Analysing Core Inflation in India: A Structural VAR Approach

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Analysing Core Inflation in India: A Structural VAR Approach[♣]

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Abstract

Effective inflation targeting requires careful selection of the inflation target. It is necessary to leave out noisy elements, which monetary policy cannot control, but this exclusion should not be done in an ad hoc way. Rather core inflation should be determined from the structure of the economy.

This paper estimates core inflation for India using Structural Vector Autoregression (SVAR). This method is based on both theory and the structure of the economy. Monthly data for wholesale price index (WPI) and index of industrial production (IIP) has been used, covering a long time span from January 1971 to July 2004. We analyze the impulse responses of inflation and output, test for several time series properties of core inflation and carry out a number of Granger causality tests between headline inflation, core inflation, output and a monetary aggregate.

Key words: Inflation Targeting, Core Inflation, Structural VAR.

JEL Classification: C32, E31, E52

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1. Introduction

Stabilization, or keeping output at its natural level, and lowering inflation are the major objectives of monetary policy makers. Inflation targeting is an approach to monetary policy, where the Central Bank aims to achieve either a particular level of inflation or more commonly keep inflation within the range.

But a major problem is deciding which measure of inflation to target. First, volatility of prices in headline or measured inflation restricts it from being a useful basis for monetary policy decisions. Second, in particular for the Indian case, there are many price indices and the index to choose for analyzing the inflationary scenario is controversial. There is no retail price index, which could be effectively used to analyze inflation. The general practice has been to use the wholesale price index (WPI), which does not include the service sector as the measure of headline inflation.[1] In view of the expansion of the service sector in recent years, this practice is questionable. However, we follow the general practice and take WPI for analyzing core inflation.

Core inflation has the advantages that it excludes the volatile component, which maybe outside the control of monetary policy, from headline inflation. It does this by identifying inflation caused by demand shocks-core inflation. But theoretical restrictions are required to identify demand shocks.

Although India has not yet adopted formal inflation targeting, some efforts have already been made to analyze core inflation. This paper differs from earlier Indian work in this area (Samanta, 1999; Mohanty, Rath and Ramaiah, 2002 etc.) by applying an advanced time series method, Structural Vector Autoregression (SVAR), to distinguish the component of core inflation from headline inflation by imposing some dynamic restrictions in tune with economic theory. We use monthly data on WPI and Index of Industrial Product (IIP) to obtain a core inflation series. It is then tested to see whether it satisfies time series properties.

The paper is organized as follows. Section 2 gives an overview of the concept, measures and uses of core inflation. Section 3 reviews some empirical literature on core inflation. Section 4 describes the identification procedure of the SVAR model. Section 5 describes the data and methodology. Section 6 presents the empirical results and Section 7 concludes.

[1] Deshpande (1985) and Samanta and Mitra (1998).

2. Core Inflation

This section gives an overview of the concept, measures and potential usefulness of core inflation.

Concepts

The literature has a variety of concepts as well as measures of core inflation. Eckstein (1981) first defined core inflation as the trend increase in the cost of factors of production. However, the recent definition of core inflation is accepted as the rate of inflation which does not have any impact on the long run natural output, that is, it is caused by excess demand. Bryan and Cecchetti (1993) define core inflation as the long run or persistent component of the measured price index, which is tied in some way to monetary growth.

It is a well-accepted fact that headline inflation is not a good indicator of underlying inflation trend in an economy. The gap between these two measures arises because of unanticipated shocks. The basic idea behind the concept of core inflation is to exclude the unexpected noise and track the component of overall price change that is expected to persist for a long time. Capturing the persistent component of headline/measured inflation would also be useful for inflation forecasting.

Second, core inflation should capture the component of price change, which is common to all items, but it should exclude changes in the relative prices of goods and services (Bryan and Cecchetti 1993).

Measures

A number of measures have been suggested for core inflation. Among the alternative measures, some exclude the same fixed set of components from overall CPI for each unit of time (say, a month), even though the changes in all those components are not large in every month. While other measures exclude only components with large price change in that particular month. Clark (2001) considers five measures in his study.[2] The measures are as follows: (a) CPI minus food and energy prices (Bureau of Labour Statistics), (b) Trimmed mean (Bryan and Cecchetti 1999), (c) Median CPI (Bryan and Cecchetti 1999), (d) CPI excluding energy (Clark 2001) and (e) CPI excluding eight most volatile components of overall index (Clark 2001).

All the above measures are based on the same principle, but none of them is theory based. Quah and Vahey (1995) use a VAR (Vector Autoregression) to measure core inflation. Our study follows this approach for measuring Indian core inflation.

