Methodology for calculating indices of macroeconomic indicators

The procedure for constructing estimates of GDP and its components of production and use at constant prices of the base year consists of two main stages:

- this is a revaluation of GDP and its components at comparable prices (prices of the previous year);
- linking these estimates by constructing chain indices in a single row.

For revaluation of GDP and its components in the prices of the previous year, methods of deflation and extrapolation are used. In some cases, the direct revaluation method is also used. The choice of revaluation method depends on the nature of the indicator being evaluated and the information available.

The extrapolation method is to multiply the cost of goods and services in the corresponding previous period by an index reflecting a change in the physical volume of goods and services in the current period compared to the corresponding previous period:

$$\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t} = \sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t-1} \cdot I^{q}_{t-1\to t}, \qquad (1.1)$$

where $\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t}$ - the value of goods and services in the current period at prices of the previous year;

$\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t-1}$ - cost of goods and services in the corresponding previous period at prices of the previous year;

$I^{q}_{t-1\to t}$ - physical volume index, reflecting the change in the physical volume of goods and services in the current period compared to the corresponding previous period.

The deflation method consists in dividing the value of goods and services in the current period by an index reflecting the change in prices for goods and services in the current period compared to the prices of the previous year:

$$\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t} = \frac{\sum_{i=1}^{n} p_{i,t} \cdot q_{i,t}}{I^{p}_{t-1\to t}}, \qquad (1.2)$$

where $\sum_{i=1}^{n} p_{i,t} \cdot q_{i,t}$ - the value of goods and services in the current period at current prices;

$I^{p}_{t-1\to t}$ - price index, reflecting the change in prices for goods and services in the current period compared to the prices of the previous year.

If the period is equal to a quarter, then the average annual prices of the previous year are used as weights.

According to the direct revaluation method, indicators in comparable prices are calculated by multiplying the number of goods and services in the current period by the prices of the previous year.

The base year is considered to be the year by which the price is determined for data at constant prices.

To reevaluate the annual values of GDP and its components at comparable prices using the extrapolation method (1.1), Laspeyres physical volume indices are used:

$$I^{q}_{L_{t-1\to t}} = \frac{\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t}}{\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t-1}}, \qquad (1.3)$$

where $I^{q}_{L_{t-1\to t}}$ - Laspeyres physical volume index, reflecting the change in the physical volume of goods and services in the current year compared to the previous year;

$p_{i,t-1}$ – price of the i-th product or i-service in the previous year;

$q_{i,t-1}$ – volume of the i-th product or i-service in the previous year;

$q_{i,t}$ – volume of i-th product or i-th service in the current year;

$i = \{1,\ldots,n\}$ - serial number of goods or services;

t и t-1 – current and previous years respectively.

To reevaluate the annual values of GDP and its components to comparable prices using the deflation method (1.2), the most acceptable theoretically are the Paasche price indices:

$$I^{p}_{P_{t-1\to t}} = \frac{\sum_{i=1}^{n} p_{i,t} \cdot q_{i,t}}{\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t}}, \qquad (1.4)$$

where $I^{p}_{P_{t-1\to t}}$ - Paashe price index (deflator), reflecting the change in prices for goods and services in the current year compared to the prices of the previous year;

$p_{i,t}$ - price of the i-th product or i-th service in the current year.

The use of the Paasche price index (1.4) for the transition from the value of GDP and its components at current prices to the value in prices of the previous year is justified by the fact that volume indices are determined, as a rule, by the Laspeyres formula (1.3), therefore, when dividing the cost index the Paasche price index yields the associated Laspeyres physical volume index. The cost index can be represented as follows:

$$I_{C_{t-1\to t}} = I^{q}_{L_{t-1\to t}} \cdot I^{p}_{P_{t-1\to t}} \equiv \frac{\sum_{i=1}^{n} p_{i,t} \cdot q_{i,t}}{\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t-1}}, \qquad (1.5)$$

where $I_{C_{t-1\to t}}$ - cost index, reflecting the change in the value of goods and services in the current period compared to the previous period.

Thus, the use of the Paasche price index allows linking the indices of cost, physical volume and prices.

Despite the obvious advantages of Paasche price indices over Laspeyres price indices, in the absence of Paasche price indices for practical reasons, deflation method (1.2) uses price indices according to the Laspeyres formula:

$$I^{p}_{L_{t-1\to t}} = \frac{\sum_{i=1}^{n} p_{i,t} \cdot q_{i,t-1}}{\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t-1}}, \qquad (1.6)$$

where $I^{p}_{L_{t-1\to t}}$ - Laspeyres price index (deflator), reflecting the change in prices for goods and services in the current year compared to the prices of the previous year.

