Agricultural Producer Price Domain in FAOSTAT

Agricultural producer price domain in FAOSTAT covers annual and monthly producer prices, annual producer price indices and producer prices at international dollars.

1. Producer Prices

1.1. Importance of producer price data

The producer's price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any VAT, or similar deductible tax, invoiced to the purchaser; it excludes any transport charges invoiced separately by the producer. [1]

Information on producer prices is of great significance to policy makers and analysts. Data on prices serve various uses including assessment of productivity and competitiveness of a commodity or sector and the evaluation of the contribution of various sectors to the economy and assessing food security. In this respect, producer price information is essential as it is used to value the production quantities recorded in FAOSTAT for various agriculture commodities and countries.

1.2. Producer price data in FAOSTAT

FAOSTAT provides data on absolute producer prices for crop and livestock products through its Price Domain on annual and monthly basis, in addition to the annual producer price indices and international dollar prices.

Annual producer prices are available in local currency unit (LCU), standard local currency (SLC)[2] and US dollars. To date, prices are available from 1991 to 2018 whilst historical data from 1966 to 1991 are available in the Price Archive section of the price domain of FAOSTAT in local currency unit only. And the monthly producer prices are available only in local currency unit from 2010 to 2018. Most data originate from country sources received through the FAO questionnaire on annual and monthly producer prices received by farmers for primary crops and livestock products. In addition, where no official data are available, these are complemented by FAO estimates. But only official producer prices from the questionnaire are published in FAOSTAT.

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[1] United Nations., European Commission., International Monetary Fund., Organization for Economic Co-operation and Development., & World Bank. (2009). *System of National Accounts 2008*. New York: United Nations.

[2] Prices in SLC are standardised to reflect data in one currency only, normally the currency in the most recent year of data reporting. Having price data series in the same currency helps in obtaining consistent data series and is needed for analysing time series data or constructing price indices.

Producer prices refer to prices received by farmers, i.e. prices determined “at the farm gate” or at the first-point-of-sale when farmers participate in their capacity as sellers of their own products. While the aim is to remain as close as possible to this concept, flexibility has to be allowed to give the specificities of each country and commodity markets. Indeed, the choice of appropriate selling points may differ depending on the country and on the marketing structure for each commodity. Wholesale prices or even prices at local markets may be appropriate proxies of farm-gate prices when the marketing chain is very limited.

1.3. Data Coverage

The price domain of FAOSTAT has the largest coverage of producer prices in the world;

i. Annual producer prices cover 179 country and 212 crop and livestock products.
ii. Monthly producer prices cover 113 country and 200 crop and livestock products.

1.4. Annual and Monthly Producer Prices Data Collection

Broadly, the process of price compilation begins with questionnaires being sent to FAO members requesting information on annual average producer prices of primary crops and livestock products, in local currency per metric ton of the reference year. Along with this, a pre-filled questionnaire of the past two years, containing the official price data which has been reported in the past by that country, is provided as well, such to enable the countries to check this information and make revisions, where applicable. In addition, this gives them an opportunity to provide data in cases where data, which was not available earlier, is now available. Further, data on monthly average producer prices of primary crops and livestock products in local currency per metric ton of the reference year is requested, in addition to other supplementary information that includes the producer price index of crop and livestock products.

The questionnaire design is the same for all countries, except for two features:

i. Language of the questionnaire
ii. The commodity list.

The questionnaire is available in three languages and, based on the country, the language applicable is chosen. The commodity list is pre-defined for each country and depends on past reporting patterns of the country, i.e. it comprises commodities for which data has been reported by respondents in the past. Respondents can also report data on commodities not part of the list.

The questionnaire on annual prices received by farmers for primary crops and livestock products covers this list of commodity groups:

- Primary food crops: cereals, starchy roots, sugar crops, pulses, nuts, oil crops, vegetables, fruit, spices
- Primary non-food products: tobacco, fibres, vegetal or animal origin
- Livestock: live weight animals, indigenous meat, milk, eggs, honey
- Derived agricultural commodities: alcoholic beverages

The information received from countries is then checked on a number of aspects

i. Local currency unit - Although, a change of national currency is rare, in case of a change this is simply shown as a break in the time series (therefore, currency check is carried out just to confirm whether or not the new rate, if any, is correctly reflected in the prices for that year).

ii. Unit of measurement - In the case of units of measurement, the non-standard units are converted into standard units by performing the necessary calculations. For example, when producer prices for animals are reported as per head these are converted into standard unit of metric tonne using the average live weight of the country information. In the case of eggs when prices are reported in dozens, the average national egg weight is used to obtain prices per metric ton.

