A Volatility and Persistence-Based Core Inflation*

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Abstract

Intuitively core inflation is understood as a measure of inflation where noisy price movements are avoided. This is typically achieved by either excluding or downplaying the importance of the most volatile items. However, some of those items show high persistence, and one certainly does not want to disregard persistent price changes. The non equivalence between volatility and (the lack of) persistence implies that when one excludes volatile items relevant information might be discarded. Therefore we propose a new type of core inflation measure, one that takes simultaneously into account both volatility and persistence. The evidence shows that such measures far outperform those based on either volatility or persistence. The latter have been recently advocated in the literature.

Keywords: Core inflation, inflation, persistence, volatility, triple weighted.

JEL Classification: C43, E31, E52

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“For example, during the previous decade when energy prices were rising and the economy was expanding, core inflation was consistently lower than headline inflation -- meaning that core inflation was a poor indicator of headline inflation for several years”

James Bullard (2011)

1 – Introduction

For most people core inflation is almost synonymous of an inflation measure that excludes volatile price changes. Indeed, core inflation is typically regarded as headline inflation less food and energy, two of the most volatile items in the goods basket. For most people volatile items just add noise to price indices.

Along time many different measures of core inflation have arisen. However, most of them take the approach above as correct and differ simply in the precise way that volatile items are treated. This is the case, for example, of the trimmed mean core, where a given percentile of the tails of the individual price distribution is excluded.¹

In this case, instead of excluding the same items in every period of time, as typical exclusion core measures do, items to be discarded are chosen following an objective statistical criterion. As a consequence, different items are excluded at different points in time.

Subsequently, given the failure of those measures in some important dimensions [see, for example, Cecchetti (2006) and OECD (2005)], the so-called volatility measures – among others – emerged. In such cases volatile items are downplayed but not excluded.

One problem with the above approaches is that they all bear in common one flawed tenet: that when one assesses inflationary pressures volatile prices just bring noise to the outlook. However, volatility is not synonymous of noise.

Another crucial dimension in which prices changes should be analysed is persistence. If changes in the price of a given good are known to be very persistent then those changes are likely to convey relevant information about inflationary pressures. Moreover, persistence also increases the chances of relevant second round effects. Hence, assuming that those changes are merely informationless noises, as the above approaches do, is a mistake that could imply important costs to policymakers.

¹ Obviously, one can also take different percentiles from each tail.
Indeed, unfortunately for both core builders and policymakers evidence shows that volatility and persistence are not equivalent dimensions of price changes. As a matter of fact, many items considered to be too volatile, and hence usually discarded, are also highly persistent. An insightful and ironic example is precisely the price of oil, which is typically excluded in core inflation measures.

Figure 1 shows the behaviour of the real price of oil from 1999 to early 2011. As it can be seen, its relative price movements are usually long lasting. This is important since long lasting relative price changes are likely to produce relevant second round inflationary effects in the price chain. Moreover, excluding such items will create a permanent wedge between core and headline price indices. Therefore, based on the evidence below, one is not advised to exclude oil prices from core measure, no matter how volatile they are.

Figure 1
Brent Crude Oil Spot Prices (US$ 1999 Prices)

(* Prices deflated by the U.S. CPI.

The steep and protracted increases in commodity prices in recent years are a testimony of the relevance and pervasiveness of such fact. Not surprisingly, Bryan and Cecchetti (1993) found evidence for the U.S. that headline inflation is a better predictor of itself than the traditional (ex-food & energy) core. More disturbing

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2 For dreadful evidence on how the exclusion of pre-determined items could produce a permanent and large wedge between core inflation and headline inflation see section 4 of da Silva Filho (2008).

3 One can argue that oil prices should be excluded since they are “…for the most part, beyond the control of the central bank.” (Blinder, 1997). However, this fact does not prevent pressure in those prices from disseminating through the economy. Moreover, using such rationale all commodity prices should be excluded, and not only oil prices.
evidence comes from Gavin and Mandal (2002), whose findings suggest that food prices do contain useful information about trend inflation in the U.S.

Despite the importance of the persistence dimension, only recently the core inflation literature has begun to pay attention to it. Indeed, Cutler (2001) seems to be the first one to have done so, inspired by the comments of Blinder (1997). A couple more papers are those of Bilke and Stracca (2008), for the Euro area, and Rangasamy (2009), for South Africa. However, those papers took the “all or nothing” approach. That is, they calculated core inflation using only the persistence dimension, while the volatility dimension was completely ignored.

