Early warnings of inflation in India

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Abstract

In India, year-on-year percentage changes of price indexes are widely used as the measure of inflation. In terms of monthly data, each observation of a one-year change in inflation is the sum of twelve one-month changes. This suggests that better information about inflationary pressures can be obtained using point-on-point monthly changes. This requires seasonal adjustment. We apply standard seasonal adjustment procedures in order to obtain a point-on-point seasonally adjusted monthly time-series of inflation in India. In three interesting high inflation episodes – 1994-95, 2007 and 2008 - we find that this data yields a faster and better understanding of inflationary pressures.

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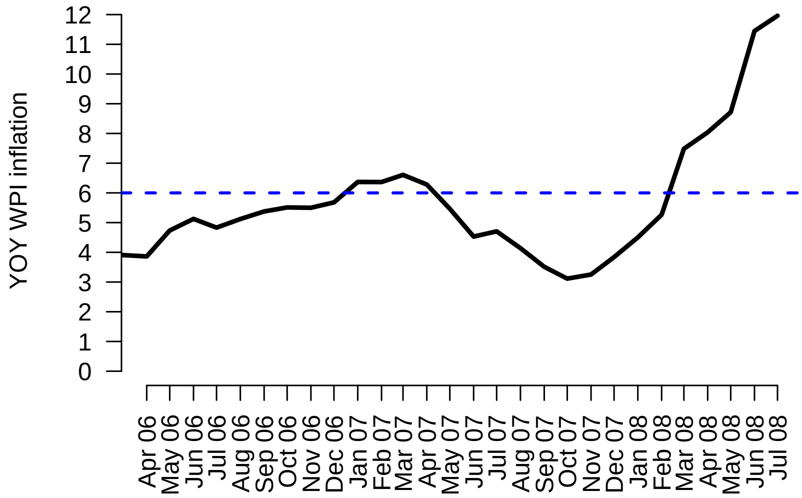
Contents

1 Introduction

The focus of inflation measurement in India is the year on year change in the wholesale price index (WPI).

Figure 1 The high inflation episodes of 2007 and 2008



As a thumb-rule, in the present environment, inflation of roughly 3% is considered acceptable and inflation of 6% and above is considered an alarming high inflation episode. Figure 1 shows the time-series of year-on-year (YOY) inflation with a horizontal line at 6%. This highlights the two recent high inflation episodes, in 2007 and 2008. In the high inflation episode of 2007, YOY inflation exceeded 6% in January 2007 and dropped below 6% in April 2007. In the high inflation episode of 2008, YOY inflation exceeded 6% in March 2008.

Inflation monitoring in India is almost entirely done using year-on-year price changes. As an example, the *Annual Report* released by the RBI are entirely couched in terms of year-on-year changes in price indexes.[1] The measure of inflation used in the *Economic Survey* released by the Ministry of Finance is the percentage difference between a moving average of the price index over the latest 12 months when compared with the identical value of a year ago.

[1] In 2007, RBI released a *Report of the internal technical group on seasonal movements in inflation* chaired by Balwant Singh. However, these ideas have not filtered into monetary policy formulation and official communications of the RBI.

YOY inflation measures have a weakness in that they represent the sum of twelve monthly changes in the price level. In working with monthly data on inflation, each observation of month-on-month inflation can be thought of as one shock or one innovation in the time-series. The YOY inflation is then an equally weighted moving average of the latest 12 shocks. Analysing the individual month-on-month price changes can yield more timely information about the inflation. When innovations arise in the inflation process, the analysis of point-on-point (POP) inflation can yield early warnings about the onset or ending of high inflation episodes, when compared with the slow response of YOY inflation.

At the same time, POP inflation measures are contaminated by seasonal effects that are not influenced by monetary policy. As an example, the arrival of a harvest in a particular month would yield a lowered estimate of POP inflation. POP inflation measures are hence likely to be inappropriate in obtaining information about inflation as a macroeconomic phenomenon.

The resolution of this problem lies in seasonal adjustment. In this paper, we apply standard methodologies of seasonal adjustment to Indian inflation data. This gives us estimates of POP seasonally adjusted (POP SA) inflation. We then explore the usefulness of this information for the purpose of analysing inflation in three interesting high inflation episodes: 1994-95, 2007 and 2008.

Our main finding is that POP SA inflation helps in obtaining superior information about inflationary pressures in the economy. This finding is not unusual in an international perspective. As an example, the *Inflation Report* of the Bank of England is almost entirely couched in terms of seasonally adjusted point-on-point inflation.

2 Methodology for seasonal adjustment

Statisticians have grappled with problems of seasonal adjustment for almost a hundred years. The first tools developed for seasonal adjustments were data-driven filters, such as moving averages, aimed at smoothing out the seasonal fluctuations (Bell and Hillmer, 1984). This strategy can decompose a time series into trend, seasonal and irregular components. These components do not need explicit models of each of these elements. The irregular component is defined as what remains after the trend and seasonal components have been removed by filters. Given the limitations of this methodology, the estimated irregular component is not white noise.

