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Abstract

Core inflation removes from headline inflation (i.e., overall CPI inflation) volatile prices. One way for removal is "exclusion" of selected commodities by setting their weights to zero, which is practiced in the Philippines—and in Brazil, Israel, Korea, Poland, and the United States, to name a few—where "food" and "energy" items are excluded. Using Philippine Statistics Authority CPI data (January 2012–July 2021) and procedures, this paper shows that core inflation by exclusion is misleading because it could be higher than headline inflation when the excluded items have positive inflation contributions. To avoid this misleading result, this paper proposes "neutralization" of the excluded commodities by keeping them in the CPI basket but making their CPIs constant, thus, neutralizing them because, in this case, they cannot contribute to inflation. Neutralization yields the logical result that core inflation is lower (higher) than headline inflation if the neutralized commodities have positive (negative) total inflation contributions. Moreover, neutralizing commodities with inflation contributions that are not statistically significantly different from zero yields core inflation with statistically the same mean but lower variance than headline inflation. A sufficient but not necessary condition to lower variance is derived that in practice is very rarely violated. Thus, neutralization permits more precise inflation forecasts for the purposes of monetary policy consistent with the overall or headline price trend of the economy.

***Keywords*:** Headline inflation, core inflation, exclusion, neutralization

JEL classification: C43, C82, E31, E58

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Changes in overall CPI (consumer price index) or "headline" inflation should concern everybody because they affect our cost of living and influence government policies. [1] However, headline inflation is subject to price volatility from short-run disruptions, for example, from bad weather or abrupt supply changes that are beyond the control of monetary policy. From the United States' experience, these disruptions caused volatility in food and energy prices. Thus, computing "core" inflation entailed removing food and energy items to determine long-term price trends for policy purposes (Blinder, 1997). For similar reasons, the Philippines also removes the same items to compute core inflation (Bangko Sentral ng Pilipinas, 2020). [2]

This paper examines the exclusion method, which is practiced in the Philippines and in other countries, of removing price volatility from headline inflation to obtain core inflation. It is shown that exclusion—by setting the weights of excluded commodities to zero to remove their inflation contributions—yields misleading results, as illustrated by Philippine data. In any case, exclusion is unnecessary because neutralization—by keeping the excluded commodities in the CPI basket but making their CPIs constant—will suffice to remove their inflation contributions.

This paper is organized as follows. The next section presents the Philippine Statistics Authority (PSA) official procedure for computing headline inflation and core inflation by the exclusion of selected non-core energy and food items. [3] An empirical illustration highlights the

[1] In the Philippines, headline inflation is used by the Bangko Sentral ng Pilipinas (BSP) as basis for inflation targeting and by the National Wages and Productivity Commission (NWPC) in wage-setting decisions.

[2] BSP (2020) selected some countries other than the Philippines that practice exclusion and described their excluded commodities. These are the United States, Brazil, Chile, Colombia, Iceland, Israel, Peru, Poland, Korea, Thailand, and Malaysia that are among the 27 countries operating a full-fledged inflation-targeting regime (Hammond, 2012).

[3] The exclusion method was adopted before PSA's creation after inter-agency discussions in 2003 among the BSP, NWPC, Department of Trade and Industry, National Economic Development Authority, National Statistics Office (NSO), the National Statistical Coordination Board (NSCB), and the Statistical Research and Training Center (SRTC). PSA was created a decade later on December 29, 2013 by the Philippine Statistical Act of 2013 (RA 10625) by merging the NSO, NSCB, the Bureau of Labor and Employment Statistics and the Bureau of Agricultural Statistics. The same law created the Philippine Statistical Research and Training Institute to replace the SRTC.

problem with exclusion and introduces this paper's proposed solution by neutralization.

The following section replicates the preceding illustration by annual (i.e., same month in year t to year $t+1$) *headline*, *core by exclusion*, and *core by neutralization* inflation using CPI data covering 13 core and non-core commodity groups during 115 months (January 2012–July 2021). The results show that core inflation by exclusion will differ from core inflation by neutralization with non-trivial implications on inflation measurement and policy. However, the neutralization results are more logical analytically and based on a firmer statistical basis.

The penultimate section raises the question of "what core inflation should measure." This question arises in light of alternative attempts to measure core inflation based on theoretical grounds other than the CPI framework based on the theory of the cost-of-living index (Wynne, 2008). The question is also relevant to the long-run objective of core inflation measurement to achieve the same rate as headline inflation but with a lower variance (Luciani & Trezzi, 2019). This paper finds that this objective is achievable by keeping all commodities in the CPI basket while neutralizing those with inflation contributions that are not statistically significantly different from zero. Moreover, a sufficient but not necessary condition is derived for neutralization to lower core inflation variance below that of headline inflation.

In conclusion, the Philippines and other countries that practice exclusion should consider adopting neutralization as proposed by this paper for core inflation measurement.

Exclusion and Neutralization Methods for Core Inflation: Results for the Philippines

Following PSA procedures (2018), let

$$I^t \equiv \text{headline CPI} \quad ; \quad I_i^t \equiv \text{CPI of commodity group } i \quad ; \quad i = 1, 2, \cdots, K\,. \tag{1}$$

In (1), t stands for a month or year and K is the total number of commodity groups. From (1),

$$I^t = \sum_{i=1}^{K} S_i^F \, I_i^t \quad ; \quad \sum_{i=1}^{K} S_i^F = 1 \quad ; \quad I^t = \sum_{i=1}^{K} \left(\frac{S_i^F}{\sum_{i=1}^{K} S_i^F} \right) I_i^t \, . \tag{2}$$

The last equation in (2) is used in the exclusion procedure to recalibrate the weights of the remaining commodities so that they sum to one. The weight S_i^F is given by

$$S_i^F \equiv \text{expenditure share of a commodity group from 2012 Family Income and Expenditure Survey (FIES)} = \text{weight of a commodity group in headline CPI} \, . \tag{3}$$

Based on the commodity classification in Table 1, let i cover the core and non-core subgroups of Food and Non-Alcoholic Beverages where non-core "food" is #2 and Transport Energy where non-core "energy" is #9. PSA excludes #2 and #9 to obtain core CPI.