For data not provided or found missing, imputation is done. Finally, the validated data are uploaded to the price domain of FAOSTAT for eventual dissemination to users.

1.5. Annual and Monthly Producer Prices Data Processing

The data analysis and processing stage has three main objectives:

1. To examine data for revisions, inconsistencies, and abnormalities and to edit, where applicable, by comparing data from the most recent questionnaire with previously available official data. In case no clear reasoning can be established for a particular price inconsistency, a communication is sent (usually e-mail) to the respondent to draw their attention and seek the reason.
2. To estimate missing data and series. This is done when price data for the latest year may not have been provided by the respondents or when commodity series may be missing. As per convention, estimation of missing time series for a commodity is usually undertaken in cases where price data has been provided by respondents for at least one year between 1995 and the latest year of the questionnaire.
3. To validate the official annual and monthly producer prices and imputed annual producer price.

1.6. Imputation procedure of missing annual producer prices

Several techniques are followed in imputing the missing producer prices, these includes:

1. Application of price changes of a similar commodity to follow the same trend, (e.g. prices of main cereal products are used to estimate missing cereal prices);
2. Application of a country's PPI (Producer Price Index) to estimate current values;
3. Application of another price indicator (e.g. Agriculture GDP deflator, GDP deflator);
4. Application of a price ratio between commodities. Those are mostly used to estimate the prices of meat indigenous and meat live weight using the ratio between the price of meat indigenous and meat live weight.
5. Application of ARIMAX method. This imputation method is applied when countries are with sufficient amount of data points. The threshold for discriminating sufficiency is chosen to be 20 observations. Due to the relatively high data requirement, this estimation technique is largely used to fill in missing observations at end points.

The main in-house application of estimated producer prices is:

- the periodic compilation of the value of production of crop and livestock products in various countries using the quantities of productions from the questionnaire on crop and livestock production and utilization,
- to derive the prices of all crop and livestock products at international dollar.

1.6.1 The imputation of missing annual producer price using ARIMAX method

The Autoregressive Integrated Moving Average Exogenous Variable (ARIMAX) based approach is used to estimate the missing observations on the annual producer prices.

Among different crops and livestock, we consider countries for which a limited number of data points is missing (countries with maximum 8 missing values) to implement time series estimation. In this regard, we first fit a group of ARIMA models with additional exogenous variables to the producer price data. Thereafter, based on Bayesian Information Criteria (BIC), we select the best in-sample specification which is subsequently used to estimate the missing values.

The ARIMAX models extend ARIMA(p, d, q) models through the inclusion of exogenous variables that have linear effect on the stationary response series y_t. The general form of the ARIMAX(p, d, q) model estimated separately for each country is:

$$\phi_p(L)(1-L)^d(y_t - c - \boldsymbol{x}_t'\boldsymbol{\beta}) = \theta_{\boldsymbol{q}}(L)\varepsilon_{\boldsymbol{t}}, \quad \varepsilon_{\boldsymbol{t}} \sim iid(0, \sigma_{\boldsymbol{\varepsilon}}{}^{\boldsymbol{2}}), \qquad (1)$$

Where AR polynomial of p: $\phi_p(L) = (1 - \phi_1 L^1 - \phi_2 L^2 - \cdots - \phi_p L^p)$, and the MA polynomial of order q: $\theta_q(L) = \left(1 - \theta_1 L^1 - \theta_2 L^2 - \cdots - \theta_q L^q\right)$, y_t is the logarithmic producer price at period t, d is to the order of integration. The parameter c represents the constant term, and $\boldsymbol{x}_t$ is a vector of observed exogenous regressors with coefficients $\boldsymbol{\beta}$.

To estimate the model in (1), we use the STATA built-in *arima* function. After having written the model in state-space form, maximum likelihood parameter estimates are obtained based on the Kalman filter. See Becketti (2013)[3] for further detailed explanation on STATA's *arima* command.

