Triple-Filter core inflation: a measure of the inflation trajectory

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Abstract: In countries with high inflation, as is the case of Brazil, the traditional cores inflation do not seem to deliver much information about the general level of prices. Therefore, we present a new measure, the Triple-Filter core inflation, which filters inflation in three ways: trimmed mean with smoothed items, seasonal adjustment and moving averages. The results allow us to say that the Triple-Filter core inflation, in addition to providing more information about the inflation trajectory than traditional core inflation, provides a more up-to-date view on the state of inflation than the accumulated inflation over 12 months.

Keywords: CPI, core inflation, smoothed trimmed mean, moving average, seasonal adjustment.

1 Introduction

The core inflation measures are used by monetary authorities as a tool to measure the stabilization of prices in the economy. Despite being a popular term among policymakers, there is still no consensus on its definition nor on what it plans to capture. The consensus is that the change in the price level, despite being a monetary phenomenon, can be influenced also by non-monetary events such as, for example, bad weather conditions that make food prices more expensive because of a reduced supply of these products to the population. However, since this event is temporary, with an improving climate food prices may fall again. This transient behavior thus adds noise to the inflation rate and, therefore, the monetary authorities should be able to distinguish between a transient effect and a persistent effect on the price level when making their decisions. Given this, an inflation measure free of such interference is desirable.

A measure of inflation free of such noise, which aims to show the persistent price movement or, in other words, the inflation trend, can be understood as the core inflation (Bryan & Cecchetti, 1994). Thus, efforts are directed to identify and remove such noise of aggregate inflation. In the 1970s, the core was understood as inflation after removing the food and energy components (*CPI less food and energy* of the United States), precisely because they are very volatile components. Over time, however, several other authors suggested ways of removing the noise from the rate of inflation. Bryan & Cecchetti (1994), for example, suggested estimators of limited influence (median and trimmed inflation) to calculate inflation. Such estimators are more robust to extreme variations that add noise to inflation, and allow a more satisfactory measure for the persistent component of inflation as compared to the core excluding the food and energy items. Dow (1994) suggested not to delete any price calculation but to recalculate its weight in proportion to the inverse of its volatility (double weight). So very volatile items have low weight in the calculation of the core inflation. In 2002, Cogley showed that the cores estimated by methods already cited still preserved high frequency variations and therefore suggested an exponential smoothing-based method that returned a measure of inflation softer than the alternative measures. There are still other estimated cores for other statistical models, such as Quah & Vahey (1995), that used multivariate systems in terms of other macro-economic variables to extract the trend of inflation and Bradley et al. (2015) and Stock & Watson (2015), who used models of unobservable components to estimate the core.

As can be seen, there are different methods that allow an estimation of the trend of inflation. However, the construction of a core alone does not guarantee its usefulness, and, on this basis, scholars have proposed methods to qualify the performance of these measures (Wynne, 1999; Clark, 2001; Rich & Steindel, 2007). Generally, the following characteristics in a core inflation are expected: (a) *Low volatility*: it is expected that the core is less volatile than the aggregate inflation; (b) *Transparency and communication with the public*: it is desirable that the core is easy to replicate and to explain to the public, making the presentation of the core dialogue simpler. As shown da Silva Filho & Figueiredo (2014), most core inflations disclosed by central banks in the world are of the exclusion, double weight or trimmed mean types. Few institutions have more complex statistical methods to calculate the core, and if such are presented, also disclose the simplest core inflation; (c) *Historical review*: it is expected that the measure does not require an historical review, that is, does not change the past or its tendency with the insertion of new data. This makes a consistent history of inflation counted using the core inflation; (d) *Capture the inflation trend*: according to Clark (2001), for a core measure to capture the trend of inflation, the core and headline inflation should present similar means, ensuring that the core does not overestimate or underestimate the long-term trend of inflation, and the trajectory of the core must follow closely the headline inflation trend. Thus, when the trend of inflation rises, so will the core. The procedures applied for the evaluation of these two criteria can be found in more detail in Clark (2001); Cogley (2002); Rich & Steindel (2007); (e) *Inflation forecasting*: It is also expected the core will help in inflation forecasts, although the literature shows that this is not a trivial task. However, some authors (Clark (2001); Cogley (2002); Rich & Steindel (2007)) used a simple linear regression to assess whether the difference between the core and the headline inflation in the current time helps predict how much headline inflation will change from the current time to a few months from now.

Several of these authors say there is no consensus on which is the best core inflation since the core do not present all of the expected characteristics (usually the items (a) and (d)) and therefore recommend the use of a set of indicators with caution, knowing the capacity of each to extract information. These findings corroborate the reason central banks do not disclose only a single measure of core and also not lean on just a single tool for decision making.

To show the usefulness of this type of measure, this article aims to present a new core inflation that meets the criteria already presented, being useful to identify the current price trend. The measure is applied to the consumer price index (CPI) of the Getulio Vargas Foundation (FGV), but can be replicated in any existing consumer price index.

To fulfill the objective of the article, it is organized as follows: in the next section is an analysis of the core measures disclosed in Brazil, mainly checking the five expected core criteria. Section 3 presents the proposed methodology, that is, how the Triple-Filter core inflation is calculated. Section 4, in addition to presenting the proposed measure, compares it with the conventional core measures especially in showing the ability of the Triple- Filter core to capture the trajectory of the headline inflation and provide information about the current state of the general level of prices. Finally, section 5 has the final considerations.