Table 1

Headline, Exclusion, and Neutralization Methods for CPI Inflation

		CPI by Commodity Groups				CPI Inflation						
						Headline		Core by Neutralization		Core by Exclusion*		
						Inflation rate = 3.3 %		Inflation rate = 2.7 %		Inflation rate = 3.5 %		
	Commodity	FIES 2012 Weights (percent)	March 2018 CPI	March 2019 CPI	Inflation Rate (percent)	March 2018 CPI	March 2019 CPI	March 2018 CPI	March 2019 CPI	Recalibrated FIES 2012 Weights (percent)	March 2018 CPI	March 2019 CPI
			(2012 index = 100)					Constant Non-core CPI				
		a	*b*	*c*	*d*	*e* = *a* x *b*	*f* = *a* x *c*	*g* = *a* x *b*	*h* = *a* x *c*	*i*	*j* = *b* x *i*	*k* = *c* x *i*
	All Items	**100.0**				**115.6**	**119.3**	**115.6**	**118.6**	**100.0**	**114.1**	**118.1**
1	Food and Non-alcoholic Beverages: Core	17.6	118.3	124.0	4.8	20.8	21.8	20.8	21.8	22.8	26.9	28.2
2	Food and Non-alcoholic Beverages: Non-core	20.8	123.3	126.0	2.2	25.6	26.2	25.6	25.6	0.0	0.0	0.0
3	Alcoholic Beverages, Tobacco, and other Vegetable-based Tobacco Products	1.6	183.9	203.7	10.8	2.9	3.2	2.9	3.2	2.1	3.8	4.2
4	Clothing and Footwear	2.9	116.3	119.2	2.5	3.4	3.5	3.4	3.5	3.8	4.4	4.5
5	Housing, Water, Electricity, Gas and Other Fuels	22.0	109.6	113.3	3.4	24.2	25.0	24.2	25.0	28.5	31.3	32.3
6	Furnishings, Houshold Equipment and Routine Maintenance of the House	2.9	115.2	119.1	3.4	3.4	3.5	3.4	3.5	3.8	4.4	4.5
7	Health	3.9	114.7	119.2	3.9	4.5	4.6	4.5	4.6	5.0	5.8	6.0
8	Transport Energy: Core	6.0	106.7	109.1	2.2	6.4	6.6	6.4	6.6	7.8	8.3	8.5
9	Transport Energy: Non-core	2.0	89.9	96.3	7.1	1.8	1.9	1.8	1.8	0.0	0.0	0.0
10	Communication	2.9	101.0	101.3	0.3	3.0	3.0	3.0	3.0	3.8	3.8	3.8
11	Recreation and Culture	1.4	111.3	114.7	3.1	1.6	1.6	1.6	1.6	1.8	2.0	2.1
12	Education	3.3	120.0	115.4	-3.8	3.9	3.8	3.9	3.8	4.3	5.1	4.9
13	Restaurants and Miscellaneous Goods and Services	12.6	112.0	116.1	3.7	14.1	14.6	14.1	14.6	16.3	18.3	18.9

Source: Author's calculations from CPI data from the Philippine Statistics Authority.

*The exclusion procedure above is illustrated in BSP (2020), *Primer on core inflation*. Following this procedure, the weights in column *i* equal the weights in column *a* divided by the sum of the weights after exclusion of non-core items #2 and #9 (100 - 20.76672 - 2.02013 = 77.21315).

In Table 1, columns *a*, *b*, and *c* show the data for (1), (2), and (3) to compute the *headline* CPI in columns *e* and *f*. The core CPI in columns *g* and *h* by neutralization differs from headline by keeping the non-core CPIs constant. In contrast, the core CPI in columns *j* and *k* by exclusion

differs from the headline by setting the non-core weights to zero, as shown in column *i*. The third equation in (2) is used to recalibrate the weights of the remaining core items in column *i*.

To show that core CPI inflation by exclusion could be misleading, let t change from 0 to 1 where the change is between any two periods. From (2), the relative change in headline CPI is

$$\frac{I^1}{I^0} = \frac{\sum_{i=1}^{K} S_i^F\, I_i^1}{\sum_{i=1}^{K} S_i^F\, I_i^0} = \sum_{i=1}^{K} \left(\frac{S_i^F I_i^0}{\sum_{i=1}^{K} S_i^F\, I_i^0} \right) \frac{I_i^1}{I_i^0} \quad ; \quad \sum_{i=1}^{K} \left(\frac{S_i^F I_i^0}{\sum_{i=1}^{K} S_i^F\, I_i^0} \right) = 1 \, . \tag{4}$$

Therefore, (4) yields

$$\frac{I^1}{I^0} - 1 = \sum_{i=1}^{K} \left(\frac{S_i^F I_i^0}{\sum_{i=1}^{K} S_i^F\, I_i^0} \right) \left(\frac{I_i^1}{I_i^0} - 1 \right) \equiv \text{headline CPI inflation rate ;} \tag{5}$$

$$\frac{S_i^F I_i^0}{\sum_{i=1}^{K} S_i^F\, I_i^0} \equiv \text{weight of a commodity group in headline CPI inflation rate ;} \tag{6}$$

$$\left(\frac{S_i^F I_i^0}{\sum_{i=1}^{K} S_i^F\, I_i^0} \right) \left(\frac{I_i^1}{I_i^0} - 1 \right) \equiv \text{contribution of a group to the headline inflation rate .} \tag{7}$$

By applying the data in columns *a*, *b*, *c*, and *d* into (1) to (5), $I^0 = 115.55132$ and $I^1 = 119.32323$—rounded to 115.6 and 119.3 in columns *e* and *f*—to yield the headline inflation of 3.3%. The differences of exclusion and neutralization from the headline may now be shown.