The steps of the implementation of the ARIMAX approach are summarized as follows:

1. As for each crop or livestock, input country-specific data series, take the natural log transformation of all series to reduce variability in skewed data, then check that all logged series are stationary and transform them appropriately (first differences, etc.) if necessary.
2. For each country i under crop j, the endogenous variable is the logarithmic producer price, which contains missing values. Within a loop, fit a group of models and single out the one with the best in-sample fit based on minimization of the BIC criterion. The list of candidate models is defined along two dimensions:

   (a) The autoregressive, integration orders, and moving average of the ARIMA(p, d, q) model, with $p \leq 3, d \leq 1, q \leq 2$. Due to the shortage of observations (we only have 28 years of time coverage for all the series), we divide the (p, d, q) specifications into three to avoid "*flat log likelihood encountered, cannot find uphill direction*" error during the best model selection process in STATA. This means the best model selection process will be carried out three times for each country under the following specifications:
      1) $p \leq 3, d \leq 1, q = 0$
      2) $p = 1, d \leq 1, q = 1$
      3) $p = 1, d \leq 1, q = 2$

   (b) The following set of exogenous regressors (before transformation): GDP, GDP per capita, gross fixed capital formation of total economy, value added of agriculture, forestry and fishing[4], gross fixed capital formation of agriculture, forestry and fishing[5], agriculture trade openness index, agriculture exports-to-value added ratio[6], and yields for each crop[7]. When one of the above country-specific time series data is incomplete, we exclude this regressor from the exogenous regressors group in the *arima* model selection process.

[3] Beketti, S. (2013). *Introduction to Time Series Using Stata*. College Station, TX: Stat Press.
[4] The first four time series can be obtained directly from the Macro Indicators domain on FAOSTAT.
[5] This time series can be obtained directly from Capital Stock domain on FAOSTAT.
[6] The main sources for trade related time series are the FAO Trade Database and the UNCTAD Merchandise trade matrix.
[7] Yields data can be obtained directly from Crops, Crops Processed and Livestock Primary and Livestock Processed domains on FAOSTAT.

3. After selecting the country-specific preferred model, construct one-step ahead forecasts to estimate missing data points on the logarithmic producer price.
4. Store results, minimum BIC value and best model specification (with parameter estimates).
5. Find the optimal model from the three best models under the above different (p, d, q) specifications and store the final estimated results.
   (a) Compare the minimum BIC value, store the lowest BIC value and corresponding model specifications.
   (b) Calculate the Root Mean Square Error (RMSE) for estimated producer price (reverse the estimated the logarithmic producer price) for the three best model and store the lowest RMSE and corresponding model specifications.
   (c) Compare the model specifications from the lowest BIC value and the lowest RMSE, if they are the same, we store it as the final model specification; if not, we graph the forecasted producer prices from both model specifications as well as the observed value to allow for graphical inspection so that final model specifications can be chosen.

2. Agricultural Producer Price Indices

2.1 General Description

The FAO Agricultural Producer Price Indices measures annual changes in the selling prices received by farmers (prices at the farm-gate or at the first point of sale). The indices are constructed using price data in standardized local currency (SLC) and are also disseminated in FAOSTAT on an annual basis.

There are two categories of producer price indices available for each country in FAOSTAT:

i. Aggregated Producer Price Indices:

Price indices are compiled at the level of commodity groups (e.g. for cereals, fruits and vegetables, etc.).

ii. Single item indices:

Price indices are also available for individual commodities, subject to data availability. Examples of these include:

i. Wheat producer price index

ii. Rice, paddy producer price index

iii. Maize producer price index

2.2 Data source

The main source of data for producer prices and production is the data reported by countries to FAO on the questionnaire on annual prices received by farmers for primary crops and livestock products and on the questionnaire on crop and livestock production and utilization. In some cases, in-house estimations are needed to fill in data gaps. The data are available in FAOSTAT in the Prices and Production data domains.

2.3 Countries Coverage:

The producer price indices are available for all countries for which both price and production data are disseminated in FAOSTAT. It covers 161 country and 196 crop and livestock products.

2.4 Time Coverage:

The time coverage of producer price indices is from 1991 to 2018.

