Delta p_{t-1} + \sum_{j=1}^{k-1} \beta_j \Delta\Delta p_{t-j} + u_t \qquad (3)$$

$D_t$ equals zero for $t < T$ and 1 for $t \geq T$.

Further, in the above estimates of persistence, Hansen (1999) shows that if the estimated coefficients are close to one (*i.e.*, follow a unit root process) the point estimates can be biased downwards for which he provides a bootstrap procedure to calculate the estimates of persistence as well as their confidence interval. As will be seen below, given the relatively lower absolute value of the estimated persistence parameters, this is not a major issue in our context.

We measure the second type of inflation persistence (type-II) by the correlation of monthly year-on-year inflation rate with corresponding change in the measure of systematic monetary policy $k \geq 0$ periods earlier, denoted by a statistic $\rho_{pm}(k)$.[4] This provides us a means to identify whether inflation responds to systematic monetary policy with a delay or not *i.e.*, the number of periods it takes for a change in monetary policy to have its peak effect on inflation. However, neither the selection of systematic stance of monetary policy nor the appropriate statistic to calculate is a straightforward issue. Drawing on the literature [for examples, Friedman

(1972) and Batini and Nelson (2001)], we first consider the change in broad money (M3) as one measure of the systematic stance of monetary policy. In selecting the change in monetary aggregates as the stance of monetary policy, Batini (2002) points out that one does not take any stand on whether money has special role in the transmission mechanism, but only views it as a quantity-side measure of the monetary conditions induced by central bank through interest rate policy or other measures. It is, however, noted that if monetary policy adjusts completely and successfully to offset non-policy shocks, there should be no observed relation between policy measures and inflation.

Second, we use the monthly weighted average call rate as the other measure of policy stance in order to capture the idea that liquidity adjustment facility (LAF) operation under the repo and reverse repo window signals the intent of monetary policy in India. For this, we confine our sample period from April 2001 onwards when LAF was introduced to monitor the call rate within the corridor set by the repo and reverse-repo rate. Here, it may be noted that the operating policy rate between repo and reverse repo rate had been dependent on the prevailing liquidity condition in the market. In the deficit mode in the system requiring injection of liquidity, the operating policy rate has been the repo rate with the call rate being gravitated towards this rate. In the case of surplus mode requiring liquidity withdrawal, reverse repo rate has been the operating rate with call rate gravitating towards it. However, due to extreme liquidity conditions, there have been instances when the call rate either exceeded that repo rate or was lower than the reverse repo rate.

## Section V
## Empirical Results

*Type-I Inflation Persistence*

Based on the lag lengths selected by SBC/AIC, there are two groups of results on persistence. In half of the cases, the optimal lag length selected by the two criterions differs. While SBC selects mostly an AR(1) process, AIC favours mostly AR(2 to 3) process. The results presented in table-2 reveal the following. First, without mean break, the persistence

is on the lower side as compared to the persistence found in several industrialised countries reported by the studies referred above. At the aggregate level, the persistence based on SBC range from 0.322 for WPI to 0.42 for CPI-AL (from 0.29 for CPI-IW to 0.67 for CPI-NML based on AIC) *i.e.*, CPI measures of inflation are more persistent than WPI. In other words, if the inflation deviates from its long-term trend due to a shock, 60 to 70 percent of the deviation would be corrected in each of the following period. This lower level of inflation persistence implies that the degree of adjustment in inflation expectation by economic agents in India due to temporary increases in inflation rate is fairly low. At the disaggregate level of WPI, the degree of persistence is the highest for 'manufacturing' [0.383 (SBC) and 0.665 (AIC)], and within it that of 'machine' (0.56). 'Food' and 'fuel' exhibit a lower level of persistence than 'non-food', 'textile' and 'machine'. In other words, similar to those found in industrialised countries where persistence is higher for