Exclusion sets the weights of the excluded items to zero, as shown in column *i*. That is,

$$S_j^F = 0 \quad ; \quad \left(\frac{S_j^F I_j^0}{\sum_{i=1}^{K} S_i^F\, I_i^0} \right) \left(\frac{I_j^1}{I_j^0} - 1 \right) = 0 \quad ; \quad j = (\#2, \#9) \, . \tag{8}$$

The effect of (8) is to increase the weights of remaining core groups in column *i*, according to the weights (in parenthesis) in the third equation in (2), and to enlarge the positive contributions of remaining core groups that could more than compensate for the loss of the positive contributions

of #2 and #9, thus, pushing core inflation higher to 3.5%, above headline inflation of 3.3%. This result makes core inflation by exclusion misleading because it is higher than the headline inflation after excluding items #2 and #9 that have positive inflation rates in column *d*.[4]

In Table 1, the neutralization columns *g* and *h* are put next to the headline columns *e* and *f* to show the logical relationship between the two. Notice first that columns *e* and *g* are identical, which shows that the initial situation (March 2018) is the same for headline and neutralization. They differ only in the final situation (March 2019) because neutralization keeps the CPIs of the neutralized items (#2 and #9) in March 2018 constant or the same in March 2019. That is,

$$I_j^0 = I_j^1 \quad ; \quad \left(\frac{S_j^F I_j^0}{\sum_{i=1}^K S_i^F I_i^0}\right)\left(\frac{I_j^1}{I_j^0} - 1\right) = 0 \quad ; \quad j = (\#2, \#9)\,. \tag{9}$$

Thus, if the CPIs of #2 and #9 are rising, which actually happened from March 2018 to March 2019, keeping them constant makes the neutralization CPI (118.6) lower than the headline CPI (119.3) in March 2019. Logically, therefore, core inflation by neutralization (2.7%) is lower than headline inflation (3.3%). This result generalizes to saying that core inflation by neutralization is lower (higher) than headline inflation if the total inflation contributions of the neutralized commodities are positive (negative).

Effects of Non-Core Commodities on Inflation

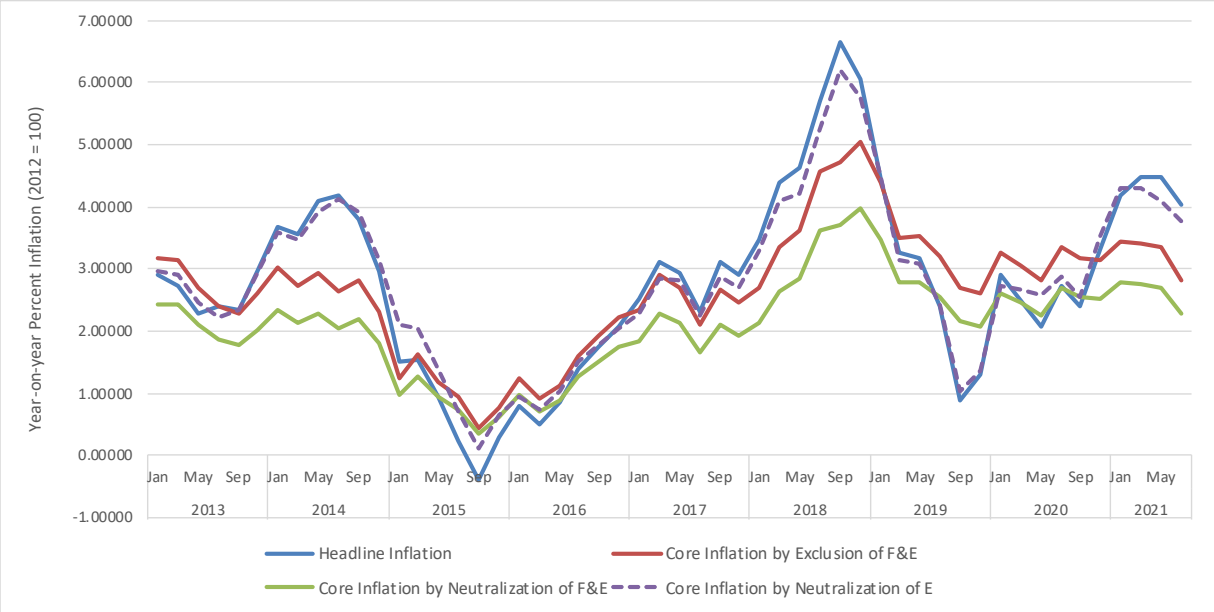
Monthly CPI data from January 2012 to July 2021 replicate the results in Table 1 to obtain

[4] While (8) replicates PSA's exclusion results in Table 1 for the Philippines, it does not necessarily represent the exclusion formula in other countries. Note that CPI aggregation in the Philippines in (2) has *fixed* 2012 FIES weights. In contrast, the United States also practices exclusion but uses the personal consumption expenditure (PCE) deflator from the GDP accounts as the basis for headline inflation (Luciani & Trezzi, 2019). However, this PCE deflator does not have fixed weights because it is based on a *chained* Fisher price index (Landefeld & Parker, 1997). Moreover, the Fisher price (quantity) index weights are much more complicated—based on combinations of Laspeyres and Paasche quantity (price) indexes and their weights—as shown by the Fisher *additive* decomposition (Balk, 2004; Dumagan, 2002) that could be the basis for decomposing headline PCE inflation in the United States.

monthly headline CPI, core CPI by exclusion, and core CPI by neutralization. The non-core items excluded or neutralized are food and transport energy. These yield year-on-year (same month in year t to year t+1) inflation rates shown in Figure 1, where F&E means non-core food and non-core energy (#2 and #9, respectively, in Table 1). For brevity, F is *non-core food,* and E is *non-core energy* that are either excluded or neutralized, depending on the discussion in this paper onward.