Uses

Two major benefits of core inflation have been identified for monetary policy purpose.[3] Central bankers undertake aggregate demand management to counter the output and price consequences of demand and supply shocks to stabilize real activities around trend/potential level of output. But reducing demand to counter the impact of supply shocks on the price level would tend to accentuate the output effects of the disturbances, resulting a trade-off between variability of output and the variability of inflation. However, if they target core inflation (as obtained by eliminating supply shocks) rather than headline inflation, minimizing variability in core inflation will be accompanied by minimum output variability. In other words, the output-inflation trade-off would evaporate automatically when policy focuses on core inflation. If the target is in the form of a medium-term inflation zone forecast it would build a buffer to allow for uncertainty and would not lead to a contraction when excess demand is negative.

Inflation targeting can help make the central bank accountable and provide an explanation for deviations of inflation from the target. The central bank has to be able to distinguish between deviations due to unanticipated shocks or due to errors. Policy accountability may be backward looking or forward looking. In both cases, core inflation helps to maintain policy credibility. When supply shocks are responsible for the deviation, core inflation helps in backward looking accounting in a sense that public can be easily convinced that the deviation was not due to misjudgment since core inflation can identify such supply shocks. On the other hand, for forward-looking accountability, a core inflation measure minimizes the confusion about the price trend in a situation when supply shocks lead to a rising trend in measured/headline inflation. In such cases, even though measured inflation rises, core inflation is stable. Therefore, central bank can adjust the policy stance by drawing attention to stable core inflation, without damaging its policy credibility.

3. A Review of the Empirics of Core Inflation

There are a number of recent articles on the identification of core inflation for many

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[2] Out of five, two are additions to the earlier literature.
[3] Samanta (1999).

countries. Core inflation is obtained by adjusting the Retail Price Index (RPI) by some of the noisy price signals, which are temporary in nature and would not respond to the monetary policy. The idea is to filter the volatile price component from the RPI.

The Bureau of Labor Statistics gives a measure of core inflation as Consumer Price Index (CPI) minus food and energy prices. The latter have historically been highly volatile. So these components should be excluded in estimating core inflation. The volatility in the prices of these items mainly arises due to unexpected supply shocks such as oil shocks or shocks due to natural calamities or industrial unrest etc.

Bryan and Cecchetti (1999) suggest the trimmed mean as the measure of core inflation. The trimmed mean removes all large relative price changes from the overall CPI inflation for each month, with the excluded components changing for each month. They argue that for a gradual change in price in the economy, trimming can result in an appropriate measure of core inflation. A second formulation of the trimmed mean measure of core inflation is known as the median CPI. This measure trims all but the mid point of the distribution of the price changes. They argue that the performance of the trimmed mean and the median CPI depends on the statistical properties of the distribution of price changes in individual items. For example, the median CPI may be superior to the trimmed mean if the distribution of price changes has very at tails on a sufficiently routine basis.

Another measure of core inflation is CPI minus the energy price only. This measure argues that prices of food away from home (imported food price) is very stable and hence may have a predictive power for future inflation. Moreover, the variability of food at home prices have declined over time. So there is no problem in including the food price for the calculation of the core inflation.

Another traditional method to calculate core inflation is CPI minus eight most volatile components (Clark, 2001). Other measures exclude goods with a substantial interest rate component and still others exclude regulated prices, changes in taxes and subsidies.

Samanta (1999) finds that the exclusion-based measures of core inflation are superior to the measured inflation (i.e., WPI for all commodities) in the Indian context, and may be more useful than conventionally measured inflation for setting monetary policy.[4] Also, he argues that money growth has stronger causal impact on certain core measures which provide improved forecasts of future inflation in a multivariate framework.

Nessen and Soderstrom (2000) formulate a theoretical model of inflation targeting

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[4] Reddy (1999) has also briefly described the need for analysing core inflation and its importance for monetary policy in India.

where they use different measures of inflation target like the core inflation (which is related to the level of real activities in the economy and can only be affected through the monetary policy), the CPI inflation and an intermediate inflation measure known as CPIX inflation (defined as CPI inflation excluding the interest rate component). They say that if shocks to inflation are temporary and exogenous, the optimal response is an unchanged interest rate, regardless of inflation measure in the objective function (barring the inflation rate component). However, if the disturbances have persistent effects, the regime matters and in that case, core inflation targeting monetary policy should not respond whereas the CPI or CPIX targeting policy must offset the long run effects of exogenous disturbance. So, the choice of the inflation measure in the process of inflation targeting matters.

Mohanty, Rath and Ramaiah (2002) attempted to study core inflation for India following the principle of exclusion and limited influence estimators of trimmed mean as well as weighted median. They test for the appropriateness of a core inflation measures and suggest that 20 percent trimmed mean appears to be the most appropriate measure.

Core inflation has also been calculated by using Kalman filter, which filters the non-core inflation components from the CPI. Quah and Vahey (1995) argue that such an approach involves some assumption about the underlying inflation, for example that the underlying inflation follows a random walk. There is a little economic interpretation for such an assumption. So they provide an alternative measure of core inflation using VAR. They assume that two types of disturbances, which are uncorrelated with each other, affect observed changes in the measure of inflation. One kind of disturbance has no impact on real output in the medium to long run and the other has unrestricted effects on measured inflation and output (but does not affect core inflation). They define the core inflation as the components of measured inflation that has no medium to long run impact on real output. They construct core inflation estimate corresponding to the first type of disturbances.

