Evaluating Core Inflation Measures for India

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Abstract

This paper discusses in some detail various existing approaches of measuring core inflation, evaluating their potential advantages and disadvantages. Then a variety of measures of core inflation for India based on three methods are constructed. Among these measures, three are based on conventional ex-food and energy principle and one measure that exclude fifteen of most volatile components are constructed. While constructing exclusion based indices of core inflation, measures are constructed such that only a small weight remains excluded from the index of the core inflation. The other two core measures are variations of 'Neo-Edgeworthian Index' are constructed by reweighting 69 disaggregated components series of WPI. Then another class of core measures are computed based on weighted exponential smoothing which was primarily developed by Cogley (2002). Estimates of core inflation based on their indices are then calculated for 1995 to 2007 (on monthly basis).

Subsequently, an empirical evaluation of these estimated core measures is performed. While choosing criteria for empirical evaluation, the following were considered: forward looking monetary policy framework viz., tracking trend inflation, and two, an attractor property of core inflation and their relative predictive power for future transient movement in inflation. The empirical findings show that the weighted exponential smoothing based measures of core inflation perform far better compared to all other measures of core inflation in terms of similarity in means, lower volatility, tracking trend inflation and an ability to predict future transient movement in headline inflation at both 12 month and 24 month horizon.

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1. Introduction

There has been a growing consensus in recent years, among the central bankers about price stability being the main goal of monetary policy. This consensus has developed as a result of a long list of empirical research that shows low and stable inflation is conductive to economic growth[1]. As a result, a number of central bankers have established either explicit or implicit inflation target[2] as the central objective of monetary policy. One important operational issue for inflation targeting concerns the following: what price index to use as a target variable? There is some agreement that central banks should be concentrating on stabilizing headline inflation but at the same time it is pointed that headline inflation is heavily affected by non-monetary – supply shock factors – such as oil price, food and administered prices which are beyond control of monetary authority.

Thus the monetary policy makers are confronted with price changes, some of which are permanent and some are temporary. Then, it is essential for any monetary authority to distinguish between these two components in inflation data. In order to do this, economists have developed alternative measures for headline inflation, called core inflation that attempt to identify permanent trend in inflation by eliminating temporary fluctuations. The problem is that there is no single agreed single approach or method of measuring core inflation because the core inflation itself is unobservable and has to be estimated. This task is a difficult one. One objective of this study is to understand the concept and measurement aspects of core inflation. As noted above, there is general notion about core inflation regarding its operational use in monetary policy framework i.e. its use as either an explicit or implicit target variable. Hence, a second objective is to evaluate empirical measures of core inflation in this framework.

1 Fischer (1993) and Barro (1995) among others present evidence of a significant negative relationship between inflation and economic growth

2 Simply put, inflation targeting is monetary policy approach in which the central bank tries to maintain inflation at a pre-targeted level by using various policy instruments at its disposal. It requires a formal announcement by the government to that effect and often requires legislative consent

Since, monetary policy affects the economy with monetary transmission lags[3], an inflation targeting central bank has to make its best assessment of future inflation (that is usually the forecast core or underlying inflation) when deciding monetary policy. When future core inflation is expected to exceed target (here target either may be headline inflation or core inflation itself), monetary policy should be tightened, (or to increase short-term interest rate). Similarly, when future core inflation is expected to be below target, monetary policy should be loosened i.e. reduce short-term interest rate. Once credibility[4] has been gained, this decision rule itself can anchor private sector expectations of inflation, which will in turn make it easier to meet the inflation target and to achieve its ultimate goal of price stability. Therefore, it has been argued that for effective monetary policy, the central banks should use or monitor core inflation for its best assessment of future inflation.

In India, RBI has no explicit inflation targeting. Indeed there are multi variable targets viz., exchange rate, growth and inflation. However RBI publishes its inflation forecast which is revised every quarter and it is committed to maintain inflation in specific band. Therefore, there is a role for core inflation for forecasting assessment. Further, recent inflationary dynamics has induced use of core inflation in policy making particularly in emerging economies. For instance, in India, episode of inflation last year was triggered primarily not by demand but rather by supply- side factors. Oil, food and commodity prices had seen sharp increases not only in India but globally. Therefore this inflation in India has been regarded as imported one, and it was reflected in headline inflation of 7.83 percent in the week ended May 3, 2008, which was above the RBI tolerance rate of 5%. Nevertheless, one could expect that this is temporary[5]

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3 Presence of the monetary transmission lag implies that changes in monetary policy in period‘t’ (today) would have effect on inflation only in periods t+1, t+2……Analogously today’s (period‘t’) inflation is partly due to impact of changes in monetary policy in periods t-1, t-2……This gap, t-1 or t+1, is estimated empirically and it may differ from country to country. In case of India, this lag is estimated to be around one year or in other words inflation today is cumulative effect of previous year’s monetary policy and, further, today’s changes in short-term interest rate by RBI would reflect in inflation figure in next year gradually.

4 Credibility of monetary policy implies that people believe monetary authority to be committed to the announced policy (here, inflation rate) in whatsoever circumstances. Here arises the question of independence of monetary authority because ruling political party often tries to push monetary authority on short-run Phillips curve to get benefit of temporary (Friedman –Lucas) price surprise.

5 Even if this shock is of permanent nature, still core inflation is useful guide for monetary policy because this shock is primarily generated through supply side and monetary policy is effective when inflation is generated by aggregate demand side factors. It may be mentioned that the present study was completed in June 2008, before

or transitory shock which might be reversible – indeed it has been reversed as reflected in WPI inflation. Then given monetary transmission lag, it is important that the central bank should generally ignore this impact of transitory shock on prices. In other words, decision should be based on core inflation rather than responding to headline inflation since a policy response to temporary shock to inflation may hit growth without reducing shock inflation. Recently Raghuram Rajan Committee suggested explicit inflation targeting for India. In this scenario there is need to develop core inflation measures for the purpose of monetary policy in India and the present study is an attempt to provide a review of concept of core inflation and provide some alternative core inflation measures for India.

The rest of the paper is organized as follows: the section 2 discuses the concept of core inflation. Section 3 reviews some of the existing approaches to measuring core inflation; evaluating their potential advantages and disadvantages. In Section 4 we construct various core inflation measures for India and evaluate them by empirically testing them against certain empirical properties of core inflation. The paper ends with some concluding remarks in section 5.

2. The Concept of Core Inflation

The term core inflation is widely used by academicians, central bankers and researchers. Despite its prevalence, like some other economic concepts, there is no agreed definition of it. Initially and also till now a number of central banks have been publishing the headline inflation after excluding food and energy items. This has been often called "core inflation". The rationale is that food and energy concern the most volatile, supply shock driven aspects which are deemed to be beyond control of a central bank. Subsequently other definitions that try to identify more accurate trend inflation have been proposed. They deal more systematically with what part is volatile and what part is persistent in measured inflation.

Here we briefly describe some, well-known definitions cited in literature.

Otto Eckstein (1981), is considered the originator of the term "Core Inflation" Eckstein defined it as "the trend increase of the cost of factors of production" and observed that this notion of core inflation "….originates in the long-term expectation of inflation in minds of

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inflationary trends were actually reversed. The underlying causes of this reversal are also global in nature and beyond the scope the present study.

households and business, in the contractual arrangements which sustain the wage-price momentum, and in the tax system.” (quoted in Roger, 1997, p.2) Eckstein definition divides core inflation into demand, supply shock and production cost.

Quah and Vahey (1995) definition is based on the assumption of a long run vertical Philips curve. They define core inflation “…..as that component of measured inflation that has no medium to long run impact on real output” (p.1130). This definition relates to that part of inflation which is anticipated, and, is, therefore output neutral in the long run. This notion is consistent with long run Philips curve hypothesis where all volume of inflation pressure is anticipated that leads no trade-off between inflation and output.

To formalize the above two notions of core inflation, and following Roger (1998) let us write:

$$\Pi_t = \Pi_t^{LR} + g(X_{t-1}) + v_t$$

Where:

Π_t is the aggregate inflation rate in period t

Π_t^{LR} is the long-run or trend inflation rate

X_{t-1} is a measure of cyclical excess demand pressure

g captures effect of X on inflation

v_t is a measure of transient disturbances to inflation

Then, Eckstein core inflation is:

$\Pi_t^C = [\Pi_t - g(X_{t-1}) - v_t] = \Pi_t^{LR}$ = the long run or trend inflation.

While non-core inflation is, Π_t^{NC} given by:

$$\Pi_t^{NC} = g(X_{t-1}) + v_t$$

Under this definition, core inflation excludes effect of cyclical demand pressure.

Quah and Vahey definition of core inflation is given by:

$$\Pi_t^C = [\Pi_t - v_t] = \Pi_t^{LR} + g(X_{t-1})$$

And non core inflation is:

$$\Pi_t^{NC} = v_t$$

The two definitions are different in sense of inclusion or exclusion of cyclical influences on core inflation. Further, we can look at these differences in terms of Philips curve.

In Eckstien definition, core inflation is related to trend inflation so, it is consistent with long run vertical Philips curve that is associated with anticipated inflation, the cyclical excess demand pressures are component of unanticipated inflation, therefore, it might be consistent with short run Philips curve.

In Quah and Vahey definition, core inflation is constituted by introducing cyclical excess demand pressure also that is seen as a component of anticipated inflation. If unanticipated inflation is considered a short run phenomenon, then one part of Quah and Vahey definition lead to short run Philips curve where cyclical part of core inflation and output will have a trade-off and other part of long run trend inflation is related to vertical Philips curve. Thus, this interpretation of Quah-Vahey definition in terms of above equation can be seen together with Quah-Vahey definition of core inflation as "…a notion consistent with the vertical long-run Philips curve interpretation of the co-movements in inflation". But Quah and Vahey argue that "…. do not restrict how quickly core-inflationary disturbances become output-neutral" (Quah and Vahey, 1995, p.1135). Roger (1998) suggests that we should not overdo the differences: the difference between a transient influence on inflation (v_t) and cyclical $(g(X_{t-1}))$ and long-term influences (Π_t^{LR}) is an artificial construct. This distinction should really be drawn with reference to the policymaker's horizon.

Bryan and Cecchetti (1993, p.3) explained core inflation by linking it to money growth. "In general, when people use the term they seem to have in mind the long-run or persistent component of the measured price index, which is tied in some way to money growth".

Blinder (1997, p.9) has defined the core inflation as "the durable part or persistent component of aggregate inflation." And that "...the durable part of the information in each monthly inflation report was the part that was useful in medium and near-term inflation forecasting".

In spite of such diversity in definition of core inflation, Roger (1998) has explained two broad views of core inflation: one, persistent components of measured inflation and two, core inflation as the generalized component of measured inflation. The latter concept implies that it is trying to capture a general trend which is present in all commodities while former concept aims at capturing directly the persistent component of inflation. In both the conceptions however, core inflation is generally associated with expectation and demand pressure component of measured inflation.

Headline Inflation and Core Inflation Distinguished:

For more clarity, to distinguish core inflation from headline inflation, the latter is quantified by rate of change of overall aggregate index which is essentially a measure of changes in the cost of living of people while the former excludes temporary supply shock components and measures only demand pressure or permanent components of the same index. The headline inflation indices constitute both anticipated and unanticipated part of inflation expectation but core inflation index is related with only anticipated components of the index. Thus core inflation is a proxy measure for capturing the underlying inflation. So for computing core inflation, there have been various methods developed by researchers to capture underlying or core component of measured inflation. The Table 1 below captures the distinguishing features of headline and core inflation.