Thus, this paper proposes a new methodology for building core inflation measures: one that takes into account simultaneously both volatility and persistence. In such a case the original weights of each item in not only resized according to their volatility but are also further re-weighted by their persistence. In that way both volatility and persistence are taken explicitly into consideration. For example, if a given good is both highly persistent and volatile its reweighing could end up producing just minor differences, in contrast to the situation in which just one criterion is used. However if a good is very volatile but little persistent or little volatile but highly persistent then its relative importance in the core will be, respectively, much lower and higher than using just the persistence or volatility criteria alone.

We test this new type of core inflation using Brazilian data. This should provide a very stringent test since not only Brazil is one of the leading emerging economies, with a well diversified economy, but is usually subjected to many shocks. Preliminary results show that this new type of core inflation measure is competitive relative to those currently used by the Brazilian Central Bank (BCB) and not only outperforms volatility core measures but also those proposed by Cutler (2001), Bilke and Stracca (2008) and Rangasamy (2009), which focus on persistence only. That is, it outperforms measures that take individually either volatility or persistence.

The paper is organised as follows: Section 2 shows evidence, using Brazilian data, that volatility and persistence are not redundant dimensions. Section 3 derives a family of volatility-persistence core inflation measures. Section 4 shows the results and assesses the performance of the proposed cores. Section 5 concludes the paper.
2 – The Non Equivalence Between Volatility and (the Lack of) Persistence

The implicit assumption behind removing volatile items from core inflation measures is not only that those changes are volatile but mainly temporary. If this is the case then the decision makes sense since, say, a 10% increase in the price of lettuce due to heavy rain is likely to be completely reversed soon, once weather conditions are back to normal. However, this might not be the case, as Figure 1 has shown for oil prices.

Figure 2
IPCA Items’ Persistence and Volatility (1999 – 2010)

Figure 2A displays the scatter plot between volatility and persistence for all the 52 IPCA items. Two aspects stand out. First, there is one clear outlier: the item “Tubers, Roots and Legumes”. Note that this item is the perfect example of what kind of item should be excluded from a core measure, given that it is both highly volatile

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4 More rigourously, the relative price increase is expected to be completely reversed. 
5 Figure panels are lettered notionally as A, B, C and D, row by row. 
6 IPCA stands for Broad Consumer Price Index. It is the official inflation targeting index in Brazil. Its components are defined, respectively, from the most to the least aggregation level as group, sub-group, item and sub-item. 
7 Section 4 explains how persistence is measured. Volatility is measured by the standard deviation of the difference between a given item’s inflation and overall inflation, unless otherwise stated. The persistence and relative volatility coefficients for each item are shown in Table A.1 in the Appendix
and has no persistence at all. Second, it is also obvious that volatility and persistence are not correlated. Ideally, as argued, if one is willing to exclude volatile items in the price index the relation should be negative. Note, however, that this might yet be the case when the sample is restricted to the most volatile items.

Thus, Figure 2B shows the evidence when the sample is divided into two halves and only those items whose volatility is above the median are considered. As it can be seen the evidence remains the same, as no correlation is found. Figure 2C goes one step further and presents the evidence when only those items that are traditionally excluded (i.e. food and energy) are considered. Although negatively correlated, the correlation is not only small but insignificant as well. Thus, the exclusion of those items is likely to imply loss of information. Finally, Figure 2D normalizes Figure 2C’s items and singles out those that besides being highly volatile are also highly persistent. Those are not good candidates for exclusion, despite the common practice of doing so.

Therefore, given the evidence above it seems a sensible strategy to look at both volatility and persistence when choosing those items in the goods basket that should be excluded or re-weighted.

3 – Taking into Account both Volatility and Persistence

One key issue when taking persistence into account is obviously how to measure it. While the standard deviation is usually accepted to be a good measure of volatility, things are not that simple with persistence. Indeed, the literature lists several methods for estimating persistence, such as the largest autoregressive root (e.g. Cogley and Sargent, 2001), the number of times the mean of inflation is crossed during a given period (Marques, 2004) and the half life (Pivetta and Reis, 2007). However, the most common method is the sum of the autoregressive coefficients in an univariate inflation equation. According to Andrews and Chen (1994) this method provides the best scalar measure of persistence.