Bjornland (2001) uses the concept of structural VAR to identify core inflation as a component of headline inflation that has no long run impact on real output. The neutrality restriction relies on the assumption of a vertical long run Phillips curve. He distinguishes between domestically generated core inflation from imported core inflation too in his analysis. He argues that when inflation is stationary, there is no need to assume a vertical Phillips curve, instead, one can assume a long run vertical supply curve, where positive demand shocks are output neutral in the long run, but increase prices permanently.

Following Quah and Vahey (1995) and Bjornland (2001) we assume the long run neutrality condition to identify the core component of headline inflation. In addition, we check for several properties for core inflation suggested by Freeman (1998).

4. Identifying the SVAR

We assume that two types of exogenous shocks govern the behaviour of measured inflation: core (demand) shocks and non-core (supply) shocks. Core inflation is then defined as the underlying movement in measured inflation associated with the shocks, which has no medium to long run impact on output. Non-core shocks, however, might have significant medium to long-term effects on output. These two types of shocks are assumed to be independent. Now we discuss how to identify core inflation.[5]

Consider a VAR (p) model, which can be expressed as follows:

$$Z_t = \alpha + A_1 Z_{t-1} + A_2 Z_{t-2} + ... + A_p Z_{t-p} + e_t \qquad (1)$$

$$\left(1 - L - L^2 - L^p\right)Z_t = \alpha + e_t$$

$$A(L)Z_t = \alpha + e_t\,, \qquad e_t \sim N(0, \Omega)$$

where *A(L)* is the matrix of lag operator. This is the reduced form model which is useful to identify the structural version of the model with certain restrictions. In our framework, $Z_t = [y_t \quad \Delta p_t]$, Z_t is covariance stationary. These two variables are sufficient for our analysis. The Wold (moving average) representation of Equation 1 would be

$$Z_t = C(L)e_t \qquad (2)$$

where $C(L) = A(L)^{-1}$ and $C_o = I$. In this representation, the elements of e_t are contemporaneously correlated, out of which we need to identify the structural shocks, which are orthogonal to each other. The Wold representation takes the following form with the structural shocks:

$$Z_t = D(L)\,\varepsilon_t; \qquad \text{where } \varepsilon_t \sim N(0, I) \qquad (3)$$

and $\varepsilon_t = \left[\varepsilon^{NC} \quad \varepsilon^{C}\right]'$ is the vector of structural disturbnaces. From Equation 2 and 3,

$$e_t = D_0 \varepsilon_t \qquad \text{and} \qquad C_j D_0 = D_j \qquad (4)$$

$$C(L)D_0 = D(L) \qquad (5)$$

$$\Omega = D_0 D_0' \qquad \text{Since Var}(\varepsilon)\text{=I} \qquad (6)$$

The main objective here is to identify the D_0 matrix, which contains four elements in our model. The symmetry of the matrix Ω = Var(e_t) and the normalization conditions impose three restriction on this matrix. Therefore, we need only one more restriction to identify D_0, for which we use our assumption of long run neutrality condition from the theory. In other words, we are getting this restriction from the definition of core inflation, which does not affect the real variables in the economy. The long run expression of Equation 3 can be written as:

$$\begin{pmatrix} \Delta z_{1t} \\ \Delta z_{2t} \end{pmatrix} = \begin{pmatrix} D_{11}(1) & D_{12}(1) \\ D_{21}(1) & D_{22}(1) \end{pmatrix} \begin{pmatrix} \varepsilon^{NC} \\ \varepsilon^{C} \end{pmatrix} \tag{7}$$

where $D(1) = \sum_{j=0}^{\infty} D_j$ is the long run matrix of *D(L).* ε^{NC} and ε^{C} are the non-core and core shocks respectively, which are orthogonal to each other. With our restriction $D_{12}(1) = 0$, $D(1)$ will be a lower triangular matrix. From Equation 5, $C(1)D_0 = D(1)$. With Equation 6,

$$\begin{aligned} C(1)D_0D_0'C(1)' &= D(1)D(1) \\ C(1)\Omega C(1)' &= D(1)D(1)' \end{aligned} \tag{8}$$

We can compute this matrix with the estimate of Ω and *C(1). D(1)* will be the unique lower triangular Choleski factor of $C(1)\Omega C(1)'$, since *D(1)* is lower triangular. The structural shocks can now be easily computed by using $D_0 = C(1)^{-1}M$; where M is the lower triangular Choleski decomposition of Equation 8. The structural shocks would be obtained with the help of D_0 and e_t using the relation $e_t = D_0\varepsilon_t$, where e_t is the residual from estimating the reduced form VAR, i.e., Equation 1.