Table 1: Headline Inflation and Core Inflation: Distinguishing features

Headline Inflation	**Core Inflation**
1. Is measured by rate of change of aggregate price index	1. Is measured by excluding temporary supply shock components and measures only demand pressure or permanent components of the aggregate price index.
2. Indicator of changes in the cost of living of people	2. Indicator of changes of monetary inflation
3. Is a measure of overall inflation trend.	3. Is a proxy measure for underlying inflation trend.
4. Captures 'transitory' or 'noisy' part of inflation also	4. Captures a notion of 'trend' inflation.
5.Constitutes permanent and transitory components of inflation	5. Inflation that is permanent and not transitory
6. Constitutes both anticipated and unanticipated part of inflation expectation	6. Is associated with anticipated components of inflation only.
7. Trade-off between headline inflation and unemployment rate in short-run due to either price-surprise (unanticipated) or real-shock i.e. changes in relative prices that altered headline (measured) inflation in short-run.	7. No trade-off because it eliminates unanticipated and relative price shock in measured inflation.

2.1 Desirable properties for a Measure of Core Inflation:

Several authors have put forward criteria that they believe a good measure of core inflation should ideally posses. Roger (1997, 1998) discuses various properties of core inflation as follow. The core inflation index should be,

Timely: The measure should be available in a timely manner. If the measure is only available with a long lag, its value to the policy makers will be greatly reduced.

Robust and unbiased: The difference between the average rate of inflation of core measure and the headline measure should be zero over a long period of time, since any difference will reduce the credibility of the measure. It is also important that the estimate of core inflation be as robust as possible on different factors, viz., sample size, variables used etc.

Verifiable: The measure of core inflation should be verifiable i.e. it should be possible for it to be calculated by any one other than its originator.

Wynne (1999) agrees with these criteria and proposed the following a set of criteria:

- The measure should be computable in real time.
- The measure should be forward looking in some sense.
- The measure should have a track record of some sort.
- The measure should be understandable by the public.
- Its history does not change each time a new observation as added
- The measure should have some theoretical basis, ideally in monetary theory.

Apart from these theoretical criteria; there are statistical methods to assess usefulness of core measures such empirical test we discuses in section 4.

3. Measuring Core Inflation

There is no single definition of core inflation, no single approach and hence no single method to measure core inflation in literature. On the contrary, there have been many approaches in literature to measuring core inflation. This section give a brief review of these various approaches to measuring core inflation, highlighting their potential advantages and disadvantages.

3.1 Exclusion Approach

The most common and also the initial approach to estimating core inflation is exclusion based core measure. Under this approach, certain components of headline index are excluded on the ground that their prices are considered to be most volatile, supply shock driven and administered and are, thus, beyond the control of central banks. Usual exclusions are captured under ‘Ex-food and energy’ strategy where existing index is reweighed by placing zero weights on these components and then remaining commodity groups are rescaled. The Bureau of Labor Statistics in the U.S.A first began to report in 1978 monthly growth of both the CPI and the Producer Price Index excluding food and energy.

There are also some other objective criteria for excluding commodities which are based on relative standard deviation of individual components in the overall price index. Generally, exclusions seem to depend on country specific circumstances or are data driven. For instance, for Canada, the eight most volatile components were selected along with indirect taxes, on the basis of historical data characteristics (Macklem, 2001).

The Bank of England excludes mortgage interest payment in headline inflation (retail price index, RPI). Further, the Bank of England uses these three core inflation measures: the GDP deflator excluding export prices; RPI excluding import prices; and a measure based on unit labor cost. These core measures are useful for measuring the effect of an external shock. “Domestically generated inflation (DGI) may be viewed as a particular type of measure of core inflation that aims to exclude the one-off price level effects of movements in the exchange rate.”(Manikar and Paisley, p.24, 2004).

The advantages of using this approach are: timely computation of core inflation simplicity in computing, and it being readily understandable to public. Moreover, these measures are calculated on the basis of a pre-defined rule, which may result in enhanced transparency (Roger, 1998). For these reasons most central banks monitor exclusion based core measures.

The main disadvantage of this approach is that it excludes certain items on once-for all basis *a priori*. Further, especially in developing countries, a large expenditure of poorer sections of the society (and also their daily living) is closely linked with food and energy. Thus, Jalan, (2002) correctly points out that in developing countries, a measure of core inflation excluding food items – which can account for more than half of the weight in the index – may not be very meaningful.

3.2 Limited Influence Estimator Approach

The limited influence estimator (LIE) approach has come after a series of work by Bryan and his co-researchers (Bryan and Pick 1991, Bryan and Cecchetti, 1993 and Bryan, Cecchetti and Wiggins, 1997). This approach is different from the previous approach in the sense that it revises excluded commodities in each period on account of their 'contribution to noise' in measured inflation. Hence this method of constructing core inflation is more systematic than the previous method. It systematically excludes a percentage of each tail of the cross-section distribution of price changes (indicating extremely low price changes in the left tail and high changes in the right tail) and takes the weighted average of price changes for the rest of components in the aggregate price index. This process is followed in each period so that a component that was extreme or an outlier in one period may not be an outlier in the following period.

If percentage truncating is 'P' percent then it is called 'P' percent trimmed mean core inflation. One extreme case is 50 percent trimmed core inflation, which removes 50% from each tail of the distribution of price changes and hence it is simply median core inflation.

Bryan and Cecchetti (1993) justify this approach, and argue that, "[t]he problem is that when the distribution of sector specific shocks is skewed, the tails of the distribution of resulting price changes will no longer average out properly. This implies that we should not use the mean of price changes to calculate the persistent component of aggregate inflation. Instead, a more accurate measure of the central tendency of the inflation distribution can be calculated by removing the tails of the cross-sectional distribution. This leads us to calculate trimmed means, which are limited-influence estimators that average only the central part of a distribution after truncating the outlying points." (Bryan and Cecchetti, 1993 p.2).

The above description of trimmed mean as a measure of core inflation argues symmetric trimming from both the tails. This is considered under assumption of kurtosis (symmetric) price distribution. Asymmetric trimming is suggested by Roger (1998) in the presence of price distribution that exhibits skewness. The economic sense of core inflation is grounded in Ball and Mankiw's (1995) menu cost model that provided a theoretical explanation of asymmetric distribution of price changes.

Problem with limited influence estimators is: how much of the distribution of price changes should be trimmed? There are some other issues regarding the trim. Should monthly or annual inflation rates be trimmed, Should seasonally adjusted or non-seasonally adjusted price data be used? (Mankikar and Paisley, 2004). However, Bryan and Cecchetti (1994) propose that the optimal trim can be found by searching across different trims and choosing the time-invariant trim that minimizes the RMSE when the underlying (that is different trimmed core inflation) measure is compared to a benchmark underlying series. The benchmark that is often chosen is a moving average of headline inflation (between 12 and 60 months). However, even if we found optimal trim or percentile in one period, it may change in another period with the sample distribution of price changes. Therefore, associated optimal trim can not claim a robust estimator at every time point. In the Indian context, Samanta (1999) observed that the measure of skewness of the cross-section distribution of price changes varies over time, leading to possible difficulties in choosing a robust level of trimming or percentile.

3.3 Reweighed Index Approach

This approach of measuring core inflation is based on reweighting of the whole price index at the disaggregated level such that the 'signal' or inflationary information in the data is maximized. Two approaches within this criterion can be distinguished: one, use a variance criterion or (standard deviation) for reweighting subcomponents of aggregate index, and two, use a persistent criterion.

3.3.1 Variance and Double Weighted Approach

This method chooses weights for the various individual prices that are inversely proportional to the volatility of those prices i.e. more variance less weight. This weighting scheme has been called as "Variance Weighted Price Index", and by Diewert (1995), who called the resulting measure of inflation a "Neo-Edgeworthian measure of inflation". Vega and Wynne (2001) applied this measure in Euro area but empirically did not find it so good, whereas Laflèche (1997), Hogan, Johnson and Laflèche (2001), and Marques et al. (2000) used standard deviation as a weighting criterion instead variance.

The Banks of Canada computes 'double weighted' core inflation measure. Under this method each component of CPI is "double weighted," first by its expenditure share, and second by a measure inversely proportional to its variability. The second weight is defined as the reciprocal of the standard deviation of the change in relative prices, where the change in the relative price is measured by the difference between the price change of a component and the total inflation rate.[8] These two weights are then multiplied. This measure includes all subcomponents at each period, thus reducing the possibility of excluding valuable information. (Armour, 2005, pp.9 to 10). However, one major disadvantage of these measures is the choice of choosing appropriate period for calculating standard deviation. It is also difficult to compute and therefore its use as a communication measure.

3.3.2 Persistent Approach

A persistent approach is due to Blinder (1997) comment on limited influence estimator. He defined core inflation as "the durable part or persistent component of aggregate inflation." And added, that "...the durable part of the information in each monthly inflation report was the part that was useful in medium and near-term inflation forecasting" (p.19*)*. This is a forward looking approach to core inflation measurement. Blinder (1997) suggests weighting scheme that goes directly with the strength of persistence of each component. In fact, this persistent weighting scheme was operationalized by Cutler (2001) using a first order auto regressive model. This weighting scheme is different from Cecchetti (trimmed mean) weighting scheme in which components are excluded from each tail of cross-distribution because of their relative extreme variances or volatility at each time points whereas core inflation measure due to Cutler (2001) excludes those components which are found less persistent measured by its negative coefficient in AR(1) model.

Its downside is that the types of products included and classification change over the period in which weights are estimated. This gives rise to unstable coefficients. Empirically it is found to be not very good. For instance Cutler (2001) found the persistent weighted core measures are ranked third among seven core measures in terms of predictive ability.

3.4 Cogley (2002) Exponential Smooth Measure

Cogley (2002) develops a core inflation measure involving the exponential smoothing of current and past aggregate price changes. This measure can be motivated by appealing to the idea that the government and private sector use adaptive methods to learn about a world in which there are occasional regime shifts in mean inflation. (Rich and Steindel, 2005, p7). This exponential measure has a number of advantages as explained by Cogley (2002): "Unlike many other approximations to low-pass filters, such as those advocated by Baxter and King (1999) or Hodrick and Prescott (1997), this filter is one sided into the past and can be implemented in real time. As Bryan and Cecchetti note, two-sided filters are less useful to monetary policy makers because they reduce the timeliness of incoming inflation data. In contrast, this filter is one-sided into the past, so its output would be available to policymakers as soon as new inflation data became available. Third, this measure is absolutely trivial to compute and depends on only one free parameter, g_0, which can be calibrated a priori. Among other things, this means that the filter coefficients need not be reestimated when new data arrive and that the history of the core series need not be revised in response to changes in parameter estimates." (Cogley, 2002 p102 to 103).

3.5 Model Based Approach

One common element all of these approaches to core inflation examined so far is that they use only price series data i.e. its univariate nature to constructing core measure. By contrast, there are multivariate models which typically use other monetary variables to derive core inflation. Such model based approach is very appealing to the central bankers because its root goes directly into monetary theory in sense that the estimation of core inflation is derived with other macro variables. It attempts to establish a link between core inflation and its underlying economic determinants – most importantly monetary policy variables. Identification of such a link, then, provides a clear rationale why monetary authorities should care about core inflation, and it also helps in understanding the extent to which they can control it. This approach was first developed by Quah and Vahey (1995) who define core inflation as the component of measured inflation that has no impact on real output in the long run. What motivates this definition is the vertical long run Phillips Curve. Their measure is constructed by placing long-run restrictions on a bivariate VAR system for output and inflation. This system is assumed to be driven by two independent types of disturbances. The first disturbance - the core shock - has no impact on real output in the long-run. The second disturbance - the non-core shock - is not restricted at all. This allows them to test whether the non-core shock has permanent effects on inflation or not.