Figure 1

Comparing Headline and Core Inflations by Exclusion and Neutralization



Source: Author's calculations from CPI data from the Philippine Statistics Authority. Similar plots of headline inflation (blue) and core inflation by exclusion of F&E (red) may be found in BSP (2020), *Primer on core inflation*. The plots of core inflations by neutralization of E (dashed purple) and of F&E (green) are the author's own.

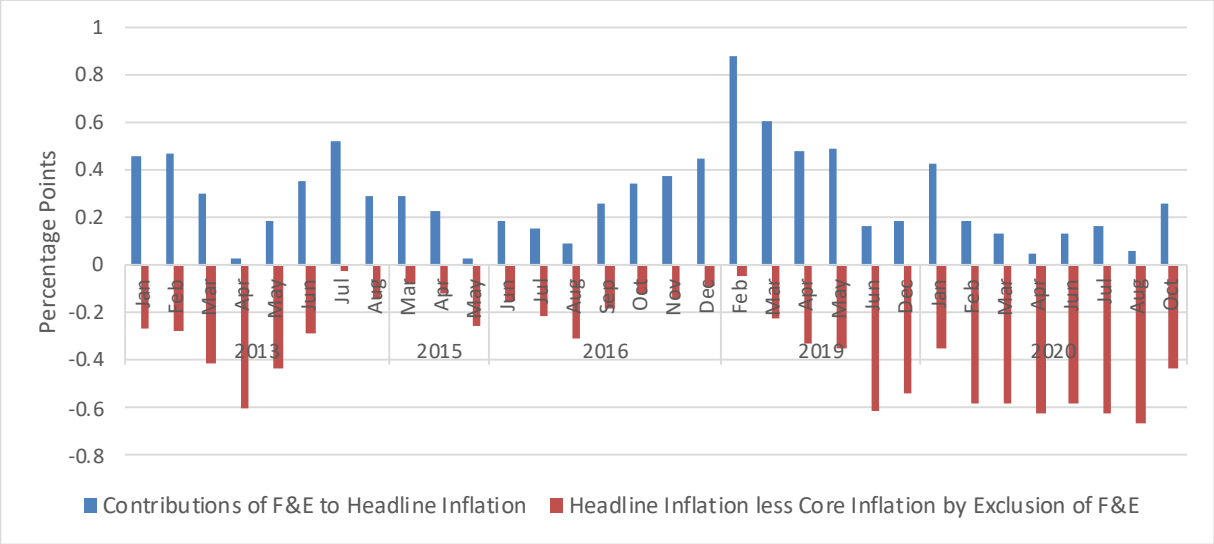
The illogical result in Table 1—where core inflation by exclusion was higher than headline inflation when F&E had a positive total contribution to inflation—is not an isolated incident because Figure 2 shows this happened in 32 out of 103 cases during January 2013 - July 2021 or 31% frequency.

Logically, core inflation should be lower (higher) than headline inflation after removal of

F&E if these removed items have a positive (negative) total contribution. However, this logical result could be violated if removal is by exclusion as shown in Figure 2, where for each positive blue bar, there is a corresponding negative red bar.

Figure 2

Misleading Core Inflation by Exclusion



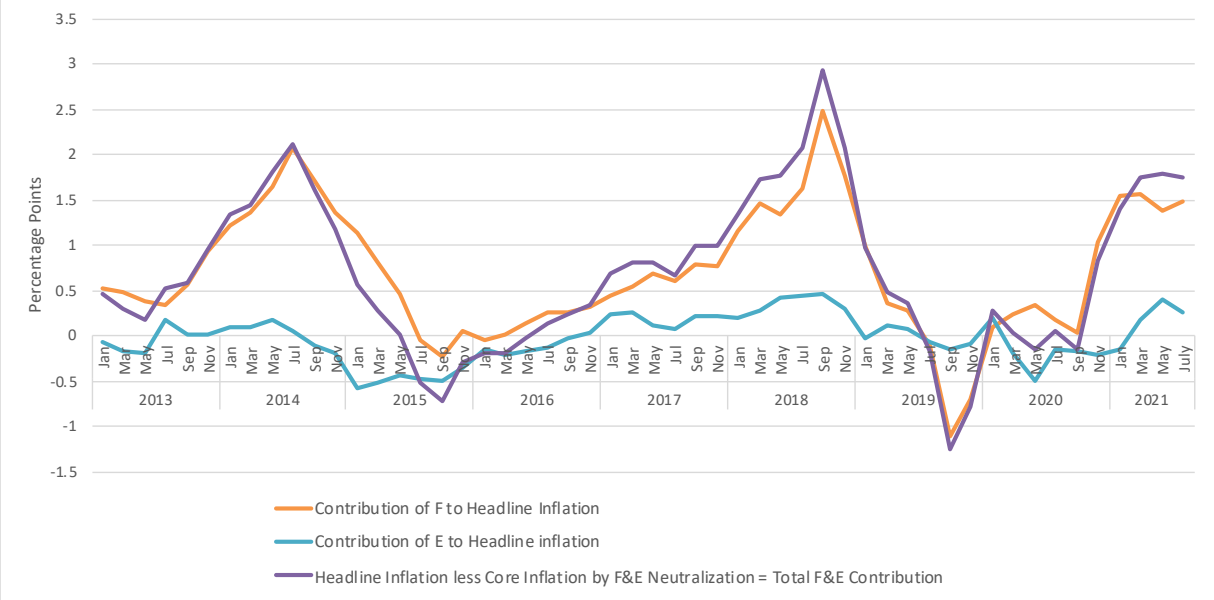
Source: Author's calculations from CPI data from the Philippine Statistics Authority.