Inflation is decomposed as the sum of supply and demand shocks respectively:

$$\Delta p = \sum_{j=0}^{\infty} D_{21}(j)\varepsilon^{NC}(t-j) + \sum_{j=0}^{\infty} D_{22}(j)\varepsilon^{C}(t-j)$$

The second component measures core inflation.

Following Quah and Vahey (1995) and Bjornland (2001), we have implemented the vertical long-run supply curve as an identifying condition. This condition restricts our core inflationary shocks to be output-neutral at the medium to long run, however, we do not restrict the length of horizons it takes to be neutralized. The data reveals this through the impulse response function and serves as an indicator of the validity of the neutrality restriction. We also do not impose as an identifying restriction that non-core inflationary shocks do not have a permanent effect on headline inflation. But the identification scheme

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[5] Giannini (1992) and Enders (2004).

used implies that non-core inflationary shocks should have little sustained impact on measured inflation; therefore if the data does not support this hypothesis it would cast doubt on the identification procedure.

We have also assumed that the two type of shocks (core and non-core) are uncorrelated to each other at all leads and lags. This allows policy causing one type of shock to react to another. Orthogonality may break down at specific points but there should be no systematic correlation for the procedure to be valid. Non-core shocks can be due to the result of policy changes by the authorities which can have permanent impact on real output.

5. Data and Methodology

We have used monthly data for WPI and IIP (proxy for real output) from International Financial Statistics-CD-ROM (column 63 and 66 respectively), published by the International Monetary Fund. Our dataset covers a time span from January 1971 to July 2004, giving 403 observations. Note that the base year for these two series is 2000. We have taken the data for M1 (the sum of currency, outside deposit money, banks and demand deposits other than those of the central government,[6] to analyze its relationship with headline and core inflation. p, iip and m1 are the wholesale price index (WPI), index of industrial production (IIP) and M1 in logarithmic terms.

The standard unit root tests - Augmented Dickey Fuller (ADF) and Phillips Perron (PP) - have been performed for all the three series, i.e., p, y and m1, both with trend and without trend. The results of unit root tests for all the series have been reported in Table 1 as follows.

Table 1: Tests of Unit Roots

Variables	ADF (at lags 4) No Trend	ADF (at lags 4) Trend	PP No Trend	PP Trend	Remark
ln(WPI)	-1.79	-2.24	-1.73	-2.02	I(1)
ln(IIP)	-0.41	-6.59	-0.38	-10.2	I(0)*
ln(M1)	0.41	0.529	-2.61	0.370	I(1)
Headline	-8.50	-8.64	-12.8	-10.9	I(0)
M1 Growth	-11.20	-11.09	-34.8	-20.8	I(0)
Core	-8.58		-20.2		I(0)

1 The tabulated value at 5% level of significance is -3.42
2 ln(IIP) has been reported as I(0), but it is non-stationary

[6] International Financial Statistics (IFS), Column number 34.

due to the presence of a trend component.

From Table 1, it is clear that p and m1 are integrated of order one. The iip series, however, is found to be free from unit root. It is non-stationary because of a trend component. Therefore, we use the first difference of p and detrended iip in order to identify the core components of inflation in our analysis.[7]

6. Empirical Results

We present the results from the SVAR[8] model used to measure core inflation in our study.[9] Figure 1 gives the impulse response functions of core (demand) and non-core (supply) shocks up to 48 months. Figure 1(a), shows that a non-core shock raises the growth in output (y) in the first month and slowly it approaches zero with large fluctuations. However, as seen from Figure 1(b), a core shock has an immediate positive impact on output, which tends to die down. This finding supports the assumption of long run neutrality of core shocks to real output. We have constructed the standard error bands for each of the impulse response functions presented in Fig 1. Core shocks are neutralized faster than the non-core shocks. Panel (c) of Figure 1 shows that the supply shocks have an immediate negative impact on inflation which starts rising subsequently and after a half year or so, it fluctuates before getting neutralized. Figure 1(d) gives the impulse response of inflation to demand shock, which shows that the sudden positive impact decreases and tends to become ineffective slowly.