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8 However, given its outlier status, it is excluded from panels B, C and D.
9 It should be mentioned that while taking persistence formally into account is a new issue in the core inflation literature, there is a large literature concerned with the dynamic properties of inflation, mainly its persistence (see Fuhrer, 2010). Indeed, the efforts to better understand the persistence of inflation, its causes, as well as the effects of aggregation culminated in the creation of the Inflation Persistence Network (IPN) (see Altissimo et al., 2006).
Therefore, in this paper the sum of the coefficients of an AR\((q)\) model is used as a measure of persistence.\(^{10}\) For each IPCA item \(j\) we run the following recursive regression using monthly data:

\[
\pi_{j,t} = \alpha_j + \sum_{i=1}^{q_j} \rho_{j,t-i} \pi_{j,t-i} + \epsilon_{j,t}
\]  
(1)

where \(\pi_{j,t} \equiv \ln P_{j,t} - \ln P_{j,t-1}\) is item’s \(j\) monthly inflation and \(P_{j,t}\) is the monthly IPCA (Broad Consumer Price Index) price index for item \(j = 1, 2, \ldots, 52\).

The degree of persistence is given by:

\[
\rho_{j,t}^* = \sum_{i=1}^{q_j} \rho_{j,t-i}
\]  
(2)

where \(q_j\) is the optimal lag length whose method of calculation is discussed in the next section.

Once volatility and persistence are estimated one can calculate the “whole family” of volatility and persistence-based core inflation measures, which is done below.

The headline IPCA inflation is computed as follows

\[
\pi_t = \sum_{j=1}^{J} w_{j,t} \pi_{j,t}
\]  
(3)

where \(w_{j,t}\) is the original expenditure weight in time period \(t\) for item \(j\), given that \(\sum_{j=1}^{J} w_{j,t} = 1\).

In general, a given core inflation measure \(k\) can be described by.\(^{11}\)

\[
\pi_{t}^{c(k)} = \sum_{j=1}^{J} w_{j,t}^{k} \pi_{j,t}
\]  
(4)

\(^{10}\) Note that it is still common to find in the literature the use of a simple AR(1) model to measure persistence. However, this procedure is correct only if the statistical process has a very short memory, otherwise persistence would be mismeasured.

\(^{11}\) This general expression fits basically most of the core inflation approaches, since they are basically methods that reweigh the prices included in the headline index. To a summary of alternative ways to build core inflation measures see Silver (2007) and Wynne (2008).
where \( \pi_t^{c(k)} \) is the core inflation at period \( t \), where \( k \) indicates the approach used to obtain the new set of normalized weights \( \tilde{\omega}_t^k \) such that \( \sum_{j=1}^{J} \tilde{\omega}_j^k = 1 \) for each \( t \).

We begin describing the volatility–persistence family of core inflation measures by the two single-weighted measures that are based on either volatility (\( v \)) or persistence (\( p \)). In these cases the weights are given by\(^{12}\)

\[
\tilde{\omega}_j^v = \frac{\sigma_j^v}{\sum_{j=1}^{J} \sigma_j^v} \quad \text{(5)}
\]

\[
\tilde{\omega}_j^p = \frac{\rho_j^p}{\sum_{j=1}^{J} \rho_j^p} \quad \text{(6)}
\]

where \( \sigma_j^v \) and \( \rho_j^p \) are, respectively, the non-normalised relative volatility and the degree of persistence of item \( j \) at time \( t \).

One possible shortcoming of these measures is they do not take into account the expenditure weights which are used to compute the headline index. In order to avoid this potential problem, two other measures of the same family arise

\[
\tilde{\omega}_j^{dw(ve)} = \tilde{\omega}_j^v w_{j,t} \quad \text{(7)}
\]

\[
\tilde{\omega}_j^{dw(pe)} = \tilde{\omega}_j^p w_{j,t} \quad \text{(8)}
\]

As they are combinations of two sets of weights they have been called in the literature as double weighted measures of core inflation. The double weighted measure that combines volatility and expenditure weights is indicated by the superscript \( dw(ve) \), shown by (7)\(^{13}\), while the measure that uses persistence instead of volatility weights is indicated by the superscript \( dw(pe) \), shown by (8).

