Productivity measures in the *OECD Productivity Database*

The *OECD Productivity Statistics* (database) (PDB) contains a consistent set of productivity measures at the total economy and at the industry levels. This section provides detailed information on the measures included in the database. While the PDB and this publication present value added based productivity indicators by relating value added to the labour and capital inputs used, productivity measures can be computed for different representations of the production process. One typical approach is to relate a volume measure of gross output to primary and intermediate inputs, as used in the KLEMS methodology, which measures the contributions of capital (K), labour (L), energy (E), material inputs (M) and services (S) to output growth. This representation is neither adopted in the PDB nor in this publication.

Productivity measures for the total economy

Labour input

Within the PDB, the preferred measure of labour input (L) is the total number of hours worked by all persons engaged in production (i.e. employees plus self-employed). Another measure of labour input, albeit less preferred, is the total number of persons employed (i.e. employees plus self-employed). The preferred source for total hours worked and total employment is the *OECD National Accounts Statistics* (database). However, this database does not provide data on hours worked for all countries, and, so, other sources are necessarily used, e.g. the *OECD Employment and Labour Market Statistics* (database). Estimates of average hours actually worked per year per person employed are also provided within the PDB. Section 6.2 presents detailed information on hours worked.

Capital input

Capital input (K) is measured as the volume of capital services, which is the appropriate measure for capital input within the growth accounting framework (see Schreyer, et al., 2003 for more details on the computation of capital services in PDB). In the PDB, capital services measures are based on productive capital stocks derived using the perpetual inventory method (PIM). The PIM calculations are carried out by the OECD, using an assumption of common service lives for given assets for all countries, and by correcting for differences in the national deflators used for information and communication technology (ICT) assets (see Schreyer, 2002; and Colecchia and Schreyer, 2002, for further information about the calculation of ICT "harmonised" deflators). The investment series by asset type used in the PIM calculations are sourced from national accounts statistics produced by national statistics offices.

From 2015, the classification of assets adopted in the PDB is in line with the 2008 SNA. Capital services are computed separately for eight non-residential fixed assets $k = 1, 2, \ldots, 8$, i.e. computer hardware, telecommunications equipment, transport equipment, other machinery and equipment and weapons systems, non-residential construction, computer software and databases, research and development and other intellectual property products. The volume index of total capital services is computed by aggregating the volume change of capital services of all individual assets using a Törnqvist index that applies asset specific user cost shares as weights:

$$\ln\left(\frac{K^t}{K^{t-1}}\right) = \sum_{k=1}^{8} \frac{1}{2}\left(v_k^t + v_k^{t-1}\right) \ln\left(\frac{K_k^t}{K_k^{t-1}}\right)$$

where:

$$v_k^t = \left(\frac{u_k^t K_k^t}{\sum_{k=1}^{8} u_k^t K_k^t}\right)$$

and u_k^t is the user cost per unit of capital services provided by asset k at time t (see Schreyer et.al., 2003). Thereby, v_k^t is the user cost share of asset k, $\frac{1}{2}\left(v_k^t + v_k^{t-1}\right)\ln\left(\frac{K_k^t}{K_k^{t-1}}\right)$ is the contribution of asset k, to total capital services in year t and K_k^t is the quantity of capital services provided by asset k in year t.

Aggregate volume indices of capital services are also computed for ICT assets (computer hardware, telecommunications equipment and computer software and databases) and non-ICT assets (transport equipment, other machinery and equipment and weapons systems, non-residential construction, research and development and other intellectual property products), using the appropriate user costs shares as weights. The aggregate volume indices of ICT and non-ICT capital services are given by:

$$\ln\left(\frac{K_{ict}^t}{K_{ict}^{t-1}}\right) = \sum_{i=1}^{3} \frac{1}{2}\left(\gamma_i^t + \gamma_i^{t-1}\right)\ln\left(\frac{K_i^t}{K_i^{t-1}}\right)$$