Other researchers expanded this approach incorporating other macro variables with different identification and specification schemes in a multivariate SVAR model such as Blix (1995), Folkertsma and Hubrich (2000), Baglino and Morana (2003) etc.

This approach is useful on grounds that it is based on monetary theory and that it is forward looking in nature. In spite of this advantage, this approach has been criticized on other grounds. One important criticism is that each time the index is reestimated, it is difficult to understand for the public. Another problem with this approach concerns the specification and identification schemes for deriving core inflation with SVAR model. As a whole, the sensitivity of the results would undermine the credibility of the core measure in public and make it unsuitable as a target for policy, particularly since it is likely that a core inflation series based on an economic model would be generated directly by the policy-maker rather than by a statistical agency. These features limit use of these measures as indicators of core inflation.

4. Measures of Core Inflation for India

Only a small number of studies have attempted to measure core inflation for India – Samanta (1999) being the first to construct a core inflation measure for India. However, he excluded a large set of administrative and other commodities whose weight was around 50 percent in WPI. Mohanty et al (2000) used LIE method. Given skewnees in the distribution of price changes in Indian data, it is not robust against a target symmetric mean inflation rate. Goyal and Pujari (2005) and Durai and Ramachandran (2007) constructed model based core inflation measures that are difficult to communicate to the public. It is pertinent to note that there has been no consensus yet among economists as to how core inflation can be best measured empirically. Indeed, a useful core inflation measure is data driven under country specific circumstances. Given this, we restrict our attention to measures of core inflation associated with the statistical approach. Among statistical approaches, we consider conventional type exclusion core measures, reweighted core measures and exponential smoothed series (Cogley, 2002). There is yet no study which has used reweighted approach and weighted exponential smoothing measure for Indian data. Taking this into account, we derived core measures from reweighting WPI index and constructing an exponential based core measure for India and compare it with conventional exclusion based core measures by taking empirical criteria viz., an ability to track trend inflation series and ability to predict future transient movement in WPI inflation.

4.1 Data and Statistics Preliminaries

The primary source of raw data for this study is the wholesale price index (WPI) compiled by Office of the Economic Adviser, Ministry of Commerce & Industry, GOI. Despite various shortcoming of WPI index, we focus on the WPI because RBI dictates its definition of price stability in terms of this price index. So, we construct core inflation measures using monthly data of WPI for the period April 1994 to March 2007. This choice of time series is dictated by the availability of consistent time series on price index with the base period 1993–1994. This base period wholesale price index (WPI) comprises 435 commodities under three main categories: (i) Primary articles; (ii) Fuel, Power, Light, and Lubricants; and (iii) Manufactured

Products with weights 22.025, 14.226, and 63.74, respectively. For computing core inflation, we use 69 components of disaggregated price indices at sub group level that are collected from RBI's Data Warehouse website. We calculate the percentage change at date '*t*' in the price of components i or inflation rate over horizon h as:

$$\pi_t = \left(\frac{p_t}{p_{t-h}} - 1 \right) * 100 \qquad (1)$$

where, π_t denotes the inflation at time' t ', ' p_t 'denotes the price index at time ' t ' and ' h ' be the time lag. The mode of measuring inflation depends on '*h*'. There are many possibilities for the measurement of inflation[6], viz., annualized/fixed base; annual point-to-point/average, where the frequency could be annual/quarterly/monthly/ weekly for WPI. Assuming unit of time as a month and setting h =1 we obtain the monthly inflation rate; i.e. it is simply the percentage change between the given month and the previous month. Setting h = 12 we obtain the annual inflation rate i.e. the percentage change in the WPI between a given month and the same month a year earlier.

In Figure 1, we report an annual inflation figure and a monthly inflation figure for India from 1994 to March 2007. It shows that the annual inflation is less volatile than monthly inflation. Table 2 presents some summary statistics for price changes at 1- and 12-month horizons. It shows average values over the sample 1995:4-2007:3 for mean, median, standard deviation, skewness and kurtosis. We can see in table 2 that there is sizable difference between monthly inflation and yearly inflation figures at both mean and median price level.

The kurtosis, skewness tends to be lower for the 12 month horizon when compared to monthly horizons. The median over this period is slightly below the mean inflation in both horizons indicating that there is some positive skewness in price distribution. The kurtosis of price changes indicates that it slightly above the value for the normal distribution of price changes.

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[6] For details see RBI 'Report of the Internal Technical Group on Seasonal Movements in Inflation 2007'.

Table 2: Summary Statistics of WPI Price Changes over 1995:4 to 2007:3

	h= 1, Monthly	h= 12, Yearly
Mean	0.4	5.18
Median	0.31	5.09
Std. Dev.	0.55	1.85
Skewness	0.73	0.53
Kurtosis	3.9	3.6
Coefficient of variation	1.37	0.35

The overall comparison suggests two distinctive features of Indian price data: first, a focus on a month-on-month figure is not advisable, as they are highly volatile. Second the distribution of price changes is positively (right) skewed. The distribution displays a degree of kurtosis larger than that for a normal distribution. This is consistent with the findings of Samanta (1999) in India and other authors for many other countries and time periods.

4.2 Estimation of core Inflation

In this section an attempt is made to estimate core inflation based on several such measures for India. The first task for computing core measures, that use exclusion principle, is to identify components in headline index that are to be excluded. One standard ad hoc approach is to exclude those components that show heavy supply shock and whose prices are not controlled by central banks. On this consideration, a wide variety of components from headline index at cross-country level are candidates for exclusion. Further, some researchers believe that, in general, monetary policy should ultimately focus on broadest price index possible. With that in mind and taking into account that RBI as well began publishing ex-food & fuel type measures we construct following exclusion core inflation measures:

(A) Exclusion based core inflation measures[7]:

- WPIEXFD: obtained by excluding food (with a weight of 15.4 percent) from WPI index.
- WPIEXFD&FL: obtained by excluding food (with a weight of 15.4 percent) and fuel categories (with a weight of 14.2 percent) from WPI index.

[7] Such exclusion type measures RBI reports under 'The Price Situation' section in its macro-monetary development report.

- WPIEXFL: computed by excluding the fuel category (with a weight of 14.2 percent) from WPI index.

We also identify exclusion components based on to be 'objective approach of exclusion' wherein those components are excluded that are found to be historically most volatile**.** We construct core index that excludes fifteen of most volatile components from WPI. These series shows as historically most volatile among 69 components series of WPI over the sample period measured by standard deviation (S.D).

- WPIEXVol: computed by excluding (with a weight of 17.22%) the series Vegetables, Condiments & Spices, Tea Coffee, Fibres, Metallic Minerals, Minerals Oils (Petrol & Petroleum Products) Canned, Fish, Salt, Edible Oils, Oil Cakes, Tea & Coffee Processing, Jute Hemp & Mesta Textiles, Wood & Wood Products, Printing & Publishing Of Newspapers[8], Periodicals, Basic Heavy Organic Chemical.

Note that most of the excluded series is also appealing to economic rational for example prices of tea & coffee edible oils, basic heavy organic chemical and petrol & petroleum products etc are mostly affected by world prices and also government policy.

Table 1 in the appendix shows the mean, standard deviations and the rank of S.D of each the components series of the WPI over the sample period. The components which are excluded from a corresponding exclusion-type of core inflation measures are highlighted.

The difference between WPIEXFD&WPIEXFL measures (combined weight 29.8%) and WPIEXVol (combined weight 17.22%) is that later core index does not exclude whole fuel and energy components series rather it excludes only 6 components (weight 6.99) from food & fuel category and remaining 9 out of 15 components excluded from outside the food and fuel baskets. With respect to fuel category, the only difference between WPIEXVol and WPIEXFL is that the former exclude only mineral oil group (6.99%) whereas later exclude all fuel category (14.2%).

[8] It is pertinent to note that calculating WPIEXVol excludes the Printing & Publishing of Newspapers, Periodical component which has 11 rank of S.D among 69 components while menu cost theory generally cites such component as example of sticky price sector, are seldom to price changes due to menu cost.

Construction of exclusion based core inflation measures:

To start with consider the well-known definition of Laspeyres price index, which is base year weighted price index. Let there be n commodities. Subscripts "t" denotes particular time 't'. in this, when $t=0$, it represents value of the concerned variable in the base period, chosen for constructing the price index. Then, Laspeyres price index P_t is given as:

$$P_t = \frac{\sum_{i=1}^{n} q_{i0}\, p_{it}}{\sum_{i=1}^{n} q_{i0}\, p_{i0}} \times 100$$

Taking $w_i = \frac{q_{i0}\, p_{i0}}{\sum_{i=1}^{n} q_{i0}\, p_{i0}}$

$$P_t = \sum_{i=1}^{n} w_i \frac{p_{it}}{p_{i0}} \times 100$$

Now, exclusion core measure is defined as a subset of the aggregate index basket. First, order goods within the aggregate index basket in such a way that the core price level includes goods 1 to m, and fully excludes goods $m+1$ to n.

$$P_t^{core} = \frac{\sum_{i=1}^{m} w_i \frac{p_{it}}{p_{io}} \times 100}{\sum_{i=1}^{m} w_i}$$

Where $m \leq n$

The denominator rescales the weights for commodities 1 to m and commodities m+1 to n are re-assigned to have weights zero. The 12-month change in this index gives exclusion based weighted year-on-year core inflation rate.

(B) Reweighting Core Inflation Measures:

Following definition in section 3.3.1, two variations of 'Neo-Edgeworthian Index' calculated as follow:

- WPISD: computed reweighting each 69 components series of WPI by using the weight as the reciprocal of the standard deviation of the change in relative prices, where the change in the relative price is measured by the difference between inflation rate of each component of WPI and the WPI inflation rate.

- WPIDW: double weighted core measure as first suggested by (Laflèche (1997)) computed reweighting each 69 components series of WPI by multiplying the WPI weight by the inverse of the standard deviation of that component inflation rate.

As noted in section 3.3.1 the choice of time window for calculating standard deviation has to be decided. For this purpose, we have taken all information available for the reference period of the study.

Construction of reweighted based core inflation measures:

Following broadly the method shown by Laflèche (1997) and marques et al (2000) we computed WPISD and WPIDW core inflation measures for India described below:

With n price components, the standard deviation weighted year-on-year core inflation measure (WPISD) computed as:

$$\text{WPISD}\,t = \left(\frac{\sum_{i=1}^{n} W\sigma_i \, p_{it}}{\sum_{i=1}^{n} W\sigma_i \, p_{it-12}} - 1 \right) * 100 \qquad (2)$$

Where p_{it} standing for price index of i th components of the WPI in period t and $W\sigma_i$ is the weight of i th component defined as the inverse of standard deviation of i th components of WPI. The $W\sigma_i$ are normalized so that they sum to one:

$$W\sigma_i = \frac{\frac{1}{\sigma_i}}{\sum_{i=1}^{n} \frac{1}{\sigma_i}}$$

Where $\sigma_i = \sqrt{\left[\left(\frac{1}{T-1} \right) \sum \left[(\pi_{it} - \pi_t) - \overline{(\pi_{it} - \pi_t)} \right]^2 \right]}$

Where σ_i is the standard deviation of i th components of WPI, π_{it} represents the year-on-year inflation rate of components i in period t and π_t for the year-on-year inflation rate of WPI in period t.

