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# Industry Level Growth and Productivity Data with Special Focus on Intangible Assets

## Report on methodologies and data construction for the EU KLEMS Release 2019

## Contract No. 2018 ECFIN-116/SI2.784491 Deliverable 3

The Vienna Institute for International Economic Studies
Wiener Institut für Internationale Wirtschaftsvergleiche

# Industry Level Growth and Productivity Data with Special Focus on Intangible Assets

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# Abstract

This deliverable provides an overview of the methods and data construction efforts concerning the revision and update in the EU KLEMS Release 2019 database with a detailed outline of the changes compared to the previous EU KLEMS releases. In particular, the report outlines the special focus on intangible assets which constitutes a major step forward in the growth and productivity accounts. This includes the provision of more detailed growth accounts differentiating between five groups of asset types (comprising ICT and non-ICT and tangibles and intangible assets) and the inclusion of supplementary intangible assets which have been constructed outside the boundaries of National Accounts. Further differences concerning methodological aspects, industry classification and coverage are described taking advantage of the availability of better data.

Keywords: growth accounting, total factor productivity, ICT, intangibles

JEL classification: C80, C82, O40, O47

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**Appendix**

# 1. Introduction

This report summarises the methodologies and data construction strategies applied for the extended and revised update of the EU KLEMS Release 2019 database. Based on the previous releases (see Timmer et al., 2010; Ark and Jäger, 2017; Jäger, 2017)[1], the EU KLEMS Release 2019 introduces some changes. The most important are the following:

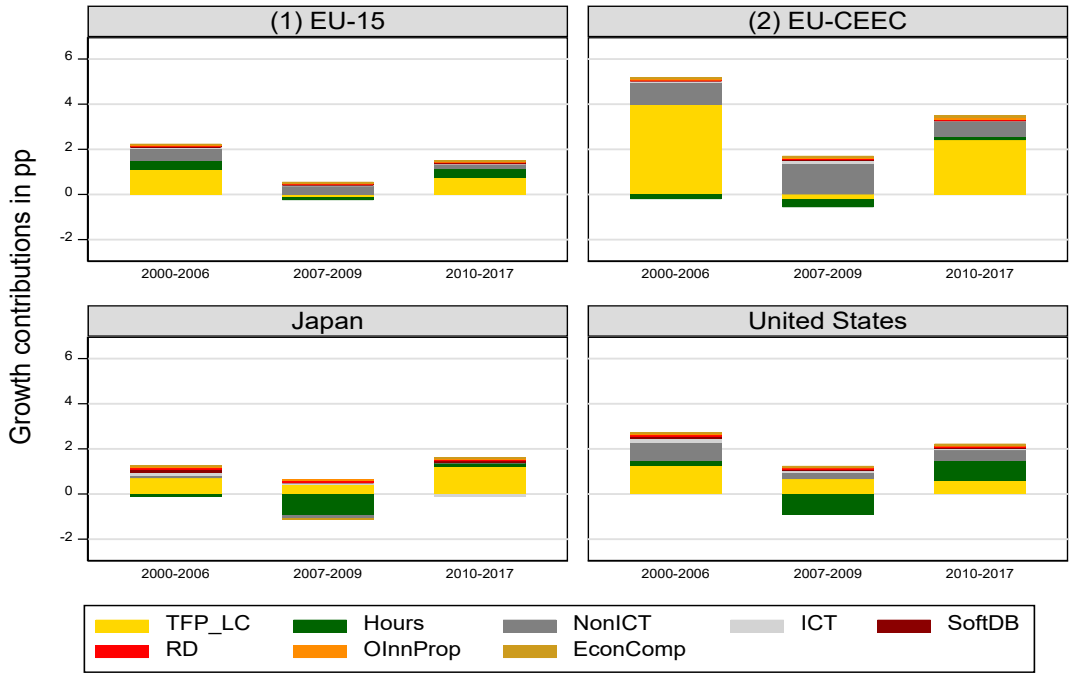
- First, the EU KLEMS Release 2019 provides two datasets, the '*statistical database*' and the '*analytical database'*. Whereas the former is fully in line with National Accounts data provided by the national statistical institutes to Eurostat, the latter includes supplementary data on investment flows and stocks emphasised in the recent literature concerning the importance of intangible assets.
  - The reported growth accounts in the 'statistical database' provide a more detailed differentiation of the contribution of various capital assets types to growth. Specifically, growth contributions are split into tangible information and communication (ICT) capital and non-ICT capital, and three types of intangible capital (software and databases, R&D and other innovative property products) separately.
  - On top of that, additional asset types, which were never capitalised in the National Accounts, are reported in the 'analytical database'. These asset types include additional information on innovative properties and economic competencies (following recent literature such as Haskel and Westlake, 2018; seminal contributions are documented in Corrado et al. 2005 and 2009; and, in the European context see Corrado et al. 2016, 2017, and 2018)[2]. Though there are major challenges in the construction of such data which are discussed, this and their integration into the growth accounting framework allows important insights concerning their importance, magnitudes and trends to be gained.
- Second, the coverage with respect to EU countries included in this release is slightly extended due to better availability of data and the integration of figures for the total economy. Further, comparable data for the US and Japan are provided which allow for comparisons with major EU competitors.
- Third, the industry classification is extended and better aligned with NACE Rev. 2 (ISIC Rev. 4), though some additional industry aggregates are reported in accordance with the industry classification in the previous releases (which originated from the NACE Rev. 1 (ISIC Rev. 3) classification).
- Fourth, some methodological refinements are introduced with respect to the construction of data which now start from original data in current and previous year prices. In particular, this allows for a more sophisticated calculation of price deflators (which is especially relevant for data on gross fixed capital formation as these can become negative (e.g. in the crisis years). In such cases discontinuities in the calculation of chain-linked volumes and price indices) might arise, which have been tried to circumvent.

