World Food Programme

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QUARTERLY STAPLE FOOD PRICE MONITORING BULLETIN

TECHNICAL NOTE

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I – Introduction

The World Food Programme (WFP) Food Security Analysis Service (OMXF) publishes a Quarterly Price Monitoring Bulletin which monitors the retail price fluctuations of the main food staples in a number of countries[1]. The ultimate goal of this Bulletin is to analyse the potential impact of these fluctuations on the cost of a minimum food basket in the various countries, on a quarterly basis. To this effect, OMXF created an 'impact index' which measures price variations of various food staples, weighted by their percentage share in total dietary consumption[2], as a tool to measure the potential impact of price variations.

In order to assess the statistical validity of the price index used to compute the potential impact of price fluctuations, the current index is compared with three alternative methods: (1) an index with data augmented for seasonal variations; (2) a geometric Laspeyres index; (3) an arithmetic Laspeyres index.

The assessment is based on three aspects of the indices: (1) the end results are compared in order to visualise any major differences in the estimated impact; (2) a statistical test on the significance of these differences is then undertaken[3], and finally; (3) a series of nine 'index' tests[4] are undertaken in order to diagnose the validity of the indices.

Section II provides a description of the format and content of the data received by OMXF in Head Quarters (HQ), as well as the process of data management necessary to obtain the data used in the bulletin. It also offers an overview of the methodology currently used for the Price Bulletin. Section III presents a similar overview of the three alternative methods, while Sections IV and V cover respectively the comparison of the indices and the final conclusions.

II – Approach of the Bulletin

A - Price Data Sources and Management

OMXF receives monthly[5] price data from VAM officers in the various WFP Country Offices (CO's). The data is integrated into a historical price database of each concerned country. It includes the prices of the main staple food items collected from a range of markets at sub-national level.

Monthly *national* averages are calculated based on those local market price data. Only those staples which account for more than 5%[6] of the total dietary consumption, as defined by the *Food Consumption Pattern of Main Food Staples* published by FAO's Statistic Division, are considered in the Bulletin.

Finally, the Bulletin computes impact indices relating to quarterly and 5-year price variations, as well as reporting variations between the previous quarter and the 5-year average of the same quarter.

[1] The June 09 bulletin covers 56 countries.
[2] Caloric contributions are taken from *Food Consumption Pattern of Main food Staples*, published by FAO's Statistic Division.
[3] The test in question is a *paired t-test* performed using STATA 10.
[4] Tests are taken from W. E. Diewert, Essays in Index Number Theory, Ch.5 *Index Numbers*. Found at http://www.econ.ubc.ca/diewert/inbook.htm
[5] In some cases weekly data is provided and monthly averages are computed for the database
[6] With the exceptions of Maize in Niger (2%); Soya bean in Bangladesh (3%); Rice in El Salvador (4%)

B – Methodology of the Bulletin

B.1.Types of Price Variations[7]

B.1.1 – Year-on-Year Variations

The year-on-year price variations are computed according to the following formulae:

$$F = \frac{m_y - m_{y-1}}{m_{y-1}} \times 100 \quad \textbf{(1)} \qquad G = \frac{q_y - q_{y-1}}{q_{y-1}} \times 100 \quad \textbf{(2)}$$

m_y = price of current month $\quad$ q_y = average price of current quarter

m_{y-1} = price of same month in previous year $\quad$ q_{y-1} = average price of same quarter in previous year

y = current year $\quad$ *y-1* = previous year

These variations are illustrated in columns F and G of the output table of the bulletin (see table 1 below). Column F measures the percentage change from the same month of the previous year, and column G measures the percentage change from the same quarter of the previous year.

B.1.2 Quarterly Variations

The quarterly price averages are calculated following the Carli index method, in order to account for seasonal variations within the quarter[8]. The formula corresponding to the Carli index[9] is:

$$q_t = \frac{1}{3}\sum\left(\frac{p_j^t}{p_j^0}\right) \quad \textbf{(3)}$$

p_j^t = price in month *j* (*j = 1, 2, 3*) $\quad$ p_j^0 = 5-year average price of same month (*j*)

q_t = quarterly price average $\quad$ *t* = quarter 1, 2, 3 or 4

The average price defined in formula (3) is then used to calculate the price variations as shown below in formulae (4) and (5).