where i represents an ICT asset and

$$\gamma_i^t = \left(\frac{u_i^t K_i^t}{\sum_{i=1}^{3} u_i^t K_i^t}\right)$$

$$\ln\left(\frac{K_{nict}^t}{K_{nict}^{t-1}}\right) = \sum_{j=1}^{5} \frac{1}{2}\left(\gamma_j^t + \gamma_j^{t-1}\right)\ln\left(\frac{K_j^t}{K_j^{t-1}}\right)$$

where j represents a non-ICT asset and

$$\gamma_j^t = \left(\frac{u_j^t K_j^t}{\sum_{j=1}^{5} u_j^t K_j^t}\right)$$

Cost shares of inputs

The total cost of inputs is the sum of the labour input cost and the total cost of capital services. The national accounts record the income of the self-employed as *mixed income*. This measure includes the compensation of both labour and capital to the self-employed but separate estimates of the two components are not generally measurable. As such, in the PDB, total labour input costs for total persons employed (i.e. employees and self-employed) are computed as the average remuneration per employee multiplied by the total number of persons employed. The preferred source for data on compensation of employees and for the number of employees as well as the number of self-employed is the *OECD National Accounts Statistics* (database).

The labour input cost is calculated as follows:

$$w^t L^t = \left(\frac{COMP^t}{EE^t}\right)E^t$$

where $w^t L^t$ reflects the total remuneration for labour input in period t, $COMP^t$ is the total compensation of employees in period t, EE^t is the number of employees in period t, and E^t the total number of employed persons, i.e., employees plus self-employed, in period t.

Total capital input cost is computed as the sum of the user costs of each capital asset type k given by $u_k^t K_k^t$, where u_k^t is the user cost per unit of capital services provided by asset type k.

The total cost of inputs is then given by

$$C^t = w^t L^t + \sum_{k=1}^{8} u_k^t K_k^t$$

and the corresponding cost shares of labour and capital are

$s_L^t \equiv \frac{w^t L^t}{C^t}$ for labour input,

$s_K^t \equiv \frac{\sum_{k=1}^{8} u_k^t K_k^t}{C^t}$ for total capital input,

$s_{K_{ict}}^t \equiv \frac{\sum_{i=1}^{3} u_i^t K_i^t}{C^t}$ for capital input derived from ICT assets i=1,2,3,

$s_{K_{nict}}^t \equiv \frac{\sum_{j=1}^{5} u_j^t K_j^t}{C^t}$ for capital input derived from non-ICT assets j=1,…,5.

Labour productivity

At the total economy level, labour productivity is measured as Gross domestic product (GDP) at market prices per hour worked.

Multifactor productivity

The underlying production function assumes "Hicks neutral" technical change, as it is represented as an outward shift of the production function that affects all factors of production proportionately:

$$Q = A\, f(L, K)$$

Differentiating this expression with respect to time and using a logarithmic rate of change, multifactor productivity growth (the rate of change of the variable A) is measured as the rate of change of volume output (Q) minus the weighted rates of change of inputs (X). In simple terms, growth in multifactor productivity (MFP) can be described as the change in output that cannot be explained by changes in the quantity of capital and labour inputs used to generate output. In the PDB MFP growth is then measured as follows:

$$\ln\left(\frac{MFP^t}{MFP^{t-1}}\right) = \ln\left(\frac{Q^t}{Q^{t-1}}\right) - \ln\left(\frac{X^t}{X^{t-1}}\right)$$

where Q is output measured as GDP at market prices and at constant prices; X relates to total inputs used and the rate of change of these inputs is calculated as a weighted average of the rate of change of labour and capital inputs, with the respective cost shares as weights. Aggregation of these inputs is by way of the Törnqvist index:

$$ln\left(\frac{X^t}{X^{t-1}}\right) = \frac{1}{2}\,(s_L^t + s_L^{t-1})\, ln\left(\frac{L^t}{L^{t-1}}\right) + \frac{1}{2}\,(s_K^t + s_K^{t-1})\, ln\left(\frac{K^t}{K^{t-1}}\right)$$

