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Measures of Core Inflation in India – An Empirical Evaluation

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This study attempts to analyse seven exclusion-based measures of core inflation in India based on WPI (2004-05=100) for the period 2004-11. These are: WPI excluding food; WPI excluding fuel; WPI excluding food and fuel; non-food manufacturing; WPI excluding fuel and basic metals and metal products; WPI excluding fuel, metal group and non-food primary articles; and non metal manufacturing. These measures were tested for volatility, unbiasedness and tracking the trend and predictive power. While WPI excluding food and WPI excluding food and fuel did not perform well in terms of volatility, the remaining five measures broadly satisfied the conditions relating to volatility, unbiasedness and tracking the trend and predictability of future inflation. A key property of core measure is that it should not revert to headline inflation. It was found that of the above five measures, all except non-food manufacturing revert back to headline inflation indicating that supply side shocks spill over to these core measures of inflation. This finding was further corroborated by granger causality and inflation persistence tests. Thus, non-food manufacturing is the only exclusion based measure which broadly satisfies all the properties of a core measure. A core measure of inflation is not an end in itself, but rather a means to achieve low and stable inflation by serving as a short-term operational guide for monetary policy. Given the loss of information content in the construction of core inflation and the relatively greater public acceptability of the headline inflation, the core measures are useful only as indicators of the underlying inflationary process rather than as policy targets. Thus, containing headline inflation, and not core inflation, should be the focus of monetary policy, particularly in countries like India, where food and fuel are a major part of the consumption basket.

Key Words : Core inflation, Inflation
JEL Classification : E31, E52

Introduction

Monetary policy works by influencing aggregate demand in the economy. However, at times an economy faces supply side shocks leading to large variations in relative prices. In such cases, headline inflation behaviour on its own could be misleading for policy purpose. Thus, a proper diagnosis of the price changes as to which price changes are transitory and which are permanent is critical. This is mainly because monetary policy operates with a lag. If increase in the price index is due

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to temporary shocks that could very soon reverse themselves, it may not require any monetary policy action. To deal with such situations, many central banks use measures of core inflation that are designed to filter the transitory price movements. Core inflation by eliminating the volatile components from the headline helps in identifying the underlying trend in headline inflation and is believed to predict future inflation better.

The Indian economy, like many other emerging market economies, has often been subject to some supply shock or the other. The Indian economy is currently experiencing high and persistent inflation. Inflation at above 8 per cent over last one and a half years has been one of the most persistent in the post-reform period. Although inflation prevailing now is generalised, it was triggered by supply side shocks, which in some form or the other have continued to persist, *albeit* with different intensity.

Price stability as defined by 'low and stable inflation' being one of the key objectives, the Reserve Bank monitors a range of price indices both at aggregate and disaggregated levels [RBI (2006)]. Changes in the wholesale price inflation (WPI) is taken as the headline inflation for policy articulation and within the WPI, non-food manufactured products inflation is considered the core inflation [Mohanty (2011)]. However, several other central banks normally use headline inflation, excluding food and energy, as measures of core inflation. An attempt, therefore, has been made in this paper to identify as to how non-food manufacturing inflation performs vis-a-vis some other measures of core inflation, normally used by several other central banks. This paper is organised into five Sections. Section II explains the concept of core inflation. It also discusses briefly various techniques that are employed to measure core inflation. Section III briefly reviews the literature on core inflation, both in the international and domestic context. Section IV tests various exclusion-based measures of core inflation for India. Section V sums up the discussions.

Section II

Core Inflation: Concept and Measurement

Concept

The term core inflation was coined by Eckstein (1981) who defined it as 'the trend increase of the cost of factors of production'

that 'originates in the long-term expectations of inflation in the minds of households and businesses, in the contractual arrangements which sustain the wage-price momentum, and in the tax system'. The concept of core inflation became popular in the 1970s during periods of high inflation and now normally refers to that component of inflation that is likely to persist for a long period, say, for several years and, therefore, useful for near-term and medium-term inflation forecasting [Blender (1997); and Byran and Ceechetti (1994)]. Most core measures are based on the concept that total inflation can be separated into two components: the core part, representing the underlying trend of inflation as shaped by the pressure of aggregate demand against capacity, and the non-core part, which reflects price movements caused by temporary shocks or relative price changes[(Lafleche (2006)].

Chairman Bernanke of the US Fed in its report to the Congress (July 2007) emphasised that core measures were motivated by a desire to track and predict persistent inflation: "… food and energy prices tend to be quite volatile, so that, looking forward core inflation (which excludes food and energy prices) may be a better gauge than overall (headline) inflation of underlying inflation trends". That is, by extracting underlying inflation trend, core inflation is able to predict future headline inflation better. If core inflation remains stable, then a surge in headline inflation is less likely to result in increase in inflation expectations, unless supply shocks get built into price expectations.

Although used by several central banks, core measure of inflation lack theoretical underpinnings. The headline measure of inflation is based on the theory of cost of living which provides a coherent framework for the evaluation of measures of headline inflation [Wynne (1999)]. The choice of a basket and weights depends on the purpose for which the index is to be used for. The consumer price index represents the cost of a basket of goods and services consumed by a typical household. Most countries, therefore, use CPI as a measure of headline inflation.

Implicit in the discussion of core inflation is the idea that this type of inflation is fundamentally different to changes in the cost of living. Some analysts have linked core inflation to the measure of price change most closely related to monetary policy. By this reasoning, inflation is a monetary phenomenon in the long run, so core inflation should measure the component of price change related to monetary phenomena [Bryan and Cecchetti (1994); Wynne (1997, 1999)]. Because sustained relative

price movements result from shifts in the relative demand for goods or changes in supply, not from monetary policy, core inflation should exclude relative prices changes. Defined in this way, core inflation is the measure over which monetary policy has the most influence [Roger (1997); Shiratsuka (1997)]. Thus, there is a well-defined concept of monetary inflation that ought to be of concern to monetary policymakers and that this type of inflation, being conceptually different to the cost of living, is not adequately captured by the standard price statistics. Thus, it is argued that central banks ought to target a price index whose rate of increase corresponds to the inflation that generates the costs that central banks are seeking to avoid by focusing on an inflation control objective [Wynne (1999)].