A negative red bar means that core inflation by exclusion is higher than headline inflation, which is misleading because, in the same period, the inflation contributions of F&E are positively shown by a corresponding positive blue bar. Thus, in Figure 1, the vertical distance between headline inflation and core inflation by exclusion mismeasures the inflation contribution of F&E. By implication, core inflation by exclusion—shown in Figure 1 by the red line generated by results following PSA procedures—is misleading for policy purposes. The culprit once again is the increase in weights of the remaining commodities to compensate for the loss of weights of the excluded commodities because weights must sum to one according to column *i* in Table 1.

The "true" total inflation contribution of F&E is the vertical distance between headline inflation and core inflation by F&E neutralization in Figure 1.[5] This total F&E contribution is plotted by the purple line in Figure 3 and displays high volatility. Disaggregation of this total shows that most of the price volatility is from F, shown by the orange line, than from E in green.[6]

Figure 3

Contributions of F&E to Headline Inflation



Source: Author's calculations from CPI data from the Philippine Statistics Authority.

It is apparent in Figure 3 that a simple t test of the null hypothesis of a zero mean of inflation contributions—based on 103 observations (Jan 2013–July 2021)—cannot be rejected in the case of E ($t = -0.6800$ and $p = 0.4981$) with a statistically insignificant negative mean (– 0.0175 %)

[5] The headline inflation contribution of a component is given by the value of (7). Technically, this value equals the change in headline inflation in (5) when only the CPI of this component is kept constant. However, this equality does not hold exactly because keeping the CPI of a component constant still changes its inflation weight in (6) due to changes in the CPIs of the other components. But the data in this study show empirically that the effect is negligible—equal to zero percentage points in most cases when rounded to the first decimal place—so that the equality holds practically.

[6] Labonte (2008) noted a study in the United States (Gavin & Mandal, 2002) that found food prices to be a better predictor of future inflation than any other measure including core inflation.

but can be rejected in the case of F ($t = 10.0376$ and $p = 0.0000$) with a statistically significant positive mean (0.7067 %).

What Should Core Inflation Measure?

So far in this paper, core inflation has been analyzed in relation to headline CPI inflation that in theory refers to a change in the cost-of-living index (COLI).[7] However, there have been attempts to measure core inflation not anchored on the COLI as theoretical basis. In reviewing various alternative approaches to measuring core inflation, Wynne (2008) noted that:

> A common theme . . . is that there is some concept of monetary inflation that is distinct from changes in the cost of living and that is a more appropriate target of monetary policy. . . . this theme has motivated several authors to look at alternative estimates of the central tendency of the distribution of prices as the best estimate of core or monetary inflation. Other authors have used dynamic frameworks along with neutrality propositions from monetary theory to try to estimate core inflation. All of these approaches suffer from this fact: <u>There is simply no agreed upon theory of money that can serve as a basis for inflation measurement that could plausibly replace the theory of the cost of living.</u>"[8] (underscoring supplied, p. 223)

Thus, a COLI-based CPI framework for core inflation remains viable. In this regard, there is the view in the literature (Luciani & Trezzi, 2019) that the objective of core inflation measurement is to have the same average rate as headline inflation over long periods but with a lower variance to

[7] The COLI is the ratio of the minimum expenditure at the new prices to the minimum expenditure at the old prices to maintain the *same* utility level. The Philippine CPI is based on a Laspeyres price index that by the axioms of expenditure minimization is an upper-bound to the COLI.

[8] Wynne (2008) categorized the alternative core inflation measures into exclusion indexes, central-tendency statistical measures, variance-weighted indexes, regression-weighted indexes, model-based trend inflation measures, and component-smoothing indexes. However, there is no mention of "neutralization" proposed in this paper.

serve the purposes of long-term monetary policy. This raises the question: Which technique for core inflation measurement—exclusion or neutralization—could achieve the above objective? Based on the preceding findings, this paper proposes that core inflation (a) keep all commodities in the CPI basket; (b) count the inflation contributions of commodities that pass the criterion of having means that are statistically significantly different from zero (e.g., F in Figure 3); and (c) neutralize those commodities that fail this criterion (e.g., E).

Graphically in Figure 1, conditions (a), (b), and (c) shift up green core inflation by neutralization closer to blue headline inflation and banish red core inflation by exclusion because (a) means no exclusion. In effect, core inflation by neutralization and headline inflation have exactly the same commodity composition and have statistically the same (i.e., no significant difference) inflation rates, whereas core inflation by neutralization may have lower variance or lower standard error and standard deviation, as shown later in Table 2. Thus, neutralization may permit more precise inflation forecasts for monetary policy purposes.

Moreover, the above conditions argue against "pre-selection" of F and E by reconsidering the old rationale for their CPI exclusion that volatility in food and energy prices are to some extent due to "causes" (e.g., weather for food and geopolitics for energy) that cannot be directly addressed by central bank monetary policy (Labonte, 2008). This rationale may appear sound but not fully sensible because monetary policy need also to address the "aftereffects"—of weather and geopolitics—if they make statistically significant differences to food and energy prices. In the latter event, the effects on prices invite monetary policy attention regardless of the causes.

At this point, the preceding discussion invites tests between headline inflation and core inflation by neutralization in light of Figure 3, which showed by simple *t* tests that E may be neutralized but not F. In this case, the appropriate tests are paired *t* tests of three null hypotheses

of *zero mean of differences* between (A) headline and core by F neutralization; (B) headline and core by E neutralization; and (C) headline and core by F&E neutralization. These paired *t* tests are equivalent to tests of no differences in means and the results are shown in Table 2.