The details of these issues are outlined in this report. Figure 1 provides an example of the final results.

[1] See www.euklems.net

[2] See www.intaninvest.net

**Figure 1 / Growth decomposition results: Total economy value added growth in %**




Note: CY, MT and PL are not included; countries are aggregated using Törnqvist shares.
Source: EU KLEMS Release 2019.

Value added, and total factor productivity growth including changes in labour composition (TFP_LC), are significantly lower after the crisis than before the crisis (with the exception of Japan). The contributions of ICT assets (tangible information and communication capital and intangible software and databases) have significantly declined, particularly so in Japan and the US. Similarly, growth of the other tangible assets (buildings and construction, machinery, transport equipment and cultivated assets) has diminished as well, whereas the contributions of intangible assets (including the supplementary assets outside the boundaries of National Accounts) have been more stable and have therefore become relatively more important. However, the graph also points towards the fact that the 'classical' growth drivers (TFP and investment in tangible assets) account for the major part of growth performance (Adarov and Stehrer, 2019, provide further details).

The report is structured as follows. In Section 2, the growth accounting methodology is outlined based on the contributions by Jorgensen et al. (2005) and Timmer et al. (2010). Section 3 outlines the data requirements and challenges together with some information on methodological refinements compared with the previous EU KLEMS releases resulting in the 'statistical database', the content of which is described. Section 4 is then devoted to the 'analytical database' including an outline of the construction of intangible assets outside the boundaries of National Accounts (following Corrado et al., 2016 and 2018) and their integration into the growth accounting framework. Finally, Section 5 provides some conclusions and potential developments to be focused on in the future.

# 2. Growth accounting approach[3]

In this section, the standard growth accounting approach is introduced including a discussion of the intended treatment of intangible assets in the framework.[4]

## 2.1. PRODUCTION AND TFP GROWTH

Let the general gross output production function be given by

$$Y_j = f_j(X_j, K_j, L_j, T_j)$$

where j denotes the industry, $Y_j$ is the measure of (real) output, and the inputs are intermediate $X_j$ (in real terms), labour (number of employed persons or hours worked) $L_j$ and the capital stock $K_j$. $T_j$ denotes the (unobserved) level of technology. All these variables have to be in real terms or physical inputs. Inputs can and – at a later stage will - be broken down into several categories, e.g. labour into educational attainment levels, age, and gender, and capital into asset types (e.g. ICT and non-ICT capital). Usually applied assumptions in this approach are: (i) competitive product and factor markets (prices equal marginal costs, factor prices equal marginal product); (ii) full input utilisation (basically due to data constraints); and (iii) constant returns to scale.

Assuming a translog functional form of the production function total factor productivity growth can be derived as (see Jorgensen et al, 2005)

$$\Delta \ln T_{GO,j} \equiv \Delta \ln Y_j - \bar{v}_{X,j} \Delta \ln X_j - \bar{v}_{K,j} \Delta \ln K_j - \bar{v}_{L,j} \Delta \ln L_j$$

with $\Delta \ln x_t = \ln x_t - \ln x_{t-1}$ denoting the growth rate. Nominal input (cost) shares (in gross output) are given by $v_{f,j} = \frac{p_{fj} F_j}{p_{Yj} Y_j}$ for inputs $F_j = X_j, K_j, L_j$ (e.g. the share of nominal intermediate inputs in gross output, the share of labour compensation and the share of capital compensation in gross output)[5]. Here, factor input prices are denoted by $p_{f,j}$, while and $p_{Y,j}$ is the price index of gross output and $Y_j$ is gross output in real terms (chain-linked volumes). Variables $\bar{v}_{f,j} = 0.5(v_{f,j,t} + v_{f,j,t-1})$ are the period average shares ('Divisia index'). By definition it holds that $\sum_f v_{f,j} = 1$ due to the assumption of constant returns to scale; this also implies that $\sum_f \bar{v}_{f,j} = 1$.

When not considering intermediate inputs, a separability assumption between intermediates and primary inputs (including technology) has to be made which implies a production function of the form

$$Y_j = f_j\left(X_j, g_j(K_j, L_j, T_j)\right)$$

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[3] See e.g. Timmer et al, 2010, Chapter 3.