Measures of core inflation, however, could not serve as a basis for inflation measurement that could possibly replace the theory of the cost of living. Measures of core inflation are thus no substitute for headline inflation. Focusing on core inflation does not mean that the central bank should not be concerned about inflation in the components excluded from this measure (e.g. food, energy etc), which represent a significant proportion of the consumer basket. Core inflation is simply a convenient guide to help the central bank achieve its objective of controlling total inflation. Most countries use measures of core inflation in addition to headline measures of inflation and not as a substitute. Of the 23 inflation targeting countries, only five countries target core inflation (Table 1). In the recent period, there have also been some countries such as Korea which have moved away from targeting core inflation to headline inflation.

Choice of a Measure

While the idea of core inflation is intuitively appealing, its practical policy usefulness has at times been questioned. There is no unique way of compiling core inflation and there is no generally accepted and intuitively plausible criterion to assess the policy usefulness of competing core inflation measures directly.

Notwithstanding the fact that there is no consensus on an appropriate measure of core inflation, literature has generally classified such measures into two broad categories: (i) statistical measures/order statistics [such as trimmed mean, weighted median, moving averages, filtered series, exponentially smoothened series and structural vector

auto regression (SVAR), among others] and (ii) exclusion-based measures, *i.e.,* by excluding some highly volatile elements from the headline such as food and fuel. Although statistical measures such as trimmed mean and median have better statistical properties of core inflation, such pure statistical measures are difficult for the public to understand and hence difficult to effectively communicate for the central banks [Wynne (1999), Clark (2001)]. The trimmed mean, for example, removes a different set of components each month, with the excluded set comprising a percentage of a distribution. More sophisticated core inflation measures such as SVAR are even more difficult to explain to the general public.

Table 1: Inflation Targeting Countries : Inflation Target

Country	Year of Introduction	Inflation Target
Brazil	1999	CPI
Chile	1991	CPI
Columbia	1999	CPI
Mexico	1999	CPI
Peru	2002	CPI
Indonesia	2000	CPI
Korea	1998	CPI
Philippines	2002	CPI
Thailand	2000	Core CPI
Czech Republic	1998	CPI
Hungary	2001	CPI
Poland	1998	CPI
Israel	1992	CPI
South Africa	2000	CPI
Turkey	2006	CPI
Australia	1994	CPI
Canada	1991	CPI-X
Iceland		CPI
New Zealand	1990	CPI-X
Sweden	1993	CPI Ex interest and Indirect tax
Norway	2001	CPI ex tax and energy
Switzerland	2000	CPI
United Kingdom	1992	CPI

Source: IMF
Note: Core CPI for respective countries explained in Table 2.

On the contrary, exclusion-based core measures have been the preferred choice of policymakers essentially because of their simplicity. They are easy to communicate to public when compared with the pure statistical measures of core inflation. The criticism that such measures often face is that completely removing the volatile items is a very crude methodology and has the potential risk of a permanent loss of significant information. Exclusion-based measures, although desirable from simplicity point of view, very often do not satisfy economic criteria. Core inflation measures based on statistical smoothing techniques provide smoother core inflation series, although they too are not supported very often by economic theory. However, most countries that use core inflation either as their inflation target or as an official core measure employ the exclusion method (Table 2). In doing so, the objective of policymakers is to keep the core inflation measure simple, well understandable and effectively communicate to the public on inflation trends and policy decisions.

Table 2: Official Core Inflation Measures: Cross-Country Practices

Core Inflation Targeting Countries	
Canada	CPIX that excludes 8 most volatile components like fruits, vegetables, gasoline, natural gas, fuel oil, mortgage interest costs, intercity transportation and tobacco products
Sweden	CPI excluding interest and indirect tax
Norway	CPI excluding tax and energy
New Zealand	CPI excluding interest charges
Thailand	Core CPI excludes fresh food and energy prices which include rice, flour, cereal products, vegetables, fruits, electricity charges, cooking gas, and gasoline.
Other countries with Official Core Measures	
Japan	CPI excluding fresh food
Peru	CPI excluding 9 volatile items like food, fruits and vegetables, urban transport, about 21.2 per cent)
United States	CPI excluding food and energy
Chile	CPI excluding 20 per cent with higher (-) variations and 8 per cent with higher (+) variations
Philippines	CPI excluding rice corn fruits vegetables, LPG, Kerosene, Oil, Gasoline, Diesel
Korea	CPI excluding non-grain agricultural products and petroleum products
Columbia	CPI excluding agricultural food, public services and transport
Spain	CPI excluding energy and unprocessed food
Netherlands	CPI (ULI) excluding fruits, vegetables and energy
Portugal	CPI (ULI) excluding energy and unprocessed food

Section III

Review of Literature

The properties of core inflation measures have been studied extensively, both internationally and domestically. At the global level, research has been conducted for core inflation based on both exclusion-based criteria and statistical measures for a number of countries, by OECD (2005), Rich and Steindel (2005), Blinder and Reis (2005), Marques, *et al* (2003) and Bryan and Cecchetti (1994). While Bryan and Cecchetti (1993) popularised the trimmed mean or weighted median techniques for computing core inflation, estimating core inflation through a structural vector auto regression (SVAR) method was suggested by Quah and Vahey (1995). In the official literature, however, a number of central banks report core inflation by excluding most volatile sub-components from CPI. For countries where core inflation is a target variable such as Canada, periodic research is conducted to evaluate the performance of existing exclusion-based core inflation measures as well as to suggest new exclusion-based measures that perform well in terms of various criteria [Armour (2006); Lafleche *et al* (2006)]. The components which are generally considered for exclusion are fresh food items, energy prices and mortgage interest payments. Recognising that all of these measures have pros and cons, Wynne (1999) observed that howsoever, core inflation is measured, for them to be useful for monetary policy formulation, it is crucial that they should be computable in real time and have some predictive power for future inflation.

