LEARNING ABOUT 2.c.1 INDICATOR

SDG Indicator 2.c.1 – Food price anomalies

Lesson: A guide to calculating and interpreting SDG Indicator 2.c.1

Text-only version

Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

working for Zero Hunger

In this lesson

A guide to calculating and interpreting SDG Indicator 2.c.1

This lesson illustrates the basic concepts behind the rationale of Indicator 2.c.1, defining a compound rate and how it deals with price volatility. It goes on to present the formula and methodology for calculating the indicator, and provides guidance on how to interpret the results, and the general food and market situation in a given country.

Learning objectives

At the end of this lesson, you will be able to:

- define the components of the Indicator of Food Price Anomalies (IFPA);
- indicate the steps in calculating the IFPA;
- calculate a compound growth rate;
- distinguish rates of price growth based on the IFPA thresholds.

Introduction

Target 2.c of the **Sustainable Development Goals (SDGs**) encourages countries to adopt measures to ensure the proper functioning of food commodity markets and their derivatives, and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility.

2.c → **2.c.1 (IFPA)** To measure progress towards this target, proposed indicator for countries is **Indicator 2.c.1** or the **Indicator of Food Price Anomalies** (**IFPA**).

The Indicator of Food Price Anomalies (**IFPA**)

The IFPA is an indirect indicator of Target 2.c, as it is a **measure of food price volatility**.
Through this indicator, countries can measure the number of years of abnormally high and volatile prices, due to improper functioning of local markets and various shocks affecting the food system, relative to a base year or period. It is important to highlight that this indicator is only a guide to understanding market dynamics. As such, it cannot be relied on as the sole element for determining whether a food price in a particular market at a given time is abnormally high or low. Results must be weighed together with other available information on market fundamentals, macroeconomic context and external shocks. This is especially important when evaluating whether or not to flag the price as an anomaly.

Price fluctuations may often be observed on markets. They may be caused by several market drivers, such as:

Shocks - Seasonal trends can also be exacerbated by **intra-annual shocks,** such as drops in supply due to either production or trade shortfalls.

Seasonality is an important attribute of agricultural prices, which predetermines the rate of price fluctuations at any given time during the calendar. For example…

- Lean season: When the lean season approaches and supplies are low, **agricultural prices tend to increase**. Prices reach their highest level at the peak of the lean season.
- **Harvest** At harvest, prices tend to decline, as new supplies enter the market.

Definition of a compound growth rate

When price change is observed we want to know:

Is the rate of change in prices normal for the period of time being observed?

The IFPA provides an answer to this question, as it detects abnormal price growth in food markets. This indicator is a weighted sum of **two compound growth rates** (**CGR**):

IFPA = A quarterly compound growth rate (CQGR) + An annual compound growth rate (CAGR)

Compound growth rates (CGR), which tend to smooth out volatile times series, are commonly used in finance to rank the returns of stocks or other financial assets based on their growth. *(Anson et al., 2011)*

To deal with price **volatility**, the IFPA **relies on a weighted compound growth rate** (**CGR**) **approach**.

CGR A compound growth rate (CGR) is a geometric mean, which assumes that a random variable grows at a steady rate, compounded over a specific period of time. A **geometric mean** is a type of average, which indicates the typical value of a set of numbers by using the product of their values, as opposed to the arithmetic mean which relies on their sum. This results in the mean calculation being less affected by extreme values in the series to be averaged, and thus allows the average not to be affected by high or low peak values *Source: Wikipedia, 2017*

$$\left(\prod_{i=1}^{n} x_i\right)^{\frac{1}{n}} = \sqrt[n]{x_1 x_2 \cdots x_n}$$

This is the formula for calculating CGR in month *t*…

Equation 1

$$CGR_t = \left(\frac{P_{t_B}}{P_{t_A}}\right)^{\frac{1}{n}} - 1$$

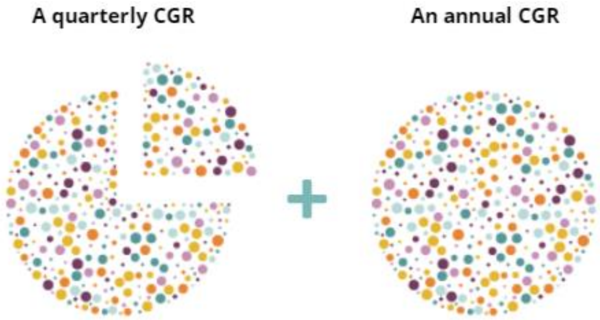
P_{ta} = The price at the beginning of the period

P_{tb} = The price at the end of the period

n = The time in months between periods A and B

Since it assumes a steady rate of growth, the CGR smoothes the effect of volatility of periodic price movements. You can see the effect in this graphic representation of a price series multiplied by its CGR.

The IFPA has several features built into its calculation to deal with seasonal effects. However, the indicator mainly relies on two compound growth rates (CGR's):



It this way, the indicator captures in a single index both sources of price variation (within the year and across years). In addition, to further account for seasonal effect, the SQGR and CAGR are calculated as a moving average over the immediately preceding 3 or 12 month period of month t. respectively, of the last available data point in the series.

Calculation of a compound growth rate

On national markets, prices have been observed from January to April. Their values are reported in this table.

January	February	March	April
50	35	65	52

Is the rate of price change for the observed time period normal?

To answer this question, we first need to define what is normal for the period, by calculating an **average change** from the beginning period to the end period over a predefined period of time. To calculate this average change, we do not use a simple arithmetic mean. CGR estimation is based on a **geometric mean**, which assumes that a random variable grows at a steady rate.