[4] Additional aspects which are not yet included concern (i) industry aggregation of growth accounts, (ii) country aggregation of growth accounts, (iii) gross output calculations of TFP and (iv) construction of TFP in levels.

[5] The shares correspond to LAB and CAP in the EU KLEMS data.

Value added production then becomes a function of capital and labour inputs and technology, i.e.

$$V_j = g_j(K_j, L_j, T_j)$$

Arguments similar to those above lead to the growth accounting equation

$$\Delta \ln T_{VA,j} \equiv \Delta \ln V_j - \bar{v}_{K,j} \Delta \ln K_j + \bar{v}_{L,j} \Delta \ln L_j$$

with $\bar{v}_{K,j}$ and $\bar{v}_{L,j}$ are Divisia shares of capital and labour costs in value added satisfying $\bar{v}_{K,j} + \bar{v}_{L,j} = 1$. Having available measures for value added and (primary) inputs as well as the respective nominal shares, TFP growth rates (based on value added) can be calculated as residual. As the focus is on value added TFP growth, this variable will be denoted as $\Delta \ln T_j$ henceforth.

Therefore, in the next sections the construction steps for labour and capital inputs are discussed in turn. In the EU KLEMS growth accounting methodology, primary input growth rates are measured by constructing capital and labour services instead of using measures of persons employed or hours worked or a total capital stock only. Therefore, the construction of these labour and capital services growth rates are discussed in the next sections.

## 2.2. LABOUR SERVICES

### 2.2.1. Methodological approach

Labour input of type $l$ in industry $j$ is measured in hours worked denoted by $H_{l,j}$[6]. The measure of (log) growth rate of labour input in industry $j$, $\Delta \ln L_j$, is a Törnqvist volume index of the growth of hours worked of type $l$ weighted by its nominal input shares which is referred to as 'labour services'. Formally this is specified as

$$\Delta \ln L_j = \sum_l \bar{v}_{L,l,j} \Delta \ln H_{l,j} \quad (1)$$

where $\bar{v}_{L,l,j} = (v_{L,l,j,t} - v_{L,l,j,t-1})/2$ denotes the Divisia index of nominal cost shares of labour type $l$. The nominal cost shares of labour type $l$ in industry $j$ are defined as

$$v_{L,l,j} = \frac{p_{L,l,j} H_{l,j}}{\sum_k p_{L,k,j} H_{k,j}} \quad (2)$$

where $p_{L,l,j}$ is the nominal factor price of labour input $l$ in industry $j$ (i.e. the hourly wage rate). By definition it holds that $\sum_l v_{L,l,j} = 1$ (and therefore $\sum_l \bar{v}_{L,l,j} = 1$).

[6] Alternatively, information on the number persons employed could be used.

### 2.2.2. Empirical strategy

The levels of hours worked in each industry j, i.e. $H_j$, are taken from the national accounts data collected from Eurostat. These are broken down into the respective labour types[7] using data from the EU labour force survey (EU LFS). As there is normally no information on hours worked by these categories, they are approximated by calculating the share of the number of workers of type l in total employment in this industry. Multiplying these shares with the number of hours worked in industry $j$ results in the number of hours worked of labour type l in industry j, $H_{l,j}$ with $\sum_k H_{k,j} = H_j$.

To calculate the nominal costs, shares data from EU SES are taken which provide information on (hourly) wages of the respective labour types for each industry, denoted by $p_{L,l,j}$, i.e. the price of labour of type l in industry j. This allows us to calculate the respective nominal factor income shares $v_{L,l,j}$ stated in Equation (2). Having generated the nominal cost shares and the level of hours worked, the growth rate of labour services and the Törnqvist volume index of labour services inputs in industry j can be calculated using Equation (1) above.

### 2.2.3. Decomposition of the labour volume index

The evolution of the Törnqvist volume index for labour services can finally be broken down into (i) a labour composition effect and (ii) a change in hours worked effect as follows:

$$\Delta \ln L_j = \sum_k \bar{v}_{L,k,j} \Delta \ln H_{k,j} - \Delta \ln H_j + \Delta \ln H_j$$

$$= \left( \sum_k \bar{v}_{L,k,j} \Delta \ln H_{k,j} - \sum_k \bar{v}_{L,k,j} \Delta \ln H_j \right) + \Delta \ln H_j$$

$$= \sum_l \bar{v}_{L,k,j} \Delta \ln \frac{H_{k,j}}{H_j} + \Delta \ln H_j$$

resulting in

$$\Delta \ln L_j = \Delta \ln LC_j + \Delta \ln H_j \quad (3)$$

The first term shows the growth contribution of the composition effect to labour services growth, the second the contribution of changes in hours worked. This expression has a straightforward interpretation as follows. First, if there is no compositional change in labour inputs measured in hours worked, i.e. $\Delta \ln \frac{H_{l,j}}{H_j} = 0$, labour services growth would correspond to the overall growth rate of hours worked in industry j. Second, if overall hours worked doesn't change, i.e. $\Delta \ln H_j = 0$, only an increase in the hours worked of workers getting a relatively higher share of labour income in this industry would result in increasing labour services. Similarly, third, labour services could change if (relative) factor prices (i.e. wages per hour worked) change and therefore the cost shares change over time. [8]

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[7] In the EU KLEMS labour accounts dimensions gender, age, and educational attainment are differentiated.