In the Indian context also, the properties of core inflation measures have been tested by some researchers [Samanta (1999); Mohanty *et al* (2000); Kar (2009); Das *et al* (2009)]. Samanta (1999) computed core inflation following the exclusion principle and concluded that the measure of core inflation, excluding primary food and non-food articles and administered items (combined weight of 46 per cent in WPI), was less volatile during the period 1993-94 to 1998-99. Mohanty *et al* (2000) made a comprehensive attempt to examine core inflation measures: trimmed mean, weighted median and exclusion-based (by excluding energy, a number of fresh food items and a few

manufactured items related to primary articles). They observed that 20 per cent trimmed mean WPI was an appropriate core inflation indicator for India. Looking at some recent studies on the subject, while Kar (2009) focussed only on statistical measures of core inflation, Das *et al* (2009) analysed both exclusion-based measures, excluding food articles, and fuel group, individually and together and some statistical measures such as mean-SD, trimmed mean, median, reweighting, HP filter, Wavelet filter and structural VAR measures. Based on his findings, Kar (2009) showed that geometric exponential smoothing and weighted percentile were most suitable tools for core inflation. Das *et al* (2009), on the other hand, found that there was no individual measure of core inflation that could be considered superior to other measures. Both these studies were based on the old WPI series with 1993-94 as base.

Section IV

Core Inflation - Empirical Evidence in India

Most countries use CPI as a measure of headline inflation. Therefore, core inflation measure in most countries are based on CPI.

However, in India, there is no single measure of inflation which captures economy-wide inflationary pressures in the economy. It is the year on year percentage change in wholesale price index (WPI), which is used as an indicator of headline inflation. Although there are four consumer price indices (CPIs), they are targeted at different population groups and none of them captures economy-wide inflationary pressures. CPI (Rural), CPI (Urban) and CPI (All India) have been launched recently, yet time series data in respect of new CPI series are not available. In view of these constraints, therefore, the Reserve Bank monitors an array of measures of inflation, both overall and disaggregated components, in the context of the evolving macroeconomic situation to assess the underlying inflationary pressures (RBI 2010).

As indicated earlier, there is no unique way of measuring core inflation. Nevertheless, for policy purposes, most central banks use exclusion-based measures of core inflation as they are easy to explain.

Recognising the simplicity and the practical significance of exclusion-based measures for monetary policy purpose, this study tests a variety of exclusion-based measures for core inflation based on the WPI and CPI-IW indices. For WPI, the monthly data for the period April 2004 to July 2011 (2004-05=100) were used. In the case of CPI-IW, the monthly series with 2001 as base year was used.

A good measure of core inflation should have three properties. First, core measure of inflation should be more stable or less volatile than headline inflation. Second, over a long period of time, average rate of core inflation should match the average rate of headline inflation and there should be no systematic divergence between the two. Also, core inflation should be able to track the trend rate of inflation. Third, if core inflation represents the underlying trend of inflation, it should then be better able to predict total or headline inflation. It is expected that core measures contain more information about the future trend of inflation than the headline inflation.

An attempt, therefore, was made to test all these properties of various exclusion-based measures.

Volatility Groups/Sub-Groups in WPI

To help us test the exclusion based measure of core inflation, volatility of various groups/sub-groups in WPI and CPI was first tested using (i) standard deviation that represents the dispersion around the mean and is the most commonly used measure; and (ii) mean of the absolute monthly change in year-over-year inflation for the period April 2015 to January 2012. This volatility measure scores over the others in terms of its less direct dependence on the persistence of inflation (Lafleche, 2006, Khettry, 2006). At a group level, 'fuel and power group turned out to be the most volatile group as expected, followed by 'primary articles' group. Within 'primary articles', non-food articles and minerals were highly volatile. Interestingly, food sub-group within primary articles was least volatile**.** Within fuel group, coal and mineral oils were very volatile. The 'manufactured products' group was least volatile. However, within manufactured groups, basic metals alloys and metal products exhibited high volatility (Table 3).

Table 3: Volatility in WPI Inflation

Commodity Group/Sub-Group	Weight	Mean	SD	Mean Abs. Chg
All Commodities	**100.0**	**6.6**	**3.0**	**0.7**
I Primary Articles	**20.1**	**10.6**	**5.1**	**1.6**
(A) Food Articles	14.3	10.0	5.1	1.8
(B) Non-Food Articles	4.3	9.7	9.3	2.3
(C) Minerals	1.5	18.4	13.3	7.2
Ii Fuel & Power	**14.9**	**7.9**	**7.8**	**1.7**
(A) Coal	2.1	9.8	10.2	1.5
(B) Mineral Oils	9.4	9.5	10.6	2.4
(C) Electricity	3.5	2.0	2.4	0.6
Iii. Manufactured Products	**65.0**	**4.9**	**2.3**	**0.5**
(A) Food Products	10.0	6.2	4.4	1.1
(B) Beverages, Tobacco & Tob. Products	1.8	7.2	2.8	0.8
(C) Textiles	7.3	3.9	5.1	0.7
(D) Wood & Wood Products	0.6	7.0	2.8	1.2
(E) Paper & Paper Products	2.0	4.1	1.4	0.5
(F) Leather & Leather Products	0.8	3.8	3.0	1.0
(G) Rubber & Plastic Products	3.0	4.3	2.7	0.7
(H) Chemicals & Chemical Products	12.0	4.3	2.8	0.5
(I) Non-Metallic Mineral Products	2.6	6.3	4.1	0.9
(J) Basic Metals, Alloys & Metal Product	10.7	6.8	7.7	1.6
(K) Machinery & Machine Tools	8.9	3.3	1.7	0.3
(L) Transport, Equipment & Parts	5.2	3.2	1.3	0.5

The volatility in domestic metal prices increased in the 2000s *vis-a-vis* the 1990s (Table 4), reflecting the sharp co-movements with global metal prices that have remained high and volatile during the 2000s due to significant demand supply imbalances. The volatility in domestic metal prices such as iron and steel and aluminum was particularly more pronounced during last 3-4 years. Non-food primary articles such as cotton, rubber, oilseeds showed large volatility in the 2000s in line with global prices as trade in such commodities increased. Domestic prices of certain minerals such as copper, zinc, iron ore and crude petroleum also remained volatile due to both domestic demand-supply imbalances and international price shocks.