By substituting the ending price (P_{tB}), the beginning price (P_{tA}) and the number of months (n) of our price series in the CGR equation, we obtain this result:

Equation 2

$$CGR_t = \left(\frac{P_{t_B}}{P_{t_A}}\right)^{\frac{1}{n}} - 1 = 1.3\%$$

The steady rate of growth of the prices series observed from January to April **is on average 1.3%**, a constant and stable rate. From this result, we can then proceed to estimate how much observed prices deviate from this average change.

How to calculate CGR

These are the values needed to calculate the CGR:

$$P_{ta}=50 \quad P_{tb}=52 \quad n=3$$

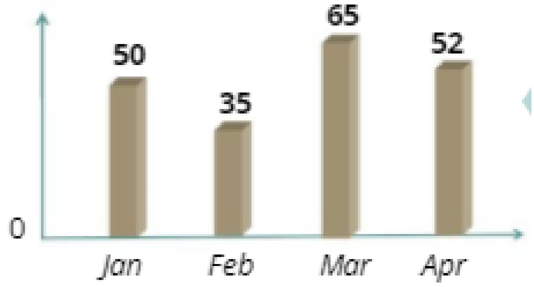
Let's substitute them in the CGR equation:

$$CGR_t = \left(\frac{P_{t_B}}{P_{t_A}}\right)^{\frac{1}{n}} - 1 \rightarrow CGR_t = \left(\frac{52}{50}\right)^{\frac{1}{3}} - 1 \rightarrow CGR_t = \sqrt[3]{1{,}04} - 1 = 1.3\%$$

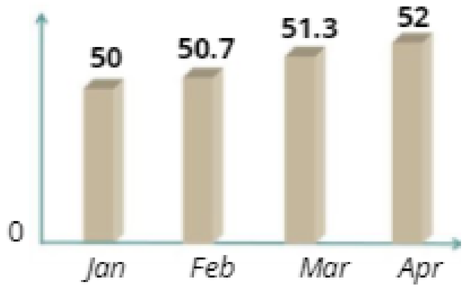
This is the result…

A comparison of the two price series

This graphical representation shows the smoothing effect of the CGR.



These are the prices observed.



This is the price series at the estimated CGR.

IN DEPTH: ARITHMETIC MEAN OR GEOMETRIC MEAN?

To estimate growth in a random variable (for example prices), we first need to define what would be the normal growth for the time period being considered. Calculating a compound growth rate (CGR) makes it possible to estimate an average change from period A to period B over a predefined period of time.

"The CGR is a geometric mean. Why not using a simple arithmetic mean? Because the arithmetic mean is affected by the level of volatility in prices."

If the volatility of prices is close to zero, then the simple arithmetic mean would be approximately equal to a geometric mean. However, if volatility is high, this renders the value of the mean a useless value for the purposes of setting a benchmark.

Let's review the price series example covering the period from January to April, already presented in the lesson (Table 1). If we calculate the **average** rate of price growth for each month from January to April, we observe that **this rate fluctuates significantly**, from -20% up to more than 80%, resulting in a period average of 11.9%.

	Jan	Feb	Mar	Apr
USD/Kg	**50**	**35**	**65**	**52**
		-30%	**+86%**	**-20%**

(Average: 11.9%)

The high level of volatility in the series renders the **mean value of little use** for the purposes of establishing a benchmark, or of evaluating if the observed price changes between January and April are within normal ranges.

The use of a geometric mean is not influenced by price volatility. Let's compare the original price series (Table 1) with the price series obtained by multiplying original prices by 1.3% - the CGR value. The CGR assumes a constant (average) rate of growth in the observed price series equal to 1.3%, giving us a stable benchmark to work from.

	Jan	Feb	Mar	Apr
USD/Kg	**50**	**35**	**65**	**52**
		-30%	**+86%**	**-20%**

(Average: 11.9%)

	Jan	Feb	Mar	April
USD/Kg	**50**	**35**	**65**	**52**
	50	**50,7**	**51.3**	**52**
			CGR=1.3%	

Example

Year 1	Year 2	Year 3	Year 4	Year5	USD/kg
92	105	88	120	95	

Compound growth rate (CGR) of the price series presented here is 0%.

This is the result of the annual compound growth rate (CAGR), whereas the average rate of growth of this price series is 5.98%. The CAGR helps to fix the limitations of calculating the arithmetic average growth.

How to determine an abnormal growth rate

By calculating the CGR, we have obtained the reference growth rate. Now, we can use both the quarterly compound growth rate (CQGR) and the annual compound growth rate (CAGR) to calculate the Indicator of Food Price Anomalies (IFPA), and thus determine what an **abnormal growth rate is**.

Indicator of Food Price Anomalies The formula for the quarterly or annual Indicator of Food Price Anomalies for a given month *t* in particular year *y* is given by Equation 2:

Equation 3

$$(XIFPA^{Z}_{yt}) = \left(\frac{CXGR_{yt} - \overline{W\_CXGR_t}}{\hat{\sigma}_{W\_CXGR_t}}\right)$$

$CXGR_{yt}$	Either the quarterly or annual CGR in month *t* for year *y*
$\overline{W\_CXGR_t}$	The weighted average of either the CQGR or the CAGR for month *t* across years *y*
$\hat{\sigma}_{W\_CXGR_t}$	The weighted standard deviation of either the CQGR or the CAGR for month *t* over years *y*

Both the average and the standard deviation are multiplied by a specific weight (W). The use of a weighted average and weighted standard deviation reduces the probability that an abnormally high price will be detected when it should not have been.

IN DEPTH: HOW TO CALCULATE THE INDICATOR OF FOOD PRICE ANOMALIES (XIFPAz/yt)

This is the formula to calculate the quarterly or annual Indicator of Price Anomalies (**XIFPAz/yt**). We have already examined the formula to calculate the compound growth rate, but in this formula we see that we calculate the CGR average and standard deviation by using a weighted approach. Why? And how do we define these weights?