**Table 2: Persistence of WPI, CPI and Components**

| Variable | Persistence with lag length based on SBC | | | | Persistence with lag length based on AIC | | | |
|---|---|---|---|---|---|---|---|---|
| | No break | One Break | Break At | Lag length | No break | One Break | Break At | Lag length |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **A. WPI** | **0.322*** | **0.264*** | 1995:5 | 1 | – | – | – | 1 |
| **I. Primary** | 0.237* | 0.216* | 1998:12 | 1 | – | – | – | 1 |
| Food | 0.073 | 0.025 | 1998:12 | 2 | – | – | – | 2 |
| Non-food | 0.334* | 0.317* | 1995:5 | 1 | – | – | – | 1 |
| **II. Fuel** | 0.129** | – | – | 1 | 0.423* | – | – | 9 |
| **III. Manufacturing** | 0.383* | 0.266* | 1995:8 | 1 | 0.665* | 0.431* | 1995:6 | 6 |
| Food | 0.08 | 0.05 | 1998:11 | 1 | 0.115 | 0.01 | 1998:11 | 3 |
| Textile | 0.428* | 0.355* | 1995:7 | 1 | 0.553* | 0.441* | 1995:5 | 3 |
| Chemical | 0.221* | 0.192* | 2001:1 | 1 | 0.307* | 0.243* | 2001:1 | 3 |
| Metal | 0.273* | 0.252* | 2002:8 | 1 | – | – | – | 1 |
| Machine | 0.56* | 0.47* | 1992:11 | 3 | – | – | – | 3 |
| **B. CPI-IW** | **0.336*** | **0.25*** | 1998:12 | 1 | 0.29* | 0.145** | 1998:12 | 2 |
| Food | 0.303* | 0.245* | 1998:12 | 1 | – | – | – | 1 |
| **C. CPI-AL** | **0.42*** | **0.39*** | 1998:12 | 1 | 0.533* | 0.481* | 1998:12 | 3 |
| **D. CPI-UNML** | **0.322*** | **0.203*** | 1998:12 | 1 | 0.67* | 0.295** | 1998:12 | 2 |

* and ** denote significance at 1% and 5%, respectively.

disaggregates which account for larger share of consumer spending, components with larger weights in WPI tend to have higher persistence in India. However, it is also interesting to note that unlike found for industrialised countries, the persistence at the disaggregate level is not consistently lower than at the aggregate level.

Second, allowing for a mean break, the persistence declines for all inflation series, including the components. As found in the literature, the results highlight the importance of controlling for mean break in estimating inflation persistence, which otherwise would lead to exaggeration of the estimated persistent parameters. At the aggregate level, it range from 0.2 to 0.39 by SBC (0.15 to 0.48 by AIC). In other words, the correction to the equilibrium level in each of the succeeding period following a shock ranges from 60 to 80 percent. CPI-AL and 'manufacturing' inflation continue to be the most persistent among the aggregates and the major components of WPI, respectively. Within the manufacturing component, 'machine' again is the most persistent. Even after allowing for mean break, the persistence at the disaggregate level is also not consistently lower than the aggregates, and 'food' and 'fuel' continue to exhibit lower persistence than 'non-food, 'textile' and 'machine'.

*Has the Persistence Declined?*

To check for the change in persistence, we employ two methods. First we estimate persistence for two sample periods, *viz.,* the pre-mean break and the post-mean break. Second, we employ rolling regressions technique to observe the change in persistence parameter over time.

Table-3 presents the estimated persistence coefficients for the two sample periods. At the aggregate level, the persistence in the post-break period declined in all, except WPI. Within WPI, the persistence in 'primary' and 'machine' was higher in the post-break period. For CPI-UNML, the persistence is nil in the post break period. In other words, barring WPI, fall in the mean rate of inflation has been associated with decline in their persistence.