As discussed in the previous section, the non equivalence between volatility and (lack of) persistence implies that the combination of the two dimensions is likely to provide valuable information about underlying inflation. Therefore, it is

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\(^{12}\) The volatility weighted index that is obtained using \( \tilde{\omega}_j^v \) is also known as “neo-Edgeworthian” index.

\(^{13}\) Since March 2010, the Brazilian Central Bank have been releasing in its quarterly Inflation Report a measure of double weighted core inflation based on volatility. The methodology of this core measure is described in da Silva Filho and Figueiredo (2011).
straightforward to think about another member of the family, where the final weights combine both persistence and volatility $dw(pv)$:

$$\hat{\omega}_{j,t}^{dw(pv)} = \hat{\omega}_{j,t}^p \hat{\omega}_{j,t}^{pv} \quad (9)$$

However, those measures can also be criticized by also not taking into account the original expenditure weights of the headline index, even though both the volatility and persistence dimensions are being considered. Therefore, another member of the family naturally arises: the measure that combines the three sets of weights: expenditure, volatility and persistence (i.e. a triple weighted core measure). This measure is indicated by the superscript $tw(pve)$, and the weight is given by

$$\hat{\omega}_{j,t}^{tw(pve)} = \hat{\omega}_{j,t}^p \hat{\omega}_{j,t}^{pv} \hat{w}_{j,t} \quad (10)$$

Note, however, that there is an alternative way of combining these three elements into a measure of core inflation. It is based on the forecast error conditional volatility of each item. Since the conditional volatility comes from an autoregression, the degree of persistence has already been taken into account. More precisely, the conditional volatility is given by the root mean square error (RMSE) for each IPCA item from the one-step ahead forecasting error using the AR($q$) model given by (1).

$$\hat{\omega}_{j,t}^{tw(rmse)} = \hat{\omega}_{j,t}^{rmse} \hat{w}_{j,t}, \text{ where } \hat{\omega}_{j,t}^{rmse} = \frac{\sum_{j=1}^{J} \hat{r}_{mse,j,t}}{rmse_{j,t}} \quad (11)$$

Note that, in practice, this measure is a double weighted measure, since it combines the set of weights obtained by the inverse of the root mean square error with the expenditure weights. However, since the forecast error is conditional on the degree of persistence, this measure is de facto a triple weighted measure. Hence, this measure is indicated by the superscript $tw(rmse)$.

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14 We would like to thank Fabio Araujo from the Research Department of the Brazilian Central Bank, who suggested this approach.
4 – Data and Estimation Strategy

In order to calculate the weights listed above the IPCA disaggregated into its 52 items is used.\textsuperscript{15} The estimation sample goes from January 1995 to December 2010. Note that this sample includes three changes in the structure of the expenditure weights. Therefore, adjustments were made so as to make the data consistent along the sample.

The relative volatility of each item of the IPCA is calculated as follows:

$$\sigma_{j,t} = \frac{1}{n-1} \sqrt{\sum_{i=1}^{n} (\tilde{\pi}_{j,t-i} - \bar{\pi}_{j,t})^2}$$ \hspace{1cm} (12)

where: \( \bar{\pi}_{j,t} = \frac{1}{n} \sum_{i=1}^{n} \tilde{\pi}_{j,t-i} \) and \( \tilde{\pi}_{j,t} = (\pi_{j,t} - \pi_t) \).

The subscripts \( j \) indexes each item in the goods basket, while \( n \) gives the number of periods used in the calculation of the standard deviation of each item’s relative inflation. A moving average of 48 months is used to calculate the item’s volatility. This time-span seems to be a good compromise between a period long enough to produce reliable inferences and a period short enough to allow recent changes in persistence to be captured. Otherwise the series could be too erratic or take very long to reflect changes in volatility pattern. Note that since \( j = 48 \) the working sample starts in January 1999 and the number of observations amounts to 144.

In order to compute the degree of persistence for all the 52 IPCA items firstly each item’s inflation is tested for seasonality. If seasonality is accepted the item’s inflation is seasonally adjusted. Then, for each item, equation (1) is recursively estimated beginning in January 1999.

The autoregressive order \( q_j \) was chosen so as to minimize the Schwarz information criterion. In the search over \( q_j \) twelve lags were used. However, given that results were unstable for certain items, we decided to chose the median optimal lag length (i.e. the lag length that is equal or greater than the chosen ones in fifty percent of the time) as the optimal lag. Also, note that when \( \rho_{j,t} \) was found to be negative it has been set to be zero, as in Cutler (2001) and Bilke and Stracca (2008). Finally, the weights were normalised so as to sum one at each period.