Equation 2

$$(XIFPA_{yt}^{z}) = \left(\frac{CXGR_{yt} - \overline{W\_CXGR_t}}{\hat{\sigma}_{W\_CXGR_t}}\right)$$

As with any indicator, for the quarterly or annual Indicator of Food Price Anomalies, we have to balance two types of errors.

The first type of error can occur when the indicator signals a price alert/watch when the reality is that markets are behaving normally. This is known as a Type I error (false positive), which leads to a significant reduction in confidence of the indicator.

A Type II error occurs when no price alert/watch is given when one should have been issued (false negative). This type of error is of greater concern for early warning purposes, as it is important not to miss an impending market shock.

We therefore modify Equation 2 to reduce the probability of a Type II error. However, both these errors are inter-related, since mitigating for a Type I error will increase the probability of a Type II error, and vice-versa.

The historical standard deviations and means are calculated giving equal weights to all time periods in the price series. So, a period of high and volatile prices at the beginning of the period will have the same weight as a more recent period of low and less volatile prices. Therefore, the threshold for a CGR to be considered abnormal may be higher than it needs be, thus resulting in a Type II error.

To avoid this error, instead of using the simple mean and standard deviation, we substitute these for a weighted mean and standard deviation. The weights are linear time weights, where the most recent past has a higher weight in the calculation of the mean and standard deviation than the beginning of the price series. The weighted mean is defined as follows:

1						
2		2006	2007	2008	2009	2010
3	2006	1	1	1	1	1
4	2007	0	0	2	2	2
5	2008	0	0	0	3	3
6	2009	0	0	0	0	4
7	2010	0	0	0	0	0
8	2011	0	0	0	0	0
9	2012	0	0	0	0	0
10	2013	0	0	0	0	0
11	2014	0	0	0	0	0
12	2015	0	0	0	0	0
13	2016	0	0	0	0	0
14		1	1	3	6	10
15						
16		QN6	QN7	QN8	QN9	QN10
17		0	1	2	3	4
18						
19	Year	QW2006	QW2007	QW2008	QW2009	QW2010
20	2006	0,00	1,00	0,33	0,17	0,10
21	2007	0,00	0,00	0,67	0,33	0,20
22	2008	0,00	0,00	0,00	0,50	0,30
23	2009	0,00	0,00	0,00	0,00	0,40
24	2010	0,00	0,00	0,00	0,00	0,00
25	2011	0,00	0,00	0,00	0,00	0,00
26	2012	0,00	0,00	0,00	0,00	0,00
27	2013	0,00	0,00	0,00	0,00	0,00
28	2014	0,00	0,00	0,00	0,00	0,00
29	2015	0,00	0,00	0,00	0,00	0,00
30	2016	0,00	0,00	0,00	0,00	0,00
31						
32	Check	0	1	1	1	1

For example, In this table, you can view the weights for the price series from year 2006 to 2010. The year 2010 has a value of 0.10%, which is just 1/10, with the base being the sum from year n=1 to n=5, the number of years between 2006 and 2010.

Equation 1

$$\overline{W\_CXGR_t} = \frac{1}{\sum_{y=1}^{Y} w_y} \sum_{y=1}^{Y} w_y CXGR_{yt}$$

W_CXGR_t - The weighted average for month *t* of the X (quarterly or annual) CGR
W_y - The weight for year *y*
$CXGR_{yt}$ - The un-weighted compound growth rate in year *y* in month *t*
Σy=1 - The summation operator over years Y

How then do we calculate the weighted standard deviation? The weighted standard deviation is then estimated as follows:

Equation 2

$$\hat{\sigma}_{W\_CXGR_t} = \sqrt{\frac{\sum_{y=1}^{Y} w_y (CXGR_{yt} - W\_CXGRt)^2}{\sum_{y=1}^{Y} w_y (\hat{Y}-1)/\hat{Y}}}$$

$\hat{\sigma}_{W\_CXGR_t}$ The weighted standard deviation for month *t* of the X (quarterly or annual) CGR

$\hat{Y}$ The total number of weights

The results of the Indicator of Food Price Anomalies (XIFPA z/yt) are then compared to the thresholds defined for abnormal price growth rate. Three thresholds have been defined:

- Normal growth rate
- Moderately high growth rate
- High growth rate

Normal price growth

$$-0.5 \leq X\_IFPA_t^Z < 0.5$$

Any **difference from the mean of the relevant $\mathbf{CXGR_{yt}}$** that is between

-0.5 ≤ X_IFPA z/t < 0.5 of the standard deviation is considered normal. While we don't consider the negative space of a price change, the same thresholds would apply when evaluating abnormally low price levels.

Moderately high price growth

$$0.5 \leq X\_IFPA_t^Z < 1$$

Moderately high price growth, for either the annual or quarterly $CXGR_{yt}$**,** is defined as a **deviation from the mean rate of growth of prices** for a particular month t that is less than one standard deviation but greater than or equal to a half standard deviation. These events are of particular interest as they can provide an early warning of possible severe market disruptions, especially when they are close to one standard deviation.

High price growth

$$X\_IFPA_t^Z \geq 1$$

The threshold for high growth in food prices is defined as an absolute positive change in the compound growth rate (CGR) - either annual or quarterly - that is at least **one standard deviation from the mean CGR over a specific month**.

Events that deviate by more than one standard deviation from historical CGR's are easy to identify and probably do not require any information from a model.

Example

These are the values of the annual Indicator of Food Price Anomalies of the last four months of 2016 ($AIFPA_t$). This is how price growth in these months can be defined.

	AIFPA 2016	
September	-0.4588	normal
October	0.1179	normal
November	0.3318	normal
December	1.3766	hign

Any difference from the mean of the relevant $CXGR_{yt}$ that is between $-0.5 \leq X\_IFPA_t < 0.5$ of the standard deviation is considered normal. Values that deviate by at least one standard deviation from historical CGR's signal a high price growth.