In the late 20th century, model-based approaches came to be applied to this problem. These were based on writing a model that expressed seasonal fluctuations, and arriving at estimates of seasonality through estimation theory applied to the data.

The simplest of these strategies is the dummy variable regression. As an example, log WPI can be regressed on twelve month dummies while excluding an intercept. This regression can be estimated by OLS or by robust regression techniques. This is a simple and readily implemented strategy. However, it is not effective at dealing with changing seasonality. The way forward lay in the Box-Jenkins approach, with the seasonal ARIMA model, where the seasonal pattern of one period is assumed to repeat in the next period with an additive random perturbation.

We conduct seasonal adjustment using the X-12-ARIMA system developed by the US Bureau of Census which combines all these three approaches. It conducts dummy variable regression for fixed seasonal effects, trading day effects, moving holiday effects (such as Easter and Thanksgiving Day) and outliers; and fits a seasonal ARIMA model thus modeling the changing seasonal pattern. X-12-ARIMA fits the following model:

$$y_t = \sum_i \beta_i x_{it} + z_t$$

where z_t follows a seasonal ARIMA $(p, d, q)(P, D, Q)_s$ model. The ARIMA identification is done automatically by analysing the autocorrelation function (ACF) and the partial autocorrelation function (PACF). A set of dummy variables reflecting various kinds of seasonal effects are used in a regression model. An iterative GLS algorithm is then used, which works in two consecutive steps. In step 1, given values of AR and MA parameters, coefficients of dummies are estimated by GLS using the covariance structure of the regression errors determined by the ARIMA model, and in step 2, given estimates of regression parameters, regression errors are calculated and the ARIMA model is estimated using MLE. These two steps are iterated till convergence is achieved.

The fitted series, adjusted for effects of regressors, including outliers, is passed through seasonal and trend filters to obtain seasonally adjusted series, trend and irregular components.

X-12-ARIMA checks that the regression residuals are white noise using the Box-Ljung q statistic. It also checks for residual seasonality in the seasonally adjusted series and irregular components using F-tests and spectral plots of these series. If seasonality is still present in the adjusted series, the program warns of visually significant peaks at seasonal frequencies for monthly series of $k/12$ cycles/month (or k cycles/year) where $1 \leq k \leq 5$ and trading day frequencies of 0.348 and 0.432 cycles/month (or 4.176 and 5.184 per year).

While X-12-ARIMA is sometimes used as a black box, seasonal adjustment requires a rich prior knowledge of the series, choice of explanatory variables, and careful diagnostic checks.

In our application of X-12-ARIMA, in addition to month dummies, the Diwali effect was modelled drawing on the ideas offered by X-12-ARIMA for handling Easter. We find that this effect is statistically insignificant in the presence of month dummies.

In terms of data resources, we use the monthly WPI series from CMIE's *Business Beacon* database. Each observation for a month is the average of all observations of WPI in the month. Our dataset runs from April, 1990 to July 2008 and has 220 observations.[2]

3 Definitions and notation

POP Point on point inflation. Computed as $\pi_t = 1200(\log p_t - \log p_{t-1})$ where p_t is the level of the price index of monthly frequency at time t. This yields an annualised measure. As an example, if a price index goes up from 100 to 101 in a month, this corresponds to an annualised rate of inflation of 11.94%.

SA Seasonally adjusted.

NSA Not seasonally adjusted.

POP SA POP inflation (as defined above) computed using the time-series of seasonally adjusted levels.

POP NSA POP inflation (as defined above) computed using the raw time-series of unadjusted levels.

[2]There are concerns about utilising this full series given the change of base year which generates a large outlier in April 1994. While x12arima detects and treats outliers, the analysis of the paper has hence been repeated using the data from May 1994 onwards. The broad results hold with this shorter time-series also.

Table 1 Correlation matrix of alternative measures of POP changes of the WPI

	NSA	X-12-ARIMA	Dummy variable reg.	STL
NSA	1			
X-12-ARIMA	0.91	1		
Dummy variable reg.	0.93	0.96	1	
STL	0.82	0.93	0.87	1

4 Robustness

4.1 Outliers

X-12-ARIMA detects outliers and ensures that they do not have a disproportionate impact on the estimated results. This addresses one key concern in real world applications.

4.2 Sensitiveness to alternative techniques of seasonal adjustment

In order to obtain an empirical sense on how sensitive the results are to alternative algorithms of seasonal adjustment, we implement three different strategies: (a) X-12-ARIMA, (b) dummy variable regression using a robust regression (Venables and Ripley, 2002) and (c) decomposition into trend, seasonality and irregular component using a non-parametric "STL" algorithm (Cleveland *et al.*, 1990) using LOESS (Cleveland *et al.*, 1992). Of these, X-12-ARIMA and the variable regression are parametric methods; however in both cases robust estimation is done to reduce the influence of extreme observations. STL is an explicitly non-parametric method.