2 An analysis of the core measures disclosed in Brazil

Currently, there are six core inflation measures disclosed in Brazil. Five of them are estimated by the Central Bank of Brazil (BCB) and have reference to the IPCA[1], the official rate of inflation in the country estimated by IBGE (2016a). The other measure refers to the CPI[2], estimated by IBRE (2016a) of the Getulio Vargas Foundation (FGV). The measures[3] vary from Jan/1999 to Mar/2016 and are shown in Figure 1. It is easy to see that all preserve a lot of noise in their history, with the trimmed mean core softer in the field but still suggesting indications of seasonality.

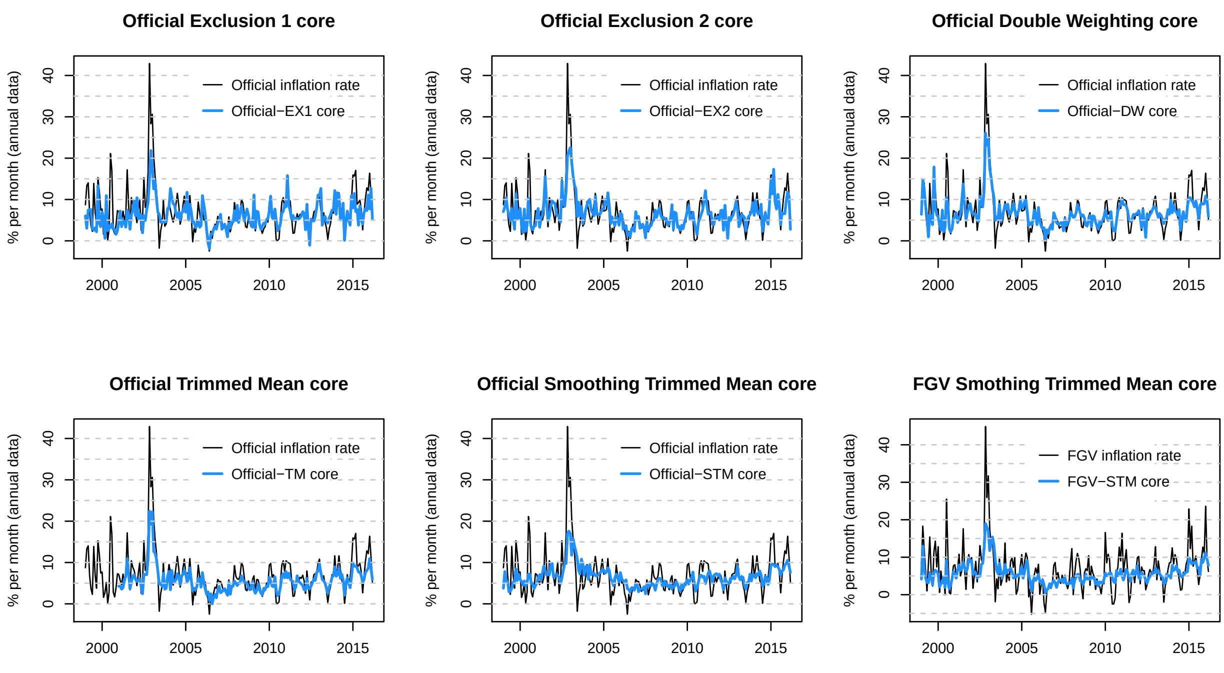

Figure 1: Core for the IPCA (IBGE) and the CPI (FGV/IBRE) - Jan/1999 to Mar/2016 (annual data)

To understand and analyze the trajectory of inflation in Brazil, however, these cores should be less noisy and also without seasonality (seasonal test[4], available in Table 1, suggests, with 95% confidence, the existence of a seasonal component in all core measures), as this component can mask the real trajectory of a time series. But despite this, these cores may still be suitable with regard to the characteristics desirable in view in section 1. The assessment of such measures is made below.

[1]the Broad Consumer Price Index (IPCA) (IBGE, 2016b).

[2]the Consumer Price Index (CPI) (IBRE, 2016b).

[3]Official-EX1: Core for the IPCA that excludes monitored items and food at home; Official-EX2: Core for the IPCA which excludes the ten most volatile items; Official-DW: Core for the IPCA using double weighting method; Official-TM: Core for the IPCA using trimmed mean; Official-STM: Core for the IPCA using trimmed mean method with smoothed items; FGV-STM: Core for the CPI using trimmed mean method with smoothed items.

[4]X-13ARIMA-SEATS seasonality test (U.S. Census Bureau, 2013).

	qs-stat	p-value
Official-EX1	21.65	0.0000
Official-EX2	28.57	0.0000
Official-DW	10.12	0.0063
Official-TM	7.08	0.0290
Official-STM	12.27	0.0021
FGV-STM	28.11	0.0000

H_0: There is no seasonality in time series.

Table 1: QS Seasonality Test

Table 2 displays descriptive statistics for the six core measures. All measurements have lower variability to the reference inflation index, highlighting the trimmed mean cores. It is noteworthy that all cores also have an average lower than the inflation rate, indicating they underestimate the long-term trend of price variation, and this average difference is more pronounced for the trimmed mean Official Brazilian CPI (Official-TM) and for the smoothed single core released by FGV (FGV-STM). This difference is mitigated when considering only the ten most recent years of information, however, it still represents a high bias around 1 percentage point for these two last mentioned cores. The Official-DW is the core that has a lower bias, however, one of the highest variability. The cores by exclusion are the ones in which the bias is not significant when assessing the most recent ten years. Except for this, all cores are classified as biased to the historical average of inflation.