How to calculate the $IFPA_y$

Once you have calculated both the quarterly and the annual Indicator of Food Price Anomalies (**IFPAyt**), there are two additional steps.

STEP 1

First you need to calculate the Indicator of Food Price Anomalies for a particular year *y* in month *t* (**$IFPA_{yt}$**) through the following weighted sum:

Equation 3

$$IFPA_{yt} = \gamma QIFPA^{Z}_{yt} + (1-\gamma) AIFPA^{Z}_{yt}$$

$QIFPA^{Z}_{yt}$	The quarterly Indicator of Food Price Anomalies in year *y* and month *t*
$AIFPA^{Z}_{yt}$	The weighted average of either the CQGR or the CAGR for month *t* across years *y*
ϒ	It is a weight with a value of 0.4

What is ϒ?

An **important component** of the **IFPAyt** is the value of **ϒ.** The weight **ϒ** establishes the relative importance of quarterly **QIFPAz/yt** anomalies to the year-on-year price variations **AIFPA z/yt**. For our purposes, **ϒ** takes **a value of 0.40**, giving more weight to the **AIFPA z/yt**, to better capture the level of prices.

STEP 1

Then, SDG Indicator 2.c.1 **(IFPAy)** is finally calculated as the arithmetic mean over t months of the **IFPAyt**.

Equation 4

$$IFPA_y = \frac{1}{t} \sum_{i=1}^{t} IFPA_{yt}$$

IFPAy The quarterly Indicator of Food Price Anomalies in year *y* and month *t*

IFPAyt The weighted average of either the CQGR or the CAGR for month *t* across years *y*

T It is a weight with a value of 0.4

The thresholds for the **IFPAy** are the same as those reviewed earlier.

$-0.5 \leq IFPA_y < 0.5$

Normal price growth

$0.5 \leq IFPA_y < 1$

Moderately high price growth

$IFPA_y \geq 1$

High price growth

How to interpret the $IFPA_{yt}$

High or normal food prices have mixed results, as shown by the following two examples.

"We buy most of our food. This long period of high prices in food commodities is seriously reducing our access to food. We sell most of the food commodities we produce in local markets. The recent growth of prices for food commodities has increased our income from food sales and is improving our access to food."

In food markets of the developing world, the net effect will depend on whether or not a household (or country) is a **net consumer or producer of food**.

IN DEPTH: HOW TO CALCULATE INDICATOR 2.C.1 (XIFPAY). THE EL SALVADOR EXAMPLE

Now let's apply calculation of the Indicator of Food Price Anomalies (**IFPAy**) to a real price series.

The price information used in this example comes from FAO's Food Price Monitoring and Analysis Tool which contains more than 1400 domestic price series across 93 countries.

The series used in this example is the Wholesale Price for Maize (White) in El Salvador. There are two versions of the price series, a **nominal** one **and the real term series**, which has been deflated using the domestic consumer price index (CPI) (2010=100), as reported by the International Monetary Fund (IMF).

	A	B	C	D	E	F
1	El Salvador, San Salvador , Maize (White), Wholesale					
2	Date (MMM-YY)	Maize	CPI	Price		
3	Jan-06	10.38	0.858876	12.08557		
4	Feb-06	10.16	0.86315	11.77084		
5	Mar-06	10.74	0.866196	12.39904		
6	Apr-06	11.07	0.872107	12.6934		
7	May-06	11.03	0.873198	12.63173		
8	Jun-06	11.72	0.880336	13.31309		
9	Jul-06	11.63	0.891385	13.04711		
10	Aug-06	11.63	0.886611	13.11737		
11	Sep-06	11.86	0.886247	13.38227		
12	Oct-06	11.44	0.882792	12.95889		
13	Nov-06	11.62	0.888293	13.08127		
14	Dec-06	11	0.896068	12.27585		
15	Jan-07	11.54	0.906525	12.72992		
16	Feb-07	12.82	0.904479	14.1739		

The real term series is the one we use in this example. We obtain it by dividing nominal prices by the defined CPI. For example, for January 2006:

$$\textbf{Price}_{\textbf{jan06}} = \frac{\textbf{10.38}}{\textbf{0.858876}}$$

STEP 1

The first step in estimating the IFPAy is to calculate Equation 2, and then organize the results by month and year.

Calculate the $\textbf{CAGR}_{\textbf{yt}}$

$$CQGR_{Dec2016} = \left(\frac{Pr_{Dec2016}}{Pr_{Sep2016}}\right)^{\frac{1}{3}} - 1$$

Calculate the **$CAGR_y$**

$$CAGR_{Dec2016} = \left(\frac{Pr_{Dec2016}}{Pr_{Dec2015}}\right)^{\frac{1}{12}} - 1$$

Please note that this is not required, but facilitates the calculations of the mean and standard deviations in Equation 2.

$CAGR_{yt}$

Let's examine these sub-steps in the Excel file.