Table 1 shows the correlation matrix of four different time-series of POP changes of the WPI: the raw data, and the three alternative seasonal adjustment methods. All three seasonal adjustment strategies explicitly deal with outliers, which would inevitably generate a loss of correlation against the raw data series. The lowest correlation in this table, of 0.82, is between the raw data and the seasonal adjustment done through STL. All the other correlations are higher than this.

Table 2 shows the numerical values obtained in recent months, which allows us to compare the results obtained by the three different methods of seasonal

Table 2 Examples of numerical values obtained with different methods of seasonal adjustment

Month	Raw	X-12-ARIMA	Dummy var. reg.	STL
2007-10	0.55	3.16	1.31	1.81
2007-11	3.89	6.37	6.17	6.00
2007-12	2.77	10.94	9.17	13.05
2008-01	9.94	13.24	12.47	20.61
2008-02	9.31	11.92	10.89	13.45
2008-03	30.17	31.14	31.63	23.01
2008-04	15.85	9.08	8.88	9.11
2008-05	12.01	7.95	10.95	9.18
2008-06	29.78	26.59	25.78	35.72
2008-07	12.86	8.57	10.15	12.11

adjustment. As an example, in January 2008, while the raw data showed inflation of 9.94%, the three different seasonal adjustment algorithms showed values of 13.24%, 12.47% and 20.61%. The three SA series are remarkably alike. This fact, coupled with the high correlations seen in Table 1, helps us have confidence that the results are not unduly sensitive to the choice of strategy for seasonal adjustment.

4.3 Extent to which seasonal adjustment removes seasonality

The intuition of spectral analysis is particularly useful in interpreting the goals and the results of seasonal adjustment procedures. Figure 2 shows the fourier decomposition of POP changes in WPI, comparing the raw series (termed NSA or not seasonally adjusted) against the X-12-ARIMA seasonally adjusted (termed SA) series.

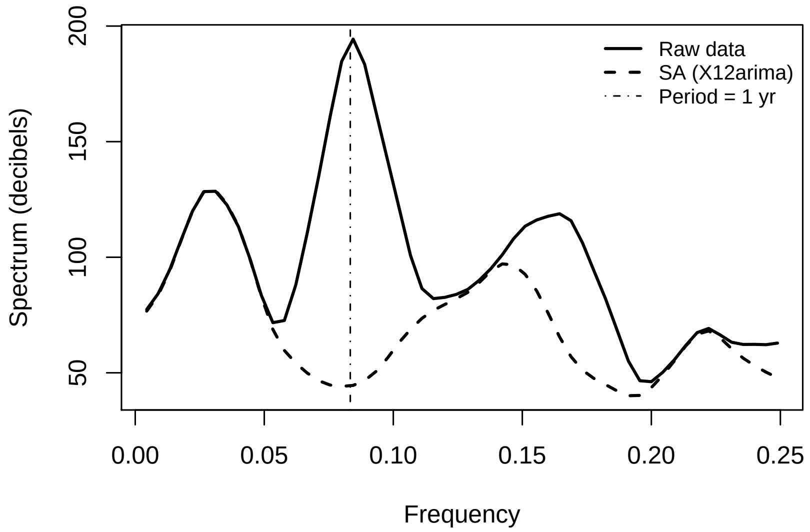
This shows that the raw series has an extremely strong peak at the wavelength of one year.[3] This peak is removed by seasonal adjustment. At low and high frequencies compared with this peak, the spectrum of the raw data

[3]The y axis shows $10 \log_{10} I(\omega)$ in units of decibels where

$$I(\omega) = \frac{1}{n}\left[\left\{\sum_{t=1}^{n} X_t sin(\omega t)\right\}^2 + \left\{\sum_{t=1}^{n} X_t cos(\omega t)\right\}^2\right]$$

is the spectral density. Smoothing is done using modified Daniell smoothers (Venables and Ripley, 2002).

Figure 2 Spectrum of NSA and SA POP changes in WPI



is close to the spectrum of the seasonally adjusted data, which suggests that other features of the time series have been unaffected by the process of seasonal adjustment.