2.5 Reference year:

The base period of the indices is the average producer prices of crop and livestock products in 2014, 2015 and 2016. The weight used for the aggregate indices (producer price index of single items and commodity group indices) is the average production value for the years 2014, 2015 and 2016.

2.6 Data Calculation:

The Agriculture Producer Price Index and the Commodity group indices are calculated using the Laspeyres formula. The index for a given commodity group A at year t is therefore equal to the value of production of the items belonging to the commodity group at current year prices using base period quantities, divided by the value of production at base period prices and quantities. Formally:

$$\mathbf{Index_{t,A}} = \mathbf{100} * \left(\frac{\sum_{\mathbf{i \in A}} \mathbf{P_{it} q_{i0}}}{\sum_{\mathbf{i \in A}} \mathbf{P_{i0} q_{i0}}} \right)$$

where:

$\boldsymbol{A}$ is a group of commodities

$\boldsymbol{P_{it}}$ is the price of item $\boldsymbol{i}$ in period $\boldsymbol{t}$.

$\boldsymbol{P_{i0}}$ is the 3-years average price of item $\boldsymbol{i}$ in base period (2014-2016)

$\boldsymbol{q_{i0}}$ is the 3-years average quantity of item $\boldsymbol{i}$ produced in base period (2014-2016)

The calculation of the producer price index depended on the Laspeyres formula that utilizes the quantities in the base period as weights, where Paasche formula utilizes the quantities in the current period as weights that can be difficult to obtain. The Paasche formula of the producer price index is given by:

$$\mathbf{Index_{t,A}} = \mathbf{100} * \left(\frac{\sum_{i \in A} \mathbf{P_{it} q_{it}}}{\sum_{i \in A} \mathbf{P_{i0} q_{it}}} \right)$$

So using Laspeyres formula is better than using Paasche formula.

The individual item indices are calculated by dividing the SLC price in a given year by the SLC price in the base year:

$$\mathbf{Index_{t,i}} = \mathbf{100} * \frac{\boldsymbol{P_{it}}}{\boldsymbol{P_{i0}}}$$

2.7 Data Forecast:

PPis are forecasted to the period *t-1* with respect to the release year, by employing a practical *double-exponential smoothing* method, including trend features, using the Holt-Winters (HW) method (Cipra, 1992) for non-seasonal series. Beyond the smoothing parameter α, the HW method includes one more parameter accounting for trend, specified according to the following general formulation adapted from Tularam and Saeed (2016):

$f_t = \alpha_1 \pi_t + (1 - \alpha_1)(f_{t-1} + \beta_{t-1})$, with $0 < \alpha_1 < 1$;

$\beta_t = \alpha_2(f_t - f_{t-1}) + (1 - \alpha_2)\beta_{t-1}$, with $0 < \alpha_2 < 1$;

in which f_t is the forecast, α_1 is the smoothing parameter, β_t and β_{t-1} are the estimated trend parameters, and α_2 is the smoothing parameter for the trend estimates. The parameters are chosen to minimize the in-sample sum of squared forecast errors.

Price Index links:

Monthly commodities prices and indices [The World Bank]
https://databank.worldbank.org/databases/commodity-price-data

Statistics on retail prices and indices [International Labor Organization]
https://ilostat.ilo.org/topics/

Primary Commodity Prices and Price Indices [IMF]
http://www.imf.org/external/np/res/commod/index.asp

The Monthly Bulletin of Statistics [United Nations]
http://unstats.un.org/unsd/mbs/app/DataSearchTable.aspx

FAO Food Price Index [FAO]
http://www.fao.org/worldfoodsituation/foodpricesindex/en/

Organization for Economic Co-operation and Development (OECD)
https://stats.oecd.org/Index.aspx?DataSetCode=PRICES_CPI#

Consumer Price Index of all-items [IMF]
https://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9-52B0C1A0179B&sId=1390030341854

Consumer Price Index of food and non-alcoholic beverages [IMF]
http://data.imf.org/?sk=4FFB52B2-3653-409A-B471-D47B46D904B5&sId=1485878855236

3. Producer Prices in International Dollars

3.1 General Description

The international dollar (I$) is a hypothetical unit of currency that has the same purchasing power parity that the U.S. dollar had in the United States at a given point in time.

The International dollar provides a way to compare prices and currency values between countries. It is widely used in economics and financial statistics for various purposes, most notably to determine and compare the purchasing power parity and gross domestic product of various countries and markets.