\textsuperscript{15} See footnote 6.
5 – Results

Besides calculating and assessing the behaviour of the volatility-persistence family of core inflation measures, it is also interesting to compare them with the measures currently calculated by the Central Bank of Brazil, named IPCA-EX, IPCA-DP and IPCA-MS.

The IPCA-EX is an exclusion-type core inflation measure, where the excluded items are defined based on both statistical and economic criteria. The IPCA-DP is a doubled weighted measure where each item’s original expenditure weights are reweighed using the item’s relative volatility, as in (7). The IPCA-MS is a trimmed mean core where the price of those items that changes infrequently during the year – mainly regulated & administered prices changes – are “smoothed”. That is, before the trim those price changes are distributed along the month in which they occur and in the following eleven months. Hence the name smoothed trimmed mean.

Figures 3 and 4 show the comparison between year-over-year headline inflation and both the currently calculated cores and the family of volatility-persistence measures described in the previous section. Note that, from the seven measures calculated according to the weights given by (5) to (11), only five are displayed below, since those constructed using the “all or nothing approach” (i.e. taking into account only volatility or persistence) presented very poor results.

This is already an important result and should be highlighted from the outset, since the persistence-based core inflation build according to (6) has been increasingly advocated in the literature.

The two graphs placed on the upper half of Figure 4 show two double weighted measures: the ones build from persistence and expenditure weights, $dw(pe)$, and persistence and volatility weights, $dw(pv)$. The third double weighted measure from the family, $dw(ve)$, is shown in Figure 3 (IPCA-DP). The two graphs placed on the lower half of Figure 4 display the two triple weighted measures (i.e. persistence, volatility and expenditure), which differ in the way they are calculated.

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16 These two measures have been published since the Inflation Report of March 2010 and their methodologies are fully described in da Silva Filho e Figueiredo (2011).
17 This measure has been published since the Inflation Report of March 2001. For a complete description of the methodology, see Figueiredo (2001).
As it can be seen, the IPCA-MS displays the smoother path among all cores – an expected result given the way it is built – while both the IPCA-DP and the DW-PE
lie very close to actual inflation. By this criterion the latter do not add extra useful information on the inflationary process, evidence that could imply that one should take simultaneously into account all three dimensions analysed: expenditure, volatility and persistence, otherwise there will be loss of information.\textsuperscript{18} Indeed, when the three dimensions are combined the paths of headline and core inflation are reasonably different from each other, even tough they remain somewhat close to one another in the second half of the sample.

It is both informative and revealing to analyse the differences in the weights of the nine IPCA groups across the several measures of core inflation.\textsuperscript{19} Table 1 shows the weights for all nine groups that make the IPCA as well as for those items that comprise the “food and energy” goods (shaded lines). As can be seen, there are many differences – sometimes large ones – between the original set of weights used in headline inflation and those used to build the core inflation measures.\textsuperscript{20}

\begin{table}
\centering
\caption{Weights for IPCA groups and selected items using volatility–persistence measures of core inflation (Jul 2006 to Dec 2010)}
\begin{tabular}{lccccc}
\hline
Groups & \multicolumn{5}{c}{Weights} \\
& \multicolumn{2}{c}{Headline IPCA} & \multicolumn{3}{c}{Double weighted} & \multicolumn{2}{c}{Triple weighted} \\
\hline
Food items & 22.0 & 18.2 & 23.7 & 20.0 & 24.4 & 17.2 \\
Food at Home & 14.6 & 6.4 & 12.8 & 13.8 & 5.6 & 6.4 \\
Meals out of Home & 7.5 & 11.8 & 10.9 & 6.2 & 18.8 & 10.8 \\
Housing & 13.3 & 15.1 & 16.1 & 15.0 & 21.5 & 14.6 \\
Household Fuels and Energy & 4.7 & 2.6 & 2.4 & 1.4 & 1.4 & 1.8 \\
Household articles & 4.4 & 3.6 & 5.3 & 13.8 & 4.5 & 2.9 \\
Apparel & 6.6 & 7.3 & 7.2 & 12.0 & 5.6 & 7.1 \\
Transportation & 19.9 & 17.4 & 16.7 & 5.0 & 14.9 & 15.6 \\
Motor Fuels & 4.9 & 1.5 & 2.7 & 0.5 & 0.9 & 1.6 \\
Health and personal care & 10.8 & 13.8 & 11.6 & 18.4 & 12.9 & 19.1 \\
Personal expenses & 9.9 & 12.1 & 6.8 & 7.0 & 8.9 & 12.5 \\
Education & 7.1 & 7.5 & 8.7 & 7.1 & 3.9 & 8.9 \\
Communication & 6.0 & 5.1 & 3.9 & 1.5 & 3.4 & 2.3 \\
\hline
& 100 & 100 & 100 & 100 & 100 & 100 \\
\hline
\end{tabular}
\end{table}