Contributions to GDP growth

In the growth accounting framework, GDP growth can be decomposed into the contributions of each production factor plus multifactor productivity:

$$\ln\left(\frac{Q^t}{Q^{t-1}}\right) = \frac{1}{2}\left(s_L^t + s_L^{t-1}\right)\ln\left(\frac{L^t}{L^{t-1}}\right) + \frac{1}{2}\left(s_{K_{ict}}^t + s_{K_{ict}}^{t-1}\right)\ln\left(\frac{K_{ict}^t}{K_{ict}^{t-1}}\right) + \frac{1}{2}\left(s_{K_{nict}}^t + s_{K_{nict}}^{t-1}\right)\ln\left(\frac{K_{nict}^t}{K_{nict}^{t-1}}\right) + \ln\left(\frac{MFP^t}{MFP^{t-1}}\right)$$

where:

$\frac{1}{2}\left(s_L^t + s_L^{t-1}\right)\ln\left(\frac{L^t}{L^{t-1}}\right)$ is the contribution of labour input to GDP growth,

$\frac{1}{2}\left(s_{K_{ict}}^t + s_{K_{ict}}^{t-1}\right)\ln\left(\frac{K_{ict}^t}{K_{ict}^{t-1}}\right)$ is the contribution of ICT capital input to GDP growth,

$\frac{1}{2}\left(s_{K_{nict}}^t + s_{K_{nict}}^{t-1}\right)\ln\left(\frac{K_{nict}^t}{K_{nict}^{t-1}}\right)$ is the contribution of non-ICT capital input to GDP growth.

Contributions to labour productivity growth

By reformulating the decomposition of output growth presented above, it is possible to decompose labour productivity growth into the contribution of capital deepening and MFP.

$$\ln\left(\frac{LP^t}{LP^{t-1}}\right) = \frac{1}{2}\left(s_K^t + s_K^{t-1}\right)\left[\ln\left(\frac{K^t}{K^{t-1}}\right) - \ln\left(\frac{L^t}{L^{t-1}}\right)\right] + \ln\left(\frac{MFP^t}{MFP^{t-1}}\right)$$

where:

$\ln\left(\frac{LP^t}{LP^{t-1}}\right) = \ln\left(\frac{Q^t}{Q^{t-1}}\right) - \ln\left(\frac{L^t}{L^{t-1}}\right)$ is labour productivity growth,

$\ln\left(\frac{K^t}{K^{t-1}}\right) - \ln\left(\frac{L^t}{L^{t-1}}\right)$ is capital deepening (i.e. growth in capital services per hour worked),

$\frac{1}{2}\left(s_K^t + s_K^{t-1}\right)\left[\ln\left(\frac{K^t}{K^{t-1}}\right) - \ln\left(\frac{L^t}{L^{t-1}}\right)\right]$ is the contribution of capital deepening to labour productivity growth.

It is also possible to reformulate the decomposition of labour productivity growth to show the contributions of ICT capital and non-ICT capital:

$$\ln\left(\frac{LP^t}{LP^{t-1}}\right) = \frac{1}{2}\left(s_{K_{ict}}^t + s_{K_{ict}}^{t-1}\right)\left[\ln\left(\frac{K_{ict}^t}{K_{ict}^{t-1}}\right) - \ln\left(\frac{L^t}{L^{t-1}}\right)\right] + \frac{1}{2}\left(s_{K_{nict}}^t + s_{K_{nict}}^{t-1}\right)\left[\ln\left(\frac{K_{nict}^t}{K_{nict}^{t-1}}\right) - \ln\left(\frac{L^t}{L^{t-1}}\right)\right] + \ln\left(\frac{MFP^t}{MFP^{t-1}}\right)$$

where:

$\frac{1}{2}\left(s_{K_{ict}}^t + s_{K_{ict}}^{t-1}\right)\left[\ln\left(\frac{K_{ict}^t}{K_{ict}^{t-1}}\right) - \ln\left(\frac{L^t}{L^{t-1}}\right)\right]$ is the contribution of ICT capital to labour productivity growth,

$\frac{1}{2}\left(s_{K_{nict}}^t + s_{K_{nict}}^{t-1}\right)\left[\ln\left(\frac{K_{nict}^t}{K_{nict}^{t-1}}\right) - \ln\left(\frac{L^t}{L^{t-1}}\right)\right]$ is the contribution of non-ICT capital to labour productivity growth.