Table 2

Testing No Differences in Means Between Headline and Core by Neutralization

Hypothesis	*t* and *p*	Pairs tested	Mean	Std. Err.	Std. Dev.	95% Conf. Interval
A	*t* = 10.0376	Headline	2.7825	0.1471	1.4934	2.4906 - 3.0743
	p = 0.0000	Core by F Neutralization	2.0758	0.0973	0.9877	1.8828 - 2.2688
B	*t* = - 0.6800	Headline	2.7825	0.1471	1.4934	2.4906 - 3.0743
	p = 0.4981	Core by E Neutralization	2.8000	0.1288	1.3067	2.5446 - 3.0554
C	*t* = 7.9560	Headline	2.7825	0.1471	1.4934	2.4906 - 3.0743
	p = 0.0000	Core by F&E Neutralization	2.0952	0.0782	0.7941	1.9400 - 2.2504

Source: Author's calculations from CPI data from the Philippine Statistics Authority.

The results indicate rejection of A; no rejection of B; and rejection of C. The rejections of A and C are consistent with the fact shown in Figure 3 that F has a mean that is significantly different from zero, but E has a mean that is not. Therefore, neutralizing F alone or both F&E yield a mean of core inflation that is significantly different from the mean of headline inflation.

However, B cannot be rejected because Figure 3 shows E has a mean that is not significantly different from zero, implying that the means of headline inflation and core inflation by neutralization of E are statistically the same. But as shown in Table 2, core inflation, in this case, has lower variance (i.e., lower standard error and standard deviation) than headline inflation and, thus, is more precise for forecasting with a narrower 95% confidence interval around its mean.

Tests similar to Table 2 for pairs of headline and core by exclusion are shown in Table 3. To evaluate the results in these tables, it is important to bear in mind that the inflation contribution lost when a commodity is excluded is the same as when it is neutralized because this contribution is given by (7) that becomes lost (zero) by exclusion in (8) or by neutralization in (9).

Table 3
Testing No Differences in Means Between Headline and Core by Exclusion

Hypothesis	*t* and *p*	Pairs tested	Mean	Std. Err.	Std. Dev.	95% Conf. Interval
A*	*t* = 3.4659	Headline	2.7825	0.1471	1.4934	2.4906 - 3.0743
	p = 0.0008	Core by F Exclusion	2.5716	0.1199	1.2165	2.3339 - 2.8094
B*	*t* = - 2.8682	Headline	2.7825	0.1471	1.4934	2.4906 - 3.0743
	p = 0.0050	Core by E Exclusion	2.8522	0.1311	1.3303	2.5922 - 3.1122
C*	*t* = 1.6727	Headline	2.7825	0.1471	1.4934	2.4906 - 3.0743
	p = 0.0975	Core by F&E Exclusion	2.6565	0.0981	0.9954	2.4620 - 2.8511

Source: Author's calculations from CPI data from the Philippine Statistics Authority.

It follows from above that the difference in means between headline and core by neutralization equals the mean of the contributions of the neutralized commodity. Recall from Figure 3 that the mean of the contributions of E is -0.0175 and that of F is 0.7067. Logically, because the mean of E is negative, Table 2 shows that when E is neutralized, the mean of core inflation rises exactly above the mean of headline by 0.0175 = 2.8000 – 2.7825. By the same logic, because the mean of F is positive, the mean of core inflation when F is neutralized falls exactly below the mean of headline by -0.7067 = 2.0758 – 2.7825.

Unfortunately, visual comparison of means in Tables 2 and 3 reveals that the above exact rise or fall in means of core inflation in Table 2 when F or E is neutralized do not hold in Table 3 when F or E is excluded, although the contribution lost when a commodity is neutralized is the same as when it is excluded. For example, Table 3 shows that the mean of core inflation when E is excluded rises above the mean of headline inflation by 0.0697 = 2.8522 – 2.7825, which is puzzling because the rise should logically equal 0.0175, the absolute value of the mean (-0.0175) of the contributions of E. This implies that the differences in means in Table 3 mismeasure the mean of the contributions of the excluded commodities. Therefore, it is statistically ill-advised to use PSA's core inflation by exclusion of F&E defined by the red line in Figure 1.

At this juncture, the analytic basis for Table 2—where neutralization lowers core inflation

variance (or its square root, the standard deviation) below that of headline inflation—may be shown. Let headline inflation from t to $t+1$ be denoted by $H^{t,t+1}$ so that (5) generalizes to

$$\text{Headline inflation} \equiv H^{t,t+1} \equiv \frac{I^{t+1}}{I^t} - 1 = \sum_{i=1}^{K} \left(\frac{S_i^F I_i^t}{\sum_{i=1}^{K} S_i^F I_i^t} \right) \left(\frac{I_i^{t+1}}{I_i^t} - 1 \right). \tag{10}$$

Moreover, let the contribution of a commodity to $H^{t,t+1}$ be $c_i^{t,t+1}$, which is given in (10) by

$$c_i^{t,t+1} \equiv \left(\frac{S_i^F I_i^t}{\sum_{i=1}^{K} S_i^F I_i^t} \right) \left(\frac{I_i^{t+1}}{I_i^t} - 1 \right) \quad ; \quad H^{t,t+1} = \sum_{i=1}^{K} c_i^{t,t+1} . \tag{11}$$

It follows from (11) that commodity contributions to headline inflation are not independent because the weights must sum to 1. Hence, over time from $t = 0, \cdots, T$, the variance of $H^{t,t+1}$ depends on the variances of the individual $c_i^{t,t+1}$ and on the covariances between pairs $(i, j), i \neq j$. Therefore, dropping the time superscript for simplicity, it follows from the standard formula for the variance of a sum (Anderson, 2003) that (11) yields

$$Var(H) = Var\left(\sum_{i=1}^{K} c_i \right) = \sum_{i=1}^{K} Var(c_i) + 2 \sum_{i<j} Cov(c_i, c_j) . \tag{12}$$