[8] This reflects the assumption that wage rates equal their marginal product (given prices). For example, if there is a compositional shift towards women or migrant workers who earn less due to discrimination, the approach would result in

## 2.3. CAPITAL SERVICES

### 2.3.1. Methodological approach

Input of capital service is measured as a Törnqvist volume index of various asset types (like building, machinery, software, etc.) given by

$$\Delta \ln K_j = \sum_k \bar{v}_{K,k,j} \Delta \ln K_{k,j} \quad (4)$$

where $K_{k,j}$ denotes the capital stock (in chain-linked volumes) of asset type $k$ in industry $j$ and $\bar{v}_{K,k,j}$ denotes nominal (Divisia) shares. These nominal shares are defined as

$$v_{K,k,j} = \frac{p_{K,k,j} K_{k,j}}{\sum_l p_{K,l,j} K_{k,j}} = \frac{p_{K,k,j} K_{k,j}}{p_{K,j} K_j}$$

where $p_{K,k,j}$ is the user costs of capital asset $k$ in industry $j$ which is assumed for the moment to be known (see below). It holds (by definition) that $\sum_k v_{K,k,j} = 1$. Variables $\bar{v}_{K,k,j,t} = (v_{K,k,j,t} + v_{K,k,j,t-1})/2$ denote Divisia shares for which again it holds that $\sum_k \bar{v}_{K,k,j} = 1$.

### 2.3.2. Empirical strategy

For the calculation of capital services, data (by industry and asset type) on the price deflators of investments and data on capital stocks in chain-linked volumes by industry and asset type, are needed (see Section 3). To calculate the user costs of capital (price of capital services or 'rental price') for each asset type the 'user-cost of capital approach' is applied. This is the price at which the investor is indifferent between buying and renting the capital good for one year. The familiar *user cost-of-capital* equation[9] is given by

$$p_{K,k,j,t} = p_{I,k,j,t-1} i_{j,t} + \delta_{k,j} p_{I,k,j,t} - (p_{I,k,j,t} - p_{I,k,j,t-1})$$

where $p_{I,k,j,t}$ is the investment price of asset type $k$ in industry *j* and $\delta_k$ is the (geometric) depreciation rate. This formula requires the calculation the *nominal rate of return* by industry $i_{j,t}$, which is given by

$$i_{j,t} = \frac{p_{K,j,t} K_{j,t} + \sum_l (p_{I,l,j,t} - p_{I,l,j,t-1}) K_{l,j,t} - \sum_l \delta_{l,j} p_{I,l,j,t} K_{l,j,t}}{\sum_l p_{I,l,j,t-1} K_{l,j,t}}$$

where $p_{K,j,t} K_{j,t} = CAP_{j,t}$ (i.e. capital income) and $K_{k,j,t}$ is the stock of capital asset type $k$ in real in chain-linked series volumes.

The capital services price can become negative in which case these are set to zero.

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a negative labour composition effect. Similarly, (exogenous) changes in wage structures imply an effect on the growth rate of labour services.

[9] For a discussion see Jorgenson et al. (2005) for details. Specifically, a geometric pattern of economic depreciation is assumed.

## 2.4. GROWTH ACCOUNTING

### 2.4.1. Contributions to value added growth and TFP growth

The above equation already delivers the contributions to (real) value added growth

$$\Delta \ln V_j \equiv \bar{v}_{K,j}\Delta \ln K_j + \bar{v}_{L,j}(\Delta \ln LC_j + \Delta \ln H_j) + \Delta \ln T_j$$

where labour inputs are differentiated by the composition and hours worked effects. When various groups of asset types are considered the equation can be written as

$$\Delta \ln V_j \equiv \bar{v}_{K,j}\sum_G \bar{v}_{G,j}\Delta \ln K_{G,j} + \bar{v}_{L,j}(\Delta \ln LC_j + \Delta \ln H_j) + \Delta \ln T_j$$

where $\sum_G \bar{v}_{G,j}\Delta \ln K_{G,j}$ is the growth rate of capital services (i.e. Tornqvist weighted growth rates of asset types with $\sum_G \bar{v}_{G,j} = 1$). In practice, this equation is used to calculate TFP growth, $\Delta \ln T_j$, as a residual, i.e.

$$\Delta \ln T_j = \Delta \ln V_j - \bar{v}_{K,j}\sum_G \bar{v}_{G,j}\Delta \ln K_{G,j} - \bar{v}_{L,j}(\Delta \ln LC_j + \Delta \ln H_j)$$

### 2.4.2. Decomposition of labour productivity per hour worked growth

Subtracting the change of hours worked growth from both sides results in

$$\Delta \ln V_j - \Delta \ln H_j \equiv \bar{v}_{K,j}\sum_G \bar{v}_{G,j}\Delta \ln K_{G,j} + \bar{v}_{L,j}\Delta \ln LC_j + \bar{v}_{L,j}\Delta \ln H_j + \Delta \ln T_j - \Delta \ln H_j$$