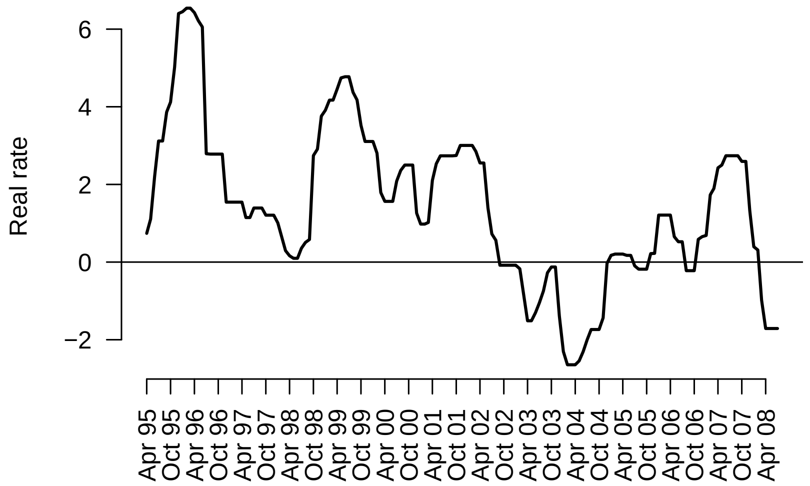
5 Early warnings

Seasonally adjusted data is well suited for short term forecasting. For this, a variety of econometric models can be applied to the seasonally adjusted data. In order to obtain greater intuition into the usefulness of seasonal adjustment, we merely examine the data looking for large values.

The 6% threshold for a 'high inflation episode' works out to the 60th percentile of the data. The 60th percentile of the POP SA WPI inflation works out to an annualised value of 6.65%. Hence, we **define a high inflation episode as year-on-year inflation exceeding 6%** and consider the consequences of putting out an **early warning when the POP SA inflation exceeds 6.65%**. In the following tables, these 'high inflation episode' or 'warning' values are shown in boldface.

In order to obtain estimates of the real interest rate at the short-end of the yield, forward-looking estimates of inflation are required. In this, we seek to adjust the nominal rate for the 90 day maturity using inflation forecasts for a 90 day horizon. To achieve this, the POP SA data is used to make

Figure 3 Short-term interest rate, expressed in real terms (smoothed)



forecasts, using an AR(6) model, for the coming three months. At each month, information available till that month is used to estimate the AR model, and to make forecasts for POP SA inflation over the coming three months using this model. The average of these three forecasts is used to convert the nominal short-term interest rate into the short-term real rate. Figure 3 shows the smoothed time-series of the real rate computed in this fashion.[4]

5.1 Example: the high inflation episode of 1994-95

Table 3 shows YOY WPI inflation, POP SA WPI inflation, and the responses of monetary policy in the high inflation episode of 1994-95.[5]

A large POP SA change took place in April 1994. This may be partly related to statistical measurement issues of WPI. At this time, the 90 day interest rate in the economy was 7.36%. In the following two months, POP SA inflation showed large values of 7.17% and 16.78%. Large values for POP

[4] Special difficulties are faced in the period from April 1993 to April 1994, where the WPI shows a value of 100 for all the months of 1993-94 and then shows a sharp jump in April 1994. Hence, the POP SA value for WPI for these months was forced to be missing before computing the real rate using the procedure described in the text.

[5] A deeper economic analysis of the exchange rate regime, loss of monetary policy autonomy and inflation in this episode is presented in Patnaik (2005).

Table 3 WPI inflation and monetary policy in the high inflation episode of 1994-95

	WPI		Short-term interest rate	
Month	YOY	POP SA	Nominal	Real
1994-04	**7.50**	**79.84**	7.36	-2.70
1994-05	**8.30**	**7.17**	7.48	-2.19
1994-06	**10.00**	**16.78**	8.25	-2.71
1994-07	**11.10**	5.56	8.83	-0.62
1994-08	**11.80**	**8.00**	8.13	-1.61
1994-09	**11.90**	3.32	8.58	-0.75
1994-10	**12.70**	**10.68**	8.77	-1.15
1994-11	**13.20**	**7.89**	8.50	-1.70
1994-12	**14.50**	**17.40**	9.42	-0.47
1995-01	**16.20**	**20.42**	10.68	-0.14
1995-02	**16.90**	**7.57**	11.29	2.64
1995-03	**16.90**	3.44	11.65	2.38
1995-04	**10.97**	**15.31**	11.72	0.74
1995-05	**10.98**	**7.97**	12.01	1.11
1995-06	**9.72**	3.19	12.46	2.21
1995-07	**9.63**	5.02	12.84	3.12
1995-08	**8.94**	1.18	12.63	3.86
1995-09	**8.93**	3.18	12.61	3.10
1995-10	**8.42**	4.56	12.78	4.12
1995-11	**8.21**	5.16	12.97	5.02
1995-12	**6.63**	-0.41	12.97	6.45
1996-01	4.99	3.20	12.97	6.40
1996-02	4.53	1.92	12.97	6.73
1996-03	4.53	3.09	12.97	6.81
1996-04	3.68	4.47	12.71	6.42
1996-05	3.57	**7.12**	12.39	6.06
1996-06	3.64	4.00	12.41	6.22
1996-07	4.26	**13.14**	10.80	2.79
1996-08	4.92	**9.16**	9.20	1.36
1996-09	5.08	4.66	10.07	2.78
1996-10	4.58	-2.49	9.50	2.96
1996-11	4.48	3.84	7.54	0.41
1996-12	5.24	**8.82**	8.10	-0.33
1997-01	5.16	3.60	8.12	1.64

SA inflation are visible till May 1995. In this period, monetary policy was; the short-term rate became negative in real terms. The short-term rate was negative in real terms all the way till January 1995.