Table 4: Metal Group Inflation in India

	Mean (per cent)	Standard Deviation
1994-2000	4.5	3.6
2001-2011	7.6	8.6
2008-2011	5.8	9.6

Exclusion Based Core Inflation Measures

Based on the observed volatility of sub-groups as presented in Table 3, seven measures of core inflation were derived:

1. WPI excluding Food: Ex-food
2. WPI excluding fuel group: Ex-fuel
3. WPI excluding food and fuel: Ex-food fuel
4. Non food manufacturing inflation: Non-food mfg
5. WPI excluding fuel group and basic metals and metal products group: Ex-fuel metal
6. WPI excluding fuel group, metal group and non food primary articles: Ex-fuel metal non-foodprim
7. Non metal manufacturing: Non-metal mfg

While the first three represent the simplest and usually applied core inflation measures in most empirical studies, the fourth one, i.e., non-food manufacturing has been recently used by the Reserve Bank as an indicator of core. The fifth, sixth and seventh measures of core inflation were constructed by excluding the highly volatile sub-groups. Apart from 'fuel group' that is the most volatile, two other sub-groups, *viz.,* metals sub-group (under manufactured products group) and non-food primary articles sub-group (under primary articles) were found to be highly volatile. Recognising this, three additional exclusion based measures – one excluding fuel group and metals sub-group and another excluding fuel group, metals sub-group and non-food primary articles sub group – were also considered in the study. Considering that metal prices are more volatile and are more directly linked to international prices than processed food in recent period, non metal manufacturing is also considered as a candidate.

Volatility of Some Exclusion-based Measures

Four different techniques were used to assess volatility of exclusion based measures of core inflation: (i) standard deviation, (ii) coefficient of variation, (iii) mean absolute change and (iv) volatility around trend for the period (Table 5). Standard deviation and mean absolute change have been explained earlier. Coefficient of variation is essentially the standard deviation normalised by mean. The last criterion following Clark (2001) was calculated by taking the volatility around the trend inflation in any given month that is simply estimated by a three-year average of overall inflation, with the average centered on the given month. It may be noted that apart from being a measure of volatility, this measure is also a guide as to how best core inflation tracks the trend rate of inflation. When trend inflation rises, for example, core inflation should increase commensurately. The accuracy with which core inflation tracks trend inflation is measured, on a monthly basis, as the standard deviation of the difference between core and trend inflation. For a core indicator that moves closely with trend, differences tend to be small, so the standard deviation is low.

Table 5: Summary Statistics of Exclusion based Core Inflation WPI Measures

	Weight	Mean	Standard Deviation	Coefficient of Variation	Mean Absolute Change	Volatility around Trend
Headline WPI	100.0	6.4	3.0	0.5	0.7	3.3
WPI Excluding Food	75.7	6.0	3.8	0.6	0.8	4.2
WPI excluding food and fuel	60.8	5.5	3.2	0.6	0.6	3.3
WPI excluding Fuel	85.1	6.4	2.6	0.4	0.6	2.5
Non-food Manufacturing	55.0	4.7	2.7	0.6	0.5	3.0
WPI excluding fuel and metal	74.3	6.3	2.3	0.4	0.6	2.0
WPI excluding fuel, Metal and non-food primary articles	68.6	5.8	1.9	0.3	0.5	1.8
Non metal manufacturing	54.2	4.5	1.4	0.3	0.3	1.3

Normally, for unbiasedness, the core mean should not be very different from the mean of headline inflation. The standard test of equality of means was conducted and it was accepted for 4 out of 7 measures of core (Table 6). With regard to three remaining measures, WPI excluding food and fuel, non-food manufacturing and non metal manufacturing, it was observed that they are biased with core mean being significantly different from that of headline. Notwithstanding the bias that was observed, the difference between headline and core inflation rates over a long period (during the 2000s) was tested to be stationary (Table 7) indicating that core in respect of these also could be considered as a useful predictor of headline inflation (BIS, 2008). Thus, all seven measures could be considered to have broadly satisfied the unbiasedness criterion.

Table 6: Test of Equality of Means

Core Inflation Measures	T statistics@	P-value
WPI Excluding Food	1.43	0.16
WPI excluding food and fuel	0.28	0.78
WPI excluding Fuel	2.40	0.01
Non-food Manufacturing	4.33	0.00
WPI excluding fuel and metal	-0.23	0.82
WPI excluding fuel, Metal and non-food primary articles	1.46	0.15
Non metal manufacturing	-5.33	0.00

@: Test of equality of means based on H0 : $\mu 1=\mu 2$ where $\mu 1$ and $\mu 2$ are means of headline and core inflation measure respectively.