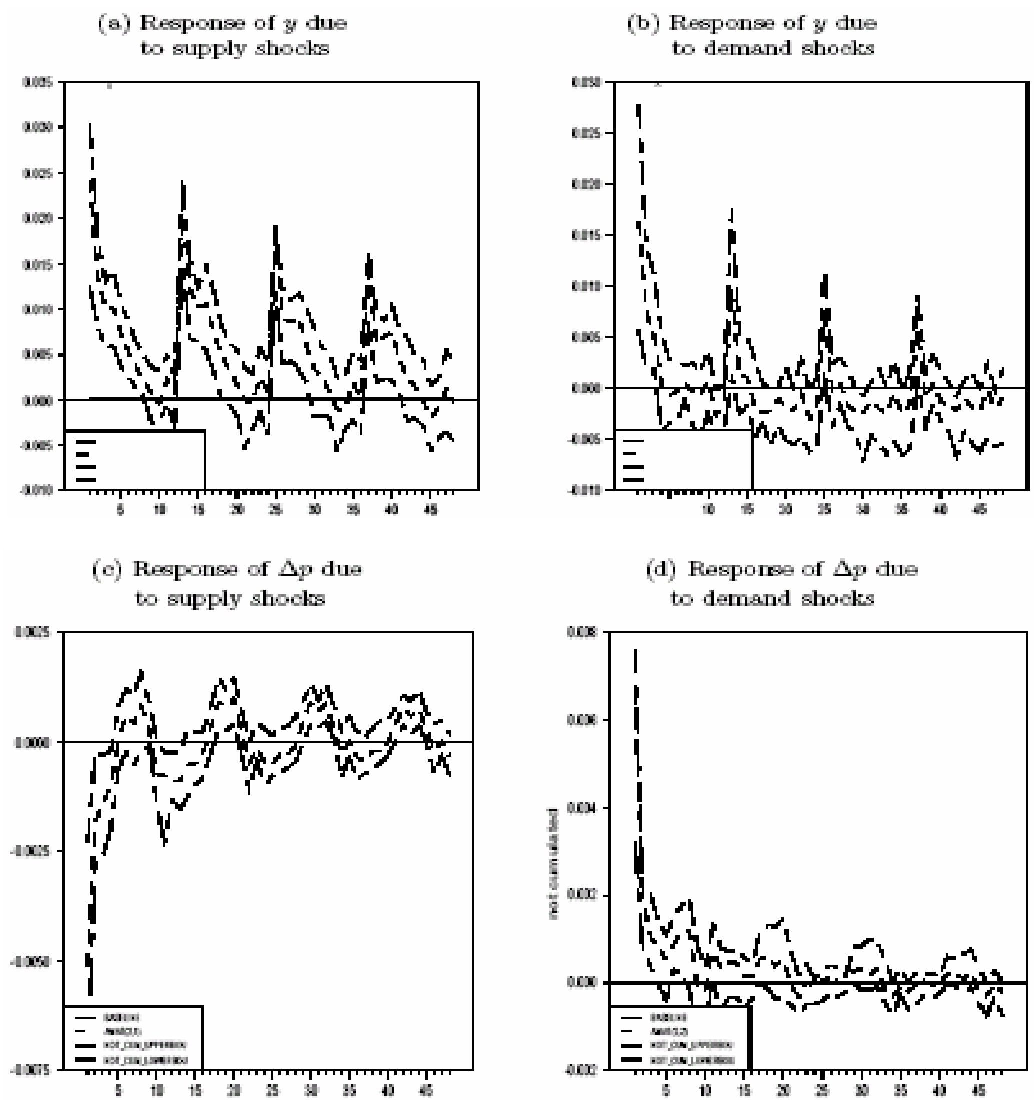
The forecast error variance decomposition (FEVD) up to 48 months, for output and inflation have been reported in Table 2, and are represented in Figure 3(a) and Figure 3 (b) respectively.

The horizontal axis gives months and the vertical axis gives the effects in percentage. Define the k month-ahead forecast error in output as the difference between the actual value of output and its forecast as of k months earlier. This forecast error is due to both unanticipated demand (core) and supply (non-core) shocks in the last k months. The figure for output at horizon k, (k =1, 2, … , 48) gives the percentage of variance of the k month-ahead forecast error due to demand and supply shocks respectively, which add up to 100. We

[7] Note that Blanchard and Quah's (1989) decomposition technique requires the vector of variables to be covariance stationary.
[8] With 13 lags , selected by SBC criteria..
[9] The estimation is performed with RATS software using a program developed by Lack and Lenz (1999).

can interpret in a similar way the figures relating to inflation.

Figure 1: Impulse Response Functions

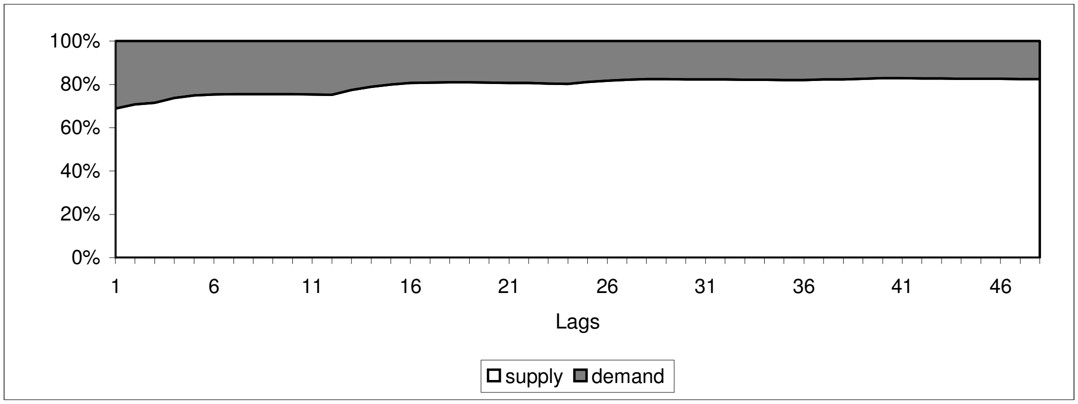


It is clear from the above analysis that non-core shocks are the main source behind the variation of real output in Indian economy. The effects of core shocks are low in the medium to long run scenario. This supports the validity of our assumption about the long run neutrality of demand shocks.