According to the theory of indices, the Laspeyres index distorts the measurement of the “true” value of the theoretical price index in the direction of overestimation, while the Paasche index - in the direction of underestimation, which is called the “Gerschenkron effect”. To eliminate this effect, the theory recommends the use of an index according to the Fisher formula, calculated as the geometric mean of the indices according to Laspeyres and Paasche:

$$I^{q}_{F_{t-1\to t}} = \sqrt{I^{q}_{L_{t-1\to t}} \cdot I^{q}_{P_{t-1\to t}}} \equiv \sqrt{\frac{\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t}}{\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t-1}} \cdot \frac{\sum_{i=1}^{n} p_{i,t} \cdot q_{i,t}}{\sum_{i=1}^{n} p_{i,t} \cdot q_{i,t-1}}}, \qquad (1.7)$$

where $I^q_{F_{t-1\to t}}$ - Fisher's physical volume index, reflecting the change in the physical volume of goods and services in the current year compared to the previous year;

$I^q_{P_{t-1\to t}}$ - Paasche physical volume index, reflecting the change in the physical volume of goods and services in the current year compared to the previous year.

$$I^p_{F_{t-1\to t}} = \sqrt{I^p_{L_{t-1\to t}} \cdot I^p_{P_{t-1\to t}}} \equiv \sqrt{\frac{\sum_{i=1}^{n} p_{i,t} \cdot q_{i,t-1}}{\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t-1}} \cdot \frac{\sum_{i=1}^{n} p_{i,t} \cdot q_{i,t}}{\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t}}}, \qquad (1.8)$$

where $I^p_{F_{t-1\to t}}$ - Fischer price index, reflecting the change in prices for goods and services in the current year compared to the prices of the previous year.

To reevaluate the quarterly values of GDP and its components to comparable prices using the extrapolation method, we use the special case of physical volume indices according to Laspeyres (1.3) to the corresponding quarter of the previous year:

$$I^q_{L_{(\tau,t-1)\to(\tau,t)}} = \frac{\sum_{i=1}^{n} \bar{p}_{i,t-1} \cdot q_{i,\tau,t}}{\sum_{i=1}^{n} \bar{p}_{i,t-1} \cdot q_{i,\tau,t-1}}, \qquad (1.9)$$

where $I^q_{L_{(\tau,t-1)\to(\tau,t)}}$ - Laspeyres physical volume index, reflecting the change in the physical volume of goods and services in quarter τ of the current year compared to the corresponding quarter τ of the previous year;

$\bar{p}_{i,t-1}$ – average annual price of the i-th product or i-service in the previous year;

$q_{i,\tau,t}$ – volume of i-th product or i-th service in the quarter τ of the current year;

$q_{i,\tau,t-1}$ – volume of the i-th product or i-th service in the corresponding quarter τ of the previous year;

τ- quarter number.

To reevaluate the quarterly values of GDP and its components to comparable prices using the deflation method, we use the special case of Laspeyres price indices (1.6):

$$I^{p}_{L_{(\tau,t-1)\to(\tau,t)}} = \frac{\sum_{i=1}^{n} p_{i,\tau,t} \cdot q_{i,\tau,t-1}}{\sum_{i=1}^{n} \overline{p}_{i,t-1} \cdot q_{i,\tau,t-1}}, \qquad (1.10)$$

где $I^{p}_{L_{(\tau,t-1)\to(\tau,t)}}$ - Laspeyres price index (deflator), reflecting the change in prices for goods and services in the current quarter τ compared to the average annual prices of the previous year;

$p_{i,\tau,t}$ - current price of the i-th product or i-th service in the quarter τ.

Data on the annual and quarterly dynamics of GDP and its components over a relatively long period are calculated using the construction of chain indices. A chain index is a series of indices of one and the same phenomenon, calculated with a basic quantity varying from period to period. For example, the annual chain index of physical volume according to Laspeyres (1.3) can be represented as follows:

$$I^{q}_{L_{0\to T}} = I^{q}_{L_{0\to 1}} \cdot I^{q}_{L_{1\to 2}} \cdot I^{q}_{L_{2\to 3}} \cdot \ldots \cdot I^{q}_{L_{T-1\to T}} \equiv \prod_{t=1}^{T} I^{q}_{L_{t-1\to t}}, \qquad (1.11)$$

where $I^{q}_{L_{t-1\to t}}$ - Laspeyres annual physical volume index (1.6) with a base value varying from period to period.