The value of (12) equals the sum of all the elements of a symmetric variance-covariance matrix where the first term is the sum of the diagonal elements and the second term is the sum of the off-diagonal elements, given that symmetry comes from the fact that $Cov(c_i, c_j) = Cov(c_j, c_i)$. For all the $K = 13$ commodities individually identified in Table 1, the value of (12) during 115 months (January 2012–July 2021) is obtained from the variances and covariances in Table 4. From this table, it can be verified that

$$Var(H) = \sum_{i=1}^{K} Var(c_i) + 2 \sum_{i<j} Cov(c_i, c_j) = 0.883 + 1.347 = 2.230 . \tag{13}$$

Table 4
Variance-Covariance Matrix of Commodity Contributions to Headline Inflation

Commodities (Table 1)	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0.056	0.079	0.016	0.001	0.048	0.003	0.005	0.005	0.018	0.001	0.000	-0.013	0.017
2	0.079	0.524	0.016	0.002	0.152	0.003	0.006	0.043	0.095	0.001	0.002	-0.020	0.024
3	0.016	0.016	0.028	0.000	0.022	0.003	0.002	0.010	0.016	0.000	0.001	-0.004	0.013
4	0.001	0.002	0.000	0.000	0.002	0.000	0.000	-0.002	-0.001	0.000	0.000	0.001	0.000
5	0.048	0.152	0.022	0.002	0.141	0.004	0.006	0.000	0.077	0.001	0.003	-0.014	0.021
6	0.003	0.003	0.003	0.000	0.004	0.001	0.000	0.001	0.001	0.000	0.000	-0.001	0.001
7	0.005	0.006	0.002	0.000	0.006	0.000	0.001	0.001	0.003	0.000	0.000	-0.002	0.002
8	0.005	0.043	0.010	-0.002	0.000	0.001	0.001	0.047	0.007	0.000	-0.002	-0.007	0.007
9	0.018	0.095	0.016	-0.001	0.077	0.001	0.003	0.007	0.065	0.001	0.001	-0.009	0.014
10	0.001	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
11	0.000	0.002	0.001	0.000	0.003	0.000	0.000	-0.002	0.001	0.000	0.001	0.000	0.000
12	-0.013	-0.020	-0.004	0.001	-0.014	-0.001	-0.002	-0.007	-0.009	0.000	0.000	0.008	-0.006
13	0.017	0.024	0.013	0.000	0.021	0.001	0.002	0.007	0.014	0.000	0.000	-0.006	0.011

Source: Author's calculations from CPI data from the Philippine Statistics Authority.

Recall that variance, by definition, is the square of standard deviation. Thus, the value of $Var(H)$ in (13), 2.230, equals the square of the standard deviation of headline inflation, 1.493, in Table 2.

Suppose now that Energy, #9 in Table 1 and Table 4, is neutralized by keeping its CPI constant. That is, for $i = 9$ in (11),

$$c_9^{t,t+1} \equiv \left(\frac{S_9^F I_9^t}{\sum_{i=1}^K S_i^F I_i^t}\right)\left(\frac{I_9^{t+1}}{I_9^t} - 1\right) = 0 \quad ; \quad I_9^t = I_9^{t+1}, \text{ all } t\,. \tag{14}$$

Let the core inflation with neutralization of #9 be denoted by J_9. In this case, (14) implies that

$$Var(c_9) = 0 \quad ; \quad Cov(c_9, c_j) = 0\,; \tag{15}$$

$$Var(J_9) = Var\left(\sum_{i\neq 9}^{K} c_i\right) = \sum_{i\neq 9}^{K} Var(c_i) + 2\sum_{i\neq 9} Cov(c_i, c_j)\,. \tag{16}$$

Following (15), neutralization yields the variance-covariance matrix in Table 5 from which

$$Var(J_9) = \sum_{i\neq 9}^{K} Var(c_i) + 2\sum_{i\neq 9} Cov(c_i, c_j) = 0.814 + 0.893 = 1.707\,. \tag{17}$$

Table 5
Variance-Covariance Matrix of Commodity Contributions to Core Inflation with Energy Neutralization

Commodities (Table 1)	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0.056	0.078	0.016	0.001	0.048	0.003	0.005	0.005	0	0.001	0.000	-0.013	0.017
2	0.078	0.522	0.016	0.002	0.151	0.003	0.006	0.043	0	0.001	0.002	-0.020	0.024
3	0.016	0.016	0.028	0.000	0.022	0.003	0.002	0.010	0	0.000	0.001	-0.004	0.013
4	0.001	0.002	0.000	0.000	0.002	0.000	0.000	-0.002	0	0.000	0.000	0.001	0.000
5	0.048	0.151	0.022	0.002	0.141	0.004	0.006	0.000	0	0.001	0.003	-0.014	0.020
6	0.003	0.003	0.003	0.000	0.004	0.001	0.000	0.001	0	0.000	0.000	-0.001	0.001
7	0.005	0.006	0.002	0.000	0.006	0.000	0.001	0.001	0	0.000	0.000	-0.002	0.002
8	0.005	0.043	0.010	-0.002	0.000	0.001	0.001	0.047	0	0.000	-0.002	-0.007	0.007
9	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0.001	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0	0.000	0.000	0.000	0.000
11	0.000	0.002	0.001	0.000	0.003	0.000	0.000	-0.002	0	0.000	0.001	0.000	0.000
12	-0.013	-0.020	-0.004	0.001	-0.014	-0.001	-0.002	-0.007	0	0.000	0.000	0.008	-0.006
13	0.017	0.024	0.013	0.000	0.020	0.001	0.002	0.007	0	0.000	0.000	-0.006	0.011

Source: Author's calculations from CPI data from the Philippine Statistics Authority.

Note that the 1.707 value of $Var(J_9)$ in (17) equals the square of the standard deviation of core inflation by E neutralization, 1.307, which is lower than 1.493 for headline inflation in Table 2.