Table 3 presents the RMSE (Root Mean Square Error) between the core measures and the long-term trend of inflation, the latter obtained by the centered moving average for 36 months on the reference inflation index. Centered moving averages are often used to estimate the trend of a time series, however, it is important to pay attention to the fact that the most recent period, which is the most interesting to assess the inflation trajectory, cannot be rated due to the loss of the most recent information in the calculation. The cores that demonstrate the lowest RMSE, among the whole set of measures, are the two core inflations by trimmed mean with smoothed items: Official-STM and FGV-STM.

	Mean	Median	Standard Deviation	Bias	p-value
Official inflation rate	**7.02 (6.07)**	**6.29 (5.79)**	**5.23 (3.55)**	-	-
Official-EX1	6.15 (5.89)	5.54 (5.41)	3.28 (2.95)	-0.86 (-0.18)	0.01 (0.19)
Official-EX2	6.65 (5.84)	6.17 (5.66)	3.53 (2.78)	-0.37 (-0.23)	0.00 (0.23)
Official-DW	6.76 (6.01)	6.29 (5.91)	3.47 (2.19)	-0.26 (-0.06)	0.00 (0.00)
Official-TM	5.71 (5.11)	5.28 (5.03)	2.98 (2.11)	-1.31 (-0.96)	0.00 (0.00)
Official-STM	6.47 (5.77)	6.17 (5.54)	2.46 (1.78)	-0.55 (-0.30)	0.00 (0.00)
FGV inflation rate	**6.90 (6.11)**	**6.42 (5.98)**	**6.00 (4.75)**	-	-
FGV-STM	5.66 (5.05)	5.28 (4.97)	2.81 (1.98)	-1.24 (-1.07)	0.00 (0.00)

Note: the statistics were obtained based on annualized measures. Figures in parenthesis are calculated considering the history of Apr/2006 to Mar/2016 (ten years), while others consider the historical series starting in Jan/1999. The p-value refers to the bias test (F test) of null hypothesis $H_0: \alpha = 0$ and $\beta = 1$, where α and β are linear regression coefficients between inflation and the core.

Table 2: Descriptive statistics and evaluation of bias to the core inflations measures of Brazil

In addition to the proximity of trends, it is also necessary to verify that the core has a long-term relationship with inflation, that is, it is expected that when the inflation trend increase (decreases), the core also

	Official trend	FGV trend
Official inflation rate	**4.85**	-
Official-EX1 core	3.27	-
Official-EX2 core	2.95	-
Official-DW core	3.04	-
Official-TM core	2.96	-
Official-STM core	1.95	-
FGV inflation rate	-	**5,56**
FGV-STM core	-	2.42

Note: the statistics were obtained based on annualized measures.

Table 3: RMSE between trend inflation and cores

increases (decreases). To verify this relationship you need to apply the following unit root and cointegration tests. The ADF unit root test (Table 4) applied to the entire series (Jan/1999 to Mar/2016) suggests that some measures are stationary, for example, Official inflation rate and CPI (FGV inflation rate). However, the same test applied only to the ten most recent years (values in parentheses in the same table), indicates that all measures are considered as a stochastic trend with a 95% confidence level, indicating the lack of inflation stability in Brazil during this recent period. Based on the results for these two time horizons, it was considered that the series are not stationary. The ADF test was reapplied to all the differentiated measures and results, with 95% confidence, indicating that they are stationary.

Since all measurements are integrated of order 1, i.e., become stationary from the first differentiation, the Johansen cointegration test was applied between the cores and the reference inflation rate. The results (Table 5) indicate that all cores have a long-term relationship with the inflation indices, but these results may differ depending on the lag considered in the test application.

As there is supposedly a long-term relationship for all measures, the adjustment dynamics can be assessed. The evaluation is made in the analysis of the coefficients λ and λ_c of the equations (1) and (2) (Mehra & Reilly, 2009), indicating how the inflation and the core adjust when there is some difference between them. It is expected that λ is negative and λ_c is zero, so we can conclude that inflation moves towards the core and

	τ-stat	Critical Value	Lag	Conclusion
Official inflation rate	-3.929 (0.262)	-2.88 (-1.95)	07 (09)	reject H_0 (do not reject H_0)
Official-EX1	-2.237 (-2.364)	-2.88 (-2.88)	11 (11)	do not reject H_0 (do not reject H_0)
Official-EX2	-2.737 (-2.169)	-2.88 (-2.88)	13 (08)	do not reject H_0 (do not reject H_0)
Official-DW	-3.486 (0.133)	-2.88 (-1.95)	07 (13)	reject H_0 (do not reject H_0)
Official-TM	-3.126 (1.085)	-2.88 (-1.95)	07 (15)	reject H_0 (do not reject H_0)
Official-STM	-2.149 (1.546)	-2.88 (-1.95)	12 (10)	do not reject H_0 (do not reject H_0)
FGV inflation rate	-3.096 (1.032)	-2.88 (-1.95)	12 (14)	reject H_0 (do not reject H_0)
FGV-STM	-2.290 (3.044)	-2.88 (-1.95)	12 (11)	do not reject H_0 (do not reject H_0)

H_0: There is unit root (time series is not stationary). Figures in parenthesis are calculated considering the history of Apr/2006 to Mar/2016 (ten years), while others consider the historical series starting in Jan/1999.