But the effect of core shocks on output in the short to medium run and the effect of non-core shocks on measured inflation is much larger than comparative decompositions in developed economies. These together with the permanent effect of non-core shocks on inflation suggest that the structure of demand and supply in a developing economy differs in significant ways. An alternative identification scheme with more elastic long run supply should also be examined.[10]

Figure 2: Forecast Error Variance Decomposition (FEVD)

(a) FEVD of Real Output



(b) FEVD of Inflation

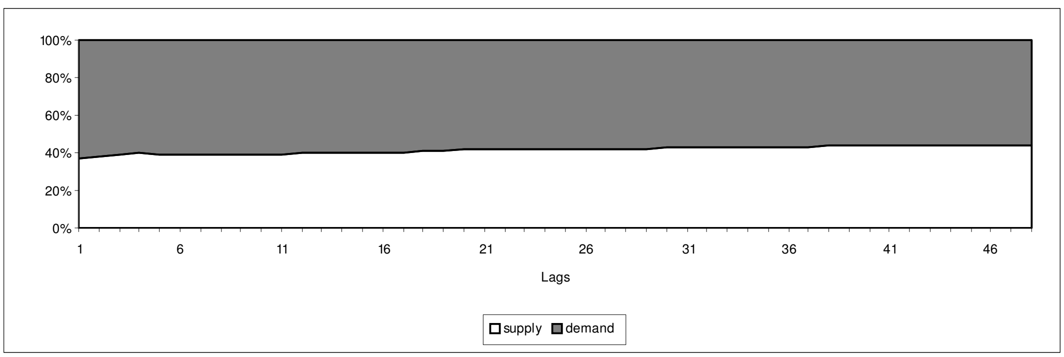


Table 2: Forecast Error Variance Decomposition (FEVD)

	y		*p*	
Months	Non-core (supply)	Core (demand)	Non-core (supply)	Core (demand)
1	68.95	31.05	37.34	62.66
2	70.64	29.36	38.15	61.85
3	71.59	28.41	39.14	60.86
4	73.81	26.19	39.57	60.43
12	75.13	24.87	39.73	60.27
24	80.32	19.68	41.82	58.18
36	81.92	18.08	43.38	56.62
48	82.49	17.51	44.46	55.54

[10] We contrast results from the alternative identification in another paper.

Long run inflation is not driven only by core shocks; supply or non-core shocks have a major impact.

Properties of Core Inflation

Core inflation has been derived as the long run demand components of headline inflation.[11] How does core inflation behave in our study? Table 3 gives the summary statistics of core and headline inflation as follows.

Table 3: Summary Statistics of Inflation Measures

Var.	Mean	S. D.	Skewness	Kurtosis
Headline	0.006	0.010	0.563	4.206
Core	-3.08E-11	0.018	0.357	3.855

* Correlation coefficient = 0.63, significant at all conventional level.

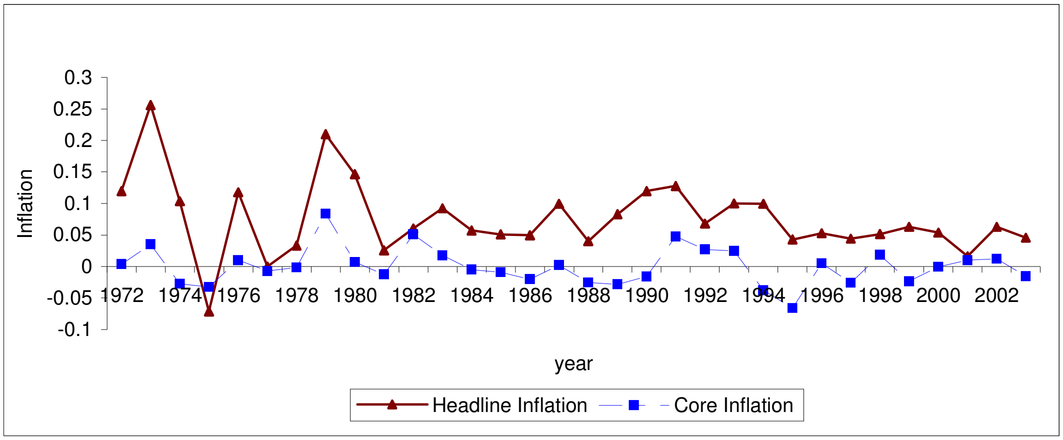
The arithmetic mean for core inflation is close to zero.[12] However, the standard error/variance of core inflation is more than that of headline inflation, because core inflation is often negative, unlike headline inflation (Figure 4), suggesting that excess demand was often negative. Skewness and kurtosis are higher in the case of headline inflation. This means that core inflation is more homogeneously distributed around the mean than is headline inflation.