For example, the two triple-weighted core inflation measures tend to drastically reduce the importance of “Food at Home”, “Household Fuels and Energy” and “Motor Fuels” items, which usually are excluded from traditional (ex food & energy) exclusion measures of core inflation. On the other hand they put a much

\textsuperscript{18} An alternative interpretation could be that the optimal core is actually so close to actual inflation that one should focus on headline inflation (i.e. the headline inflation is its own best core).

\textsuperscript{19} See footnote 6. The weights of all IPCA items are shown in Table A.1 in Appendix.

\textsuperscript{20} The weights in Table 1 are given by the average of monthly weights between July 2006 and December 2010. This sample represents that one covered by the latest POF (Household Budget Survey), the survey that determines the structure of the expenditure weights for the IPCA.
greater weight on the item “Meals out of home”, which is much less volatile than the “Food at Home” item. Note that both items are excluded from the U.S. exclusion core.

Table 2 displays some descriptive statistics for the seven core inflation measures depicted by Figures 3 and 4. Note that all measures underestimated headline inflation during the sample. The monthly bias ranges from 0.05 p.p. for TW-RMSE to 0.02 p.p. for IPCA-DP and DW-PE. In terms of volatility, all measures have lower standard deviations than headline IPCA. Indeed, for the vast majority of available methods core inflation will be less volatile than inflation by construction, and this result should does not mean much.

### Table 2
Descriptive statistics: IPCA and Core Measures (Jan 1999 to Dec 2010)

<table>
<thead>
<tr>
<th>Monthly data</th>
<th>Mean</th>
<th>Median</th>
<th>Standard Deviation</th>
<th>Correl. IPCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headline IPCA</td>
<td>0.55</td>
<td>0.48</td>
<td>0.43</td>
<td>1.00</td>
</tr>
<tr>
<td>IPCA-DP</td>
<td>0.53</td>
<td>0.48</td>
<td>0.30</td>
<td>0.91</td>
</tr>
<tr>
<td>IPCA-EX</td>
<td>0.52</td>
<td>0.47</td>
<td>0.29</td>
<td>0.83</td>
</tr>
<tr>
<td>IPCA-MS</td>
<td>0.51</td>
<td>0.47</td>
<td>0.21</td>
<td>0.68</td>
</tr>
<tr>
<td>DW: persistence and expenditure</td>
<td>0.53</td>
<td>0.47</td>
<td>0.34</td>
<td>0.93</td>
</tr>
<tr>
<td>DW: persistence and volatility</td>
<td>0.51</td>
<td>0.45</td>
<td>0.34</td>
<td>0.80</td>
</tr>
<tr>
<td>TW: persistence, volatility and expenditure</td>
<td>0.52</td>
<td>0.48</td>
<td>0.27</td>
<td>0.81</td>
</tr>
<tr>
<td>TW: rmse</td>
<td>0.50</td>
<td>0.47</td>
<td>0.23</td>
<td>0.84</td>
</tr>
</tbody>
</table>

As to the correlation between each core inflation measure and headline inflation, the highest values come from the IPCA-DP and the DW-PV (0.91 and 0.93, respectively) – the two least biased measured – an evidence already suggested by Figures 3 and 4. However, note that one could argue that at such high levels of correlation the associated measures do not provide extra useful information besides that already contained in headline inflation. In this case, one could argue once more that the “optimum” core would conceptually be so close to headline inflation that actual inflation would be the best “core” of itself. Note that in this criterion the IPCA–MS displays the lowest correlation (0.68) among all measures. This result as well as the lowest standard deviation is due to the smoothing scheme utilized by this approach.