El Salvador, San Salvador , Maize (White), Wholesale						
Date (MMM-YY)	Maize	CPI	Price	Month	Year	CQGR-Equation 1
Jul-15	22.29	1.079794	20.64282	7	2015	0.030660332
Aug-15	20.68	1.076431	19.21164	8	2015	0.014478144
Sep-15	19.93	1.072375	18.58491	9	2015	-0.001446705
Oct-15	19.14	1.095621	17.46954	10	2015	-0.054116866
Nov-15	18.79	1.094929	17.16093	11	2015	-0.036927771
Dec-15	18.35	1.094137	16.7712	12	2015	-0.033649726
Jan-16	18.8	1.094731	17.17317	1	2016	-0.005687305
Feb-16	19.09	1.091763	17.48547	2	2016	0.00626453
Mar-16	19.89	1.0913	18.22597	3	2016	0.028116064
Apr-16	19.81	1.0886	18.19769	4	2016	0.019503129
May-16	19.28	1.0894	17.69782	5	2016	0.004031686
Jun-16	19.03	1.0905	17.45071	6	2016	-0.014384563
Jul-16	18.47	1.0893	16.95584	7	2016	-0.023285245
Aug-16	18.49	1.0866	17.01638	8	2016	-0.013002959
Sep-16	18.34	1.0833	16.92975	9	2016	-0.010051755
Oct-16	16.49	1.086	15.18416	10	2016	-0.036118127
Nov-16	15.19	1.0859	13.9884	11	2016	-0.0632287
Dec-16	14.17	1.0839	13.07316	12	2016	-0.08256209
Jan-17	13.01	1.092	11.91392	1	2017	-0.077666586
Feb-17	12.46	1.091773	11.41263	2	2017	-0.065586108

For example: The compound growth rate for the last quarter of 2016 is calculated as follows:

$$CQGR_{Dec2016} = \sqrt[3]{\frac{13.073}{16.929}} - 1 = -0.082\%$$

Please note: The CQGR can only be calculated up to the second quarter of 2006, since the data to calculate the corresponding values for each month during the first quarter would necessitate data from 2005, which we do not have.

Data by month

Date	Month	Year	CQGR	CAGR
Jan-06	1	2006		
Jan-07	1	2007	-0.006	0.004
Jan-08	1	2008	-0.052	0.021
Jan-09	1	2009	-0.045	-0.009
Jan-10	1	2010	-0.026	-0.011
Jan-11	1	2011	0.087	0.036
Jan-12	1	2012	-0.064	-0.011
Jan-13	1	2013	-0.021	-0.025
Jan-14	1	2014	-0.039	-0.008
Jan-15	1	2015	0.035196	0.042604958
Jan-16	1	2016	-0.00569	-0.007420958
Feb-06	2	2006		
Feb-07	2	2007	0.027	0.016
Feb-08	2	2008	0.016	0.012
Feb-09	2	2009	-0.013	-0.009
Feb-10	2	2010	-0.025	-0.010
Feb-11	2	2011	0.131	0.043
Feb-12	2	2012	-0.014	-0.022
Feb-13	2	2013	-0.024	-0.023
Feb-14	2	2014	-0.024	-0.003
Feb-15	2	2015	0.03851	0.038501548
Feb-16	2	2016	0.006265	-0.005658142

These are sub-steps 1.1 1.2 and 1.3

1.1 $CQGR_{yt}$

Month	Year	CQGR-Equation 1
1	2006	
2	2006	
3	2006	
4	2006	0.016491286
5	2006	0.023807734
6	2006	0.023992943
7	2006	0.009203692
8	2006	0.012654509
9	2006	0.001729115
10	2006	-0.002259049
11	2006	-0.000918196
12	2006	-0.028355757
1	2007	-0.005924618
2	2007	0.027101027
3	2007	0.08348329

1.2 $CAGR_{y}$

Month	Year	CAGR-Equation 1
1	2006	
2	2006	
3	2006	
4	2006	
5	2006	
6	2006	
7	2006	
8	2006	
9	2006	
10	2006	
11	2006	
12	2006	
1	2007	0.004338016
2	2007	0.015601842
3	2007	0.019398969
4	2007	0.022115885
5	2007	0.033933995
6	2007	0.042933826

1.3 Data by month

Date	Month	Year	CQGR	CAGR
Jan-06	1	2006		
Jan-07	1	2007	-0.006	0.004
Jan-08	1	2008	-0.052	0.021
Jan-09	1	2009	-0.045	-0.009
Jan-10	1	2010	-0.026	-0.011
Jan-11	1	2011	0.087	0.036
Jan-12	1	2012	-0.064	-0.011
Jan-13	1	2013	-0.021	-0.025
Jan-14	1	2014	-0.039	-0.008
Jan-15	1	2015	0.035196	0.042604958
Jan-16	1	2016	-0.00569	-0.007420958
Feb-06	2	2006		
Feb-07	2	2007	0.027	0.016
Feb-08	2	2008	0.016	0.012
Feb-09	2	2009	-0.013	-0.009
Feb-10	2	2010	-0.025	-0.010
Feb-11	2	2011	0.131	0.043
Feb-12	2	2012	-0.014	-0.022
Feb-13	2	2013	-0.024	-0.023
Feb-14	2	2014	-0.024	-0.003

STEP 2

The second step in estimating the **IFPAy** is to define the weights that will be used to calculate the weighted means and standard deviations.

The weight structure is flexible. What is important is that

the value for the means and standard deviations for year (*t+i*) have a greater weight than the values for year (t), which corresponds to the beginning of the series.

QW2016
0,0182
0,0364
0,0545
0,0727
0,0909
0,1091
0,1273
0,1455
0,1636
0,1818
0,0000

For example: The quarterly weight for the year 2006 has a value of **0.0182%**, which is just 1/55, with the base being the sum from year n=1 to n=10, the number of years between 2006 and 2015. The year 2015 has a weight of **0.18%,** which is 10/55.

This table presents the weight structure. The only difference between the quarterly and annual weights is that the latter start from 2007, since the $CAGR_y$ is only calculated from 2007.