In above, splitting the sample period into two allows us to compare only two point estimates and cannot observe the evolving trend in the

**Table 3: Change in Persistence of WPI, CPI and Components**

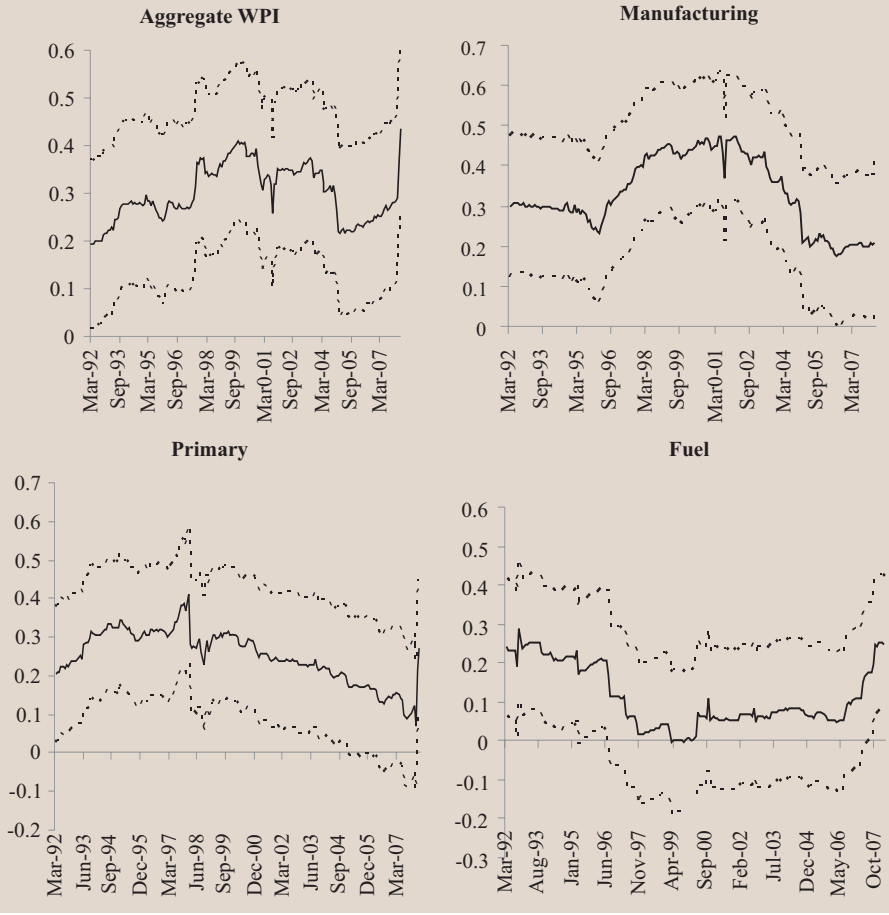
| Variable | Persistence with lag length based on SBC | | Persistence with lag length based on AIC | |
|---|---|---|---|---|
| | Before Mean Break | After Mean Break | Before Mean Break | After Mean Break |
| 1 | 2 | 3 | 4 | 5 |
| **I. WPI** | 0.227* | 0.313* | – | – |
| **II. Primary** | 0.208* | 0.237* | – | – |
| Food | 0.10 | -0.26** | – | – |
| Non-food | 0.322* | 0.31* | – | – |
| **III. Fuel** | – | – | – | – |
| **IV. Manufacturing** | 0.292* | 0.217** | 0.45* | 0.41* |
| Food | 0.04 | 0.06 | 0.05 | 0.04 |
| Textile | 0.346* | 0.364* | 0.484* | 0.407* |
| Chemical | 0.20* | 0.118 | 0.263** | 0.127 |
| Metal | 0.385* | 0.13 | – | – |
| Machine | 0.45* | 0.50* | – | – |
| **V. CPI-IW** | 0.274* | 0.17*** | 0.173** | 0.05 |
| Food | 0.258* | 0.21** | – | – |
| **VI. CPI-AL** | 0.389* | 0.362* | 0.51* | 0.317* |
| **VII. CPI-UNML** | 0.21** | -0.04 | 0.286* | -0.08 |