Table 4: Augmented Dickey & Fuller Test

Eigenvalue	Test Statistic	Critical Value	No. of cointegration equations	Conclusion
Official inflation rate & Official-EX1 core				
0.077	15.52	14.26	None	reject H_0
0.025	5.00	3.84	At most 1	reject H_0
Two cointegrating equations at the 5% level.				
Official inflation rate & Official-EX2 core				
0.198	44.94	14.26	None	reject H_0
0.089	18.89	3.84	At most 1	reject H_0
Two cointegrating equations at the 5% level.				
Official inflation rate & Official-DW core				
0.097	20.24	14.26	None	reject H_0
0.069	14.22	3.84	At most 1	reject H_0
Two cointegrating equations at the 5% level.				
Official inflation rate & Official-TM core				
0.209	41.60	14.26	None	reject H_0
0.080	14.90	3.84	At most 1	reject H_0
Two cointegrating equations at the 5% level.				
Official inflation rate & Official-STM core				
0.142	29.79	14.26	None	reject H_0
0.017	3.48	3.84	At most 1	do not reject H_0
One cointegrating equation at the 5% level.				
FGV inflation rate & FGV-STM core				
0.237	54.09	14.26	None	reject H_0
0.031	6.27	3.84	At most 1	reject H_0
Two cointegrating equations at the 5% level.				

Table 5: Johansen Cointegration Test.

the core does not move toward inflation.

$$\Delta\pi_t = \alpha + \lambda\mu_{t-1} + \sum_{k=1}^{p} \alpha_k \Delta\pi_{t-k} + \varepsilon_t \quad (1)$$

$$\Delta\pi_t^c = \alpha + \lambda_c\mu_{t-1} + \sum_{k=1}^{p} \alpha_k \Delta\pi_{t-k}^c + \varepsilon_t \quad (2)$$

where:
π_t is the inflation rate (annualized monthly percent change);
π_t^c is the core inflation (annualized monthly percent change);
μ_{t-1} is the cointegration vector, which comes down to $\pi_t - \pi_t^c$ if the core is unbiased;
$\Delta = 1 - L$ in which L is the lag operator such that $L^n y_t = y_{t-n}$.

The results shown in Table 6 suggest that the adjustment dynamic is given appropriately only for the FGV-STM core, that is, it can be concluded that only inflation moves towards the core and not the other way (λ significant and negative and λ_c not significant). However, the same analysis for the ten most recent years (figures in brackets in Table 6) does not suggest the expected dynamic for any of the measures. In some cases, for example Official-EX1 and Official-TM cores, the dynamic occurs in two possible ways: the core moves toward inflation (λ_c significant) and inflation moves towards the core (λ significant and negative).

	λ	$\bar{R}^2$	λ_c	$\bar{R}^2$
Official-EX1	-0.2943*** (-0.2337*)	0.2034 (0.1237)	0.2423*** (0.2039***)	0.4610 (0.5633)
Official-EX2	-0.2305* (0.1642)	0.1747 (0.2262)	0.3279*** (0.3099**)	0.2772 (0.3173)
Official-DW	-0.3692* (0.0615)	0.1816 (0.2196)	0.2450** (0.2303*)	0.1627 (0.2843)
Official-TM	-0.3256* (-0.3746**)	0.1082 (0.1341)	0.2936*** (0.1894*)	0.1951 (0.1561)
Official-STM	-0.3523*** (0.0834)	0.1747 (0.2204)	0.1571*** (0.1445**)	0.2264 (0.3087)
FGV-STM	-0.6172*** (-0.1477)	0.3124 (0.5007)	-0.0037 (0.0663)	0.0942 (0.2609)

Note: significance levels: 5% (*), 1% (**) e 0.1% (***).
The statistics were obtained based on annualized measures. Figures in parenthesis are calculated considering the history of Apr/2006 to Mar/2016 (ten years), while others consider the historical series starting in Jan/1999.

Table 6: Dynamic between inflation and core inflation - Jan/1999 to Mar/2016

In order to verify that the difference between the core and the inflation in the current time (t) helps predict inflation in 1 and 2 years ($t+12$ and $t+24$), it was estimated using the equation (3).

$$\pi_{t+h} - \pi_t = \alpha + \beta(\pi_t^c - \pi_t) + \varepsilon_t \quad (3)$$

where:
π_t is the inflation rate (annualized monthly percent change);
π_t^c is the core inflation (annualized monthly percent change).

By observing the results in Table 7, we note that, for the two forecast horizons ($h = 12, 24$), the trimmed mean cores inflation have a greater predictive capacity when considering the complete historical series than the most recent 10 years. However, this prediction capacity drops considerably for the most recent period, which leads one to question the usefulness of the core today. Considering the complete historical series, for a year ahead forecast ($h = 12$), the Official trimmed mean with and without smoothing stands at (adjusted R^2 equals 35%) while for two years ahead ($h = 24$) the Official-TM takes on $\bar{R}^2$ equals 42%. For the past 10 years, the FGV-STM core has the highest predictive ability for a year ahead forecast (adjusted R^2 equals 16%) and Official-TM core is the most appropriate for two years ahead (adjusted R^2 equals 25%). Although the values are relatively low, by the simplicity of the model, such values are acceptable and are also useful to compare the performance of the cores between them.