The change in variance due to neutralization may be obtained by subtracting Table 5 from Table 4 element by element and the results are shown in Table 6.

Table 6
Changes in Variance-Covariance Due to Energy Neutralization (Table 4 minus Table 5)

Commodities (Table 1)	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0.000	**0.001**	0.000	0.000	0.000	0.000	0.000	0.000	**0.018**	0.000	0.000	0.000	0.000
2	**0.001**	**0.002**	0.000	0.000	**0.001**	0.000	0.000	0.000	**0.095**	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.016**	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**-0.001**	0.000	0.000	0.000	0.000
5	0.000	**0.001**	0.000	0.000	**0.001**	0.000	0.000	0.000	**0.077**	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.001**	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.003**	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.007**	0.000	0.000	0.000	0.000
9	**0.018**	**0.095**	**0.016**	**-0.001**	**0.077**	**0.001**	**0.003**	**0.007**	**0.065**	**0.001**	**0.001**	**-0.009**	**0.014**
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.001**	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.001**	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**-0.009**	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.014**	0.000	0.000	0.000	0.000

Source: Author's calculations from CPI data from the Philippine Statistics Authority.

To get some insight into Table 6, note that neutralization changes the weight of the inflation contribution of the neutralized commodity as can be seen by comparing (11) and (14). This changes the weights of the others because the weights must sum to 1 and, thus, changes variances and covariances from Table 4 to Table 5. However, most of the latter changes round

off to zero at two decimal places in Table 6 where it appears that the non-zero changes at three decimal places are essentially the same as the elements in row 9 and column 9 in Table 4 that sum to the value of the right-hand side of (18) below. Therefore, allowing for rounding discrepancies, the condition for the decrease in variance due to neutralization may be given as

$$Var(H) - Var(J_9) \approx Var(c_9) + 2\sum_{j \neq 9} Cov(c_9, c_j) \geq 0\,. \tag{18}$$

The reason for (18) is that by neutralizing #9 in Table 5, the variance and covariances of #9 in Table 4 appear to be the only ones that remain in Table 6.

Empirically, the condition in (18) is satisfied because (13), (17), and the right-hand side of (18), using Table 4, yield

$$Var(H) - Var(J_9) = 0.523 \approx 0.065 + 0.447 = 0.512\,. \tag{19}$$

However, it is important to note from (18) that neutralization does not necessarily lower variance because—while $Var(c_9) \geq 0$ is true by property of variance—$Cov(c_9, c_j)$ could be positive, zero, or negative. But it appears that to satisfy (18), $\sum_{j \neq 9} Cov(c_9, c_j) \geq 0$ is sufficient although not necessary because (18) could be true even if $\sum_{j \neq 9} Cov(c_9, c_j) \leq 0$ given that $Var(c_9) \geq 0$. By looking at Table 6, the above sufficient condition means that in Table 4 the sum of the covariances in the row and column of the neutralized commodity is non-negative.

Therefore, lowering the variance is an empirical issue but is very likely in practice because violating the above sufficient condition is very rare as may be seen in Table 4 where it is violated *only* by row 12 and column 12 for Education from which $\sum_{j \neq 12} Cov(c_{12}, c_j) = -0.076$ and $Var(c_{12}) = 0.008$. Substituting these values into (18) yields $Var(c_{12}) + 2\sum_{j \neq 12} Cov(c_{12}, c_j) = -0.144$, which implies that the variance of core inflation rises with neutralization of Education.

Except in the case of Education, it can be verified that Table 4 yields core inflation with lower variance than headline inflation by neutralizing any commodity. However, for core inflation by neutralization to achieve the other goal of having statistically the same mean as headline inflation, this study proposed the neutralization criterion that the commodity should have a mean of inflation contributions that is not significantly different from zero. Interestingly, this study found that only Energy or #9 satisfies the above criterion. Therefore, when Energy in Figure 3 is neutralized, the core inflation by neutralization is defined in Figure 1 by the dashed purple line that visually is very close to the blue line defining headline inflation. This is supported in Table 2 by non-rejection of hypothesis B that there is no statistically significant difference in means between headline inflation and core inflation by neutralization of Energy in the Philippines. In a way, this statistical finding justifies the current official use of headline inflation as the basis for BSP's inflation targeting policy and for NWPC's wage-setting decisions. However, using core inflation with Energy neutralized appears a better alternative for having the same mean and lower variance (or standard deviation) compared to headline inflation.

Finally, while the condition for neutralization to lower core inflation variance is simple—as given by (18) from the difference between Table 4 and Table 5—a similar condition for exclusion to lower core inflation variance is not that simple. The reason is that exclusion reduces the number of commodities so that the dimension and all elements of the variance-covariance matrix—from contributions of remaining commodities to core inflation by exclusion—are entirely different from Table 5. Therefore, unlike the logical or systematic relation between Table 4 and Table 5 that yields Table 6, there is no such relation between the variance-covariance matrix for core inflation by exclusion and the variance-covariance matrix in Table 4 for headline inflation.

Conclusion

This paper found that core inflation by the exclusion of pre-selected commodities from the CPI basket yields illogical results that are misleading in practice. In contrast, it showed that the alternative by "neutralization"—keeping all commodities in the CPI basket and setting constant the CPIs of those with inflation contributions that are not statistically significantly different from zero—is a logical and practical procedure for measuring core inflation. This benefits policymakers by permitting them to focus on commodities whose prices make statistically significant differences to headline inflation and, therefore, really matter to the economy. Moreover, the analytic advantage is that the core inflation rate will be statistically the same as the headline inflation rate, but core inflation will have a lower variance, thus, permitting more precise inflation forecasts for monetary policy purposes consistent with the overall or headline price trends. Thus, the long-term objective of core inflation measurement is technically and practically more achievable by neutralization than by exclusion. Therefore, countries that now practice exclusion should consider adopting neutralization for measuring core inflation.

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