From June 1995 onwards, POP SA inflation dropped sharply. However, large values for YOY inflation continued to be recorded, since YOY inflation is the average of the last 12 values for POP inflation.

Monetary policy tightening is visible right from the start. The real rate, which was negative, started rising. In June 1995, when POP SA inflation had started easing, the real rate was +2.21%.

The short term rate stayed above 2% in real terms till August 1996. Over this period, YOY WPI inflation ebbed away. However, when judged by POP SA data, WPI inflation had subsided 14 months earlier, by June 1995.

Examining POP SA data does not substantially alter the date at which the tightening began. However, POP SA inflation had subsided by June 1995, which suggests that the easing could have begun earlier and progressed faster. In this period, the use of POP SA data would have given a useful early warning that inflation had subsided.

5.2 Example: the high inflation episode of 2007

Table 4 shows the events of the high inflation episode of 2007. Going by the year-on-year series, the high inflation episode erupted in January 2007 and ended in April 2007. The POP SA data, however, shows a very different picture. It shows that the high inflation episode began in May 2006 : an early warning of 8 months. POP SA inflation was high in the period from May 2006 till October 2006: over this period, inflation averaged 7.81%.

The inflationary pressures subsided by October 2006, before the high inflation episode had even showed up in the year-on-year data. To the extent that policy responses took place after October 2006, they were possibly in the wrong direction.

In the critical period from May 2006 to October 2006, when there was high inflation, monetary policy was expansionary. Monetary policy tightening is visible much later. The real rate went up from -0.55% in September 2006 to 3.35% in June 2007. Inflation had subsided before the tightening began.

Table 4 WPI inflation in the high inflation episode of 2007

	WPI		Short-term interest rate	
Month	YOY	POP SA	Nominal	Real
2006-04	3.86	6.98	5.58	0.52
2006-05	4.73	**10.58**	5.68	0.11
2006-06	5.12	**7.56**	6.03	0.65
2006-07	4.83	2.43	6.40	1.03
2006-08	5.12	**8.53**	6.38	-0.38
2006-09	5.37	**9.62**	6.51	-0.55
2006-10	5.51	**8.14**	6.61	-0.22
2006-11	5.49	4.15	6.63	0.59
2006-12	5.67	4.48	6.90	0.69
2007-01	**6.36**	5.71	7.25	0.66
2007-02	**6.36**	3.39	7.79	1.90
2007-03	**6.60**	5.98	7.71	1.73
2007-04	**6.28**	3.05	7.62	2.43
2007-05	5.46	0.61	7.62	2.74
2007-06	4.53	-3.25	7.44	3.35
2007-07	4.71	3.64	5.31	0.40
2007-08	4.14	2.66	6.77	2.50

5.3 Example: the high inflation episode of 2008

Table 5 shows facts about inflation in the high inflation episode of 2008. From December 2007 onwards, inflation pressures were visible in the POP SA data. They burst into the public consciousness in March 2008, with reports of high YOY WPI inflation. The use of POP SA data would have given an early warning by three months.

A high rate of POP SA inflation is visible all the the way to the latest data for July 2008. The future evolution of this high inflation episode is as yet unclear.

The short term real interest rate was at 2.59% in November 2007, the last month prior to large inflation shocks. This plunged to -4.50% in March 2008. At a time of positive inflationary shocks, monetary policy was expansionary. Real rates remain very low when compared with those required to rein in inflation. The last observation of the real rate, -0.88% in July 2008, remained much below the level of +2.59% in November 2007, before this inflationary episode began. This suggests that until July 2008, monetary policy tightening aiming to combat inflation has not taken place.

Table 5 Inflation in the high inflation episode of 2008

Month	WPI YOY	WPI POP SA	Short-term interest rate Nominal	Short-term interest rate Real
2007-08	4.14	2.66	6.77	2.50
2007-09	3.51	3.21	7.07	3.00
2007-10	3.11	3.16	7.04	3.04
2007-11	3.25	6.38	7.40	2.59
2007-12	3.83	**10.95**	7.42	1.33
2008-01	4.50	**13.24**	7.09	0.40
2008-02	5.26	**11.92**	7.34	0.31
2008-03	**7.48**	**31.14**	7.29	-4.50
2008-04	**8.03**	**9.08**	7.17	-0.98
2008-05	**8.33**	**7.95**	7.38	-1.71
2008-06	**11.44**	**26.60**	8.13	-4.78
2008-07	**11.96**	**8.57**	8.94	-0.88

6 Looking forward into the high inflation episode of 2008

How might inflation play out in coming months? The key issue that is of importance is inflation persistence. If economic agents build inflationary expectations into their decisions, this will lead to persistence of inflation.