	Percent (%)										
Quaterly											
Year	Weight 2006	Weight 2007	Weight 2008	Weight 2009	Weight 2010	Weight 2011	Weight 2012	Weight 2013	Weight 2014	Weight 2015	Weight 2016
2006	-	1	0.3333	0.1667	0.1000	0.0667	0.0476	0.0357	0.0278	0.0222	0.0182
2007	-	-	0.6667	0.3333	0.2000	0.1333	0.0952	0.0714	0.0556	0.0444	0.0364
2008	-	-	-	0.5000	0.3000	0.2000	0.1429	0.1071	0.0833	0.0667	0.0545
2009	-	-	-	-	0.4000	0.2667	0.1905	0.1429	0.1111	0.0889	0.0727
2010	-	-	-	-	-	0.3333	0.2381	0.1786	0.1389	0.1111	0.0909
2011	-	-	-	-	-	-	0.2857	0.2143	0.1667	0.1333	0.1091
2012	-	-	-	-	-	-	-	0.2500	0.1944	0.1556	0.1273
2013	-	-	-	-	-	-	-	-	0.2222	0.1778	0.1455
2014	-	-	-	-	-	-	-	-	-	0.2000	0.1636
2015	-	-	-	-	-	-	-	-	-	-	0.1818
2016	-	-	-	-	-	-	-	-	-	-	-
Annual Weights											
Year		Weight 2007	Weight 2008	Weight 2009	Weight 2010	Weight 2011	Weight 2012	Weight 2013	Weight 2014	Weight 2015	Weight 2016
2007		-	1	0.3333	0.1667	0.1000	0.0667	0.0476	0.0357	0.0278	0.0222
2008		-	-	0.6667	0.3333	0.2000	0.1333	0.0952	0.0714	0.0556	0.0444
2009		-	-	-	0.5000	0.3000	0.2000	0.1429	0.1071	0.0833	0.0667
2010		-	-	-	-	0.4000	0.2667	0.1905	0.1429	0.1111	0.0889
2011		-	-	-	-	-	0.3333	0.2381	0.1786	0.1389	0.1111
2012		-	-	-	-	-	-	0.2857	0.2143	0.1667	0.1333
2013		-	-	-	-	-	-	-	0.2500	0.1944	0.1556
2014		-	-	-	-	-	-	-	-	0.2222	0.1778
2015		-	-	-	-	-	-	-	-	-	0.2000
2016		-	-	-	-	-	-	-	-	-	-

STEP 3

The third step is to estimate the weighted means and weighted standard deviations.

3.1 This is the formula to calculate the weighted means.

$$\overline{W\_CXGR_t} = \frac{1}{\sum_{y=1}^{Y} w_y} \sum_{y=1}^{Y} w_y CXGR_{yt}$$

3.2 This is the formula for the weighed standard deviation.

$$\hat{\sigma}_{W\_CXGR_t} = \sqrt{\frac{\sum_{y=1}^{Y} w_y (CXGR_{yt} - W\_CXGRt)^2}{\sum_{y=1}^{Y} w_y (\hat{Y}-1)/\hat{Y}}}$$

3.3 Now, we have all the components to calculate Equation 2.

$$\mathrm{XIFPA}_{yt}^{Z} = \left(\frac{CXGR_{yt} - \overline{W\_CXGR_t}}{\hat{\sigma}_{W\_CXGR_t}} \right)$$

3.1 W_CXGR$_t$

The quarterly weighted average for December 2016 has been calculated by multiplying the CQGRs of December from year 2006 to 2016 by the related weights, and subdividing the result for the sum of the weights (=1). As you can see, reorganizing data has proved useful…

3.2 σ$_{W}$_CXGR$_t$
And this is how the weighted standard deviation has been calculated in the Excel file.

Quarterly Weighted Standard Deviation-Equation 4											
Month	Qwsd2006	Qwsd2007	Qwsd2008	Qwsd2009	Qwsd2010	Qwsd2011	Qwsd2012	Qwsd2013	Qwsd2014	Qwsd2015	Qwsd2016
1			0,003949745	0,02969012	0,02377101	0,01936887	0,06126995	0,06082051	0,05317847	0,04817457	0,04888390
2			0,018067352	0,01115533	0,01892425	0,02183071	0,06992119	0,06377548	0,05932406	0,05474755	0,05112543
3			0,055655527	0,03765730	0,03390494	0,03071795	0,06265206	0,05871760	0,05428521	0,04819845	0,04426876
4			0,049270404	0,03328791	0,02456289	0,02599849	0,02705428	0,03669268	0,03229870	0,02932274	0,02987157
5			0,050631174	0,04049322	0,03212251	0,03515519	0,03344737	0,03926179	0,03008400	0,02746736	0,02739804
6			0,065259436	0,05314735	0,06223339	0,05114058	0,06007253	0,06122066	0,04679147	0,04440712	0,04254771
7			0,073611501	0,06567377	0,05806236	0,04607760	0,04330112	0,04323987	0,03303625	0,04491246	0,04103274
8			0,027466739	0,02677854	0,02488273	0,02675123	0,02507125	0,02176354	0,01667054	0,04625595	0,04431771
9			0,009540710	0,01041765	0,00777343	0,05782604	0,06940845	0,05941638	0,04581914	0,04425786	0,04029365
10			0,039429841	0,02433354	0,01889734	0,03335951	0,04921387	0,04215032	0,03254252	0,03112384	0,02867676
11			0,071494193	0,04457821	0,03583047	0,04059694	0,07291215	0,06228453	0,04957362	0,04487519	0,04193411
12			0,039468257	0,03068545	0,02568316	0,02061528	0,03279679	0,02959374	0,02284231	0,02565543	0,02378999

STEP 4
The final step is then to estimate the **IFPAyt** and **IFPAy**.