Table 7: Unit Root Test for the Headline Minus Core (HMC) Variable

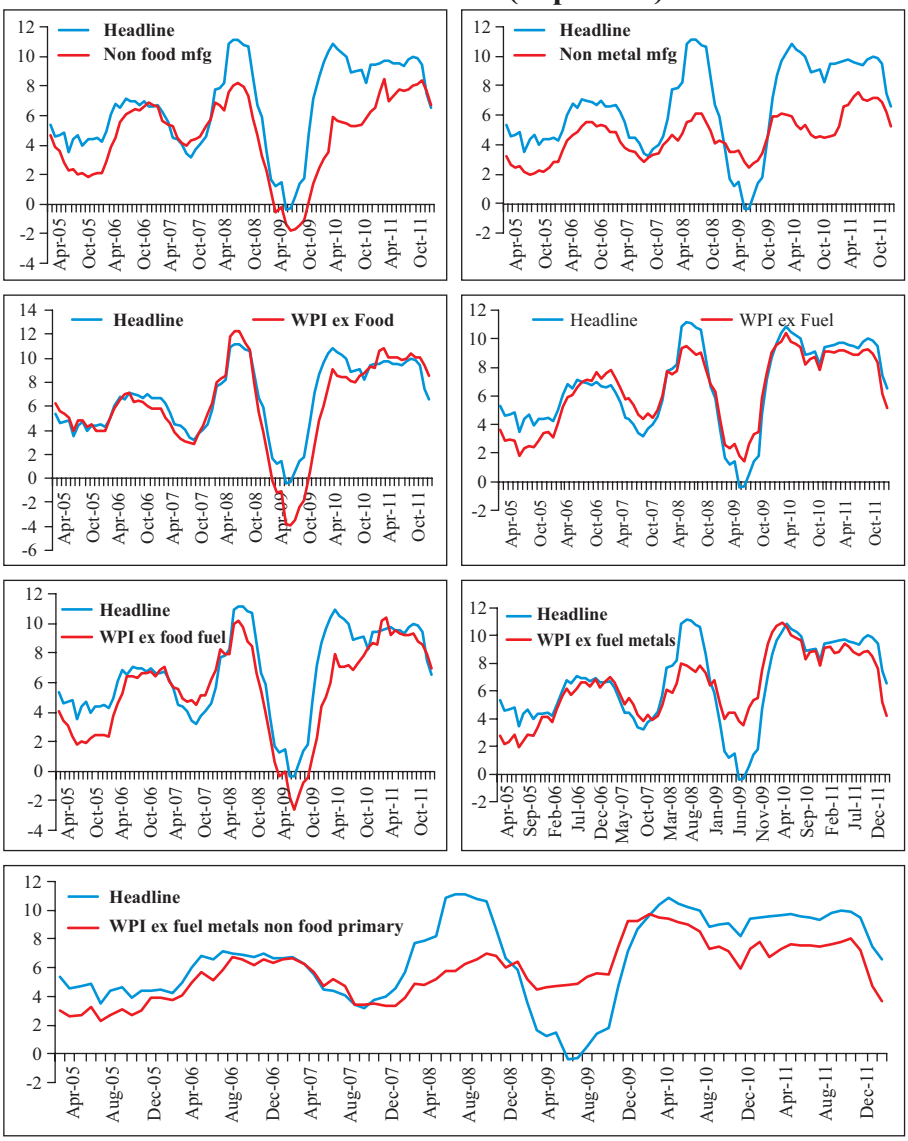
Core Inflation Measure	ADF Test statistic	P value
WPI excluding Food and fuel group	-3.1	0.03
Non-food Manufacturing	-3.2	0.02
Non metal manufacturing	-3.7	0.00

Although most evaluations of core inflation measures do not include breadth as a criterion, some observers believe that, in general, monetary policy should focus on a core measure that even after exclusion is broad enough to capture at least more than 50 per cent of the commodity base. Going by that logic, all the seven exclusion-based measures that were considered in this paper, including non-food manufacturing are broad enough to be considered as candidates for core inflation measures.

Of the seven measures of core inflation that were tested, two measures, *viz.,* WPI ex-food, and ex-food and fuel were more volatile than headline inflation by all criteria. Volatility around trend of these two measures was also higher than the headline WPI. However, of the other five, four core measures *viz.,* ex-fuel, ex-fuel metal, ex-fuel metal non-foodprim and non-metal mfg were less volatile than headline inflation and they also performed well in tracking the trend behaviour. In the case of non-food manufacturing, while volatility was lower in terms of three measures – standard deviation, mean absolute change and volatility around trend – it was higher than headline in terms of coefficient of variation (CV). Notwithstanding the importance of CV, it may be noted that most studies on core inflation emphasise the other three measures of volatility. CV is generally considered better than standard deviation when the units are different so that the standard deviations are normalised by their means. However, given the same unit in the case of core measures, standard deviation that essentially represents the volatility around mean is considered more direct and appropriate for comparison purposes and further normalisation of it by mean is not felt necessary. Overall, considering that non-food manufacturing has performed better than headline in three out of four criteria of volatility, it could be considered as a candidate for core measure along with the other three as long as it satisfies the other core properties well as tested in the following sections.

Table 8 sets out the graphical representation of the 7 exclusion-based core inflation measures.

Table 8: Headline Inflation vs Exclusion-based Core Inflation Measures (in percent)



It is interesting to note that even though food as a group (including both food articles and food products) is more volatile than headline WPI, the core inflation measure arrived at by excluding food from headline is more volatile. This is essentially because of the potentially offsetting co-movements among the other components and the volatility of the food component is not high enough to compensate for that. This has also been observed in case of other economies (Khettry, 2006). Clark (2001) also argues that it could be reasonable to include food prices in a measure of core inflation given that it is less volatile. If the food and energy price shocks are transitory, with upward spikes that are quickly reversed leaving the medium-term aggregate price path unchanged, policymakers would probably like to ignore them. However the latest behaviour shows that food prices in India are developing a structural component because of rise in aggregate demand for certain protein items such as pulses, egg, meat, fish and milk with higher incomes [Gokarn (2010)]. Also, because of better distribution systems, the volatility that was observed in food prices, say, in the 1990s was not observed in the 2000s. Thus, the reduction in volatility in food prices is due to two reasons: reduction in volatility in the transitory component and increasing importance of the structural component determined by increasing income levels. It is the latter that has led food inflation to stabilise at a higher mean level providing the justification for their inclusion in core measures. A study by BIS (2008) also has shown that given the persistent nature of food price inflation in many EMEs, food price inflation's predictability of headline inflation is increasing, which is not the same as that of energy.

As CPI is the headline inflation in many countries and a core CPI based on exclusion-based criteria is usually used by policymakers, an attempt was also made to examine the volatility of CPI-IW (industrial workers) (base 2001) *vis-a-vis* core CPI-IW measure by excluding food, fuel and both (Table 9). Exclusion-based measures of CPI core in India were found to be more volatile than overall CPI inflation in terms of all three criteria, thus suggesting that they cannot be used as core inflation measures.

Table 9: Headline and Exclusion based Core Inflation CPI Measures (April 2005 to October 2011)

Measure	Weight	Mean	Standard Deviation	Mean Absolute Change	Volatility around Trend
Headline CPI- IW	100.0	9.3	2.65	0.69	1.88
CPI Excluding Food	51.5	7.8	3.28	1.01	1.66
CPI excluding Fuel Group	93.6	9.5	2.81	0.76	2.04
CPI excluding food and fuel group	45.1	7.9	3.52	1.16	2.06

Tests of Predictability

An important feature of a good core inflation measure is that it should help predict future headline inflation. In the literature, the most common approach to judge predictability is based on the idea that if current headline inflation differs from the core, overtime headline inflation should move toward core. Divergence between headline and core should be temporary. For example, when current headline inflation is below core, in future, headline inflation should rise and if current headline inflation is above core, it should decline in future.