The WPI fuel and WPI primary have substantial external and policy influences. It is WPI manufacturing which is primarily influenced by the behaviour of the private sector.[6]

Figure 4 shows the ACF of the POP SA time-series of WPI manufacturing. It shows strong positive autocorrelations in the early months. This shows the extent of inflation persistence which is now found in India. Through this inflation persistence, the recent shocks to POP SA WPI manufacturing are likely to be correlated with further above-trend values in coming months.

Table 6 looks closer at the sub-components of the overall WPI series. All values shown are POP SA annualised inflation. There were large shocks to WPI Primary from December 2007 to March 2008. WPI Fuel had large shocks in many of the months also. WPI Manufacturing shows high inflation for almost all the months shown.

The key question that arises after the March shock is that of inflation per-

[6] WPI manufacturing has a great deal of tradeables; it is hence influenced by the exchange rate and by global inflationary conditions also.

Figure 4 Autocorrelation function of POP SA WPI manufacturing

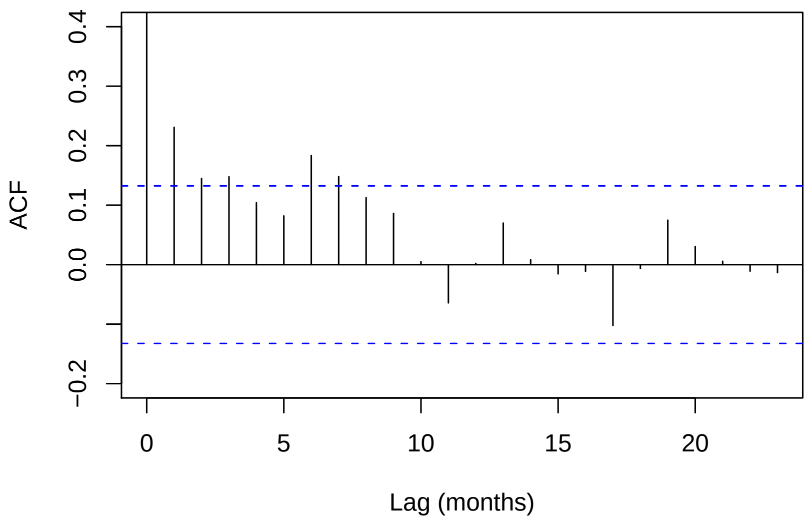


Table 6 POP SA inflation of WPI components

Month	Primary	Fuel	Manufacturing	Overall
2007-12	10.56	24.20	5.63	10.94
2008-01	16.25	9.80	10.29	13.24
2008-02	31.26	5.61	5.86	11.92
2008-03	34.82	18.72	33.64	31.14
2008-04	-6.38	3.42	13.80	9.08
2008-05	8.33	9.43	10.04	7.95
2008-06	1.65	88.08	12.70	26.60
2008-07	13.31	4.06	11.15	8.57

Table 7 Forecasts for POP SA using ARMA models

Month	WPI Manufacturing	WPI Overall
2008-08	7.97	8.69
2008-09	11.54	10.55
2008-10	8.82	8.52
2008-11	7.68	7.29
2008-12	7.89	9.18
2009-01	7.47	7.51

sistence. To the extent that economic agents are placed in a well structured monetary policy framework, their inflation expectations get anchored. A large shock like the March shock then does not generate further reverberations. In the Indian setting, inflation persistence did arise: with WPI Manufacturing inflation of 13.8% in April, 10.04% in May, 12.7% on June and 11.15% in July.

The simplest notion of forecasting is that of undertaking univariate time-series forecasting using ARMA models of the POP SA series. These models have no economic content; they do not reflect the impact of economic considerations such as the expansionary stance of monetary policy with negative real rates, the coming fuel price rises or the inflationary impact of the recent rupee depreciation. They only reflect an efficient utilisation of the autocorrelation structure in the POP SA time-series.

Table 7 shows ARMA forecasts for the POP SA series for WPI manufacturing and WPI. Given the greater inflation persistence in WPI manufacturing, the recent positive shocks to WPI manufacturing are projected to induce positive shocks in the coming six months of data. In the case of the overall WPI, there is a faster convergence to the long-term mean, given lower persistence.

Figure 5 and Figure 6 restate these forecasts for the POP SA series into point estimates for the forecasted levels of the two price indexes.

Figure 7 and Figure 8 restate these point estimates into the familiar year-on-year inflation estimates which are widely used in India. This suggests that WPI inflation may worsen towards the end of the year before declining. However, even by June 2009, YOY WPI inflation may continue to be in the region of 8%.