Likewise double weighted year-on-year core inflation measure (WPIDW) computed as:

$$\text{WPIDW}_t = \left[\frac{\sum_{i=1}^{n} Wd_i \, p_{it}}{\sum_{i=1}^{n} Wd_i \, p_{it-12}} - 1 \right] * 100 \qquad (3)$$

Where Wd_i is the double weight of the i th component defined as the product of WPI weights (w_i) for the i th component and the inverse of the standard of the i th components $\left(\frac{1}{\sigma_i} \right)$. These weights are normalized so that they sum to one.

$$Wd_i = \left[\frac{\left(w_i * \frac{1}{\sigma_i} \right)}{\left(\sum_{i-1}^{n} w_i * \frac{1}{\sigma_i} \right)} \right]$$

The differences and intuition behind these two measures is that WPISD aim is to maximize inflationary signal from data as giving weight as per the components volatility and discard completely the economic importance of that components whereas the WPIDW provides a compromise between the economic significance of a component and inflationary signal it provides by multiplying the WPI weight by the inverse of the standard deviation of that component inflation rate. WPIDW thus augments WPI-related weights with weights proportional to volatility. For illustration see in the appendix table1 in that mineral oils and edible oils and cereals are seen to be most volatile therefore has to be excluded or give less weight in core measures, but they are equally more weight items in WPI basket.

Apart from this we use weighted exponential smoothing measure for constructing core inflation measure for India described below:

(C)Weighted Exponentially Smoothed Core Measurers:

- WPIES: The exponentially smoothed version of the headline inflation (as originally proposed by Cogley (2002) defines the core measure as a one sided geometric distributed lag of current and past inflation.

Cogley's (2002) formulation is given by:

$$\tilde{\pi}_t = g_0 \sum_{j=0}^{\infty} (1-g_0)^j \pi_{t-j} \tag{4}$$

Above equation defines the core measure as a one sided geometric distributed lag of current and past inflation. where $\tilde{\pi}_t$ – the period t estimate of mean inflation π – denotes the relevant aggregate inflation measure and g_0 is the gain parameter which is assumed to lie between 0 and 1. Cogley (2002) set the gain parameter g_0 = 0.125. Note that in constrcuting the WPES meaures, the choice of gain parameter (g_0) need to be made since smaller is the g_0, the smoother is the series but more backward looking.We use this measure for Indian data by setting parameter as in Cogley (2002) and also for other values of the gain parameter, g_0[9].

The monthly estimates of WPI inflation rate and the estimates of measured core inflation rate are given in the appendix table 2 for the period from 1995:4 to 2007:3. In Figure 2 these inflation rates are plotted over time. When we look at these figures, the movements in various core inflation rates appear to evolve largely similar to the WPI. However, WPIES core measures exhibits a smooth graph compared to other conventional Ex-Food and Ex-Energy core measures.

4.3 Evaluation of the Proposed Core Inflation Measures

In preceding section we computed various alternative core inflation measures for India. Now it is imperative to see, from a monetary policy point of view, which core measure is a relatively more useful measure. For this, a number of empirical criteria have been proposed in the literature and there is no consensus on which criterion is the best among these. We use the two most important criteria that are useful for forward looking monetary policy viz.

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[9] We have estimated the model for a large number of different values of g_0 and examined the explanatory power (see equation (6), section 4.3.2 below) of the resulting core inflation measure in terms of predictability of future inflation.

- A similarity of means in core inflation series and headline inflation series (i.e., unbiasedness) and low volatility
- An ability to track the trend in headline inflation series.
- an *attracto*r property of core inflation measure
- an ability to predict future transient movement in headline inflation

4.3.1 Tracking Trend Inflation

A good core measure can be evaluated based on its accuracy to track long term trend inflation i.e. over a long period of time, the average rate of core inflation should match the average rate of overall inflation, or core inflation should move closely with the trend rate of inflation. More specifically, deviation between two series should be minimized. For doing this, there are some statistical methods in literature such as similarity in mean inflation rate of core inflation and headline inflation or to examine coefficient of variation. Another way is to compute root mean square error (RMSE).

Table 3: A Comparison of Inflation Variability

Core Inflation Measures	Mean	S.D	Variability(C.V)
WPI	5.18	1.85	0.35
WPIEXFD	5.17	2.13	0.41
WPIEXFL	4.28	2.22	0.52
WPIEXFD&FL	4.04	2.44	0.6
WPIEXVol	4.61	1.73	0.38
WPISD	4.54	1.96	0.43
WPIDW	4.9	1.65	0.34
WPI ES1 (g=0.125)	5.19	1.07	0.21
WPIES2 (g=0.065)	5.21	0.74	0.14

Table 3 lists the mean and standard deviation of each of the various core measures, as well as the WPI. In terms of variability, as captured by coefficient of variation (C.V), all exclusion type core inflation rates are more volatile than WPI inflation; only WPIDW core measure and the exponential based WPIES core measures are less volatile than WPI inflation. For the WPIES1 the standard deviation (S.D.) is 1.07 and C.V. is 0.21 and for WPIES2 is 0.74 and 0.14. In comparison, the corresponding values are mush higher for WPI headline values.

Apart from comparing mean and coefficient of variation, as noted above, the core inflation series should also move closely with the trend rate. When trend inflation rises, for example, core inflation should also move accordingly. This criterion is applied by estimating root mean squared error (RMSE) measure which is given by

$$RMSE^{Core} = \sqrt{\left\{\frac{1}{T}\sum\left(\pi_t^{Trend} - \pi_t^{Core}\right)^2\right\}} \quad (5)$$

where π_t^{Trend} is an estimate of the trend of inflation at time t and π_t^{Core} is a particular measure of core inflation at time t.

While computing RMSE (5) we replaced each core measure one by one and compared it with reference-trend inflation series to assess which core measure has less deviation around trend inflation series. For, calculating the trend inflation series we followed benchmark given by Bryan and Cecchetti (1994,) and other researchers. Trend inflation in a given month is simply estimated as two sided 36 & 24-month moving average of WPI inflation (see figure 3).

Table 4: Root Mean Squared Error over the Sample Period

Core Inflation Measures	RMSE (36-MA)	RMSE (24-MA)
WPIEXFD	2.04	1.67
WPIEXFL	2.1	1.95
WPIEXFD&FL	2.39	2.25
WPIEXVol	1.28	1.58
WPISD	1.58	1.48
WPIDW	1.35	1.16
WPIES1	0.89	0.8
WPIES2	0.63	0.77

According to RMSE criterion, as Table 4 shows, the exponential based core inflation series (WPIES) consistently outperform all other conventional type core measures. For example, RMSE value of WPIES1 core measure is 0.89 (Column2). By contrast for the conventional core measures such as WPI excluding food, WPI excluding Food & Fuel and WPI excluding Fuel, the RMSE values are over and above 2.0.

We also calculated trend inflation series as 24-month moving average of WPI headline inflation series. The results are similar to 36-month moving average. Only difference is that now all conventional Ex-food and fuel core measures and reweighted core measures have improved its RMSE values to some extent compared to that of 36-moth moving average. However, RMSE values for WPIES2 and WPIEXVol has slightly increased from 1.28 to 1.58

and 0.63 to 0.77 respectively. Overall, in tracking trend inflation, the WPIES measures and WPIDW outperforms the conventional type core measures.

4.3.2 Predicting Future Inflation

Before discussing the regression results, it is interesting to examine whether the core measure has any indicator properties for the future trend in inflation. We present the simple correlations between each core measure and the WPI at 12 months, 24 months horizon.

Table 5: Correlation of Core Measures with Future WPI Inflation

Core Inflation Measures	WPI	WPI (t+12)	WPI (t+24)
WPIEXFD	0.92	-0.36	0.78
WPIEXFL	0.81	-0.32	0.65
WPIEXFD&FL	0.79	-0.21	0.43
WPIEXVol	0.85	-0.27	-0.05
WPISD	0.76	-0.31	0.04
WPIDW	0.93	-0.35	-0.21
WPIES1	0.49	-0.44	-0.23
WPIES2	0.32	-0.38	0.03

Table 5 shows at 12 months horizon, WPI is negatively correlated with all of the core inflation measures. While at 24 month horizon, WPI is positively correlated with most of the core inflation measures. The exception is the exponential based core measure (WPIES1), WPIEXVol and WPIDW which are slightly negatively correlated. This pattern of correlation at 12 and 24 month horizons suggest that as Hogan et al. (2001) interpreted for Canada data that shocks excluded from core measures do reverse themselves over these horizons.

Seeing as at 24 month horizon, correlations between WPI and all conventional core measures are highly positive suggesting that they do have useful information on the future trend in inflation. The highest correlation at 24 months is 0.78 between WPI and WPIEXFD; WPIEXFL at 0.65 is the next highest. However it should be noted that the degree of correlation between headline inflation and different underlying inflation measures at various lag and lead is subject to central bank response to shocks. There is also no *a priori* justification about how much and what pattern of correlation should be expected. Therefore it is important to look at more than just simple correlations in the data.

Now, we look at the ability of different core inflation measures to forecast future movement in headline inflation. Although there are different ways to judge the predictive ability of a core measure, one common approach is often used in literature by many researchers that if current headline inflation differs from the underlying core inflation rate, headline inflation should move towards core inflation rate. When current overall inflation is below core, overall inflation should rise. To assure this, we follow the regression model that has been used in studies by Clark (2001), Hogan, Johnson and Laflèche (2001), Cutler (2001) and Cogley (2002) and Rich and Steinde (2007).

We estimate the following regression model – replacing one by one each of the core inflation series and evaluate their ability of forecasting future transient movement in headline inflation at one to two year horizon[10] within the sample period.

$$\pi_{t+h} - \pi_t = \alpha + \beta\left(\pi_t^{Core} - \pi_t\right) + u_t \qquad (6)$$

where π denotes overall headline inflation (WPI) and π^{Core} refers to one of the indicators of core inflation, both measured on a year-over-year basis and u_t is the random error term. The parameter *h* takes the values of 12 and 24 (months).

The above model has two attractive features first, being a simple specification it is easy to interprets and second, it can be used (interpreted) in two way viz., testing attractor property of core measure and ability of forecasting future transient movement in WPI. The intuitive explanation (or interpretation) of the above specification can be put in this way: Suppose in period t inflation figure for headline and core are 10% and 8 % respectively. The 2% inflationary gap in period t is then said to be 'noise' or transitory disturbance components if and only if headline inflation tends toward core inflation rate i.e., 8% in period $t+1$. Analogously in reverse case, the 2% inflation difference in period t is said to be underlying inflationary components if and only if headline inflation will move toward core inflation i.e., at 10% in period $t+1$. Thus, in above regression, the 'if and only if' condition will be tested by testing restrictions β=1 and α=0. If β is less than one, then it understates the transitory movements; if it is greater than one, then it overstates the transitory movements. This test captures to what extant transient movements will reverse toward core inflation after shock to headline inflation. The coefficient α captures the systematic bias in the measure. Therefore the joint restriction α=0 and β=1 also indicates that core inflation is an unbiased predictor of

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[10] The choice of this horizon is motivated by usual knowledge about the lags in the monetary policy transmission process in India.

headline inflation. Consequently once restriction $a = 0$ and $\beta = 1$ in equation (6) is statistically tested then core inflation possesses some information about future movement in headline inflation and this proportion of information, in terms of R^2, can be gauged among alternative core inflation measures.

Table 6 and 7 present the results of OLS estimation for all eight core measures at 12 month and a 24 month horizon.