In order to check the ability of each core inflation measure to track the trend of headline inflation, the root mean squared error (RMSE) of each measure (in relation to a centered moving average using 13, 25 and 37 months) was calculated. Then the relative performance of each core’s RMSE (in relation to headline inflation’s RMSE)
was calculated. The results are displayed in Table 3 and, as can be seen, they are robust as to whether the moving average is calculated using 13, 25 or 37 months.

It should be firstly called to attention that the persistence-based measures that have been proposed in the literature have a very poor performance in this criterion. Indeed, note that the persistence-expenditure core advocated by Babestskii, Coricelli and Horvath (2007) and Rangasamy (2009) present, by far, the worst performances of Table 3. Moreover, as mentioned earlier, the results from the single-weighted persistence-based core advocated by Cutler (2001) and Bilke and Stracca (2008) have not been presented given their dismal overall performances. That situation repeats itself here, as its performance is even worse than the double-weighted persistence-based measures. On the other hand, the two proposed measures (TW-PVE and TW-RMSE) that take into account both volatility and persistence (along with expenditure weights) easily outperforms the above cores, in accordance to our initial intuition.

### Table 3

<table>
<thead>
<tr>
<th>Measures of core inflation</th>
<th>Relative RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13-month</td>
</tr>
<tr>
<td>IPCA-DP</td>
<td>0.67</td>
</tr>
<tr>
<td>IPCA-EX</td>
<td>0.59</td>
</tr>
<tr>
<td>IPCA-MS</td>
<td>0.48</td>
</tr>
<tr>
<td>DW: persistence and expenditure</td>
<td>0.70</td>
</tr>
<tr>
<td>DW: persistence and volatility</td>
<td>0.70</td>
</tr>
<tr>
<td>TW: persistence, volatility and expenditure</td>
<td>0.59</td>
</tr>
<tr>
<td>TW: rmse</td>
<td>0.55</td>
</tr>
</tbody>
</table>

When all core measures are compared the one with the best performance in this criterion is the smoothed trimmed mean core. However, this result should be seen with great care since, as warns by Silva Filho and Figueiredo (2011), this core inflation measure produce errors with very poor dynamics, since there are long periods in which it sizably under and over “predicts” inflation, an evidence clearly depicted by Figure 3.

Therefore, overall the core inflation measures proposed in this paper not only clearly outperform those based on persistence that have been recently advocated in the literature, but are also extremely competitive in relation to those cores currently calculated by the BCB.
5 – Concluding Remarks

The concept of core inflation is intimately linked to that of volatility. Indeed, most approaches for building core inflation measures are simply different ways of either excluding or downplaying volatile items. The rationale behind such approaches is, therefore, the same: that volatile items basically brings noise to the assessment of the inflation outlook. However, this conclusion has a serious flaw.

Another key – and usually forgotten – dimension over which price changes should be analysed is persistence. If changes in the price of a given good are known to be very persistent then those changes are likely to convey relevant information about inflationary pressures, as they are more likely to get all the way through the price chain (i.e. second round effects). This importance has recently begun to be recognized as some economists are advocating core inflation measures based on item’s persistence.

A problem with such proposals, though, is that they take an “all or nothing” approach, since they ignore completely the volatility dimension. However, the evidence presented in the paper shows that volatility and (the lack of) persistence are not equivalent dimensions, which means that if one focus on either volatility or persistence alone relevant information will be thrown away.

Therefore, a new type of core inflation measure is proposed: one that takes simultaneously into account both volatility and persistence. The evidence presented here shows that this new approach far outperforms the persistence-based measures that have been proposed in the literature, which present a very poor performance. The same holds for those measures that focus only on volatility.