Unit labour costs and their components

Unit labour costs (ULCs) measure the average cost of labour per unit of output produced. They are calculated as the ratio of total labour costs (in national currency, current prices) to real output (in national currency, constant prices). At the total economy level, real output is measured as GDP at market prices and constant prices. Equivalently, ULCs may be expressed as the ratio of total labour costs per hour worked in current prices to real GDP per hour worked in constant prices, i.e., labour productivity.

In principle, the appropriate numerator for ULC calculations is total labour costs of all persons engaged. In practice, however, this information is not readily available for most countries. As such,

OECD total labour cost estimates used in calculating ULCs are based on adjusted estimates of compensation of employees (COE), compiled according to the System of National Accounts (SNA).

Compensation of employees as defined in the SNA excludes labour compensation for the self-employed which is covered in the item *mixed income*. Estimates of the compensation component (per hour worked) of mixed income are set as compensation of employees per hour worked. This assumption may be more or less valid across different countries.

Unit labour costs are therefore compiled as follows:

$$\frac{COMP^t \frac{H^t}{HE^t}}{Q^t}$$

where $COMP^t$ reflects the total compensation of employees in period t, H^t is the total number of hours worked by all persons employed in period t, HE^t is the total number of hours worked by employees in period t and Q^t is GDP at market prices and constant prices in period t.

Productivity measures at industry level

The conceptual approach used to estimate productivity at industry level follows that for the total economy. However the same quantity (and quality) of data that is available for the whole economy estimates is not always available at the detailed industry level. Hence some approximations are necessary and, so, some differences may prevail between the whole economy estimates and those at industry level.

Productivity measures at industry level are computed for 14 economic activities, each defined in accordance with the International Standard Industrial Classification of All Economic Activities (ISIC) Rev.4.

Labour input

Labour input is measured as total hours worked by all persons engaged in production, i.e. employees plus self-employed, broken down by industry. Another measure of labour input presented in the database is total number of persons employed (i.e. number of employees and numbers of self-employed).

Labour productivity

At the industry level, labour productivity is measured as gross value added at basic prices per hour worked and growth rates are determined using constant price estimates of gross value added. Comparable measures are also derived per person employed.

Contributions to labour productivity growth

The contribution of an economic activity to labour productivity growth of a group of economic activities (e.g. total business sector, total services) is compiled using a Törnqvist index as follows:

$$Cont(i,t) = \frac{1}{2}\left[\left(\frac{Q_{cur,i,t}}{Q_{cur,tot,t}} + \frac{Q_{cur,i,t-1}}{Q_{cur,tot,t-1}}\right)\theta_t\left(Q_{con,i}\right) - \left(\frac{L_{i,t}}{L_{tot,t}} + \frac{L_{i,t-1}}{L_{tot,t-1}}\right)\theta_t(L_i)\right]$$

where:

i is an economic activity,

tot is an aggregate of economic activities including economic activity i,

$Qcur$ is gross value added at current prices,

$Qcon$ is gross value added at constant prices,

L is the number of hours worked,

$\theta_t(x)$ is the annual growth rate of x between time $t-1$ and t.

The database also presents contributions to labour productivity growth by economic activity on an employment (persons) basis.

Unit labour costs and their components

Unit labour costs (ULCs) measure the average cost of labour per unit of output produced. They are calculated as the ratio of total labour costs (in national currency, current prices) to real output (in national currency, constant prices). For main economic activities, real output is measured as gross value added at basic prices and constant prices. Equivalently, ULCs may be expressed as the ratio of total labour costs per hour worked in current prices to real gross value added per hour worked, i.e. labour productivity.

Total labour costs used for the calculations of ULCs by economic activity are computed as described above for the total economy. ULCs by economic activity are compiled as follows:

$$\frac{COMP^{i,t}\,\dfrac{H^{i,t}}{HE^{i,t}}}{Q^{i,t}}$$

where i reflects the economic activity, $COMP^t$ reflects the total compensation of employees in period t, H^t is the total number of hours worked by all persons employed in period t, HE^t is the total number of hours worked by employees in period t and Q^t is gross value added at basic and constant prices in period t. The database presents ULCs by economic activity on an employment (persons) basis.

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