4.1 Calculate the **IFPAyt** as the weighted sum of the quarterly Indicator of Food Price Anomalies, and the annual Indicator of Food Price Anomalies. Please note that **γ** is a weight with a value of 0.4.

$$IFPA_{yt} = \gamma QIFPA_{yt}^{Z} + (1-y)AIFPA_{yt}^{Z}$$

4.2 Calculate Indicator 2.c.1 (**IFPAy**) as the arithmetic mean over *t* months of the **IFPAyt.**

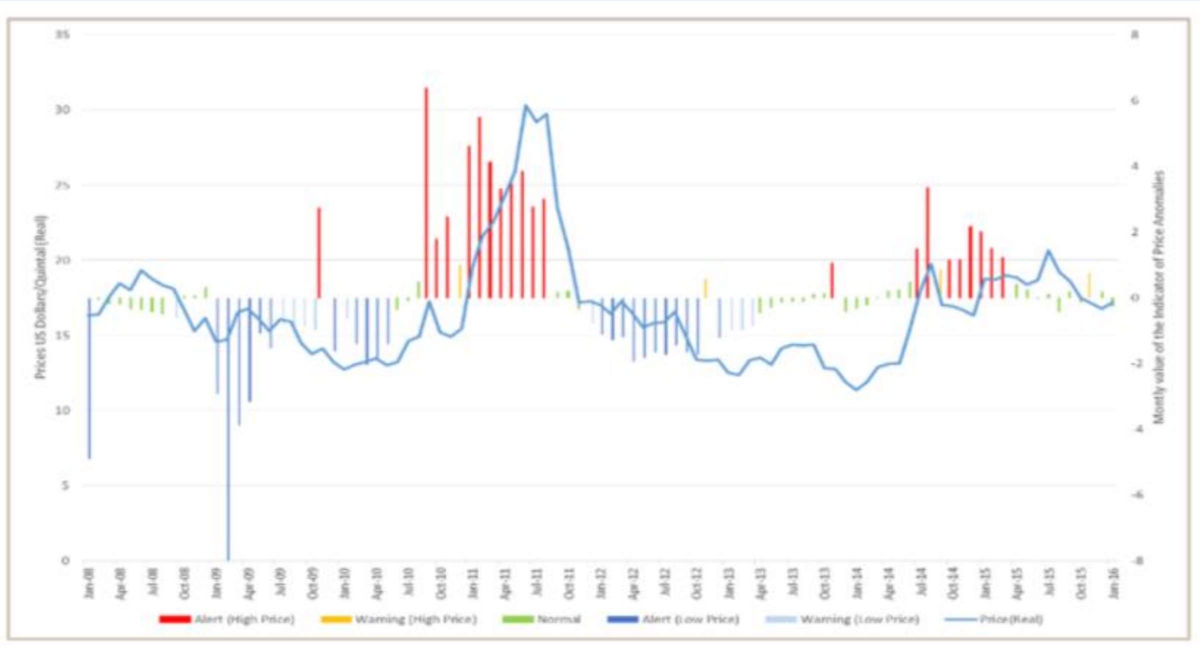
$$IFPA_y = \frac{1}{t} \sum_{i=1}^{t} IFPA_{yt}$$

The results of our calculations:

Panels A and B present results for the QIFPAz/yt and AIFPAz/yt , including those for the subcomponents needed to obtain their estimates.

Panel C presents results for the **IFPAyt** and **IFPAy**.

This is a graphical representation of the wholesale white maize prices and values of the Indicator of Food Price Anomalies in San Salvador, El Salvador.



The example uses the wholesale price for maize (white) in San Salvador, El Salvador as reported by the Ministry of Agriculture and Livestock of El Salvador.

The focus of our analysis is the price series from January 2006 to December 2016.

The data can be directly downloaded from FAO's Food Price Monitoring and Analysis Tool (FPMA-Tool) www.fao.org/giews/food-prices/tool/public/#/home. In the FPMA Tool there are two versions of this price series:

- one in nominal terms;
- a second in real terms, which has been deflated using the domestic CPI (2010 = 100) as reported by the IMF.

For this example, we use the series in real terms. There are the results for 2016 for the wholesale price of maize in El Salvador presented in three panels:

Panel A

	$CQGR_t$[1]	$\overline{W\_CQGR_t}$[2]	$\hat{\sigma}_{W\_CQGR_t}$[3]	$QIFPA_t$[4]
	%			
Jan.	-0.5687	-1.0441	4.8884	0.0972
Feb.	0.6265	1.0643	5.1125	-0.0856
Mar.	2.8116	3.3573	4.4269	-0.1233
Apr.	1.9503	2.9629	2.9872	-0.3390
May	0.4032	1.9392	2.7398	-0.5606
Jun.	-1.4385	2.3903	4.2548	-0.8999
Jul.	-2.3285	3.8622	4.1033	-1.5087
Aug.	-1.3003	4.5428	4.4318	-1.3185
Sep.	-1.0052	0.0703	4.0294	-0.2669
Oct.	-3.6118	-4.4146	2.8677	0.2800
Nov.	-6.3229	-5.8168	4.1934	-0.1207
Dec.	-8.2562	-4.3824	2.3790	-1.6283

These are the results of the Quarterly Indicator of Food Price Anomalies ($QIFPA^z_t$) related to January 2016.

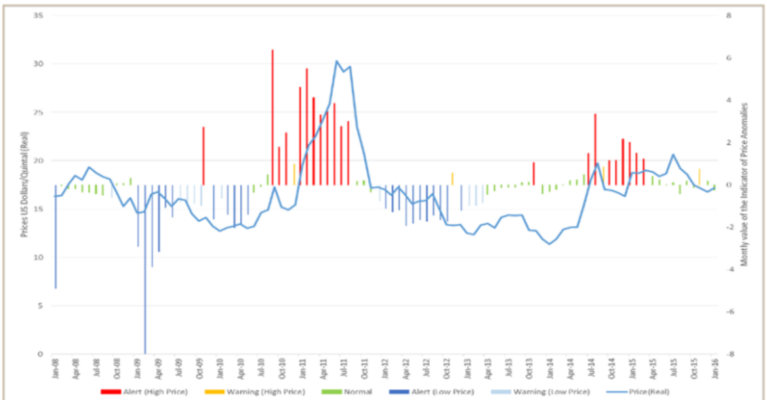
The $CQGR_{(2016\_Jan)}$ is **- 0.57%**, meaning that prices declined by this amount during the period October 2015 to January 2016.