$$E = \frac{q_t - q_{t-1}}{q_{t-1}} \times 100 \quad \textbf{(4)} \qquad H = \frac{q_t - q_{5t}}{q_{5t}} \times 100 \quad \textbf{(5)}$$

q_t = average price of current quarter $\quad$ q_{t-1} = average price of previous quarter

q_{5t} = 5-year average of q_t

[7] Price variation methodologies are the same for each of the 4 indices.
[8] The seasonal variations based on quarterly price changes are calculated according to the calendar year. An alternative could have been to choose the seasonal calendar of each country in order to compare price changes according to harvest, post-harvest, lean and pre-harvest seasons. However the high number of countries included in the bulletin makes this alternative time consuming and cumbersome. Furthermore, the timing of this bulletin is on a quarterly basis and as such using the calendar year is more convenient.
[9] ILO (2004): *Consumer Price Index Manual: Theory and Practice (2004),* Web link:: http://www.ilo.org/public/english/bureau/stat/guides/cpi/index.htm

Formulae (4) and (5) are illustrated in table 1 below. Columns E and H report respectively the variation from the previous quarter and the variation from the five year quarterly average. The price change reported in column H indicates whether there is a structural shift of the current price from its long-term seasonal pattern.

Table 1. Section of Output Table from the Bulletin

Regions	Countries	Main staple food	Caloric contribution (%)	Change from Last Quarter (% Change)	Monthly Change from Last Year (% Change)	Quarterly Change from Last Year (% Change)	Quarterly Change from Last 5-Years (% Change)	Contribution to the Cost of the Food Basket (%)	
								Cumulative Impact of the quarter	Cumulative Impact from 5-years Average
A	B	C	D	E	F	G	H	I	J
	Benin	Maize	21	-1	3	32	103	2	55
		Cassava products	16	20	79	67	68		
		Rice	11	1	41	48	85		
		Sorghum	6	-17	107	128	213		
	Burkina Faso	Sorghum	27	-2	17	23	28	-2	22
		Millet	22	-4	13	29	26		
		Maize	15	-2	15	20	38		
		Rice	6	-4	-11	-7	58		
	Cameroon	Maize	14	10	48	38	36	2	11
		Cassava	12	4	18	12	21		
		Rice	9	-1	2	12	36		
		Plantains	5	1	-8	-9	1		

B.2 – Impact Indices

Assuming that the caloric contribution, reported in column D, is a proxy of the relative importance of the food item in the food basket, the likely impact of the change in price is captured by multiplying the price variation by the caloric contribution and dividing the product by 100. This is done for each food item, and the sum of these results by item is considered as the overall potential impact. For example, the likely *quarterly impact* of the price variations in Mauritania is computed by multiplying the *quarterly price variation* of wheat and imported rice, -18% and 0.9% respectively, by their respective *caloric contribution*, 30% and 11%, then dividing by 100. The resulting potential impacts are -5% and 0%[10], and the sum of these figures is considered as the overall potential impact of price changes on the cost of the (minimum) food basket composed of wheat and imported rice.

The same process is followed to compute the potential impact related to 5-year quarterly average prices rather than the quarterly variation.

The formulae for these impact indexes, using the column letters to represent the various components, are:

$$\text{Quarterly impact} = \sum_i \left(\frac{D_i \times E_i}{100} \right) \quad \textbf{(6)} \qquad \text{5-year impact} = \sum_i \left(\frac{D_i \times H_i}{100} \right) \quad \textbf{(7)}$$

where *i* represents each different food item

B.3 – Limitations

The main advantage of the current methodology is its theoretical simplicity and its practicality. Households with diverse calorie sources are likely to be less affected by price rises than households with a single calorie source, unless significant price increases are witnessed for each major caloric contributor of the food basket. Furthermore, there exists a component which, *à priori* controls for seasonal variations.

[10] Note that results are rounded to the nearest integer.

However, this approach based on the Carli formula may overestimate the potential impact of price fluctuations as it does not take into account substitution effects. In addition, results should be interpreted with caution as they do not capture the impact of the long term trend in food prices. Furthermore, the approach does not account for indirect impact. For instance, substitution and income effects due to price changes are disregarded. Similarly, it does not provide insights into the causes of the price increases. Finally, this approach does not account for the severity of the likely impact which may differ between households due to different incomes and food baskets by wealth or livelihoods groups and coping capacity.

III – Alternative Methods

A –Seasonal Variations Augmentation (SVA) Method

The SVA method amplifies price patterns due to seasonal variations. This method concerns only a manipulation of the data, rather than modifying the actual calculations which lead to the index. It entails multiplying each monthly price by a 'seasonal coefficient' which is constructed using the price data averaged over 5 years. This coefficient is the ratio of the monthly 5-year average and the annual 5-year average.