This expression can be manipulated

$$\Delta \ln V_j - \Delta \ln H_j \equiv \bar{v}_{K,j}\sum_G \bar{v}_{G,j}\Delta \ln K_{G,j} + \bar{v}_{L,j}\Delta \ln LC_j + (\bar{v}_{L,j} - 1)\Delta \ln H_j + \Delta \ln T_j$$

$$\Delta \ln V_j - \Delta \ln H_j \equiv \bar{v}_{K,j}\sum_G \bar{v}_{G,j}\Delta \ln K_{G,j} + \bar{v}_{L,j}\Delta \ln LC_j - \bar{v}_{K,j}\Delta \ln H_j + \Delta \ln T_j$$

This can also be written as (note that $\sum_G \bar{v}_{G,j} = 1$)

$$\Delta \ln V_j - \Delta \ln H_j \equiv \bar{v}_{K,j}\sum_G \bar{v}_{G,j}\Delta \ln K_{G,j} + \bar{v}_{L,j}\Delta \ln LC_j - \bar{v}_{K,j}\sum_G \bar{v}_{G,j}\Delta \ln H_j + \Delta \ln T_j$$

resulting in

$$\Delta \ln V_j - \Delta \ln H_j \equiv \bar{v}_{K,j}\left(\sum_G \bar{v}_{G,j}(\Delta \ln K_{G,j} - \Delta \ln H_j)\right) + \bar{v}_{L,j}\Delta \ln LC_j + \Delta \ln T_j$$

This decomposes value added per hour worked growth, capital services per hour worked growth, the labour composition effect and TFP growth.[10] Again, in practice, TFP growth is calculated as a residual, i.e.

$$\Delta \ln T_j = (\Delta \ln V_j - \Delta \ln H_j) - \bar{v}_{K,j}\left(\sum_G \bar{v}_{G,j}(\Delta \ln K_{G,j} - \Delta \ln H_j)\right) - \bar{v}_{L,j}\Delta \ln LC_j$$

[10] When distinguishing various groups of asset types, the derivation is analogous.

Note that the contribution of TFP for labour productivity growth is the same as for value added growth.

### 2.4.3. Decomposition of labour productivity per employed person growth

Subtracting the change of growth of employed persons from both sides results in

$$\Delta \ln V_j - \Delta \ln E_j \equiv \bar{v}_{K,j} \sum_G \bar{v}_{G,j} \Delta \ln K_{G,j} + \bar{v}_{L,j} \Delta \ln LC_j + \bar{v}_{L,j} \Delta \ln H_j + \Delta \ln T_j - \Delta \ln E_j$$

The RHS is the growth rate of labour productivity per person employed. This expression can be manipulated

$$\Delta \ln V_j - \Delta \ln E_j \equiv \bar{v}_{K,j} \left( \sum_G \bar{v}_{G,j} \left( \Delta \ln K_{G,j} - \Delta \ln E_j \right) \right) + \bar{v}_{L,j} \Delta \ln LC_j + \bar{v}_{L,j} (\Delta \ln H_j - \Delta \ln E_j) + \Delta \ln T_j$$

which expresses the growth rate of labour productivity per person employed as the growth rate of capital per person employed weighted by the capital share, the change of labour composition weighted by the labour share, total factor productivity growth and the growth differential between hours worked and persons employed (growth rate of working hours per employed person weighted by the labour share). For example, hours worked per person employed growing faster than the number of persons employed would impact positively on the labour productivity per person employed. Consequently, TFP growth is measured as

$$\Delta \ln T_j = (\Delta \ln V_j - \Delta \ln E_j) - \bar{v}_{K,j} \left( \sum_G \bar{v}_{G,j} \left( \Delta \ln K_{G,j} - \Delta \ln E_j \right) \right) - \bar{v}_{L,j} \Delta \ln LC_j - \bar{v}_{L,j} (\Delta \ln H_j - \Delta \ln E_j)$$

In this EU KLEMS 2019 Release, the effect of growth differentials between hours worked and employment (weighted by the labour share) is stated explicitly; therefore the contribution of TFP growth to labour productivity per person employed growth is the same as for value added and value added per hour worked. In the previous EU KLEMS releases, TFP growth included the growth differential, i.e. it was formally defined as

$$\widetilde{\Delta \ln T_j} = \Delta \ln T_j + \bar{v}_{L,j} (\Delta \ln H_j - \Delta \ln E_j)$$

Finally, note that the contribution of labour composition change is also the same as for value added and value added per hour worked growth whereas the contributions of capital services growth (by asset type) differ because they are now measured relative to employed persons (rather than hours worked).

# 3. The 'statistical database'

This section provides an overview of the coverage of the database (as of January 2019) as well as a discussion on the issues of data collection and manipulation. The overview is structured by data groups: (i) national accounts data, (ii) data to calculate labour services, and (iii), data to calculate capital services. Before that an overall assessment of the coverage is provided.