* and ** denote significance at 1% and 5%, respectively.

persistence parameter. Further, for the series where no break in the mean was observed, even the comparison of two point estimates cannot be carried out. It is also possible that the persistence in some of these series had undergone a gradual change without having any significant structural break at any distinct point of time. Therefore, in the following, the persistence coefficients along with their 95 per cent confidence intervals represented by the dotted line from time varying rolling regressions of 120 window sizes are presented for AR process based on SBC.[5]

It is observed from the rolling regression coefficients that the persistence in aggregate WPI initially increased followed by a declining trend before suddenly increasing towards the end of the sample period. Among the major components, the persistence in 'manufacturing', whose weight in the aggregate is about 64 percent, show a stable trend at the beginning and end part of the sample period, but the stable level is lower in the later part. In the middle part, the persistence initially increased sharply and declined in a similar fashion. With regard to 'primary' and 'fuel' component, in the former the persistence increased initially and declined, while in the latter an opposite trend is observed. However, both the components show a stiff increase towards the end of the sample

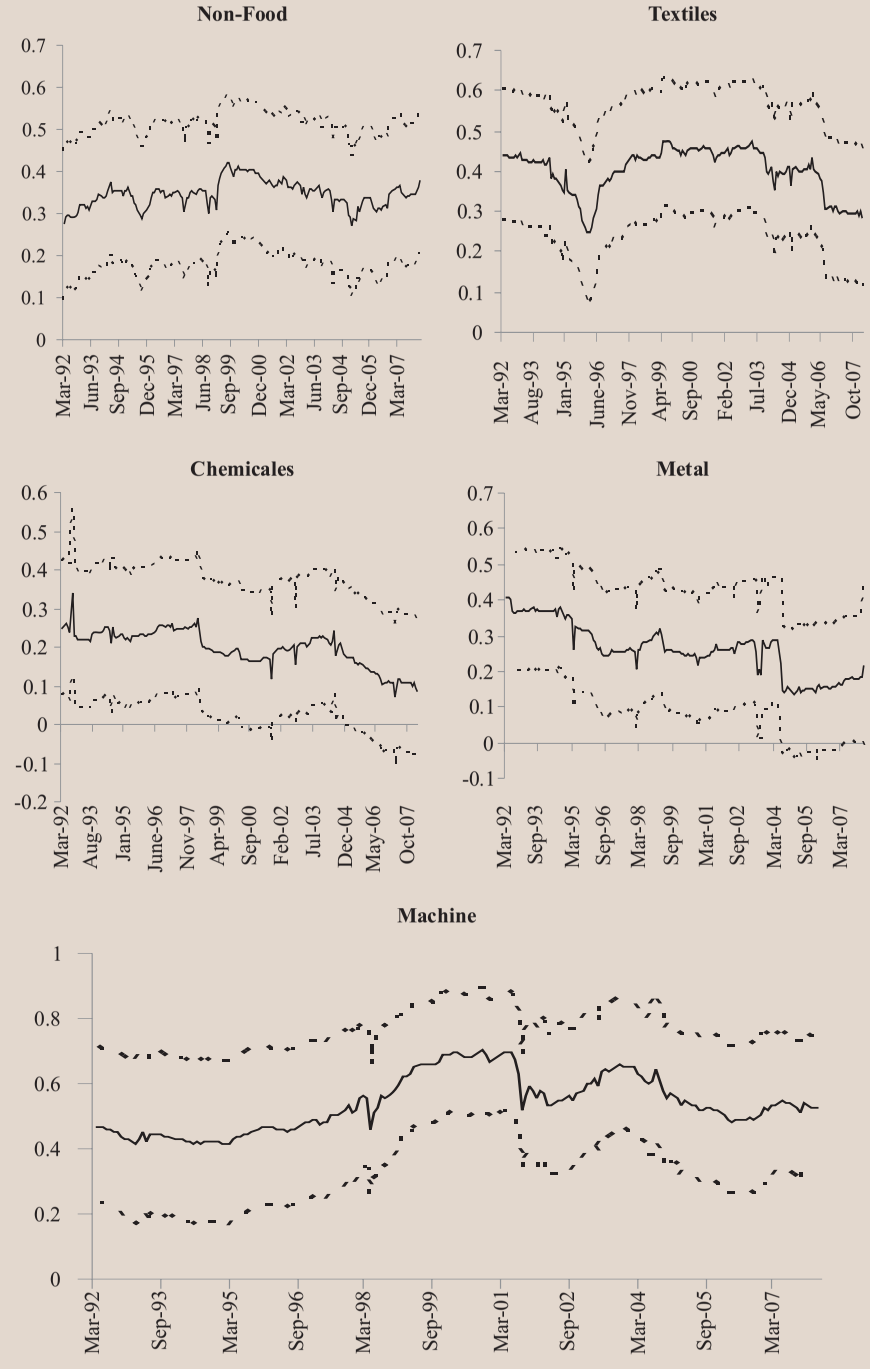
**Chart-2:Rolling Estimates of Persistence in WPI and Its Major Components**