The predictive content in alternative measures of core inflation can be gauged from regressions of the change in headline inflation from today to some point in the future on the current gap between core and headline inflation. This standard regression model has been used **extensively** in many other studies on core inflation [Clark (2001); Cogley (2002), Lafleche *et al* (2006)]. The advantage of this gap approach model over other studies which simply regress headline inflation on lags of headline and core is that the difficulties posed by persistence in inflation are taken care of by taking the gap approach instead of taking lagged inflation as independent variables [Clark (2001)][1]. The model used is specified below:

$$\pi_{t+h} - \pi_{t} = \alpha + \beta (\pi^{core}_{t} - \pi_{t}) + e_{t} \text{ ..... } (1)$$

1 While some recent papers have attacked the inflation predicting properties of core inflation, it is generally observed that Clark's gap approach is better than the level approach of core inflation with the accuracy being about 80 per cent (Filho, 2011).

where π denotes headline WPI inflation and π^{core} refers to one of the indicators of core inflation, both measured on a year-over-year basis. The parameter *h* can take the values of 1,3,6, 9, 12 and 24 (months), so that the current gap between core and headline inflation is predicting how much overall inflation will change over the next, say, 1 month to 2 years. If core is higher than headline today, in future, headline should increase, implying $\beta>0$. It may be noted that this simple formulation captures only the predictive content of core inflation measures while in reality there may be many other variables potentially useful for forecasting headline inflation. Literature suggests that core inflation measure that is obtained by stripping the volatile elements can capture better the trend/permanent inflation but may not capture its transitory components [Marques *et al* (2003); Armour (2006)]. That is why headline inflation retains good informational content and the predictive power of core inflation measures generally is not very high, which essentially depends upon the nature of commodities excluded, their volatility and their weight in the overall index. However, equation (1) could also be augmented with activity variables such as GDP, industrial production, etc., so that the explanatory power goes up (as in equation (2).

$$\pi_{t+h} - \pi_t = \alpha + \beta (\pi^{core}_t - \pi_t) + \mu x_t + e_t \text{ ..... } (2)$$

where x denotes certain activity variable.

Regression (1) was tested with 3 months, 6 months, 9 months, 12 months and 24 months line horizons. However, the best results were obtained with a forecasting horizon of 9 months (Table 10). The t-statistic for regression coefficients indicate that, among the exclusion based measures that were considered, co-efficient β was positive and statistically significant for WPI Ex-fuel, non-food mfg, WPI Ex-fuel metal, WPI Ex-fuel metal non-foodprim and non-metal mfg. Equations with last three variables had relatively high predictive power. Non-food manufacturing inflation also has some predictive power, but lower than the others. Results with 12 month horizon are set out in Annexure I.

Table 10: Testing for Headline Reverting to Core

Core Inflation Measures (h=9)	Coefficient β (t-statistic)	Regression R^2
WPI Excluding Food	-0.11 (0.18)	0.20
WPI excluding Fuel Group	2.53 (5.6)***	0.33
WPI Excluding Food and Fuel group	0.35 (0.82)	0.02
Non-food Manufacturing	0.72 (2.1)**	0.12
WPI excluding Fuel group and Basic Metal and Metal Products group	2.03 (8.7)***	0.55
WPI excluding Fuel group, Basic Metal and Metal Products group and non-food primary articles	1.77 (9.7)***	0.60
Non metal manufacturing	2.08 (11.7)***	0.68

Figures in parenthesis indicate the t-statistic.
*, ** and *** indicates significance level at 10, 5 and 1 per cent level.

While $\beta>0$ is generally tested to examine whether headline reverts to core inflation [Clark (2001); Lafleche et al (2006)], some studies also specifically test for the condition that $\alpha=0$ and $\beta=1$, *i.e.,* the hypothesis that headline inflation fully reverts to core within the desired time horizon. If α is not equal to 0, it allows for core inflation to be a biased predictor of headline inflation over a given sample period, for example, in cases where commodity price shocks are predominantly on the upside or downside. In the current study as well, we reject at the 5 per cent significance level the joint hypothesis that α equals zero and β equals 1, *i.e.,* the hypothesis that headline inflation fully reverts to core within the time horizon of 9 months. This result is in line with the BIS (2008) study that has shown that for many EMEs, sharp movements in commodity prices have kept the headline higher than core, with α being significantly positive.

Attempt was made to check the predictive power of model (2) by incorporating change in lagged IIP growth as one of the activity variables along with 9-month forecasting horizon (results not reported here). With the inclusion of lagged IIP growth as an activity variable, predictive power increased in all cases, which was on expected lines.

We further investigated whether core inflation measures show any tendency of reverting to headline by considering the reverse regression [as tested in Lafleche et al (2006) and BIS (2008)] *i.e.,* whether current gap between core and headline impacts the gap between future and current core measure of inflation over the same 9 month horizon. Generally, if headline is higher than core measure due to some transient shock, it should not affect the core inflation in future, implying that β should be statistically insignificant. As can be seen from Table 11, all core inflation measures, except non-food manufacturing, show that β coefficient is statistically significantly *albeit* with lower explanatory power than previous regression. This shows that headline inflation is able to explain four measures of core, *viz*., Ex-fuel, Ex-fuel metal, Ex-fuel metal non-foodprim and Non-metal mfg. Thus, these four measures revert to headline inflation as well, thereby suggesting that after some time the supply shocks spill over to these measures of core. In view of this, they cannot serve as good measures of core inflation, despite their high predictive power. However, in the case of non-food manufacturing, it is not possible to reject the hypothesis that $\beta = 0$ suggesting that headline inflation does not influence the non-food manufacturing measure of core.

Table 11: Testing for Core Reverting to Headline

Core Inflation Measures (h=9)	Coefficient β (t-statistic)	Regression R^2
WPI excluding Fuel Group	1.39 (3.6)***	0.17
Non-food Manufacturing	-0.09 (-0.35)	0.02
WPI excluding Fuel group and Basic Metal and Metal Products group	0.81 (4.9)***	0.20
WPI excluding Fuel group, Basic Metal and Metal Products group and non-food primary articles	0.43 (3.5)***	0.16
Non metal manufacturing	0.55 (5.8)***	0.35

Figures in parentheses indicate the t-statistic.
*, ** and *** indicates significance level at 10, 5 and 1 per cent level.