It should be emphasised that these forecasts have no economic content. They do not reflect economic policy issues such as expansionary monetary policy with negative real rates, the inflationary impact of the recent currency depreciation, the impending price rises of petroleum products, etc. They merely

Figure 5 WPI and forecasts (Levels)

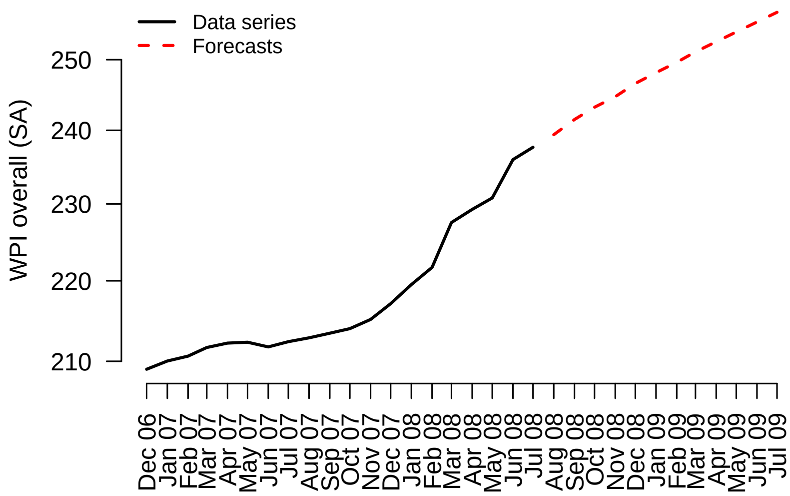


Figure 6 WPI Manufacturing and forecasts (Levels)

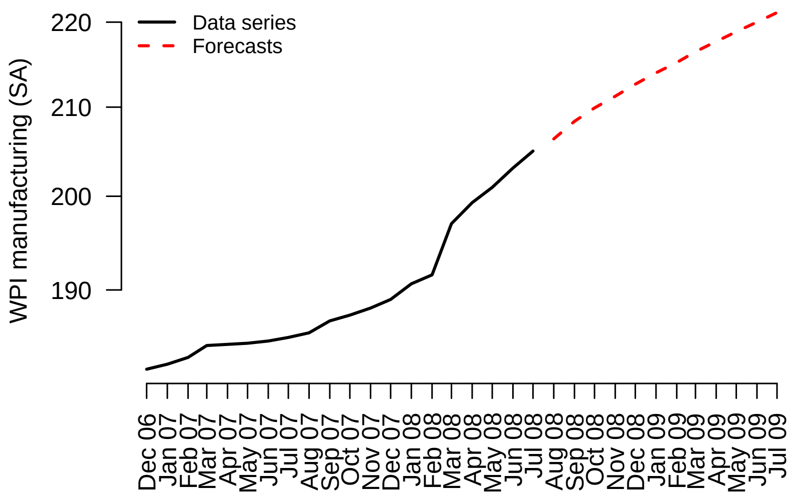


Figure 7 WPI and forecasts (YOY)

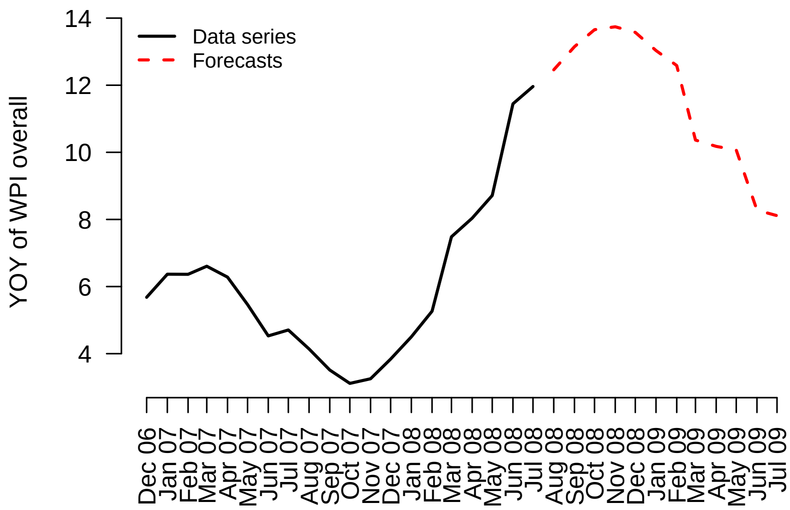
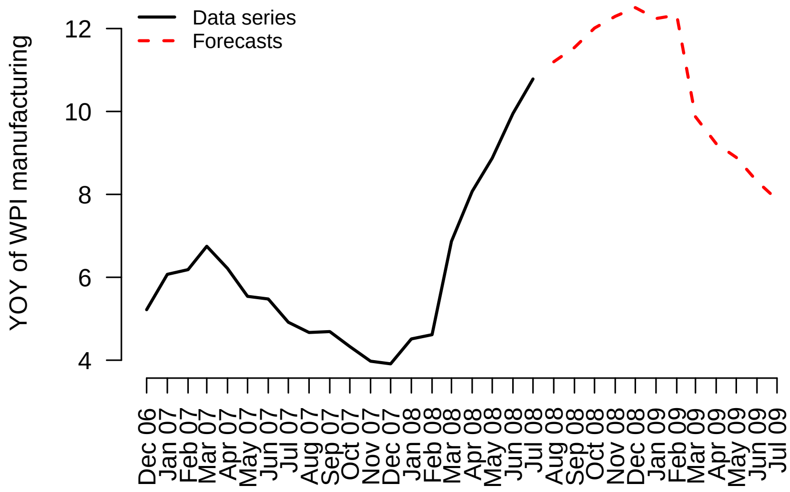