period similar to the stiff increase in the aggregate WPI (Chart 2).

Among the sub-components, the persistence in 'non-food' shows an overall slowly increasing trend. The persistence in 'textiles' and 'chemicals' have tended to decline in the more recent period after exhibiting fluctuations around a slowly declining trend. 'Metals' after showing a low and stable persistence towards the later part of the sample period appears to have experienced some jump in the level of persistence in the most recent period. The persistence in 'machine' increased initially and followed an overall declining trend. However, some increase is

**Chart-3: Rolling Estimates of Persistence in Sub-Components in WPI**



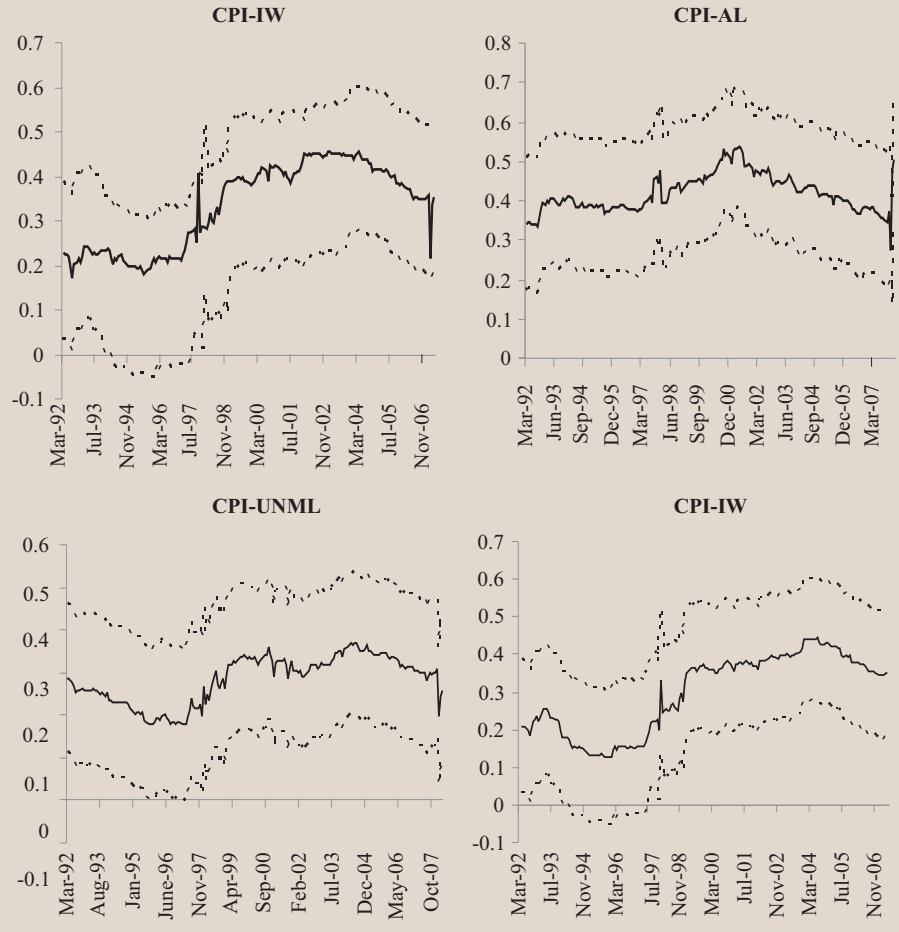
discerned in the more recent period that it is at an elevated level than at the beginning of the sample period (Chart 3).