It is based on the twin concepts of purchasing power parities (PPP) of currencies and the international average prices of commodities. It shows how much a local currency unit is worth within the country's borders. It is used to make comparisons both between countries and over time. For example, comparing per capita gross domestic product (GDP) of various countries in international dollars, rather than based simply on exchange rates, provides a more valid measure to compare standards of living.[8]

3.2 Objectives

The International dollar is a currency unit used by economists and international organizations to compare the values of different currencies. International dollar comparisons between countries have been adjusted to reflect currency exchange rates, but also adjusted to reflect purchasing power parity (PPP) and average commodity prices within each country.

International dollars for a single year are typically presented as the current international dollar—reflecting the current year's exchange rates and current PPP adjustments. When figures are compared

[8] *https://en.wikipedia.org/wiki/International_dollar*

across years, they may also be adjusted for inflation so as to represent currencies in constant (international) dollars for a base year.

When comparisons are made between years, as well as between countries, the International dollar figures may be further adjusted to compensate for inflation. In that case, a base year will be specified, and all figures between countries and between years will be expressed in constant international dollars. [9]

The main in-house application of price data is the periodic compilation of International Dollar Prices which serve:

- as benchmark prices in the weighting pattern of the production index number,
- to derive the value of production at constant prices, to carry out international comparisons.

The "international commodity prices" are used in order to avoid the use of exchange rates for obtaining continental and world aggregates, and also to improve and facilitate international comparative analysis of productivity at the national level. These "international prices", expressed in so-called "international dollars", are derived using a Geary-Khamis formula for the agricultural sector. This method assigns a single "price" to each commodity. For example, one metric ton of wheat has the same price regardless of the country where it was produced.

3.3 Strategy of Compiling Producer Prices at International Dollars

International Dollar Prices are derived using a **Geary-Khamis formula** for the agricultural sector. This method assigns a single "price" to each commodity. For example, one metric ton of wheat has the same price regardless of the country where it was produced.

The Geary-Khamis method provides a way of calculating Purchasing Power Parities (PPP) from observed price and quantity data on N products from M countries:[10]

i. M purchasing Power Parities, $PPP_1, PPP_2, \dots\dots\dots\dots, PPP_M$

ii. International Dollar prices of N products, $P_1, P_2, \dots\dots\dots\dots, P_N$

Let p_{ij} and q_{ij} denote the Producer Prices (LCU/Metric Ton) and quantities (Metric Ton) of i^{th} Agriculture product in j^{th} country. Also let P_i denote the International Dollar Price of i^{th} product. The Geary-Khamis method is defined through the system of inter-related equations below.

$$P_i = \frac{\sum_{j=1}^{M} p_{ij} q_{ij} / PPP_j}{\sum_{j=1}^{M} q_{ij}}$$

[9] https://www.business-case-analysis.com/international-dollar.html

[10] Organization for Economic Co-operation and Development., & World Bank. (2001). *Integration of CPI and PPP: Methodological Issues, Feasibility and Recommendations*. University of New England, Australia. http://www.oecd.org/sdd/prices-ppp/2424597.pdf

, and

$$PPP_j = \frac{\sum_{i=1}^{N} p_{ij} q_{ij}}{\sum_{i=1}^{N} P_i q_{ij}}$$

, where PPP_j is the PPP of for a product aggregate $i = 1,2,\ldots,N$ for a country $j = 1,2,\ldots,M$.

These equations are used for all the Agriculture products and the currencies of the countries involved. The PPPs resulting from the Geary-Khamis method are transitive and the method has the property of "additivity" which is useful when national accounts at constant prices (or in a common currency) are compiled.

The values of the national accounts aggregates of countries participating in a comparison are equal to the sum of the values of their components when both aggregates and components are valued at current national price levels. Additivity requires this identity to be preserved when the values of the aggregates and their components are valued at international price levels. An aggregation method is additive if, for each country being compared, it provides real values for aggregates that are equal to sum of the real values of their constituent basic headings. [11]

3.4 Time Coverage:

The time coverage of producer prices at international dollars is for years 2000, 2005 and 2015.

3.5 Data Coverage:

Producer prices at international dollars covers 242 crop and livestock products.

Bibliography

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