Table 6: Predicting Future Transient Movement in Inflation at 12 Month

Core Inflation Measures	R^2	α (s.e)	β (s.e)	p-value $(H_0: \alpha = 0, \beta = 1)$
WPIEXFD	0	-0.25 (0.51)	-0.06 (0.56)	0.16
WPIEXFL	0.01	-0.08 (0.70)	0.17 (0.48)	0.08
WPIEXFD&FL	0.01	-0.08 (0.66)	0.14 (0.32)	00
WPIEXVol	0.15	0.44 (0.57)	1.10** (0.41)	0.71
WPISD	0.05	0.15 (0.68)	0.45 (0.41)	0.10
WPIDW	0.15	0.39 (0.51)	1.58** (0.45)	0.44
WPIES1(0.125)	0.37	-0.31 (0.42)	1.05** (0.19)	0.74
WPIES2(.065)	0.52	-0.34 (0.37)	1.16** (0.15)	0.40

Table 7: Predicting Future Transient Movement in Inflation at 24 Month Horizon

Core Inflation Measures	R^2	α (s.e)	β (s.e)	p-value $(H_0: \alpha = 0, \beta = 1)$
WPIEXFD	0.1	-0.27 (0.47)	-0.95** (0.31)	00
WPIEXFL	0.12	0.38 (0.69)	0.71* (0.34)	0.08
WPIEXFD&FL	0.02	0.01 (0.67)	0.26 (0.35)	0.02
WPIEXVOL(15)	0.14	0.28 (0.57)	0.95** (0.38)	0.78
WPISD	0.1	0.23 (0.74)	0.58 (0.42)	0.08
WPIDW	0.05	0.03 (0.58)	0.83* (0.40)	0.83
WPIES(0.125)	0.44	-0.26 (0.38)	1.04** (0.16)	0.78
WPIES(.065)	0.55	-0.27 (0.34)	1.07** (0.13)	0.61

Notes: * denote the coefficient is significantly different from zero at 5 per cent level and ** at 1 per cent level. Standard errors (s.e) were calculated using the Newey-West (1987) covariance matrix estimator to account for autocorrelation of the regression residuals.

At 12 month horizon, we cannot reject the H_0 that β =1 and α =0 for WPIEXFD, WPIEXVol, WPIDW, WPIES1 and WPIES2 core measures suggesting that these core measures are unbiased predictors of headline inflation. This result also suggests as in Hogan et al (2001) interpretation that what has been excluded by these measures might capture the transitory movements in the WPI. Further, note that estimated β coefficient value for WPIEXVol and exponential based core measures particularly WPIES1 are very close to 1 and significant at 1 per cent level suggesting that the deviation ($\pi_t^{Core} - \pi_t$) of these core measures are correctly measuring the magnitude of transient movement in ($\pi_{t+12} - \pi_t$). Note that although, WPIDW may not be rejected null hypothesis of joint restriction but estimated β value is 1.58, considerably above 1 at the 12 month horizon. Null hypothesis of unbiasedness is easily rejected for WPI excluding food & energy (WPIEXFDFL) core measure. The *p*-values for WPIFL and standard deviation weighted (WPISD) core measure are 0.08 and 0.10, suggesting that these measures are not unbiased. Since the estimated β coefficients values for theses measures are well below 1, suggesting that these measures might be under predicting the transient movements in the WPI.

When we move to 24 month horizon the regression results are similar. The null hypothesis of joint restriction, β=1 and α=0 are not rejected for the core measures: WPIEXVol, WPIDW, WPIES1 and WPIES2, Indeed p -values for these core measures have improved greatly. Further the estimated β coefficients are also fairly close to 1 particularly for exponential based core measures and WPIEXVol. This result suggests that these core inflation measures are attractor of headline inflation i.e. the deviations between core and headline inflation are not persistent and that headline inflation moves towards core inflation. On the other hand, the *p*-values for conventional WPIEXFD, WPIEXED&FL core measures and WPISD are again significant. In case for WPIFL though β coefficients value has improved fairly such that it is closer to1 now, the null hypothesis of unbiased predictor is rejected at 10 % per cent level.

Now taking a closer look at R^2 values of the unbiased core measures, the exponential smoothing based core measures clearly out perform the WPIEXVol and WPIDW core measures at both horizons. Equation for both exponential core inflation measures WPIES1 and WPIES2 has showed the highest R^2 value of 37 % to 55%. Among these unbiased core measures, WPIES2 has the highest R^2 0.55, and WPIDW has of the lowest R^2 0.05.

For WPIEXFD and WPIEXFD&FL R^2 values are negligible indeed it almost zero for WPIEXFD at 12 month horizon. In case of WPIFL, as we mentioned above, when we move to

24 month horizon, we find improved and also significant β coefficient which is reflected in its R^2s value from 0.01 to 0.12. Nevertheless, the WPIEXVol clearly performs much better among all exclusion type core measures.

It may be mentioned that estimated β coefficient at both horizons is negative for the case of WPI excluding food. However, since R^2 value is very low, it is not useful to go deeper in understanding the reasons for such behavior.

Overall, these empirical suggest the following:

First: the exponential smoothing based measures of core inflation perform far better compared to all other measures of core inflation. Second, the conventional ad hoc ex-food and energy core measures performed poorly relative to WPIEXVol core measure suggesting that instead of excluding whole category of food and energy measures exclusion should be based on some objective criteria.

5. Conclusion:

Since the inception of the term core inflation, there is neither a commonly accepted theoretical definition nor an agreed method of measuring it. Because of the fact that it is unobservable, it has to be estimated. One of the objectives of this paper was to review existing theoretical approaches of measuring core inflation. We, then, constructed several measures of core inflation for India. Among these measures, three are based on popular ad hoc exclusion principle and one measure that excludes fifteen of most volatile components. While constructing exclusion based core indices, we determined that it should be done such that small amount of weight is excluded in constructing the core index. The other two core measures, which are variations of ‘Neo-Edgeworthian Index’, were constructed by reweighting 69 disaggregated components series of WPI. Further, another class of core measures were constructed based on weighted exponential smoothing which was primarily developed by Cogley (2002). Subsequently, an empirical evaluation of these estimated core measures is performed. These empirical exercises suggested two findings: first: in terms of similarity in means, lower volatility, tracking trend inflation, testing attractor property of core inflation and an ability to predict future transient movement in headline inflation at both 12 month and 24 month horizon, the exponential based (WPIES) measures of core inflation seem to be superior to all other measures of core inflation. Second: the conventional ad hoc ex-food and energy core measures performed poorly compared to a measure (WPIEXVol) that excludes fifteen of most volatile components suggesting that instead of excluding whole category of food and energy, exclusion should be based on some objective criteria.

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Figure 1: The annual and monthly inflation rates for India from 1994 through April 2007

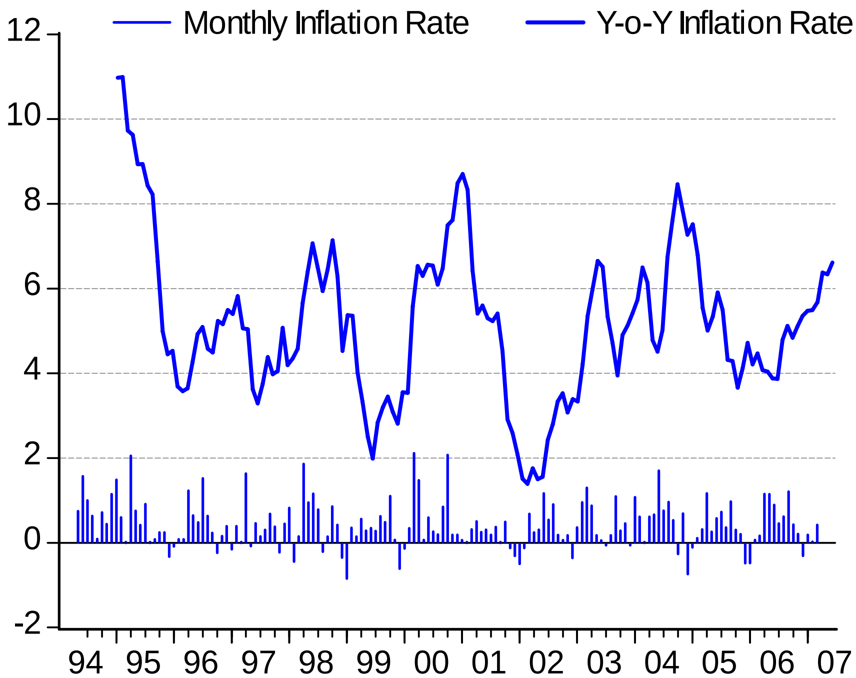
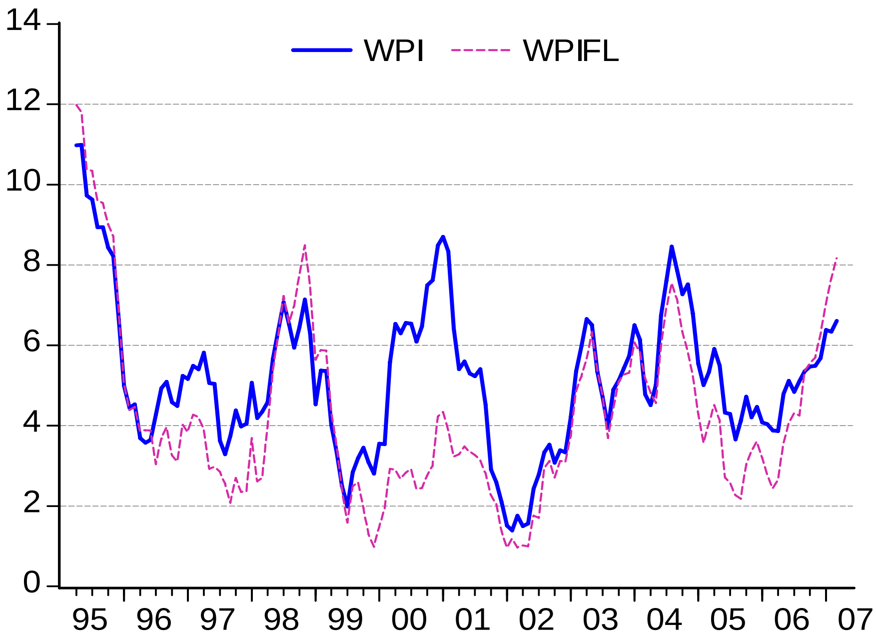
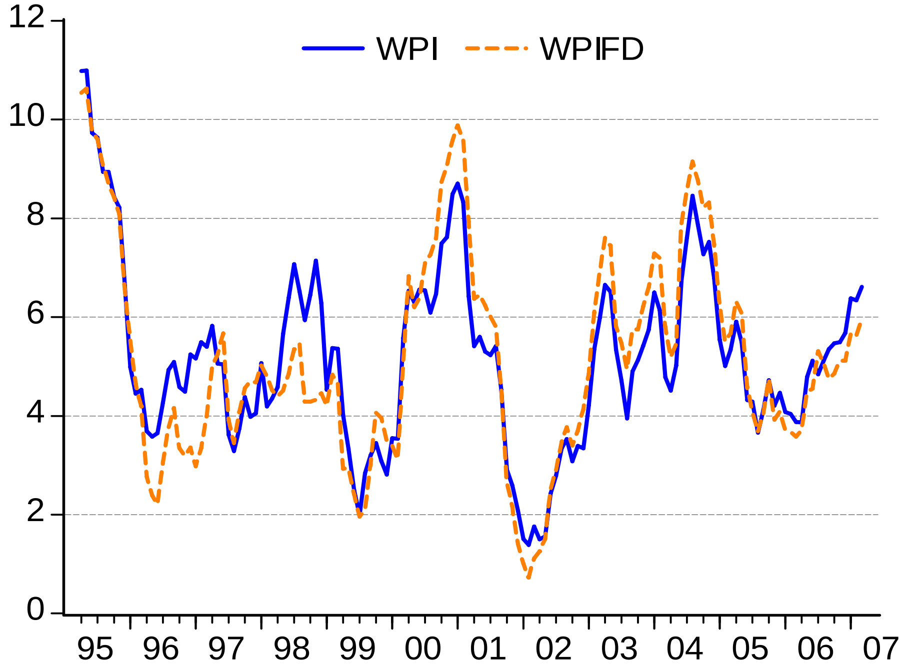