		Jan/1999 to Mar/2016			Apr/2006 to Mar/2016		
		$\bar{R}^2$	β	**t-stat**	$\bar{R}^2$	β	**t-stat**
$h = 12$	Official-EX1	0.29	0.888 (0.1001)	8.871***	0.07	0.406 (0.1293)	3.141***
	Official-EX2	0.28	1.172 (0.1341)	8.744***	0.04	0.389 (0.1646)	2.365*
	Official-DW	0.21	1.238 (0.1690)	7.343***	0.09	0.634 (0.1698)	3.737***
	Official-TM	0.35	1.467 (0.1521)	9.641***	0.13	0.656 (0.1524)	4.302***
	Official-STM	0.35	1.008 (0.0971)	10.380***	0.13	0.516 (0.1164)	4.433***
	FGV-STM	0.30	0.910 (0.0989)	9.207***	0.16	0.469 (0.0969)	4.842***
$h = 24$	Official-EX1	0.22	0.814 (0.1108)	7.345***	0.11	0.663 (0.1697)	3.910***
	Official-EX2	0.21	1.029 (0.1471)	6.999***	0.11	0.759 (0.1932)	3.932***
	Official-DW	0.19	1.244 (0.1859)	6.212***	0.14	1.100 (0.2409)	4.567***
	Official-TM	0.42	1.503 (0.1387)	10.836***	0.25	1.272 (0.1970)	6.460***
	Official-STM	0.29	0.935 (0.1081)	8.645***	0.19	0.817 (0.1496)	5.458***
	FGV-STM	0.27	0.925 (0.1113)	8.307***	0.20	0.678 (0.1225)	5.532***

Note: β standard deviation in parenthesis; t-stat is the test statistic of β parameter.

Table 7: Forecasting inflation rate using core inflation

With the results presented, we conclude that no core inflation measure has optimum performance when considering all the analyzed criteria. All core inflations underestimate the inflation trend, and this is the most expressive feature in the cores inflation by trimmed mean, however these are less noisy than the Official-EX1, Official-EX2 and Official-DW cores inflation, which underestimate less. All the measures also have a long-term relationship with inflation, but this relationship does not occur properly for any of them, except for the FGV-STM. However, this ratio can also be questioned because the ability to attract inflation is considered a failure for the most recent period of data. The forecast capacity is most relevant for the trimmed mean cores inflation, although it can be questionable in the most recent period.

In view of this, it is worth the effort to find another measure of core inflation that satisfies the criteria used in this study.

3 Trend Measure: Triple-Filter Core inflation

Viewing the analysis in section 2, we notice the poor performance of the currently disclosed core inflations in Brazil, and the trimmed mean with smoothed items are the ones that stand out when considering bias, forecast, adjustment dynamics and proximity of the aggregated inflation. Similar conclusions can be found in other studies of the core measures in Brazil (da Silva Filho & Figueiredo, 2011; Santos & Castelar, 2013; da Silva Filho & Figueiredo, 2014). Because of this, three procedures are suggested in order to improve the performance of a core by smoothing trimmed mean and find a trend measure for inflation:

1. Recalculate the trimmed mean with smoothed items core inflation changing the number of items that

will be removed in the lower and upper tails;

2. Remove the identified seasonality;
3. Apply a short filter of moving averages to remove the high frequency component remaining after seasonal adjustment.

The smoothing trimmed mean core inflation excludes from the price index the items with the highest and lowest variations in the period. So, every month it is decided whether an item remains or is excluded from the index calculation. By using smoothing, it allows that some items have a chance to not be summarily excluded. For example, administered items that have less frequent adjustments, but at significant times. Smoothing divides the variation of these predefined items in 12 and also distributes in a 12-month horizon. The smoothed items account for about 37% of the FGV inflation basket[5].

Changing the number of items that will be removed from the core calculation is intended to approximate the average of the core inflation to the average of the headline inflation, eliminating the average bias. Removal of the seasonal component is important to avoid misinterpretation regarding the time series trend. To deseasonalize the series, the seasonal adjustment program X-13ARIMA-SEATS (U.S. Census Bureau, 2013) was used. However, even with seasonal adjustment, a time series may still be considered volatile, precisely because the purpose of seasonal adjustment is only to remove the seasonal component and not the high frequency component (irregular/noise). Economic analysts generally use smoothing techniques to try to capture the supposed tendency of a volatile time series, such as, for example, moving averages. If there is seasonality in the time series, usually the order 12 is used (variation accumulated in 12 months) or higher to analyze the trajectory of inflation (as is done in Brazil). The downside here is that the current inflation is very affected by past values. In this article, however, after removal of seasonality, one can employ a moving average of short order (three months) for the purpose of removing only high-frequency variations. Thus, current inflation is little influenced by the past (equation (4)). After these three filters (extreme variations, seasonality, noise), there is the (annualized) Triple-Filter core inflation (TF core inflation).

$$\pi_{i,t}^{TF} = \left[\left(\prod_{i=0}^{2} \frac{\pi_{i,t-i}^{AJ}}{100} + 1 \right)^{\frac{12}{3}} - 1 \right] \times 100. \tag{4}$$

Where:
$\pi_{i,t}^{AJ}$ is the core inflation seasonally adjusted (monthly percent change);
$\pi_{i,t}^{TF}$ is the annualized Triple-Filter core.