Step 1: Construct monthly Seasonal Coefficient (SC)

$$SC_{Benin-maize-may} = \frac{\text{5 year average price of Maize in Benin for month of May}}{\text{5 year average price of Maize in Benin for the whole year}} \quad \textbf{(8)}$$

Step 2: Adjust prices for Maize in Benin for the month(s) of May

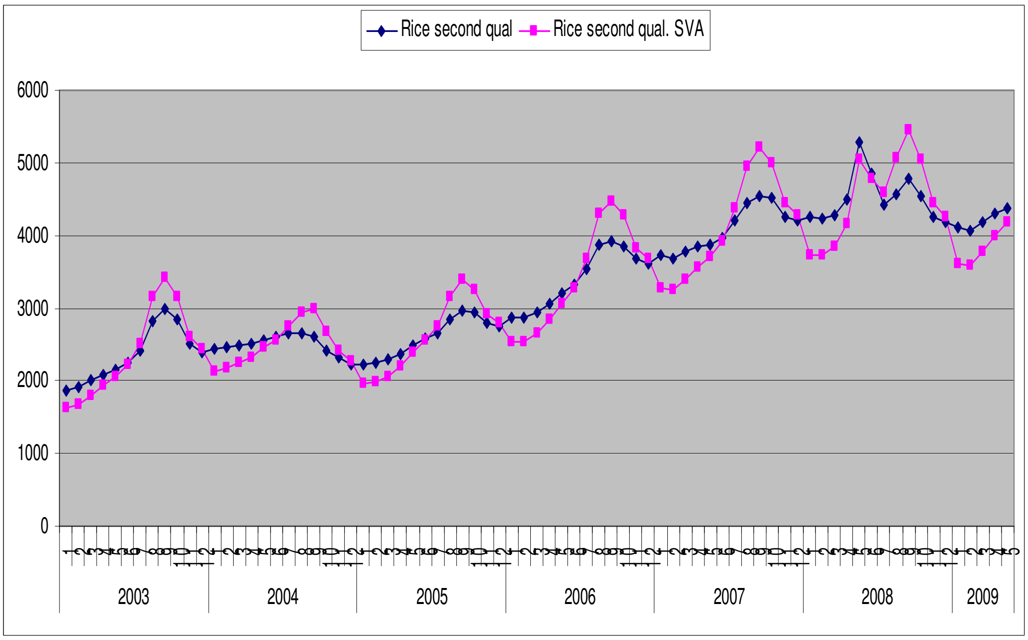
$$\text{SVA price of Maize in Benin in May} = \text{reported prices of maize in May} \times SC_{Benin-maize-may} \quad \textbf{(9)}$$

Step 3: Calculate the potential impact multiplying the SVA price by the caloric contribution as in the current methodology.

If the SC is greater than 1, the SVA method will magnify the estimated impact of the price change on the cost of the food basket. Hence it gives more importance to seasonal fluctuations. The limitations of this method are the same as the current method used in the bulletin.

The graph below illustrates the difference between the SVA price and the current price data for second quality rice in Lao PDR.

Figure 1. Price Trends Using the Current Index vs. the SVA Index



B – Geometric Laspeyres Index (GLI)

The GLI method differs substantially in terms of calculations from the Bulletin and SVA methods. It is a weighted Geometric Laspeyres index. This method entails computing the geometric mean of price ratios of the different food items in question, weighted by their respective caloric contribution. The formula for this index is:

$$P_{GL} = \prod \left(\frac{p_i^t}{p_i^0} \right)^{w^i} = \frac{\prod \left(p_i^t\right)^{w_i}}{\prod \left(p_i^0\right)^{w_i}}, \sum w_i = 1 \qquad \textbf{(10)}$$

p_i^t = price in current period p_i^0 = price in reference period

w_i = caloric contribution of commodity *i*

Note that the equation poses the restriction $\sum w_i = 1$. This restriction implies that the food items studied cover the whole food basket.

In both instances of calculation of the potential impact of quarterly price changes in relation to the previous quarter or the 5-year average, the price in the current period p_i^t is the mean quarterly price of the item in question. The reference period prices p_i^0 are the mean prices of the previous quarter for the quarterly impact, and the 5-year average price of the same quarter, for the impact in relation to 5-year price patterns.