Figure 2: WPI and Alternative Core Inflation Rate





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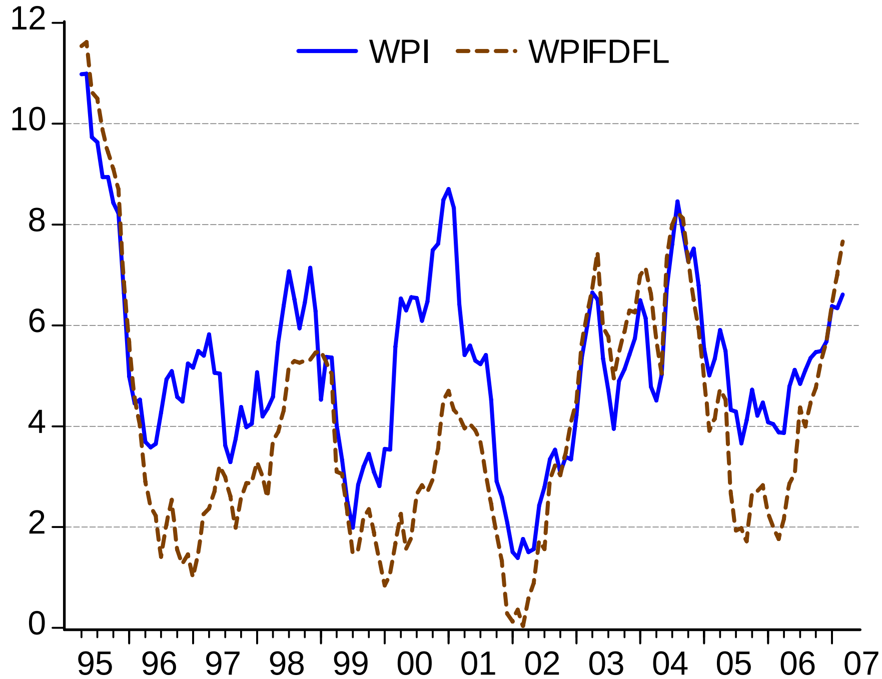

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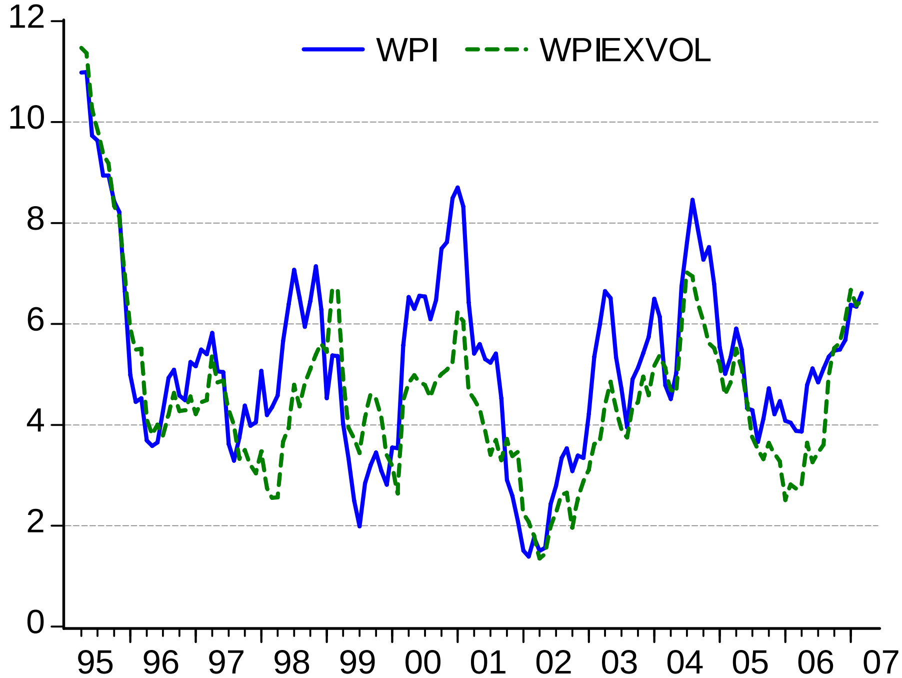
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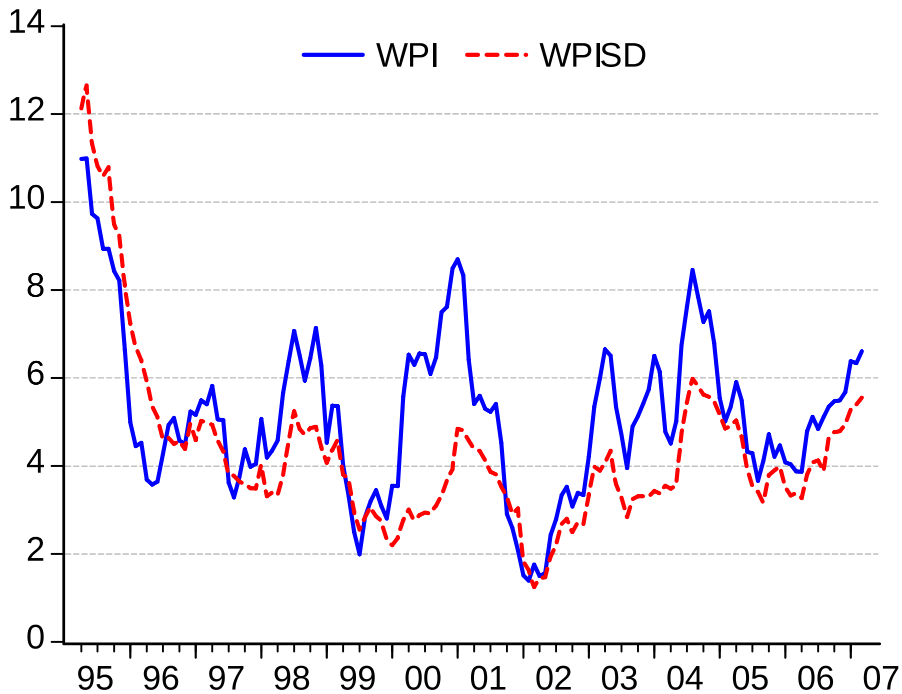
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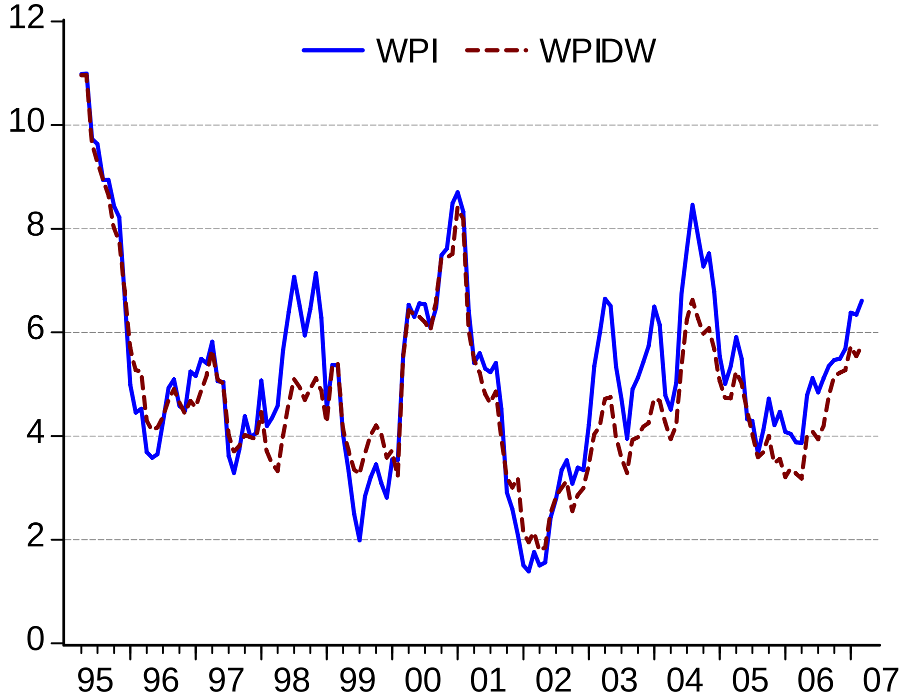
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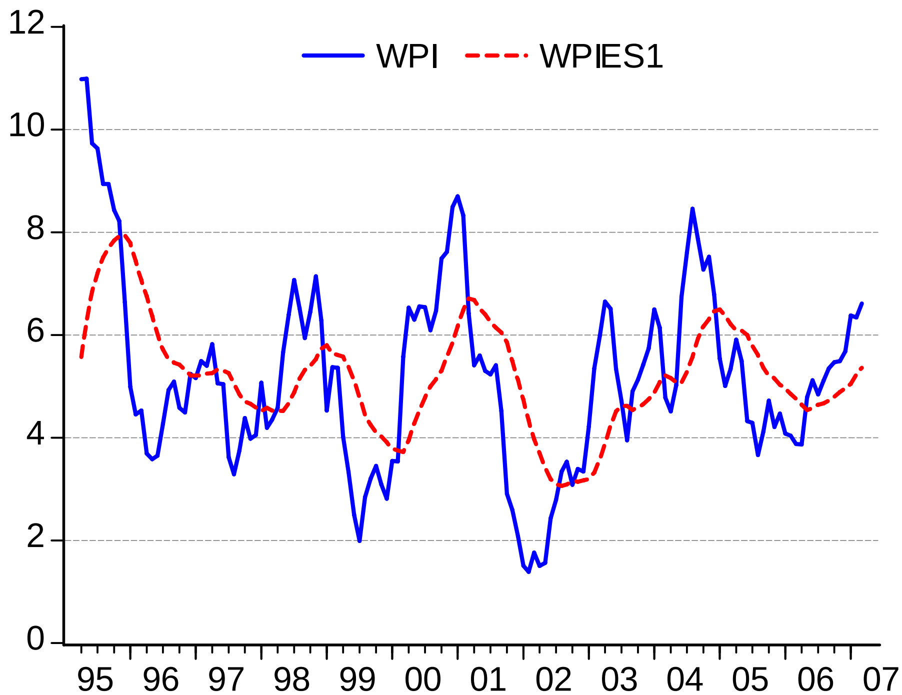
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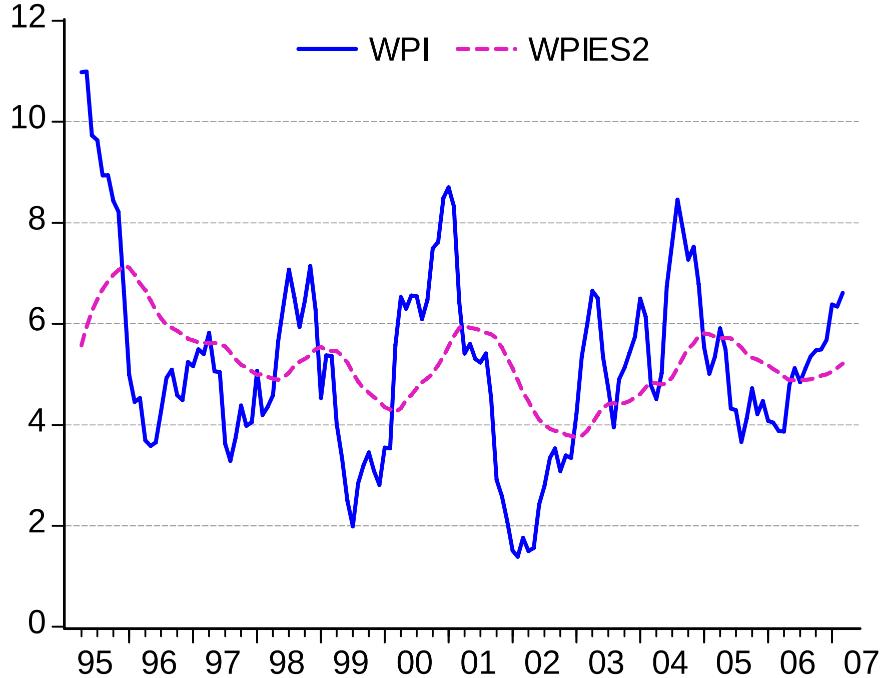
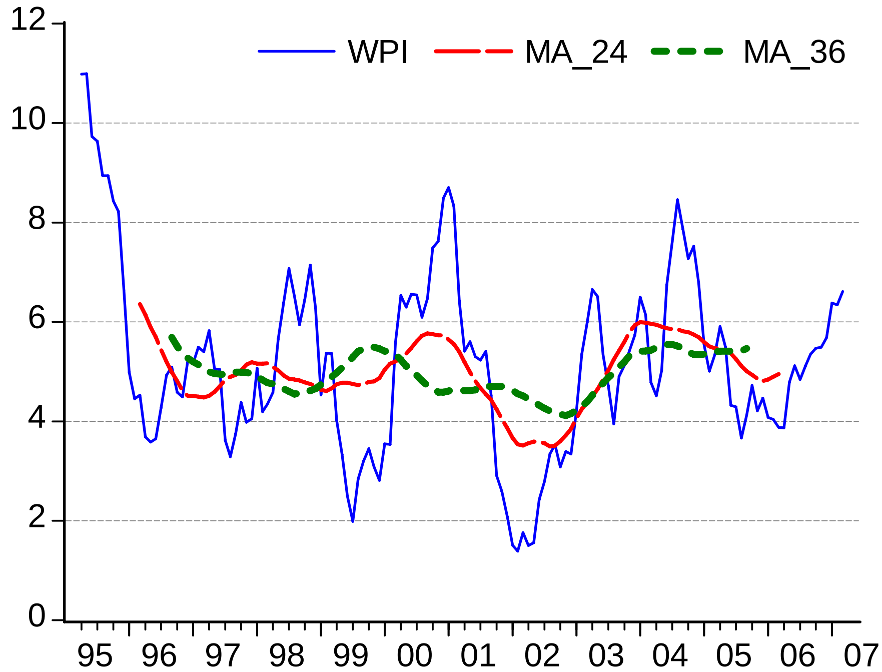