Figure 4, which plots both the measures of inflation, shows that core inflation follows headline inflation closely, almost all the time, but headline inflation always exceeds core. All components of WPI inflation, the inflation rate and core inflation follow the same cyclic pattern. In the recession periods of stabilization in the early nineties and the slowdown in industrial output growth in 1997, demand shocks contributed sharp fluctuations to core inflation. Core inflation was often negative during growth slowdowns, for example during the late nineties, suggesting that demand was much below potential supply. Both the inflationary measures revolve around the same trend as it is seen from Figure 4. We have calculated the correlation coefficient, which is equal to 0.63, which is found to be highly significant. We have obtained the correlation coefficient between the

[11] We have calculated the core inflation series with the help of the long run matrix and the structural innovations.
[12] We get the mean of the non-core inflation and headline inflation identical.

output (y) and headline inflation.[13] It is found that there is a highly significant and negative correlation among them, which suggests that there is a there is a counter-cyclical behavior between output growth and inflation in India. [14]

Figure 3: Headline and Core Inflation



We have plotted inflation and core inflation against the measures of monetary aggregate also, which are given in Figure 5 and Figure 6 respectively. The growth of M1 (i.e., m1) follows the same pattern as the inflationary measures follow. However, the volatility in m1 is more than that of the inflationary measures, suggesting the role that administered prices have played in damping Indian price and inflation fluctuations.

Following Freemans (1998) suggestion we have tested for the time series properties of core inflation. Samanta (1999) derived four measures of core inflation by various methods and tested for Granger causality. We compare our results with these studies. First we have tested for the presence of a unit root in core inflation. The estimated core inflation series should have the same level of integration as the headline inflation has. Remember that the headline inflation is stationary in our case. The results for unit root tests have been given in Table 1. No unit root was found in core inflation. So, core inflation series in our exercise satisfies the first property. Since, both the inflation series are stationary, we avoid the cointegration test (as a trivial case).

We have performed Granger Causality test between the two measures of inflation:

[13] Bhattacharya and Lodh (1990)discuss the relationship between inflation, output growth, monetary growth etc. more elaborately.

headline and core. The results have been reported in Table 4.

Figure 4: M1 Growth and Headline Inflation

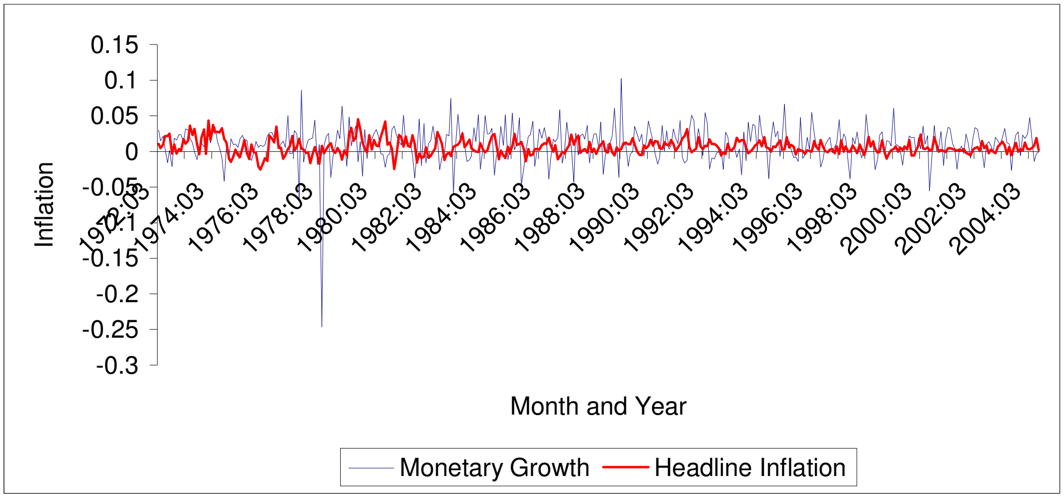
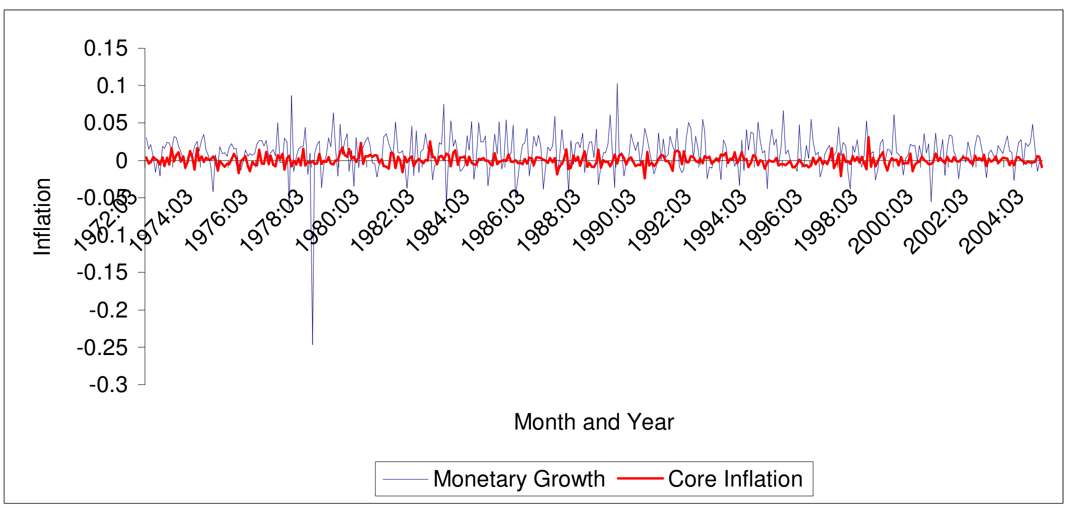