The broad trends in the persistence of aggregate CPIs indicate an overall increase during a longer part of the sample period followed by slow declines that they remain higher than at the beginning of the sample period. However, we find some sharp swings towards the end of the sample period. The trend in the persistence of CPI-IW is more or less mirror imaged in its major component viz., 'food' (Chart 4).

*Type-II Inflation Persistence*

As mentioned above, we measure this type of inflation persistence

**Chart-4: Rolling Estimates of Persistence of CPIs and Components**



by estimating the lag at which the response of monthly year-on-year inflation to 1) corresponding growth in M3 and 2) monthly weighted average call rate is the maximum.

Table 4 presents the results for different sub-periods. The sub-periods have been selected based on the different monetary policy framework adopted during the period under consideration. Literature suggests that different monetary policy regime may alter the velocity of money, and consequently, the lag response of inflation to systematic monetary policy could change. Thus, estimation across sub-sample allows for changes in steady-state velocity growth due to regime changes (Batini, 2002). One, the period up to 1997:3 is considered as the period of monetary targeting. As monetary targeting with feedback began from 1985-86, we considered two overlapping sub-periods coinciding with this framework: i) 1983:4 (beginning of the sample period) to 1997:3 (end of formal monetary targeting); and ii) 1985:4 beginning of monetary targeting to 1997:3 (end of formal monetary targeting). Second, the period beginning with 1997:4 is treated as the period with multiple indicator approach framework. Third, as mentioned above, for call rate as the measure of systematic monetary policy, the period since 2001:4 (introduction of LAF) only is considered.

As would be expected, it is seen that the relationship between growth in money supply and inflation is positive and statistically significant in almost all the inflation series (aggregate as well as the components). For the full sample period, the correlation coefficients are not very large ranging from 0.176 (manufactured food) to 0.341 (CPI-UNML food). The maximum lag impact of money growth is about 29 months on WPI, while on the CPIs the maximum impact is felt instantaneously. Among the components of WPI, the maximum lags are on 'fuel', 'manufactured food' and 'textile' (29 to 36 months). On manufacturing inflation, the maximum impact is felt after three months, though within its sub-components it ranges from 0 to 36 months and no impact ('metal'). Full sample period, as mentioned above, may not allow for changes in steady-state velocity growth due to regime shifts, and therefore, could differ from the behavior during the sub-periods.

It is seen that the maximum lag impact in general turns out to be much longer during the monetary targeting framework, which at the aggregate level range from 25 months for CPI-IW to 32 months for WPI. Further, money growth in general had a longer lag impact on food items (both manufactured and non-manufactured components). As a result,