The methodology presented will be applied only to the FGV inflation rate (CPI) but can be easily replicated for any consumer price index. The first filtering methodology excludes items with extreme variations

[5]The items that are smoothed in the trimmed mean methodology are:Residential Rental, Residential Housing, Residential Electricity Tarifs, Gas Bottles, Piped Gas Rate, Residential Water and Sewerage Rates, Dentist, Doctor, Psychologist, Health Insurance, Other Health Professionals, Gastroprotective, Psychotropic and Anorectic, Analgesic and Antipyretic, Anti-inflammatory and Antibiotic, Flu and Antitussive, Antiallergic and Bronchodilator, Vasodilator For Blood Pressure, Calming And Antidepressant, Contraceptive, Dermatological, Vitamin E Fortifying, Antimycotic and Parasiticide, Medicine For Diabetes, Medicine for Osteoporosis, Optician Medicines, Elementary Education, Secondary Education, Early Childhood Education (Pre-school), Higher Education, Early Childhood Education (Daycare) Post-Graduate Course, Boat And Hovercraft fares, Metro Fare, Bus Fare, Urban Taxi Fare, School Transportation, Urban Train Fare, Transport Rate for Van And Similar, Interurban Bus Fare, Ethanol, Gasoline, Lubricating Oil, Diesel Oil, Natural Gas, Property taxes, Tolls, Compulsory Vehicle Insurance, Phone Card, Postal Rate, Internet Access, Lottery Tickets, Lottery in general, Residential Phone Rates, Mobile Phone Rates.

that accumulate 20% of the lower tail and 13% of the upper tail, leaving 67% of the original weight of the basket of products. The estimation made by FGV/IBRE considers 20% for the two tails. The seasonally adjusted specifications (second filter) were set considering the complete historical series from January 1999 to March 2016. Two outliers were detected (Feb/1999 and Nov/2002), which were kept to perfect the quality of seasonal adjustment. The SARIMA(0 1 1)(1 0 0)$_{12}$ model was fitted was not applied to the processing of the data.

4 Results

The TF core inflation, shown in Figure 2, is the estimated trend measure for the CPI (FGV/IBRE) following the procedures seen in the section 3. Clearly, the measure is less volatile than the price index and note that its trajectory is increasing from 2010, whereupon the indicator floats around the inflation target ceiling (6.5%) stipulated by the Central Bank, reaching beyond it significantly from 2014. The latest available data (2016) point to a possible stabilization and even decrease of the price trend.

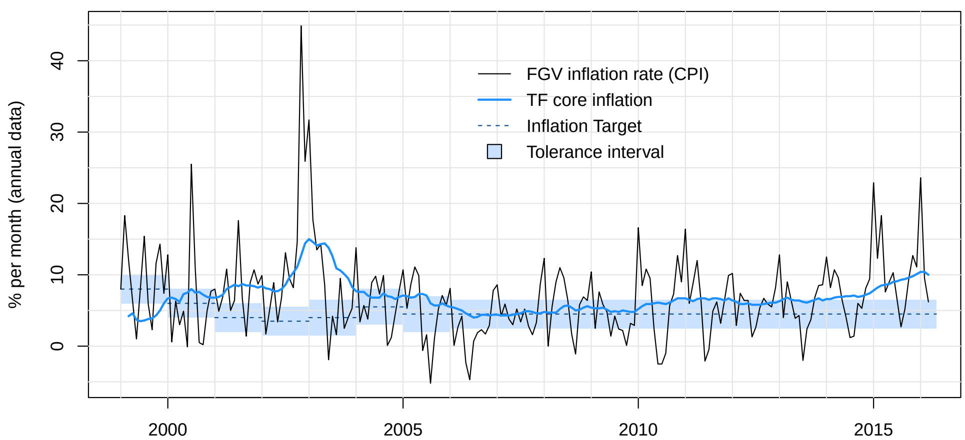

Figure 2: TF core inflation of CPI (FGV/IBRE) - Mar/1999 a Mar/2016 (annual data)

Furthermore, the analysis of the TF core inflation (Table 8) allows us to conclude that the measure is not biased (p-value = 0.58), that is, the core inflation does not underestimate or overestimate the inflation trend. The conclusion is also valid when analyzing the ten most recent years (p = 0.29). These first positive results were achieved after the new definition of the number of items with extreme variations that should be excluded in calculating the trimmed mean methodology.

When measuring the distance between the TF core inflation and the price trend obtained by the moving averages (Table 9), this distance can be considered small compared to the core inflation now published by FGV/IBRE (FGV-STM), concluding that, on average, the TF core inflation follows the inflation trend closer than the current FGV core inflation.

	Mean	Median	Standard Deviation	Bias	p-value
FGV inflation rate	**6.90 (6.11)**	**6.42 (5.98)**	**6.00 (4.75)**	**-**	**-**
TF core inflation	6.86 (6.16)	6.59 (6.04)	2.21 (1.47)	-0.04 (0.05)	0.58 (0.29)

Note: the statistics were obtained based on annualized measures. Figures in parenthesis are calculated considering the history from Apr/2006 to Mar/2016 (ten years), while the others consider the historical series starting in March 1999. The p-value refers to the null hypothesis bias test $H_0 : \alpha = 0$ and $\beta = 1$. There are no indications that the core inflation is biased towards the two time cuts.