## 3.1. COVERAGE

### 3.1.1. Country and time coverage

The database covers all EU28 Member States (as of October 2019) and comparable data for Norway, Japan and the US to the extent possible.[11] Data and results for Japan were delivered from RIETI and Hitotsubashi University[12]. Data for the US were collected from the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS)[13]. Further, data for Belgium were delivered by the Federal Planning Bureau[14] and data on gross fixed capital formation and capital stocks for Spain were delivered by IVIE.[15] The data are presented for the period 1995-2017 though this differs across countries, industries and variables (see sections below for further details). Further details on country specific data availability and adjustments are reported in a specific note.[16]

In addition, various aggregates are provided. For the basic National Accounts data these are aggregates for EU28, EU27 (i.e. without UK) and the Euro Area EA-19. With respect to growth accounts, four country groups are provided: the EU12 comprises the countries for which data are available for the period 2000-2017 (though in some cases data for 2017 had to be estimated) and includes Austria, Belgium, Czech Republic, Germany, Denmark, Spain, Finland, France, Italy, Netherlands, Sweden, and UK. A second group of countries, the EU20, includes those countries for which data are available from 2008 (until 2016) including in addition to the countries mentioned above Estonia, Hungary, Latvia, Lithuania, Luxembourg, Romania, Slovak Republic, and Slovenia. These groups are further presented excluding the UK, labelled as EU11 and EU19.

[11] Additional data might become available for Russia (see Jäger et al., 2019, for preliminary results).

[12] We would like to thank our collaborators Prof. Kyoji Fukao and Kenta Ikeuchi; see www.rieti.go.jp/en/database/JIP2018/index.html

[13] We would like to thank Matthew Russels and Chris Sparks for assistance.

[14] We would like to thank Chantal Kegels and Bernadette Biatour from the Federal Planning Bureau for collaboration and advise.

[15] We would like to thank Matilde Mas (IVIE) for providing these data.

[16] Available at www.euklems.eu.

### 3.1.2. Industry classification

The industry list used in EU KLEMS Release 2019 is presented in Table 1. Compared to the industry list in EU KLEMS 2017 (and older releases), some changes have been implemented resulting in 40 detailed industries in the EU KLEMS Release 2019 database. Further, data for the total economy are presented as well.

The most important changes compared to the industry list in the previous EU KLEMS releases are that some more detailed industries are included separately (NACE codes 20, 21, 26, 27, D, E and 49-52), two additional aggregates are included (O-Q and R_S)[17]; for total figures, aggregates for both the total economy (A-U) and for total industries (A-S) are tracked. To align with previous versions of the EU KLEMS releases and due to data constraints in some countries, an additional three aggregates are provided (C20_C21, C26_C27 and D_E).

The general strategy is to collect data from Eurostat at the level of industries at all levels of (dis-)aggregation as shown in Table 1. Therefore, only three aggregates have to be calculated in addition, i.e. TOT_IND, MARKT and R_S, (and for the additional aggregates C20_C21, C26_C27 and D_E). Importantly, data are collected at current and previous year prices allowing us to calculate the required aggregates. The data for total economy (TOT) are available from Eurostat and are included in the cases of countries which do not report industry details. A second reason (apart from the possibility to build aggregates) for starting from current and previous-year-price data, and calculating the chain-linked data, is that Eurostat provide deflators restricted to only one decimal after the comma, which has created some slight inconsistencies in the previous EU KLEMS releases (see Jäger, 2017), and to construct smoother time series of deflators which are especially important for gross fixed capital formation data (see details below).

**BOX 1 / CALCULATION OF CHAIN LINKED VOLUMES AND PRICE INDICES**

Information collected from Eurostat is current prices ($X_{CUR,t}$) and previous year prices ($I_{PYP,t}$). Based on these data a chain-linked series (at reference prices for year $T$) is calculated (recursively) as by first defining a base year, i.e. $X_{CLV,t} = X_{CUR,t}$ for $t = T$. Then the chain-linked series are calculated as $X_{CLV,t+1} = X_{CLV,t} \frac{X_{PYP,t+1}}{X_{CUR,t}}$ for $t > T$, and $X_{CLV,t} = X_{CLV,t+1} / \frac{X_{PYP,t+1}}{X_{CUR,t}}$ for $t < T$. Finally, the price deflator is then given by $p_{X,t} = \frac{X_{CUR,t}}{X_{CLV,t}}$. This deflator is also provided by Eurostat, however only at a precision to 3 decimal places. To assure consistency this strategy is used.

[17] The former aggregate O-U is no longer included. In Eurostat, data aggregate R-U would be provided which is however replaced by R-S to be consistent with the growth accounting exercise.