Figure 3 MA average of Headline Inflation (WPI) with 36 MA and 24 MA



Appendix :

Table1: Statistics on the 69 subcomponents series of WPI.

Components	Mean	S.D	Rank of S.D	WPI Weight	WPISD Weight	WPIDW Weight
a1. Cereals	5.02	7.10	42.00	4.41	1.40	3.82
a2. Pulses	6.84	11.08	18.00	0.60	0.93	0.35
b1. Vegetables	7.86	25.24	3.00	1.46	0.43	0.39
b2. Fruits	8.27	11.18	17.00	1.46	0.93	0.83
c. Milk	4.97	3.63	65.00	4.37	2.70	7.27
d. Eggs,Meat & Fish	5.99	7.09	43.00	2.21	1.47	2.00
e. Condiments & Spices	6.02	14.39	9.00	0.66	0.76	0.31
f. Other Food Articles(Unproccessed Tea&Coffee)	4.48	19.16	4.00	0.24	0.54	0.08
a. Fibres	1.21	13.30	12.00	1.52	0.78	0.73
b. Oil Seeds	3.85	10.64	21.00	2.67	0.91	1.49
c. Other Non-Food Articles	6.30	3.93	60.00	1.95	2.44	2.93
a. Metallic Minerals	23.10	53.56	1.00	0.30	0.20	0.04
b. Other Minerals	1.14	5.30	52.00	0.19	1.61	0.19
a. Coal Minning	7.07	7.67	40.00	1.75	1.37	1.48
b. Minerals Oils Petrol and Gas	11.99	11.82	15.00	6.99	0.89	3.82
c. Electricity	7.67	5.52	50.00	5.48	1.68	5.68
a. Dairy Products	5.51	6.36	46.00	0.69	1.81	0.77
b. Canning, Preserving & Processing of fish	9.92	14.56	8.00	0.05	0.65	0.02
c. Grain Mill Products	6.95	10.84	19.00	1.03	0.97	0.62
d. Bakery Products	4.75	6.04	49.00	0.44	1.65	0.45
e. Sugar,Khandsari & Gur	3.89	9.01	28.00	3.93	0.97	2.36
f. Manufacture of Common Salts	11.32	39.30	2.00	0.02	0.28	0.00
g. Cocoa, Choclate Sugar & Confectionery	3.79	3.84	63.00	0.09	2.54	0.14
h. Edible Oils	3.59	12.82	14.00	2.76	0.82	1.39
i. Oil Cakes	4.78	12.92	13.00	1.42	0.64	0.56
j. Tea & Coffee Proccessing	5.82	16.26	7.00	0.97	0.66	0.40
k. Other Food Products n.e.c	5.04	5.31	51.00	0.15	1.88	0.18
a. Wine Industries	6.17	10.40	25.00	0.27	1.00	0.17
b. Malt liquor	5.59	6.80	44.00	0.04	1.22	0.03
c. Soft Drinks & Carbonated Water	4.60	10.22	26.00	0.05	1.01	0.03
d. Manufacture of Bidi,Cigarettes,Tobacco & Zarda	6.61	3.90	61.00	0.97	2.34	1.41
a1. Cotton Yarn	1.54	8.48	33.00	3.31	1.24	2.54
a2. Cotton Cloth (Mills)	3.04	4.79	54.00	0.90	2.41	1.34
b1. Man Made Fibre	-0.66	8.35	35.00	4.41	1.37	3.71
b2. Man Made Cloth	1.85	3.00	67.00	0.31	2.97	0.57
c. Woolen Textiles	2.50	6.56	45.00	0.19	1.60	0.19

d. Jute Hemp & Mesta Textiles	6.73	14.31	10.00	0.68	0.71	0.30
(D) Wood & Wood Products	6.42	17.20	6.00	0.17	0.63	0.07
a. Paper & Pulp	4.32	10.69	20.00	1.23	1.11	0.84
b. Manufacture of Board	3.72	8.49	32.00	0.24	1.30	0.19
c. Printing & Publishing of Newspapers,Periodicals etc	8.61	13.71	11.00	0.58	0.74	0.26
(F) Leather & Leather Products	3.48	7.94	38.00	1.02	1.33	0.84
a. Tyres & Tubes	2.85	7.62	41.00	1.29	1.45	1.15
b. Plastic Products	2.74	3.84	62.00	0.94	2.43	1.40
c. Other Rubber & Plastic Products	5.28	10.46	23.00	0.17	1.03	0.11
a. Basic Heavy Inorganic Chemical	3.95	8.41	34.00	1.45	0.97	0.86
b. Basic Heavy Organic Chamical	5.08	18.58	5.00	0.45	0.59	0.17
c1. Fertilisers	3.72	4.35	56.00	3.69	2.73	6.21
c2. Pesticides	-0.01	7.97	37.00	0.47	1.18	0.34
d. Paints, Varnishes & Laquers	2.07	4.45	55.00	0.50	1.73	0.53
e. Dyestuffs & Indigo	-0.11	4.17	58.00	0.18	2.48	0.27
f. Drugs & Medicines	7.35	8.52	30.00	2.53	1.18	1.84
g. Perfumes, Cosmetics, Toiletries etc	5.59	5.25	53.00	0.98	1.79	1.08
h. Turpentine, Synthetic Resins and Plastic materials	2.31	10.42	24.00	0.75	1.00	0.46
i. Matches, Explosives and Other Chemicals n.e.c	2.80	3.51	66.00	0.94	2.52	1.46
a. Structural Clay Products	5.92	6.35	47.00	0.23	1.68	0.24
b. Glass Earthernware Chinaware & their products	3.28	8.52	31.00	0.24	1.32	0.19
c. Cement	5.14	8.61	29.00	1.73	1.29	1.38
d. Cement Slate & Graphite Products	4.71	7.80	39.00	0.32	1.39	0.27
a1. Iron & Steel	8.05	10.60	22.00	3.64	0.96	2.15
a2. Foundries for Casting Forging & Structurals	6.86	8.34	36.00	0.90	1.25	0.69
a3. Pipes Wires Drawing & Others	5.49	6.07	48.00	1.59	1.65	1.62
a4. Ferro Alloys	3.63	11.73	16.00	0.09	0.91	0.05
b. Non-Ferrous Metals	7.35	10.14	27.00	1.47	0.96	0.87
c. Metal Products	3.08	3.83	64.00	0.67	2.89	1.19
a. Non-Electrical Machinery & Parts	5.03	2.78	68.00	3.38	3.34	6.97
b. Electrical Machinery	1.87	4.15	59.00	4.98	2.26	6.96
a. Locomotives Railway Wagon & Parts	1.54	4.33	57.00	0.32	1.88	0.37
b. Motor Vehicles, Motorcycles, Scooters, bicycles & parts	3.68	2.67	69.00	3.98	4.25	10.42

Table 2: Monthly Estimate of WPI headline Inflation and alternative Core Inflation Rate: 1995 to 2007:3