Figure 5: M1 Growth and Core Inflation



The LR (Likelihood Ratio) test for non-causality rejects the null hypothesis that the coefficients of lagged values of core inflation explaining headline inflation are zero. In other words, core inflation Granger causes headline inflation. But the reverse is nor true. Similarly, the causality test between y and core inflation shows that there is unidirectional causality between them running from core inflation to y. The Granger causality test has been performed for core inflation and headline inflation versus the

[14] This is also done with the output growth before adjusting for prices (i.e., nominal output growth). The correlation coefficient between *iip* and Δp is –0.17, which is significant at all the conventional levels of significance.

monetary measure. Since m1 is found to be integrated of order one, we take its first difference. Table 4 reports the causality results between the growths of m1 with the inflationary measures. We found no causation between m1 and core inflation, which differs from Samanta's (1999) result. However, we find a bi-directional causation between m1 and headline inflation.

Table 4: Granger Causality Tests

Variables	Null Hypothesis	LR Statistics	Lags	Remark
Δp & y	Δp DGC y	22.92 (0.00)	13	GC
	y DGC Δp	53.93 (0.00)	13	GC
Δp & Core	Δp DGC Core	0.788 (0.67)	1	DGC
	Core DGC Δp	21.10 (0.00)	1	GC
y & Core	y DGC Core	0.778 (1.00)	13	DGC
	Core DGC y	40.36 (0.00)	13	GC
Δp & Δm1	Δp DGC Δm1	57.39 (0.00)	12	GC
	Δm1 DGC Δp	58.15 (0.00)	12	GC
Core & Δm1	Core DGC Δm1	15.64 (0.20)	12	DGC
	Δm1 DGC Core	12.23 (0.42)	12	DGC

Freeman (1998) analyzed Granger causality through error correction representation since he found cointegration among the headline and core inflation measures. For one measure of core inflation (i.e., change in median CPI) he found bi-directional causality with CPI inflation (headline inflation) whereas for another measure of core inflation (i.e., CPI less food and energy) he found unidirectional causation running from headline to core inflation.

Our results show that while core inflation granger causes all three of the other variables, none of them granger cause core inflation. This suggests that monetary policy was unable to target demand and by responding to supply shocks led to a pro-cyclical aggravation of shocks.

7. Conclusions

This article identifies core inflation from WPI inflation in India using the SVAR technique to identify demand shocks. This exercise used the assumption of long run neutrality that demand does not affect output in the long-term. Core inflation always lies below headline inflation but is more volatile, suggesting that monetary policy was pro-cyclical, aggravated shocks, and allowed recession periods of excess demand to develop.

After deriving core inflation, we have checked whether it satisfies the basic time series properties or not. In this regard we see that it is stationary as is headline inflation. Several Granger causality tests have been carried out. We have analyzed the association of core inflation and headline inflation with the monetary aggregate also. From these analyzes, we found that core inflation behaves better than headline inflation.

However, the identification of core inflation needs to be done with more care. Our results suggest that a major area to be explored is the nature of the supply response in a developing economy where short-run bottlenecks constrain supply but output is much below the long-run potential. Our results can be improved by using a better measure of headline inflation as well as a better proxy for real output.

As the current literature emphasizes the role of core inflation in inflation targeting, careful work in this area can give useful inputs for monetary policy. Targeting the core inflation series we derive would have resulted in a more counter-cyclical monetary policy that would have smoothed shocks and reduced output losses.

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