On average, from 2006 to 2015, prices in January, during the same quarter, declined by **–1.04%**.

The difference between the $CQGR_{(2016\_Jan)}$ and its mean $(W\_CQGR)_{jan}$ is 0.48. This difference is only **0.097%** of the weighted standard deviation ($^{\sigma}{}_{(W\_CQGR\_Jan)}$).

A value of **0.097%** for the $QIFPA^Z_{(2016\_Jan)}$ does not exceed the threshold ($- 0.5 \le QIFPA_t < 0.5$) for a **normal price change**.

But is there something in the market that could help us better understand this result?



In El Salvador, the main maize season harvest begins in August and finishes in October/November. Then second and third season harvests conclude by late February. So maize supplies in the market **tend to be high in a normal year in January**, putting downward pressure on prices. Therefore, it is not surprising that prices in January tend to decline (on average -1.04) and that the fall in growth in the last quarter, as reflected by the $CQGR_{(2016\_Jan)}$, was therefore normal, given that maize output in 2016 was relatively good.

Panel B

	$CAGR_t$[5]	$\overline{W\_CAGR_t}$[6]	$\hat{\sigma}_{W\_CAGR_t}$[7]	$AIFPA_t$[8]
	%			
Jan.	-0.7421	0.5098	2.7034	-0.4631
Feb.	-0.5658	0.4642	2.7210	-0.3786
Mar.	-0.3440	0.3758	2.6252	-0.2742
Apr.	-0.2952	0.3270	2.7743	-0.2243
May	-0.3241	0.2948	3.1164	-0.1986
Jun.	-0.5594	0.2086	3.5124	-0.2187
Jul.	-1.6263	0.3125	3.1668	-0.6122
Aug.	-1.0061	0.1758	3.1975	-0.3696
Sep.	-0.7743	0.1801	2.0801	-0.4588
Oct.	-1.1616	0.2162	2.1242	-0.6486
Nov.	-1.6890	-3.6889	6.0272	0.3318
Dec.	-2.0545	0.2484	1.6729	-1.3766

Panel B shows the estimates of the compound annual growth rate of 2016 ($CAGR_{(2016\_Jan)yt}$).

Prices in January 2016 declined by **–0.74%** from a year earlier.

The weighted average shows that, historically, prices increased by **0.51%** during this period.

The difference between the $CAGR_{(2016\_Jan)}$ and its mean is –1.25.

This implies that a $CAGR_{(2016\_Jan)}$ –0.74 can be considered normal, since the value of -0.46 for the $AIFPA_{(2016\_Jan)}$ did not exceed the threshold of a normal price change ($-0.5 \leq AIFPA_{Jan} < 0.5$).

The estimates of the $AIFPA_{yt}$ and its subcomponents are more susceptible to supply shocks.

If we are witnessing a year where supply declined relative to the previous year, prices will grow at a higher rate than may be normal. They may decline at a faster rate if we are facing a good production year, or a surge in imports.

Panel C

	$IFPA_t$
Jan.	-0.239
Feb.	-0.261
Mar.	-0.214
Apr.	-0.270
May	-0.343
Jun.	-0.491
Jul.	-0.971
Aug.	-0.749
Sep.	-0.382
Oct.	-0.277
Nov.	0.151
Dec.	-1.477
$IFPA_{2016}$[10]	-0.4604
$IFPA_{2015}$	0.5075
$IFPA_{2014}$	0.8850

A value of **-0.239** for the $IFPA_{(2016\_Jan)}$ can be considered normal, as it **as it falls within the threshold** $-0.5 \leq IFPA_{\_Jan} < 0.5$.

To obtain the value of the $IFPA_{2016}$ the twelve month average of the $IFPA_{yt}$ in 2016 was calculated. This value was **-0.4604**, again indicating a normal variation in white maize prices for the year 2016, as the threshold of $-0.5 \leq IFPA_{2016} \geq 0.5$ was not exceeded.

By contrast, in the years 2014 and 2015, white maize prices were moderately high, and in 2014 they were close to the threshold of abnormally high prices ($IFPA_y \geq 1$).

Summary

The indicator for countries to measure progress towards Target 2.c is **Indicator 2.c.1 or the Indicator of Food Price Anomalies (IFPA)**. The IFPA is an indirect indicator of Target 2.c, as it is a measure of food price volatility, detecting abnormal growth of prices in food markets.

The indicator relies on a weighted compound growth rate approach that deals with price volatility, and makes it possible to account for both within year and across year price growth. Compound growth rates (CGR) tend to smooth out volatile times series and are to be preferred to arithmetical means.

The thresholds for food price growth are defined as follows:

$$\left(\frac{CXGR_{yt} - \overline{CXGR_t}}{\hat{\sigma}CXGR_t}\right) = XIFPA^z_{yt} \begin{cases} 0.5 \leq X_{IFPA^z_t} < 1 & \text{Moderately High } (X\_IPA^M_t) \\ X\_IFPA^z_t \geq 1 & \text{High } (X\_IPA^A_t) \\ -0.5 \leq X\_IFPA^z_t < 0.5 & \text{Normal } (X\_IPA^N_t) \end{cases}$$

Instead of using the simple mean and standard deviation, a weighted mean and standard deviation are used in this calculation. The weights are linear time weights, where the most recent past has a higher weight than the beginning of the price series.

$IFPA_{yt}$ is obtained on the basis of the quarterly and annual Indicators of Food Price Anomalies. The SDG Indicator 2.c.1 is then calculated as the arithmetic mean over t months of the $IFPA_{yt}$:

$$IFPA_y = \frac{1}{t} \Sigma_{i=1}^{t} IFPA_{yt}$$