	WPI	WPIEXFD	WPIEXFD &FL	WPIEXFL	WPISD	WPIDW	WPIES1	WPIES2
Apr-95	10.98	10.54	11.54	11.98	12.13	10.96	5.57	5.57
May-95	10.99	10.63	11.62	11.81	12.65	10.96	6.25	5.93
Jun-95	9.73	9.77	10.63	10.38	11.33	9.64	6.84	6.25
Jul-95	9.63	9.6	10.5	10.34	10.81	9.29	7.2	6.48
Aug-95	8.94	9.08	9.87	9.6	10.59	8.96	7.51	6.68
Sep-95	8.94	8.71	9.43	9.54	10.79	8.64	7.69	6.83
Oct-95	8.43	8.42	9.1	9.01	9.49	8.01	7.84	6.97
Nov-95	8.22	8.09	8.7	8.72	9.26	7.77	7.92	7.06
Dec-95	6.64	6.56	6.86	6.86	8.12	6.79	7.95	7.14
Jan-96	4.99	5.55	5.67	5.07	7.24	5.70	7.79	7.11
Feb-96	4.45	4.65	4.57	4.39	6.71	5.27	7.44	6.97
Mar-96	4.53	4.19	4.02	4.47	6.40	5.24	7.07	6.8
Apr-96	3.69	2.77	2.9	3.87	5.94	4.29	6.75	6.66
May-96	3.58	2.39	2.43	3.89	5.36	4.11	6.37	6.46
Jun-96	3.65	2.21	2.22	3.88	5.11	4.17	6.02	6.28
Jul-96	4.27	3.06	1.41	3.04	4.60	4.36	5.72	6.11
Aug-96	4.93	3.75	2.05	3.68	4.64	4.67	5.54	5.99
Sep-96	5.09	4.16	2.54	3.96	4.50	4.91	5.46	5.92
Oct-96	4.58	3.35	1.55	3.26	4.57	4.66	5.42	5.86
Nov-96	4.49	3.19	1.27	3.11	4.38	4.43	5.31	5.78
Dec-96	5.24	3.36	1.46	4.03	4.95	4.68	5.21	5.7
Jan-97	5.16	2.98	1.01	3.84	4.59	4.56	5.21	5.67
Feb-97	5.49	3.34	1.47	4.27	5.02	4.86	5.21	5.63
Mar-97	5.4	4	2.26	4.21	4.98	5.17	5.24	5.62
Apr-97	5.82	4.99	2.37	3.91	4.94	5.66	5.26	5.61
May-97	5.06	5.25	2.71	2.93	4.57	5.09	5.33	5.62
Jun-97	5.04	5.67	3.21	2.97	4.33	5.01	5.3	5.59
Jul-97	3.62	3.91	2.99	2.85	3.82	4.02	5.26	5.55
Aug-97	3.29	3.45	2.61	2.56	3.77	3.71	5.06	5.43
Sep-97	3.75	4.09	1.99	2.08	3.65	3.81	4.84	5.29
Oct-97	4.38	4.56	2.57	2.7	3.57	4.02	4.7	5.19
Nov-97	3.98	4.7	2.87	2.35	3.49	3.97	4.66	5.13
Dec-97	4.05	4.68	2.87	2.36	3.49	3.94	4.58	5.06
Jan-98	5.07	5.02	3.29	3.69	4.02	4.46	4.51	4.99
Feb-98	4.19	4.81	3.01	2.62	3.31	3.70	4.58	5
Mar-98	4.35	4.52	2.59	2.7	3.40	3.48	4.53	4.95
Apr-98	4.58	4.4	3.7	3.99	3.34	3.33	4.51	4.91
May-98	5.66	4.51	3.89	5.36	3.79	4.01	4.52	4.89
Jun-98	6.39	4.85	4.31	6.27	4.55	4.60	4.66	4.94
Jul-98	7.07	5.35	5.17	7.23	5.24	5.10	4.88	5.03

Aug-98	6.52	5.46	5.29	6.56	4.85	4.95	5.15	5.16
Sep-98	5.94	4.29	5.26	6.98	4.71	4.69	5.32	5.25
Oct-98	6.45	4.29	5.29	7.74	4.86	4.91	5.4	5.3
Nov-98	7.14	4.33	5.31	8.49	4.89	5.12	5.53	5.37
Dec-98	6.28	4.46	5.46	7.5	4.42	4.88	5.73	5.49
Jan-99	4.53	4.21	5.49	5.64	4.07	4.26	5.8	5.54
Feb-99	5.37	4.83	5.27	5.88	4.37	5.35	5.64	5.47
Mar-99	5.36	4.67	5.04	5.87	4.59	5.40	5.61	5.46
Apr-99	4.02	2.93	3.1	4.35	3.81	4.14	5.58	5.46
May-99	3.33	2.94	3.05	3.51	3.70	3.73	5.38	5.36
Jun-99	2.5	2.41	2.29	2.41	2.97	3.35	5.12	5.23
Jul-99	1.99	1.96	1.48	1.59	2.56	3.26	4.8	5.05
Aug-99	2.84	2.1	1.54	2.49	2.83	3.67	4.45	4.86
Sep-99	3.2	3.01	2.17	2.59	3.06	4.01	4.25	4.72
Oct-99	3.45	4.06	2.35	1.96	2.86	4.20	4.11	4.63
Nov-99	3.09	3.96	1.89	1.3	2.75	4.05	4.03	4.55
Dec-99	2.81	3.51	1.36	0.99	2.34	3.59	3.91	4.45
Jan-00	3.55	3.41	0.84	1.48	2.20	3.72	3.78	4.35
Feb-00	3.54	3.12	1.05	1.93	2.37	3.22	3.75	4.3
Mar-00	5.58	5.04	1.67	2.93	2.77	5.52	3.72	4.25
Apr-00	6.53	6.83	2.26	2.9	3.01	6.42	3.95	4.33
May-00	6.3	6.2	1.56	2.68	2.77	6.34	4.28	4.48
Jun-00	6.56	6.38	1.78	2.83	2.88	6.30	4.53	4.59
Jul-00	6.54	7.09	2.65	2.92	2.94	6.19	4.78	4.72
Aug-00	6.09	7.26	2.83	2.42	2.92	6.04	5	4.84
Sep-00	6.47	7.59	2.7	2.45	3.09	6.59	5.14	4.92
Oct-00	7.49	8.73	2.93	2.76	3.32	7.41	5.3	5.02
Nov-00	7.62	9.07	3.56	3	3.66	7.44	5.58	5.18
Dec-00	8.49	9.58	4.51	4.23	3.93	7.52	5.83	5.34
Jan-01	8.7	9.88	4.7	4.34	4.84	8.41	6.16	5.55
Feb-01	8.33	9.61	4.32	3.89	4.81	8.19	6.48	5.75
Mar-01	6.42	7.93	4.21	3.23	4.58	6.04	6.71	5.92
Apr-01	5.41	6.37	3.96	3.29	4.39	5.48	6.68	5.95
May-01	5.6	6.45	4.05	3.48	4.34	5.23	6.52	5.92
Jun-01	5.3	6.24	3.92	3.35	4.14	4.81	6.4	5.9
Jul-01	5.23	6.01	3.7	3.27	3.87	4.64	6.27	5.86
Aug-01	5.41	5.81	3.07	3.14	3.80	4.86	6.14	5.82
Sep-01	4.52	4.51	2.46	2.82	3.53	3.97	6.05	5.79
Oct-01	2.91	2.67	1.89	2.27	3.31	3.20	5.86	5.71
Nov-01	2.59	2.16	1.33	2.05	2.91	3.01	5.49	5.53
Dec-01	2.08	1.41	0.28	1.36	3.03	3.19	5.13	5.33
Jan-02	1.51	1.01	0.13	0.96	1.83	2.14	4.74	5.12
Feb-02	1.39	0.73	0.36	1.19	1.63	1.95	4.34	4.89
Mar-02	1.76	1.12	0.04	0.97	1.25	2.14	3.97	4.66
Apr-02	1.5	1.26	0.58	1.02	1.44	1.79	3.7	4.47
May-02	1.56	1.51	0.89	1	1.48	1.85	3.42	4.28

Jun-02	2.43	2.52	1.73	1.76	1.94	2.50	3.19	4.1
Jul-02	2.79	2.9	1.56	1.71	2.19	2.83	3.09	3.99
Aug-02	3.34	3.47	2.93	2.94	2.67	3.00	3.06	3.92
Sep-02	3.53	3.77	3.22	3.12	2.80	3.13	3.09	3.88
Oct-02	3.08	3.4	3.03	2.71	2.50	2.55	3.15	3.86
Nov-02	3.39	3.7	3.47	3.12	2.71	2.86	3.14	3.8
Dec-02	3.34	4.14	4.09	3.09	2.67	3.00	3.17	3.78
Jan-03	4.22	4.86	4.49	3.75	3.33	3.44	3.19	3.75
Feb-03	5.35	6.09	5.64	4.86	3.98	4.03	3.32	3.78
Mar-03	5.99	6.91	6.21	5.23	3.89	4.17	3.57	3.88
Apr-03	6.65	7.6	6.72	5.64	4.06	4.72	3.87	4.02
May-03	6.51	7.45	7.45	6.33	4.35	4.75	4.22	4.19
Jun-03	5.34	5.81	5.98	5.39	3.58	4.00	4.51	4.34
Jul-03	4.71	5.47	5.77	4.76	3.30	3.59	4.61	4.41
Aug-03	3.95	4.95	4.95	3.69	2.84	3.29	4.62	4.43
Sep-03	4.9	5.75	5.47	4.42	3.24	3.93	4.54	4.39
Oct-03	5.13	5.75	5.87	5.1	3.31	3.98	4.59	4.43
Nov-03	5.42	6.22	6.29	5.27	3.31	4.18	4.65	4.47
Dec-03	5.74	6.6	6.26	5.32	3.30	4.25	4.75	4.54
Jan-04	6.5	7.29	6.99	6.07	3.43	4.72	4.87	4.61
Feb-04	6.14	7.19	7.14	5.84	3.37	4.67	5.08	4.74
Mar-04	4.78	5.8	6.62	5.18	3.55	4.26	5.21	4.83
Apr-04	4.51	5.19	5.73	4.82	3.48	3.94	5.16	4.82
May-04	5.02	5.46	5.05	4.57	3.56	4.20	5.07	4.8
Jun-04	6.74	7.9	7.33	5.99	4.73	5.32	5.07	4.82
Jul-04	7.61	8.55	8	6.92	5.45	6.25	5.28	4.94
Aug-04	8.46	9.15	8.22	7.55	5.98	6.63	5.57	5.12
Sep-04	7.86	8.76	8.12	7.14	5.82	6.27	5.93	5.33
Oct-04	7.27	8.22	7.31	6.33	5.62	5.98	6.17	5.5
Nov-04	7.52	8.32	6.51	5.85	5.57	6.08	6.31	5.61
Dec-04	6.79	7.47	5.93	5.27	5.46	5.68	6.46	5.74
Jan-05	5.54	6.25	5	4.29	5.18	5.06	6.5	5.81
Feb-05	5.01	5.51	3.91	3.57	4.86	4.74	6.38	5.79
Mar-05	5.34	5.67	4.15	4.06	4.90	4.73	6.21	5.74
Apr-05	5.91	6.32	4.73	4.51	5.04	5.24	6.1	5.71
May-05	5.49	6.09	4.53	4.13	4.67	5.01	6.08	5.72
Jun-05	4.32	4.58	2.66	2.71	3.95	4.50	6	5.71
Jul-05	4.29	4.1	1.93	2.58	3.56	4.04	5.79	5.62
Aug-05	3.66	3.67	1.98	2.27	3.41	3.59	5.61	5.53
Sep-05	4.12	4.04	1.72	2.18	3.17	3.69	5.36	5.41
Oct-05	4.72	4.75	2.67	3.03	3.79	4.00	5.21	5.33
Nov-05	4.21	3.92	2.71	3.36	3.90	3.48	5.15	5.29
Dec-05	4.47	4.09	2.83	3.6	3.99	3.56	5.03	5.22
Jan-06	4.08	3.72	2.27	3.2	3.52	3.21	4.96	5.17
Feb-06	4.04	3.67	2.01	2.78	3.33	3.36	4.85	5.1
Mar-06	3.88	3.58	1.76	2.44	3.37	3.27	4.75	5.03

Apr-06	3.87	3.71	2.16	2.64	3.27	3.18	4.64	4.95
May-06	4.79	4.48	2.86	3.55	3.80	3.99	4.54	4.88
Jun-06	5.12	4.55	3.04	4.05	4.08	4.09	4.57	4.88
Jul-06	4.84	5.31	4.37	4.31	4.13	3.94	4.64	4.89
Aug-06	5.11	5.08	4	4.25	3.88	4.19	4.67	4.89
Sep-06	5.35	4.75	4.46	5.36	4.65	4.76	4.72	4.9
Oct-06	5.47	4.86	4.76	5.54	4.77	5.15	4.8	4.93
Nov-06	5.49	5.11	5.29	5.7	4.79	5.22	4.89	4.97
Dec-06	5.68	5.12	5.67	6.28	4.94	5.27	4.96	5
Jan-07	6.38	5.66	6.42	7.04	5.28	5.73	5.05	5.05
Feb-07	6.34	5.61	7	7.66	5.39	5.54	5.22	5.13
Mar-07	6.61	5.97	7.66	8.17	5.55	5.74	5.36	5.21