

Methodology of gross output growth decomposition in KLEMS productivity accounts for the Polish economy

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(December 2023)

The commonly practiced decomposition of gross value added (GVA) growth into the contributions of production factors (understood as labour and capital services) and multifactor productivity (MFP) contribution can be developed into a decomposition of gross output growth, on the condition, however, that price indices for intermediate consumption are available. This opens the possibility to clear the residually calculated MFP from sometimes substantial effects of substitution between the production factors and the intermediate consumption – this substitution causes that MFP obtained from GVA growth decomposition is not exactly that disembodied in labour and capital technological and organizational progress as theoretically it should be. If the data on gross output and intermediate consumption are of good quality, and the tool effects associated with additional computations are negligible, then this additional procedure of gross output growth rate decomposition can bring important analytical benefits, associated with outsourcing (i.e. the main mechanism of labour substitution by intermediate consumption) monitoring, and associated with the blurred boundary between capital investments and intermediate consumption outlays (i.e. in the area of changing accountancy and tax regulations and changes in their interpretation, and also some other circumstances, including leasing).

In processing the appropriate calculations, it is best to remain consistent with the already carried out computations for the GVA growth decomposition.

The starting point is the formula for the gross output growth, at the given aggregation level j in period t ¹:

$$\Delta \ln Y_{jt} = \bar{v}_{jt}^X \Delta \ln X_{jt} + \bar{v}_{jt}^K \Delta \ln K_{jt} + \bar{v}_{jt}^L \Delta \ln L_{jt} + \Delta \ln A_{jt}^Y \quad (1)$$

¹ See: references to the parallel document: *Methodology of gross value added growth decomposition in KLEMS productivity accounts for the Polish economy*.

where Y is gross output, X – intermediate consumption, K – capital, L – labour (the contributions of these two factors understood as contributions of their services), whereas A^Y is the *multifactor productivity* (MFP), that can be considered as a variant of TFP applied in KLEMS accounts. These values are subscribed to indicate that they concern industries j and periods t . Δ , for all values under this symbol, denotes changes between time periods $t - 1$ and t , usually considered as yearly periods. \bar{v} with appropriate superscripts and subscripts denote average value shares of the given factors' remunerations in gross output (indicated in superscripts as X , K or L) between time periods $t - 1$ and t , that are calculated according to formula $\bar{v} = (v_t + v_{(t-1)})/2$ (for simplicity the subscript j present in formula (1) has been omitted here).

The above-mentioned formula should be made consistent with that for the decomposition of GVA growth:

$$\Delta \ln V_{jt} = \bar{w}_{jt}^K \Delta \ln K_{jt} + \bar{w}_{jt}^L \Delta \ln L_{jt} + \Delta \ln A_{jt}^V \quad (2)$$

where V stands for GVA, and the other symbols (with appropriate superscripts and subscripts) have the same meaning as in formula (1) but, with the exception of capital K and labour L , take different values. The analogical average shares \bar{w} (in GVA) are not identical to average shares \bar{v} from formula (1) (they are calculated in a similar way to average shares \bar{v} by linear interpolation). Also, the contribution of MFP in the decomposition of GVA V growth is not identical in percentage points to the contribution of MFP in the decomposition of gross output Y growth, although its absolute growth in the ideal case where there would be no variability associated with intermediate consumption should be identical.

The consistency between formulae (1) and (2) will be achieved if some terms from formula (2) are inserted in formula (1):

$$\Delta \ln Y_{jt} = \bar{v}_{jt}^X \Delta \ln X_{jt} + \left(\frac{V_{jt}}{Y_{jt}}\right) \bar{w}_{jt}^K \Delta \ln K_{jt} + \left(\frac{V_{jt}}{Y_{jt}}\right) \bar{w}_{jt}^L \Delta \ln L_{jt} + \Delta \ln A_{jt}^Y \quad (3)$$

In formula (3) the contributions of production factors (labour and capital services) to GVA growth from formula (2) are multiplied by the ratios between GVA and gross output value at industry level j . These ratios are calculated (by similarity to the shares) with the use of linear interpolation, as arithmetic averages between two time periods.

The factor contributions from formula (3) are decomposed in KLEMS accounting into sub-contributions:

$$\left(\frac{V_{jt}}{Y_{jt}}\right) \bar{w}_{jt}^K \Delta \ln K_{jt} = \left(\frac{V_{jt}}{Y_{jt}}\right) \bar{w}_{jt}^{KIT} \Delta \ln KIT_{jt} + \left(\frac{V_{jt}}{Y_{jt}}\right) \bar{w}_{jt}^{KNIT} \Delta \ln KNIT_{jt} \quad (4)$$

$$\left(\frac{V_{jt}}{Y_{jt}}\right) \bar{w}_{jt}^L \Delta \ln L_{jt} = \left(\frac{V_{jt}}{Y_{jt}}\right) \bar{w}_{jt}^L \Delta \ln H_{jt} + \left(\frac{V_{jt}}{Y_{jt}}\right) \bar{w}_{jt}^L \Delta \ln LC_{jt} \quad (5)$$

Where KIT indicates ICT capital and $KNIT$ – non-ICT capital, and where H indicates hours worked and LC – labour composition, but there exist other variants of labour factor decompositions demonstrated in parallel on this internet site.

In order to make the contribution of MFP to gross output growth comparable with the contribution of MFP to GVA growth it is required to transform it according to the following formulae:

$$\Delta \ln A_{jt}^{V*} = \left(\frac{y_{jt}}{v_{jt}} \right) \Delta \ln A_{jt}^Y \quad (6)$$

The values in the parentheses are arithmetic averages between two time periods ratios between gross output and GVA (i.e., conversely in comparison with the previous formulae (3), (4) and (5)). The results should approximately meet the condition: $\Delta \ln A_{jt}^{V*} \approx \Delta \ln A_{jt}^V$ (the term on the right-hand side is taken from formula (2)). If it is not so, then it can be assessed that the substitution between the production factors and the intermediate consumption is substantial, i.e., important changes are under way in the outsourcing and in the way of attributing some outlays to either capital outlays or intermediate consumption outlays. It is therefore possible to monitor these processes from the macroeconomic point of view. Finally, a sub-decomposition of the intermediate consumption contribution into sub-contributions of energy, materials and services would allow even further analyses of these processes.

In the same way as for the GVA growth decomposition, the data for the gross output growth decomposition are presented as contributions to aggregate gross output growth rate (data in Excel table marked by A, B, C and D) or as contributions to industry gross output growth rates (data in Excel tables marked by A', B', C' and D').