Table 8: Descriptive statistics and evaluation of bias to the Triple-Filter core inflation

	FGV trend
FGV-STM	2,42
TF core inflation	1,41

Table 9: RMSE between FGV trend inflation and Triple-Filter core

It is also possible to conclude that the TF core inflation and the inflation trend have a long-term relationship because, with 95% confidence, the two time series are first order integrated (Table 10) and cointegrated (Table 11). The dynamics of this long-term relationship between the TF core inflation and the CPI is given as expected (see Table 12). Since λ is negative and significant, when inflation is above or below the core inflation, it will tend to move towards the core inflation. There is no evidence of the opposite movement (core toward inflation), since λ_c is not significant. This dynamic is maintained when evaluating the ten most recent years of data. These results together demonstrate that the TF core inflation captures the inflation trend properly.

Table 13 presents the estimation results of the equation (3) to see if the difference between the core inflation and the inflation in the current time (time t) helps to predict how inflation will change in a year or two. It can be favorably concluded using the core inflation, since the coefficient β is significant for the two time horizons.

The statistics $\bar{R}^2$, although considerably lower, still show that the core inflation is an important factor in the prediction of inflation. When comparing TF core inflation performance with the current FGV Core Inflation (FGV-STM) only in regard to this forecast, there are no arguments in favor of using one or the other, since the predictive ability of the two core inflations are similar.

	τ-stat	**Critical Value**	**Lag**	**Conclusion**
FGV inflation rate	-3.096	-2.88	12	reject H_0
FGV inflation rate (recent)	1.032	-1.95	14	do not reject H_0
TF core inflation	-1.982	-2.88	16	do not reject H_0
TF core inflation (recent)	1.852	-1.95	18	do not reject H_0

H_0: There is unit root (time series is not stationary).
ADF test is applied considering the history of Mar/1999 to Mar/2016 and the ten most recent years of data.

Table 10: Augmented Dickey & Fuller Test

Eigenvalue	Test Statistic	Critical Value	No. of cointegration equations	Conclusion
0,115	23,41	14,26	None	reject H_0
0,007	1,43	3,84	At most 1	do not reject H_0

One cointegrating equation at the 5% level.

Table 11: Johansen Cointegration Test between IPC and Triple-Filter core

	λ	$\bar{R}^2$	λ_c	$\bar{R}^2$
TF core inflation	-1.925***	0.4372	-0.0021	0.5885
TF core inflation (recent)	-0.515***	0.5392	0.005	0.2851

Note: significance levels: 0.1% (***)
The dynamic is evaluated considering the history of Mar/1999 to Mar/2016 and the ten most recent years data.

Table 12: Dynamic between CPI and Triple-Filter core inflation

Also it is necessary to assess whether over time the TF core inflation trajectory remains similar to adding new observations, since seasonal adjustment is used. For this evaluation, we adopted the following:

1. Setting the specification of seasonal adjustment model considering only the data until Dec 2014;
2. Run the seasonal adjustment month-to-month from Jan 2015 to Mar 2016 according to the specification defined in (1) and store the result of each month;
3. Deseasonalize the full range according to the specification defined in (1) and compare it with the number obtained in (2).

The annualized TF core inflation series obtained from the two previously explained ways can be seen in Figure 3.

Note that from 2014 there is a small change between the two series. This change is most evident in the months of January and February 2016, in which the difference between the series is, respectively, 0.5 and 0.4 percentage points (with annualized information). Except in the months of March and April 2015 wherein the estimated core inflation with the complete series moves from 8.5% to 8.6% while the other core inflation recedes from 8.4% to 8.3%, the trajectory of the core inflations is similar. These results show the robustness of the proposed core inflation and that the seasonal adjustment month-to-month is similar when using all the observations of the series available. This result and others (softness, bias, cointergration, adjustment dynamic, seasonal robustness and prediction) shown in this section show the quality of the measure of the core inflation proposal.

Still in order to show the usefulness of TF core inflation, shown in Figure 4 is the annualized core against the CPI accumulated in 12 months. The latter is the main drive of the general public to follow the trajectory of inflation (Ferreira et al. (2016); Gaglianone et al. (2016)). It appears that the *turning points* of inflation behavior are perceived faster with TF core inflation. For example, in 2010, the core inflation floated around 6%, exceeding the ceiling of the inflation target in November (6.7%). By analyzing the accumulated inflation, however, one only notices a flirtation with the target ceiling 6 months later in May 2011. In 2013, the same happens: the core inflation floats around the target ceiling and passes it three times in February, March and November, however, the accumulated inflation only came to exceed the ceiling for the first time in May 2014.

		$\bar{R}^2$	β	**t-stat**
$h = 12$	TF core inflation	0.28	0.687 (0.0786)	8.737***
	TF core inflation (recent)	0.15	0.381 (0.0809)	4.701***
$h = 24$	TF core inflation	0.29	0.745 (0.0871)	8.562***
	TF core inflation (recent)	0.20	0.575 (0.1026)	5.602***

Note: β standard deviation in parenthesis; t-stat is the test statistic of β parameter.