**Table 4: Correlations Between Various Measures of Inflation and Change in Systematic Monetary Policy (Growth in M3 and Call rate) (maximum positive and negative value)**

| Components | Growth in M3 | | | | Call rate |
|---|---|---|---|---|---|
| | **Full Sample** | **1983:4 to 1997:3** | **1985:4 to 1997:3** | **1997:4 to 2008:3** | **2001:4 to 2008:3** |
| 1 | 2 | 3 | 4 | 5 | 6 |
| **I. WPI** | 0.243 (k=29) (4.24) | 0.206 (k=32) (2.56) | 0.244 (k=32) (2.72) | 0.106 (k=27) (1.09) | -0.527 (k=8) (-6.28) |
| **II. Primary** | 0.281 (k=0) (5.27) | 0.236 (k=29) (2.93) | 0.244 (k=29) (2.76) | 0.517 (k=1) (8.01) | -0.362 (k=35) (-2.86) |
| Food | 0.242 (k=0) (4.44) | 0.261 (k=29) (3.28) | 0.295 (k=29) (3.43) | 0.539 (k=1) (8.63) | -0.397 (k=28) (-3.46) |
| Non-food | 0.179 (k=0) (3.19) | 0.175 (k=0) (2.15) | 0.171 (k=0) (2.09) | 0.173 (k=1) (2.03) | -0.351 (k=44) (-2.48) |
| **III. Fuel** | 0.273 (k=25 (4.87) | 0.234 (k=22) (2.97) | 0.233 (k=23) (2.95) | 0.341 (k=25) (3.95) | -0.471 (k=7) (-5.24) |
| **IV. Manufacturing** | 0.246 (k=3) (4.49) | 0.399 (k=3) (6.06) | 0.428 (k=3) (6.18) | 0.106 (k=0) (1.22) | -0.371 (k=8) (-3.70) |
| Food | 0.176 (k=29) (2.98) | 0.274 (k=27) (3.49) | 0.287 (k=27) (3.35) | 0.07 (k=0) (0.8) | -0.276 (k=0) (-2.70) |
| Textile | 0.202 (k=36) (3.41) | -0.276 (k=0) (6.25) | 0.405 (k=3) (5.71) | 0.18 (k=30) (1.86) | -0.233 (k=0) (-2.23) |
| Chemical | 0.30 (k=6) (5.63) | 0.351 (k=32) (4.63) | 0.394 (k=32) (5.40) | 0.493 (k=6) (11.13) | -0.266 (k=32) (-2.02) |
| Metal | none | 0.274 (k=6) (3.45) | 0.245 (k=6) (3.04) | none | -0.461 (k=8) (-5.04) |
| Machine | 0.229 (k=0) (4.17) | 0.235 (k=0) (3.20) | 0.288 (k=0) (4.05) | 0.21 (k=0) (2.50) | -0.273 (k=16) (-2.40) |
| **V. CPI-IW** | 0.318 (k=0) (6.11) | 0.244 (k=25) (3.08) | 0.313 (k=25) (3.75) | 0.486 (k=1) (7.23) | -0.429 (k=29) (-3.83) |
| Food | 0.305 (k=0) (5.81) | 0.239 (k=26) (3.0) | 0.293 (k=26) (3.45) | 0.574 (k=0) (9.76) | -0.435 (k=35) (-3.68) |
| **VI. CPI-AL** | 0.305 (k=0) (5.81) | 0.265 (k=27) (3.48) | 0.342 (k=27) (4.15) | 0.551 (k=1) (8.98) | -0.413 (k=35) (-3.41) |
| **VII. CPI-UNML** | 0.341 (k=0) (6.66) | 0.239 (k=27) (2.99) | 0.289 (k=27) (3.38) | 0.563 (k=0) (9.4) | -0.444 (k=35) (-3.79) |

**Notes:** Figure in lower parentheses is t-statistics.

the CPIs in which the weight of food is the maximum, monetary policy worked with longer lags.

During the period of multiple indicator framework, however, the maximum impact of growth in money supply on most of inflation series was felt with a much shorter lag than compared to the earlier period and in many of the WPI components, notably the major component 'manufacturing', the correlation turned insignificant. As a result, the correlation between money supply and the aggregate WPI inflation was much weaker and statistically insignificant in the post monetary targeting framework. On the CPIs with large component of food, the maximum impacts were either instantaneous or after one month and with much higher correlation coefficients. The same phenomenon is also evident in the food component (both manufactured and non-manufactured) of WPI.