## Table 1 / Industry list for EU KLEMS Release 2019

| Sort_ID | indnr | code | desc |
|---|---|---|---|
| 1 | Agg | TOT | TOTAL ECONOMY (A-U) |
| 2 | *Agg | TOT_IND | TOTAL INDUSTRIES (A-S) |
| 3 | *Agg | MARKT | MARKET ECONOMY (all industries excluding L, O, P, Q, T, and U) |
| 4 | 1 | A | Agriculture, forestry and fishing |
| 5 | 2 | B | Mining and quarrying |
| 6 | Agg | C | TOTAL MANUFACTURING |
| 7 | 3 | …10-12 | …Food products, beverages and tobacco |
| 8 | 4 | …13-15 | …Textiles, wearing apparel, leather and related products |
| 9 | 5 | …16-18 | …Wood and paper products; printing and reproduction of recorded media |
| 10 | 6 | …19 | ...Coke and refined petroleum products |
| 11 | 7 | … 20 | …Chemicals and chemical products |
| 12 | 8 | … 21 | …Basic pharmaceutical products and pharmaceutical preparations |
| 13 | 9 | …22-23 | …Rubber and plastics products, and other non-metallic mineral products |
| 14 | 10 | …24-25 | …Basic metals and fabricated metal products, except machinery and equipment |
| 15 | 11 | … 26 | …Computer, electronic and optical products |
| 16 | 12 | … 27 | …Electrical equipment |
| 17 | 13 | …28 | …Machinery and equipment n.e.c. |
| 18 | 14 | …29-30 | …Transport equipment |
| 19 | 15 | …31-33 | …Other manufacturing; repair and installation of machinery and equipment |
| 20 | 16 | … D | …Electricity, gas, steam and air conditioning supply |
| 21 | 17 | … E | …Water supply; sewerage; waste management and remediation activities |
| 22 | 18 | F | Construction |
| 23 | Agg | G | WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES |
| 24 | 19 | …45 | …Wholesale and retail trade and repair of motor vehicles and motorcycles |
| 25 | 20 | …46 | …Wholesale trade, except of motor vehicles and motorcycles |
| 26 | 21 | …47 | …Retail trade, except of motor vehicles and motorcycles |
| 27 | Agg | H | TRANSPORTATION AND STORAGE |
| 28 | 22 | … 49 | …Land transport and transport via pipelines |
| 29 | 23 | … 50 | …Water transport |
| 30 | 24 | … 51 | …Air transport |
| 31 | 25 | … 52 | …Warehousing and support activities for transportation |
| 32 | 26 | …53 | …Postal and courier activities |
| 33 | 27 | I | Accommodation and food service activities |
| 34 | Agg | J | INFORMATION AND COMMUNICATION |
| 35 | 28 | …58-60 | …Publishing, audio-visual and broadcasting activities |
| 36 | 29 | …61 | …Telecommunications |
| 37 | 30 | …62-63 | …IT and other information services |
| 38 | 31 | K | Financial and insurance activities |
| 39 | 32 | L | Real estate activities |
| 40 | 33 | M-N | Professional, scientific, technical, administrative and support service activities |
| 41 | Agg | O-Q | PUBLIC ADMINISTRATION, DEFENCE, EDUCATION, HUMAN HEALTH AND SOCIAL WORK ACTIVITIES |
| 42 | 34 | O | Public administration and defence; compulsory social security |
| 43 | 35 | P | Education |
| 44 | 36 | Q | Health and social work |
| 45 | *Agg | R-S | ARTS, ENTERTAINMENT, RECREATION; OTHER SERVICES AND SERVICE ACTIVITIES, etc. |
| 46 | 37 | R | Arts, entertainment and recreation |
| 47 | 38 | S | Other service activities |
| 48 | 39 | T | Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use |
| 49 | 40 | U | Activities of extraterritorial organizations and bodies |
| | | | |
| 991 | *Agg | C20_C21 | …Chemicals; basic pharmaceutical products |
| 992 | *Agg | C26_C27 | …Computer, electronic, optical products; electrical equipment |
| 993 | *Agg | D_E | Electricity, gas, steam; water supply, sewerage, waste management |

Note: *denotes aggregates not defined by Eurostat.

## 3.2. NATIONAL ACCOUNTS DATA

### 3.2.1. Data collection

The intention of this update of the EU KLEMS data is to include as many countries as possible. The first results presented below suggest that the coverage might have been increased compared to the EU KLEMS 2017 release for two reasons: first, data – particularly with respect to gross fixed capital formation and capital stocks – became gradually more complete across countries. Second, growth accounting is also calculated at the aggregate levels rather than following the bottom-up approach as in previous KLEMS releases. The reason for this is that nowadays data from National Accounts are available at current and previous year prices. As these are additive across industries, these can be used to calculate aggregates and to provide growth accounting results separately at each level of aggregation. This means that countries only reporting data at more aggregate industries can be considered as well.[18] Table 2 and Table 3 provide overviews of data availability and adjustments with respect to the EU Member States.