Figure 8 WPI Manufacturing and forecasts (YOY)



project the POP SA series for WPI and WPI manufacturing into the future using ARMA models; they efficiently utilise the autocorrelation structure of these series for the purpose of forecasting.

7 Areas for further research on seasonal adjustment

There are two key areas where further work is required.

The first is the issue of seasonal adjustment of weekly data. When working with monthly data, there is a clear definition of the corresponding month of the previous year. In contrast, when working with weekly data, the corresponding week of the previous year is an imprecise notion. Some years have 52 weeks while others have 53 weeks. Festivals such as Diwali, Holi or Id occur in different weeks of the year across different years.

The standard techniques of seasonal adjustment do not apply when dealing with weekly data. Given that the Indian WPI data comes out every week, there is a need to explore the research literature (Pierce *et al.*, 1984; Harvey *et al.*, 1997) so as to achieve seasonal adjustment of weekly WPI data.

The other important issue that frequently stems in seasonal adjustment procedure is the choice between direct and indirect treatment. The procedure of getting an aggregate seasonally adjusted series by summing seasonally adjusted component series is called indirect seasonal adjustment of the aggregate series. In this paper, the strategy that we have followed consists of application of seasonal adjustment directly to the aggregate data, which is termed 'direct' seasonal adjustment (Hood and Findley, 2001).

In general, when component series have distinct seasonal patterns, indirect adjustment is more appropriate than direct adjustment. On the other hand, when component series are noisy, but have similar seasonal pattern, aggregation of the series may cancel out noise, and direct seasonal adjustment will be of better quality. This is an area for further research.

8 Conclusions and implications

At present, in India, inflation forecasting does not take place to a substantial extent. Inflation monitoring is primarily about reading data about *past* inflation. In this task, monitoring recent values of the point-on-point seasonally adjusted inflation appears to be particularly useful in understanding inflationary pressures, when compared with monitoring year-on-year inflation which is the moving average of the latest twelve data points of point-on-point inflation.

In the three high inflation episodes examined in this paper, POP SA data would have been useful in obtaining early warnings:

- In the 1994-95 high inflation episode, POP SA data is not useful in obtaining an early warning of the onset of high inflation. However, it shows that this episode of inflation subsided by June 1995, while tight monetary policy was in place till August 1996.
- In the 2007 high inflation episode, POP SA data shows that inflationary pressures erupted in May 2006 and ended in October 2006. In the standard YOY data, the high inflation episode began in January 2007 and ended in April 2007. On both the onset and the end of the high inflation episode, POP SA data yields an early warning of eight and six months respectively.
- In the 2008 high inflation episode, POP SA data shows that inflationary pressures erupted in December 2007. This was a significant early warning when compared with the YOY data which showed high inflation in March 2008. This early warning is particularly important given the expansionary monetary policy followed between December 2007 and March 2008. Real rates, computed using forecasted values for POP SA WPI inflation, show that there has been no monetary policy tightening in this episode.

Since monetary policy cannot influence seasonal factors, the analysis of inflation with a focus on linkages with monetary policy cannot be conducted with NSA POP data. It can either use YOY or POP SA data. As this paper has demonstrated, POP SA data is a better foundation for such analysis.

Since monetary policy acts with a lag, decisions about the short-term interest rate taken at a certain point in time only influence the economy at future dates. A well structured monetary policy framework requires analytical support in the form of mechanisms for *anticipating* future inflation and responding to it ahead of time. As an example, the Taylor rules which are fairly effective in describing the behaviour of modern inflation-targeting central banks consume *forecasts* of future inflation and future GDP growth as inputs.

A new level of sophistication in inflation forecasting is, then, a critical element in the implementation of the reforms to the monetary policy framework that have been recommended by the Percy Mistry and Raghuram Rajan Committees. The point-on-point seasonally adjusted data examined in this paper will play a useful role in the effort of forecasting inflation and thus supporting the effort of monetary policy reform.

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