The correlation between inflation and weighted monthly average call rate is also expectedly negative and statistically significant in all. At the aggregate level, the maximum impact of call rate on WPI is felt after 8 months. On the other hand, the maximum impact on CPIs is after 29 to 35 months. At the disaggregate level, the maximum impacts of interest rate on 'primary', 'chemicals', 'machine' in WPI and 'food' in CPI-IW are felt with a much longer lag ranging from 16 to 44 months. The maximum impact is instantaneous on 'manufactured food' and 'textile', while on 'fuel' and 'manufacturing' (within it 'metal') they ranged from 7 to 8 months. It is observed that during the comparable period, inflation series, in general, respond to interest rate with a much longer lag than change in money supply.

## Section VI

## Concluding Remarks

Using monthly data for the period 1982:4 to 2008:3, the behaviour of persistence in the alternative measures of inflation in India was analysed, both at the aggregate and disaggregate level. Drawing on the literature, we employed two measures of inflation persistence *viz.,* the autoregressive property of the inflation series and the number of periods it takes for the systematic monetary policy to have its maximum effect on inflation rate. It is revealed from the autoregressive properties that,

irrespective of the alternative inflation measures, the level of inflation persistence in India is relatively on the lower side. Conforming to the results found in the literature, this lower level of inflation persistence in India is particularly evident when allowed for break in the mean rate of inflation observed mostly around the second half of the 1990s. However, unlike observed in several industrialised countries, the persistence in disaggregates is not consistently lower than the aggregates. Among the components of WPI, 'manufacturing' inflation is the most persistent. 'Food' and 'fuel' exhibit a lower level of persistence than manufacturing and its components.

With the general decline in the mean rate of inflation since the mid-90s, persistence in most of the inflation measures also declined. However, due to rise in the persistence in some of its components, persistence in WPI inflation did not show a commensurate fall. The rolling regressions reveal sharp rise in the persistence of WPI in the more recent period due to 'primary', 'fuel' and 'metal' components. With regards to CPIs, the persistence increased during a longer part of the sample period followed by slow declines.

Change in money growth has statistically significant impact on almost all the inflation series. In general, the maximum lag impact of money growth was much longer during the higher inflationary period up to the mid-1990s (coinciding with monetary targeting regime) than the period thereafter with lower inflationary environment (coinciding with multiple indicator approach). During the period of higher inflation, the maximum lag impact of money supply was much longer on food items than non-food items, but shortened substantially with the decline in inflation rate. On the other hand, monthly weighted average call rate is found to have a statistically significant negative impact on all the inflation series. It is also observed that, in general, the maximum impact of interest rate on inflation is felt with a much longer lag than that of change in money supply.

## Notes

[1] However, persistence in high inflation periods has negative connotation, which may not be the case with periods of low inflation. In the period of high inflation there is the vicious circle of high inflation accompanied by high inflation in future, while in the case of disinflation or price stability the circle is virtuous with the inertial of inflation expectation breaking down and inflation steadily falling (Hondroyiannis and Lazaretou, 2004).

[2] For 'food' component of CPI-IW, the time period is from 1982:4 to 2007:6 due to non-availability of data in the source material. We chose the beginning of the sample period from 1982:4, as this was one of the revised base year in the past.

[3] In our context, since we use monthly data series, the rate of inflation is the annualized month-to-month inflation rate obtained from the price series adjusted for seasonality. This is in conformity with the standard practices in the literature. Further, the problem of base effect associated with inflation measured on year-on-year basis, as the property of such series tends to alter with the frequency of data, would be largely absent.

[4] It may be noted that, in contrast to type-I persistence, the measure of inflation rate here is on year-on-year basis.

[5] No significant differences in the trend of the estimated persistence parameters are observed when the window size of the rolling regression was 108. However, they are not reported in order to conserve space.

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