Table 13: Forecasting inflation rate using core inflation

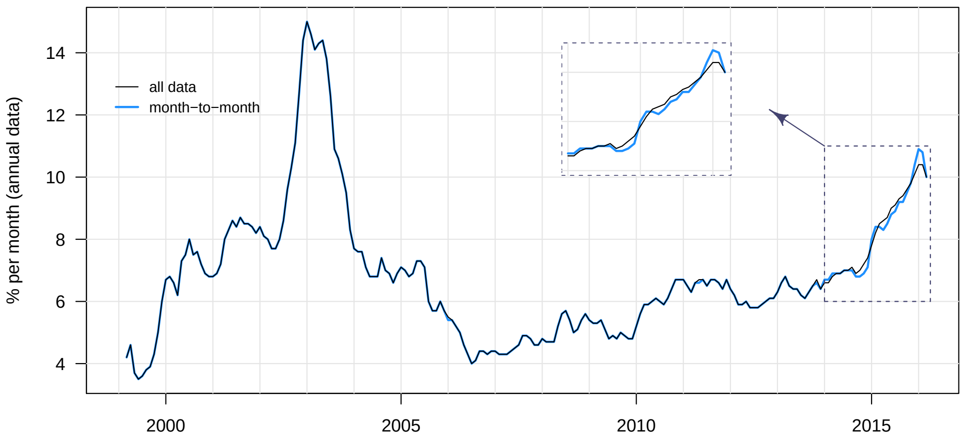

Figure 3: Evaluation of seasonal adjustment (annual data)

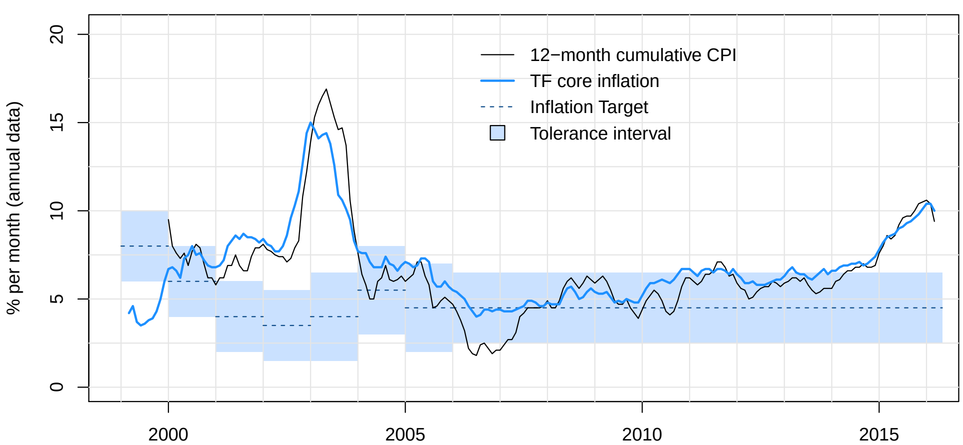

Figure 4: Annualized TF core inflation and 12-month cumulative CPI - Mar/1999 a Mar/2016

5 Final Remarks

The results shown in this article demonstrate that the TF core inflation should be used as a reference measure for the inflation path in place of the traditional core inflations, especially in countries with higher inflation and regulated prices, as is the case of Brazil. In this context, the traditional core inflations bring little information about the trajectory of the general price level, so the argument of simplicity in the core inflation calculation is not valid like it is in countries like the US who only remove energy and food from the estimate.

An important feature of TF core inflation is the improved communication between the monetary authority and the general public. Being a measure little influenced by discrepant events and seasonal effects, the annualization becomes feasible (an uncommon practice in countries with high inflation) allowing the public to have a clearer idea about the behavior of prices over a full year without having to carry a significant load of information from 12 months ago (a common practice in countries with high inflation is accumulating inflation over 12 months). Significant, because the core inflation also carries the past 12 months of information, however variations are softer due to the smoothing methodology in the calculation of trimmed mean and are applied to only 37% of the basket of products. It is important that the property of the TF core inflation to save little past information allows a variation in the clearest tip to events occurring at the present time.

Such features previously argued (clearer trend, improved communication, clearer view with what happens in the present time) are easily confirmed observing the history of the TF core inflation and relating it to the events in Brazil. By comparing Figures 1 and 2, it is easy to see that the tendency of the TF core inflation is lighter and less volatile as compared with traditional cores. As for annualization and improved communication, observing Figure 2, there are three events that support this argument. It appears that since 2003 there is a clear convergence of inflation to the target, achieved in 2006, and inflation remains on target to approximately the end of 2010. From this period, inflation measured by the core inflation touches the target ceiling until January 2014, when the goal is not met.

The third characteristic is observed when comparing the TF core inflation over 12 months (Figure 4), where it appears that the behavior of the accumulated inflation is perceived faster with TF core inflation. It can be argued that the policymakers use other techniques besides the accumulated inflation in 12 months and therefore have full knowledge of price movements. However, in Brazil, the main tool used by the general public to assess where inflation is at the present time is the accumulated inflation over 12 months, and this, by definition, carries with it a large amount of past information, which may not reflect the current price situation. Therefore, the TF core inflation will allow the general public to have a more accurate understanding of the trend of prices allowing greater vigilance to short-term movements of price increase and, on the other hand, a smaller effort from the Central Bank to decrease price levels and, in the future, may serve as an anchor in the dissemination process for the Brazilian society in general.

Finally, a natural continuation of this work will be the treatment of the smoothing of the administered prices and other predefined items (section 3) adopted in conjunction with the method of trimmed mean. Such treatment will allow the TF core inflation to better reflect inflation in the present time.

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