The process of computation of the index first entails calculating the weighted price ratio of the different items, with weights as the exponent, and second multiplying the product of these weighted ratios by 100.

For example, the process for the calculation of the quarterly impact index for Benin is as follows:

$$\left(\frac{206.3}{180.8}\right)^{0.41}\times\left(\frac{193}{168.7}\right)^{0.12}\times\left(\frac{231.3}{217}\right)^{0.02}\times\left(\frac{472.5}{483.2}\right)^{0.09}\times 100-100 = 8\% \quad \textbf{(11)}$$

In the case of the 5-year impact index, the denominator of the ratios would be the 5-year average price of the same quarter.

One advantage of the geometric indices is that "*[…] geometric indices are likely to be less subject than their arithmetic counterparts to [the kinds of] index number biases [discussed in later sections]*" (ILO, 2004)[11]
In fact, geometric indices do not present an upward bias as with the Carli index.

One major limitation in the use of this geometric index, however, is the fact that the sum of the weights should be unity. In other words, the food items should be representative of the whole food basket, and this is not the case with the Bulletin, where, in some cases, the items considered represent as little as 31% of the share in total dietary energy consumption. The GLI method does not address issues regarding substitution effects either.

C – Arithmetic Laspeyres Index (ALI)

The ALI, also known simply as the Laspeyres index, is similar to the Geometric index. However rather than using the weights as the exponent of the ratios, the ALI requires multiplying the ratios by the weights. Furthermore, the *sum* of the weighted ratios is multiplied by 100, as opposed to the *product* of the weighted ratios as in the geometric index.

Thus, the formula for the arithmetic index is:

$$P_l = \sum w_i \times \left(\frac{p_i^t}{p_i^0}\right) \quad \textbf{(12)}$$

p_i^t = price in current period p_i^0 = price in reference period

w_i = caloric contribution of commodity *i*

Using the same example as in section III B, the arithmetic quarterly impact index is calculated as follows:

$$\left(\left(\frac{206.3}{180.8}\right)\times 0.41+\left(\frac{193}{168.7}\right)\times 0.12+\left(\frac{231.3}{217}\right)\times 0.02+\left(\frac{472.5}{483.2}\right)\times 0.09\right)\times 100-100 = 14\% \quad \textbf{(13)}$$

As for the geometric index, the price in the reference period (i.e. the denominator) is the mean price of the previous quarter in the case of the quarterly impact, and for the 5-year impact, it is the 5-year average price of the same quarter.

Unlike the GLI, the ALI over-estimates price variations and hence their potential impact on the cost of the food basket. In addition, it does not take into consideration the change in consumption patterns linked to increases in relative prices.

[11] Chapter 1, page 9.

IV – Validity of the Methods

A – Comparison of Impact Indices

The first step in testing the validity of these methodologies is to compare the potential impacts estimated from the different indices. To this effect, 'comparison tables' are created in order to visualize the magnitude of the differences between the methods. Note that in order to compare the indices, the weights (i.e. caloric contributions) were computed in a way that their sum equals 100%, whilst keeping the same proportions. This was done by solving equations in order to obtain a parameter by which the weights could be multiplied in order to obtain a sum of 100%.

In the case of Benin for example, where the weights are 21%, 16%, 11% and 6%, the following calculations were undertaken:

First, the following equation was solved for x: $21x + 16x + 11x + 6x = 100$, where we obtain $x = \frac{50}{27}$.

Then all weights were multiplied by $\frac{50}{27}$, in order to obtain adjusted weights which sum up to 100%.

When the sum of the weights is set to 100%, it is rather difficult to draw a firm conclusion by comparing all four methods. The simple comparison of the impacts does not depict any pattern when comparing all the countries in the database. Table 2 illustrates an example for Cameroon and Cote d'Ivoire. The validity of the methods is therefore investigated further, using statistical tests.

Table 2. Differences in Impacts Using Different Price Indices

Cameroon Quarterly Impact				
	GLI	Current	SVA	ALI
GLI	-	-4	0	1
Current	4	-	4	5
SVA	0	-4	-	0
ALI	-1	-5	0	-

Cameroon 5-year Impact				
	GLI	Current	SVA	ALI
GLI	-	1	1	8
Current	-1	-	0	7
SVA	-1	0	-	7
ALI	-8	-7	-7	-

Cote d'Ivoire Quarterly Impact				
	GLI	Current	SVA	ALI
GLI	-	0	1	-5
Current	0	-	2	-5
SVA	-1	-2	-	-6
ALI	5	5	6	-

Cote d'Ivoire 5-year Impact				
	GLI	Current	SVA	ALI
GLI	-	4	1	-3
Current	-4	-	-3	-7
SVA	-1	3	-	-4
ALI	3	7	4	-

Note that the differences in the matrices are calculated by subtracting the row from the column

B – Paired T-test

In order to investigate the statistical significance of the differences in the results, the validity of the methods is tested using paired t-test techniques on a cross-country dataset (56 countries). The statistical tests are undertaken using STATA 10 software.