Considering that base metal prices are more volatile and are directly linked to international prices, there is an argument that metals should be excluded from the core. However, as seen above, in case of all the three

different measures excluding metal group from the core that this paper considered, it was observed that even though commodity price impact on certain segments of metal group is high, the metal group is a critical element of core inflation as any core measure of inflation excluding metal group shows a tendency to revert to headline inflation, violating one of the major properties of core. It may also be noted that while volatility could be one criterion to decide on what should be/should not be part of the core, it cannot be the sole criterion. A hypothetical sub-set of WPI can be constructed which could yield the least volatility, but that may not satisfy the basic core properties and hence, may not be of use in the conduct of monetary policy. Besides, the linkage between global and domestic prices is both commodity and period specific. To truly capture the impact of international commodity prices, one has to go beyond the two-digit classification and requires periodic revisions in the core.

Causality

To further confirm the previous results, an attempt was also made to test whether there was any causal relationship between the headline and the core measures of inflation. This is referred to in the literature as the attraction conditions, *i.e.,* core inflation should cause headline but not *vice versa* [Rodrigues *et al* (2002)]. In other words, headline inflation tomorrow will fall towards core inflation today. However, if inflation expectations are not stable, core inflation tomorrow will converge to headline today. If the inflation series are stationary, these attraction conditions can also be checked. Given that the headline and core inflation measures are stationary, Granger causality tests were performed to assess the direction of causality in the long run. Core inflation measure should generally be able to Granger cause headline and not *vice versa*. Of the seven measures tested, only non-food manufacturing WPI satisfies the condition at 5 per cent level of significance. While some other measures such as Ex-food and Ex-food fuel do not Granger cause headline inflation, some other measures such as Ex-fuel metal and Ex-fuel metal non-foodprim exhibited a two-way causality, suggesting that shock to headline inflation get translated into expectation of higher inflation down the road leading to generalised inflation (Table 12). No clear results on the direction of causality were observed in the case of Non-metal manufacturing also. Thus, Granger causality suggests that only non-food manufacturing satisfies the attraction condition and corroborate the earlier findings.

Table 12: Granger Causality Test Results

Core Inflation Measures	Headline does not Granger cause Core		Core does not Granger cause Headline	
	F statistic	P value	F statistic	P value
WPI Excluding Food	0.94 (5)	0.46	1.65 (5)	0.16
WPI excluding Fuel Group	1.84 (4)	0.13	2.10 (4)	0.09*
WPI Excluding Food and Fuel group	1.86 (3)	0.14	1.87 (3)	0.14
Non-food Manufacturing	1.86 (3)	0.14	2.85 (3)	0.05**
WPI Excluding Fuel and metal group	5.06 (3)	0.00***	4.06 (3)	0.02**
WPI Excluding Fuel group, Metal Group and non food primary articles	3.58 (3)	0.02**	2.10 (3)	0.09*
Non metal manufacturing	0.87 (5)	0.50	1.2 (5)	0.32

Lag length in the model chosen on the basis of SIC criteria in given in the brackets.
*, ** and *** indicates significance level at 10, 5 and 1 per cent level.

A inflation persistence test was also performed for the core inflation measures in respect of which headline inflation tended to converge to core inflation (Annex II). It was observed that while all the four measures of core inflation tested were persistent, non-food manufacturing inflation turned out to be relatively more persistent than others.

Thus, non-food manufacturing inflation that represents 55 per cent of the weight in headline WPI satisfies all the laid down criteria of a core measure. This also implies that 45 per cent of inflation component consists of non-core component which represents price movements caused by temporary shocks. In most countries, the share of core component is much larger, generally about 80 per cent (Table 13, next page). This suggests that inflation management for monetary policy is much more challenging in India than in other countries.

Section V

Summing Up and Some Final Reflections

The headline inflation rate is not wholly under the control of the central bank in the short run. Various economic developments beyond the control of the central bank may generate short run or transitory changes in the inflation rate. Hence, policymakers in many countries focus on the more persistent movements in inflation, called core inflation. A good measure of core inflation helps separate the noise

from signals about current and future trends in inflation. If price fluctuations from non-monetary sources can be excluded, the resulting core inflation could be regarded as a measure of the inflation that is the outcome of policy. Therefore, measure of core inflation could be considered more controllable by the monetary authority than published inflation rates.

Table 13: Weight of the Core Inflation measure: Cross Country

Country	Core Inflation Measure	Weight
Canada	CPIX that excludes 8 most volatile components like fruits, vegetables, gasoline, natural gas, fuel oil, mortgage interest costs, intercity transportation and tobacco products	82.2
Thailand	Core CPI excludes fresh food and energy prices which include rice, flour, cereal products, vegetables, fruits, electricity charges, cooking gas, and gasoline.	75.95
Philippines	CPI excluding rice corn fruits vegetables, LPG, Kerosene, Oil, Gasoline, Diesel	81.6
Peru	CPI excluding 9 volatile items like food, fruits and vegetables, urban transport	78.8
United States	CPI excluding food and energy	77.7
Chile	CPI excluding 20 per cent with higher (-) variations and 8 per cent with higher (+) variations	72

The Indian economy has been subject to repeated and significant supply side shocks from time to time. Examples of such shocks in the recent period were drought of 2009 and oil price rise in 2010 that kept headline inflation persistently high. In this context, the use of core inflation for monetary policy purposes assumes importance, particularly in terms of communicating to public what the Reserve Bank's actions are trying to achieve. The Reserve Bank uses non-food manufacturing as an indicator of core. However, several other countries use headline minus food and energy as measures of core inflation. In this backdrop, an attempt was made to assess as to which measure of core inflation is more relevant in the Indian context.

For a core inflation measure to serve its purpose, it must satisfy three criteria. One, core measure of inflation should be more stable or less volatile than headline inflation. Two, over a long period of time,

average rate of core inflation should match the average rate of headline inflation and there should be no system divergence between the two. Also, core inflation should be able to track the trend rate of inflation. Three, if core inflation represents the underlying trend of inflation, it should then be better able to predict total or headline inflation.