The results have far-reaching consequences not only for those building core inflation measures but mainly for those using them, since the way policymakers understand and face the inflation outlook could change if they take into account both volatility and persistence.
References


Table A.1 - Measures of persistence and volatility for IPCA items and the weights for different core measures

<table>
<thead>
<tr>
<th>Code</th>
<th>Items</th>
<th>Persistence</th>
<th>Relative volatility</th>
<th>IPCA</th>
<th>IPCA-DP</th>
<th>P&amp;E</th>
<th>P&amp;V</th>
<th>PV&amp;E</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1101</td>
<td>Rice, beans and corn</td>
<td>0.51</td>
<td>3.70</td>
<td>0.95</td>
<td>0.14</td>
<td>0.78</td>
<td>0.32</td>
<td>0.12</td>
<td>0.13</td>
</tr>
<tr>
<td>1102</td>
<td>Flour and prepared flour mixes</td>
<td>0.64</td>
<td>1.42</td>
<td>0.58</td>
<td>0.26</td>
<td>0.84</td>
<td>1.75</td>
<td>0.41</td>
<td>0.28</td>
</tr>
<tr>
<td>1103</td>
<td>Tubers, roots and legumes</td>
<td>0.03</td>
<td>6.62</td>
<td>0.62</td>
<td>0.04</td>
<td>0.08</td>
<td>0.02</td>
<td>0.00</td>
<td>0.04</td>
</tr>
<tr>
<td>1104</td>
<td>Sugar and sweets</td>
<td>0.55</td>
<td>3.05</td>
<td>0.75</td>
<td>0.15</td>
<td>0.82</td>
<td>0.61</td>
<td>0.18</td>
<td>0.19</td>
</tr>
<tr>
<td>1105</td>
<td>Green vegetables</td>
<td>0.02</td>
<td>3.17</td>
<td>0.17</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
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<tr>
<td>1106</td>
<td>Fruits</td>
<td>0.09</td>
<td>2.29</td>
<td>0.83</td>
<td>0.15</td>
<td>0.49</td>
<td>0.21</td>
<td>0.07</td>
<td>0.13</td>
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<tr>
<td>1107</td>
<td>Meats</td>
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<td>1.72</td>
<td>2.05</td>
<td>0.69</td>
<td>1.66</td>
<td>0.51</td>
<td>0.42</td>
<td>0.58</td>
</tr>
<tr>
<td>1108</td>
<td>Fish</td>
<td>0.02</td>
<td>1.33</td>
<td>0.26</td>
<td>0.11</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.10</td>
</tr>
<tr>
<td>1109</td>
<td>Processed meat and fish</td>
<td>0.52</td>
<td>1.01</td>
<td>0.72</td>
<td>0.41</td>
<td>0.60</td>
<td>1.16</td>
<td>0.34</td>
<td>0.41</td>
</tr>
<tr>
<td>1110</td>
<td>Poultry and eggs</td>
<td>0.32</td>
<td>2.43</td>
<td>1.08</td>
<td>0.23</td>
<td>0.82</td>
<td>0.40</td>
<td>0.17</td>
<td>0.30</td>
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<tr>
<td>1111</td>
<td>Dairy products</td>
<td>0.44</td>
<td>1.88</td>
<td>2.04</td>
<td>0.61</td>
<td>1.44</td>
<td>0.42</td>
<td>0.35</td>
<td>0.63</td>
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<tr>
<td>1112</td>
<td>Bakery products</td>
<td>0.59</td>
<td>1.28</td>
<td>1.91</td>
<td>1.02</td>
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<td>1.84</td>
<td>1.43</td>
<td>1.15</td>
</tr>
<tr>
<td>1113</td>
<td>Fats and oils</td>
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<td>2.53</td>
<td>0.42</td>
<td>0.10</td>
<td>0.51</td>
<td>0.75</td>
<td>0.13</td>
<td>0.13</td>
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<td>1114</td>
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<td>1.63</td>
<td>2.03</td>
<td>1.75</td>
<td>2.43</td>
<td>1.63</td>
<td>1.92</td>
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<tr>
<td>1115</td>
<td>Canned food</td>
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<td>0.90</td>
<td>0.16</td>
<td>0.11</td>
<td>0.18</td>
<td>1.95</td>
<td>0.12</td>
<td>0.10</td>
</tr>
<tr>
<td>1116</td>
<td>Spices, seasoning, condiments and sauces</td>
<td>0.44</td>
<td>0.71</td>
<td>0.38</td>
<td>0.30</td>
<td>0.34</td>
<td>1.43</td>
<td>0.22</td>
<td>0.28</td>
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<tr>
<td>1201</td>
<td>Food away from home</td>
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<td>0.49</td>
<td>7.46</td>
<td>11.78</td>
<td>10.93</td>
<td>6.25</td>
<td>18.83</td>
<td>10.79</td>
</tr>
</tbody>
</table>

Appendix