The hypothesis tested is that the mean difference between the potential impacts estimated using the above methods is equal to 0. In other words, the test determined whether the measured difference in potential impacts using two methods is due to chance or is systematic. If one chooses 5% as the significance level, the difference between two methods is considered to be significant, if the probability of the t-value of the alternative hypothesis (i.e. no difference) is inferior to 5%.

All the paired-tests performed indicate that the differences cannot be considered as statistically significant at 5% significance level and 46 degrees of freedom.

C - 'Index' Tests

The validity of the methods is further tested by performing 9 'index' tests as recommended in the literature (Diewert, 2005)[12]:

BT1: *Identity Test*: "if prices and quantities are all equal in the two periods (or for the two regions under consideration), then the price index should be unity."

BT2: *Proportionality Test*: "if all period 2 prices are multiplied by α, then the new price index should equal α times the old price index".

BT3: *Invariance to Changes in Scale Test*: "the price index should remain unchanged when each price in both periods is multiplied by the same number α".

BT4: *Commensurability Test*: "the index should remain unchanged if each good is measured in different units."

BT5: *Time Reversal Test*: "if we interchange the role of periods 1 and 2 in [the] price index, then the new price index should equal the reciprocal of the original index."

BT6: *Commodity Reversal Test*: "the price index should remain unchanged when the ordering of the products is changed"[13].

BT7: *Monotonicity Test*: "if period 2 prices increase in any manner, then the price index cannot decrease.

BT8: Mean Value Test: "the price index should lie between the smallest and the largest price ratios over all commodities".

BT9: *Circularity Test*: "if we have price and quantity data for three time periods, then the product of the price index going from period 1 to period 2 times the price index going from period 2 to 3 should equal the price index going from period 1 to 3 directly."

The table below illustrates the outcomes of the tests on the different indices. ✓ denotes passed tests, and X denotes failed tests.

Table 3. Index Tests Results

Test	Index Used for Potential Impact Estimate			
	Current	**SVA**	**GLI**	**ALI**
BT 1 ***Identity***	✓	✓	✓	✓
BT 2 ***Proportionality***	✓	✓	✓	✓
BT 3 ***Invariance to Changes in Scale***	✓	✓	✓	✓
BT 4 ***Commensurability***	✓	✓	✓	✓
BT 5 ***Time Reversal***	X	X	✓	X
BT 6 ***Commodity Reversal***	✓	✓	✓	✓
BT 7 ***Monotonicity***	✓	✓	✓	✓
BT 8 ***Mean Value***	✓	✓	✓	✓
BT 9 ***Circularity***	✓	✓	✓	✓

Note that in order to ensure the validity of the tests, the computed weights whose sum are equal to unity were used.

As is visible from the table above, only the geometric index passes all 9 tests, while the current, SVA and ALI indices failed the time reversal test (BT5).

[12] Web link: http://www.econ.ubc.ca/diewert/inbook.htm

[13] From OECD Glossary of Statistical Terms, http://stats.oecd.org/glossary/detail.asp?ID=5712

V – Conclusions

In this technical note, several tests were undertaken using different methods to assess the validity of the price index used in the current WFP (OMXF) Quarterly Price Monitoring Bulletin against alternative indices such as the geometric Laspeyres index, the arithmetic Laspeyres index and an index which emphasized seasonal variations (SVA). The results do not exhibit any significant difference between the current method and the proposed alternatives.

Overall, the paired t-tests showed that the differences between all the indices cannot be considered as statistically significant. In addition, the results of the index tests show that the different alternative indices are quite similar to the price index used in the bulletin.

All the methods, including the current one, face the same limitations regarding the potential impacts of staple food price changes on the cost of the food basket: substitution and income effects due to price changes are not accounted for in their potential impact on the cost of the food basket. Similarly, they do not provide insights into the causes of the price increases. Finally, the methods do not account for the severity of the likely impact which may differ between households due to different incomes and food baskets by wealth or livelihoods groups and coping capacity.

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