The Laspeyres quarterly chain index of physical volume can be represented as follows:

$$I^{q}_{L_{(\tau,0)\to(\tau,T)}} = I^{q}_{L_{(\tau,0)\to(\tau,1)}} \cdot I^{q}_{L_{(\tau,1)\to(\tau,2)}} \cdot \ldots \cdot I^{q}_{L_{(\tau,T-1)\to(\tau,T)}} \equiv \prod_{t=1}^{T} I^{q}_{L_{(\tau,t-1)\to(\tau,t)}}, \quad (1.12)$$

where $I^{q}_{L_{(\tau,t-1)\to(\tau,t)}}$ - Laspeyres quarterly physical volume index with a base value varying from period to period.

Such a procedure is performed separately for all components of GDP and GDP as a whole. With this approach, a discrepancy may arise between GDP as a whole and the sum of its components, calculated at constant prices (non-additivity problem). The reason for this discrepancy is changes in the structure of weights used to calculate the individual links of chain indices. It is also worth noting that for quarterly values there is a discrepancy in the chronological aggregation of indicators over time. Accordingly, when re-evaluating quarterly indicators by the chain linking method in a period remote from the base year by more than one year, the procedure of updating the physical volume indices is performed for further correct coupling.

The indices of the physical volume and prices of GDP and its production and use components are calculated based on the use of time series construction methodology, compliance with the recommendations of the 1993 SNA, developed under the auspices of the UN Statistical Commission and the IMF Quarterly National Accounts Guidelines.

Starting in April 2011, data on GDP and its components are published at constant prices in 2008 (previously, 2003 prices were used as constant prices).

The transition to a new base period when constructing the dynamic series of GDP and its components is caused by the fact that, as the reporting period moves away from the base, the discrepancies in the structure of the constituent components of the indicators of the base period and subsequent years increase. Changing the base period when constructing a dynamic series of indicators allows you to level out these discrepancies and provide greater reliability of the dynamic characteristics of published indicators.

Revisions of the dynamic series of GDP and its components to constant prices associated with a change in the base period are common practice in the statistical services of many countries and are carried out regularly, usually with a frequency of five years.

The dynamic series of GDP and its components at constant prices are calculated by dividing (for quarters 2003-2007) and multiplying (for quarters 2009, 2010 and beyond) quarterly data for 2008 at average annual prices for 2008 by the corresponding chain indices of physical volume GDP and its components:

$$\sum_{i=1}^{n} \bar{p}_{i,\tau,2008} \cdot q_{i,\tau,2011} = I^{q}_{L(\tau,2008)\to(\tau,2011)} \cdot \sum_{i=1}^{n} \bar{p}_{i,\tau,2008} \cdot q_{i,\tau,2008}, \qquad (1.13)$$

where $\sum_{i=1}^{n} \bar{p}_{i,\tau,2008} \cdot q_{i,\tau,2011}$ - valuation of GDP in the quarter of 2011 in average annual prices of 2008;

$\sum_{i=1}^{n} \bar{p}_{i,\tau,2008} \cdot q_{i,\tau,2008}$ - valuation of GDP in the quarter of 2008 in average annual prices of 2008;

$I^{q}_{L(\tau,2008)\to(\tau,2011)}$ - chain index of physical volume (1.12), reflecting the change in the physical volume of GDP in the quarter of τ 2011 compared to the same quarter of 2008.

$$\sum_{i=1}^{n} \bar{p}_{i,\tau,2008} \cdot q_{i,\tau,2006} = \frac{\sum_{i=1}^{n} \bar{p}_{i,\tau,2008} \cdot q_{i,\tau,2008}}{I^{q}_{L(\tau,2006)\to(\tau,2008)}}, \qquad (1.14)$$

where $\sum_{i=1}^{n} \bar{p}_{i,\tau,2008} \cdot q_{i,\tau,2006}$ - valuation of GDP in the quarter of τ 2006 at the average annual prices of 2008;

$I^{q}_{L_{(\tau,2006)\to(\tau,2008)}}$ - chain index of physical volume (1.12), reflecting the change in the physical volume of GDP in the quarter of 2006 compared with the same quarter of 2008.

The dynamic series of GDP and its components for annual values in constant prices of 2008 are calculated in the same way.