'Fuel and power' group of WPI was found to be the most volatile in India, followed by primary articles and manufactured products. Within fuel group, mineral oils and coal sub-groups were more volatile. Within primary articles, minerals and non-food articles sub-groups were more volatile. Significantly, food articles sub-group was about half volatile as the non-food articles group and about 1/3rd less volatile than the minerals sub-group. Interestingly, studies in respect of many other EMEs also find that food inflation is less volatile than fuel. This perhaps is due to the reason that the rise in food prices is becoming persistent.

Considering the volatility of various groups/sub-groups of WPI, the study tested seven measures of core inflation, *viz.,* WPI excluding food; WPI excluding fuel; WPI excluding food and fuel; non-food manufacturing; WPI excluding fuel and basic metals and metal products; WPI excluding fuel, metal group and non-food primary articles; and Non-metal manufacturing. These measures were tested for three properties, *viz.*, (i) volatility; (ii) unbiasedness and capability to track trend; and (iii) predictive power. A measure of core inflation, if it is to serve its intended purpose, should not revert to headline inflation. This condition, therefore, was also tested.

Of the seven measures tested, two measures, *viz.,* WPI excluding food; and WPI excluding food and fuel did not perform well in terms of volatility, tracking the trend behaviour and predicting the future inflation. However, the remaining five measures, *viz.,* WPI excluding fuel; non-food manufacturing; WPI excluding fuel and metal group; WPI excluding fuel, metal and non-food primary articles and Non-metal manufacturing inflation broadly satisfied the conditions relating to volatility, unbiasedness and tracking the trend, and predictability.

To test the predictive power of measures of core inflation, change in headline inflation from today to some points in the future (6 months,

9 months, 12 months and 24 months) was regressed on the current gap between core and headline inflation. This is the standard regression model used in many other studies. Although equations were tested with different time horizons results, however, were better with a time horizon of 9 months. That is, headline inflation converges to four core measures of inflation in nine months. However, headline does not covert to core measure of inflation fully. It appears that sharp movements in commodity and food prices have kept the headline higher than the core. Explanatory power of regression with only core as the independent variable is generally not very high. The explanatory power of the equation improves with the inclusion of activity variables.

Even though the five measures satisfied the three criteria, it needs to be ensured that these measures of core inflation also satisfy the condition they do not revert to headline inflation. It will suggest that supply side shocks spill over to these core measures of inflation as a result of which inflation becomes generalised. Such measures, as a result, could not serve as good measures of core inflation even though they may have high predictive power. Of the four measures, it was found that all measures, except non-food manufacturing, revert to headline inflation. Non-food manufacturing measure does not reverse to headline. It, thus, performed well in all the criteria.

Granger causality tests were also carried out to confirm that headline inflation reverts to core and not *vice versa.* Of the seven measures tested, only non-food manufacturing WPI satisfies the causality condition. While two measures, *viz.,* WPI ex-food and WPI ex-food and fuel do not Granger cause headline inflation, two other measures such as WPI ex-fuel metal; and WPI ex-fuel metal non-food primary articles, exhibited a two-way causality, suggesting that shock to headline inflation get translated into expectation of higher core inflation (WPI ex-fuel metal and WPI ex-fuel metal non-food primary articles) down the road leading to generalised inflation. No clear results on the direction of causality were observed in the case of Non-metal manufacturing. Inflation persistence tests showed that while most core inflation measures considered were persistent, non-food manufacturing inflation turned out to be relatively more persistent than others.

The Study also tested core measure of inflation based on CPI-IW by excluding food and fuel separately and also together. However, measures of inflation based on CPI-IW were more volatile than the CPI inflation.

Thus, non-food manufacturing, which the Reserve Bank uses as a measure of demand side pressures, is the only measure which satisfies all the properties of a core measure. One weakness of exclusion-based measure is that the appropriate components to exclude may change overtime. Central banks, therefore, have tried to address this concern by two ways: (i) periodically re-evaluating the behaviour of prices and (ii) tracking a range of core inflation measures instead of one. It, therefore, is felt that all the seven measures of core and some others as are considered necessary need to be reviewed periodically.

Non-food manufacturing component represents 55 per cent of the weight in WPI. It, therefore, suggests that 45 per cent of inflation component consists of non-core component which represents price movements caused by temporary shocks. In most countries, the share of core component is much larger, generally about 80 per cent. This suggests that inflation management by monetary policy is much more challenging in India than in other countries.

A core measure of inflation is not an end in itself, but rather a means to achieve low and stable inflation. Given the loss of information content in the construction of core inflation and the relatively greater public acceptability of the headline inflation, the core measures are useful only as indicators of the underlying inflationary process rather than as policy targets. The measure of headline inflation is based on the solid theory of the cost of living. Thus, containing headline inflation, and not core inflation, should be the focus of monetary policy. That is, core inflation measures cannot substitute for measures of headline inflation. However, they could be used to serve as a short-term operational guide for monetary policy.

Annex I: Testing for Headline reverting to Core at 12 months horizon

Core Inflation Measures (h=12)	Coefficient β (t-statistic)	Regression R^2
WPI Excluding Food	-0.11 (0.18)	0.20
WPI excluding Fuel Group	2.6 (5.8)***	0.36
WPI Excluding Food and Fuel group	-0.01 (0.10)	0.01
Non-food Manufacturing	0.68 (1.90)*	0.10
WPI excluding Fuel group and Basic Metal and Metal Products group	2.17 (9.64)***	0.61
WPI excluding Fuel group, Basic Metal and Metal Products group and non-food primary articles	1.97 (12.4)***	0.72

Figures in parenthesis indicate the t-statistic.
*, ** and *** indicates significance level at 10, 5 and 1 per cent level.

Annex II: Persistence of the Exclusion-Based Core Measures

Core Inflation Measures	Based on SBC		Based on AIC	
	Extent of Persistence	Chosen lag length	Extent of Persistence	Chosen lag length
WPI excluding Fuel Group	0.926*	1	-	1
Non-food Manufacturing	0.942*	1	-	1
WPI excluding Fuel group and Basic Metal and Metal Products group	0.929*	1	0.917*	12
WPI excluding Fuel group, Basic Metal and Metal Products group and non-food primary articles	0.922*	1	0.919*	12

* Denotes significance at 1 per cent level.

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