Data for current prices and previous year prices are downloaded from Eurostat. These data are used to calculate the aggregates not directly available from Eurostat (TOT_IND, MARKT and R_S). In some cases, smart imputations have been made which will be documented. Several cross-checks on consistency (i.e. industry aggregations and asset aggregations) are underway in a more systematic manner. In such cases, these will be carefully documented and might be communicated to Eurostat. Specifically, data on output (P1), intermediate consumption (P2) and (gross) value added (B1G) in million units of national currency in current prices (CP_MNAC) and previous year prices (PYP_MNAC) are downloaded from Eurostat. The respective current price variables in EU KLEMS are denoted by GO (gross output), II (intermediate inputs) and VA (value added). The chain-linked volumes (2010) are denoted by GO_QI, II_QI and VA_QI respectively and have been calculated using the formula in Box 3.1. The resulting chain-linked volumes (2010) data have been checked with the original data from Eurostat (CLV10_MNAC). Price index is calculated as GO_P = GO/GO_QI, II_P = II/II_QI and VA_P = VA/VA_QI. The results are cross-checked with the price index (implicit deflator) in national currency (2010=100), which is provided by Eurostat (PD10_NAC), however rounded to one decimal place.

This procedure is different from the EU KLEMS Release 2017 where the variables in chain-linked volumes were calculated as GO_QI = GO/GO_P. This created small inconsistencies with Eurostat data on GO_QI due to rounding errors as the price index is provided to only one decimal place.

Another advantage in using previous year prices is the possibility to construct aggregates which are not readily available in Eurostat (i.e. TOT_IND, MARKT and R-S) as data are additive at every NACE activity.

In addition, compensation of employees in millions of national currency (D1) is downloaded. Further, data on persons employed (EMP), employees (EMPE) and hours worked (H_EMP and H_EMPE) are collected.

[18] For those countries which deliver disaggregate data, cross-checks can be made on whether properly aggregated growth accounting results performed at the more detailed industry level and those derived at the aggregate level are the same (which ideally should be the case).

**Table 2 / Overview of NA data availability for EU28 Member States – Current data and employment levels**

| | Current levels | | | | Employment levels | | | |
|---|---|---|---|---|---|---|---|---|
| | VA | GO | II | COMP | EMP | EMPE | H_EMP | H_EMPE |
| AT | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| BE | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1999-2017 | 1995-2017 |
| BG | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| CY | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| CZ | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| DE | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| DK | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| EE | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| EL | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| ES | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| FI | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| FR | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| HR | 1995-2016 | 1995-2016 | 1995-2016 | 1995-2016 | 2008-2017 | 2008-2017 | 2008-2017 | 2008-2017 |
| HU | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 2000-2017 | 2000-2017 |
| IE | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| IT | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| LT | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| LU | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| LV | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 2000-2017 | 2000-2017 |
| MT | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| NL | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| PL | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| PT | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 2010-2017 | 2000-2017 |
| RO | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| SE | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| SI | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| SK | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| UK | 1995-2016 | 1995-2016 | 1995-2016 | 1995-2016 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |

Note: Dark green: full coverage; green: full time period and industries with wiiw estimates; light green: missing sub-industries or years; purple: missing years.
Source: EU KLEMS Release 2019.

**Table 3 / Overview of NA data availability for EU28 Member States – Prices and quantities**

| | Prices | | | Volumes | | |
|---|---|---|---|---|---|---|
| | VA_P | GO_P | II_P | VA_QI | GO_QI | II_QI |
| AT | 1995-2017 | 1995-2016 | 1995-2016 | 1995-2017 | 1995-2016 | 1995-2016 |
| BE | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| BG | 1995-2017 | | | 1995-2017 | | |
| CY | 1995-2017 | | | 1995-2017 | | |
| CZ | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| DE | 1995-2017 | 1995-2016 | 1995-2016 | 1995-2017 | 1995-2016 | 1995-2016 |
| DK | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| EE | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| EL | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| ES | 1995-2017 | | | 1995-2017 | | |
| FI | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| FR | 1995-2017 | 1995-2016 | 1995-2016 | 1995-2017 | 1995-2016 | 1995-2016 |
| HR | 2000-2016 | 2007-2016 | 2007-2016 | 2000-2016 | 2007-2016 | 2007-2016 |
| HU | 1995-2017 | 1995-2016 | 1995-2016 | 1995-2017 | 1995-2016 | 1995-2016 |
| IE | 1995-2017 | | | 1995-2017 | | |
| IT | 1995-2017 | 1995-2015 | 1995-2015 | 1995-2017 | 1995-2015 | 1995-2015 |
| LT | 1995-2017 | | | 1995-2017 | | |
| LU | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| LV | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| MT | | | | | | |
| NL | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| PL | 1995-2017 | 1995-2016 | 1995-2016 | 1995-2017 | 1995-2016 | 1995-2016 |
| PT | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| RO | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| SE | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 | 1995-2017 |
| SI | 1995-2017 | 2000-2016 | 2000-2016 | 1995-2017 | 2000-2016 | 2000-2016 |
| SK | 1995-2017 | 1995-2015 | 1995-2015 | 1995-2017 | 1995-2015 | 1995-2017 |
| UK | 1995-2016 | 1995-2016 | 1995-2016 | 1995-2016 | 1995-2016 | 1995-2016 |

Note: Dark green: full coverage; green: full time period and industries with wiiw estimates; light green: missing sub-industries or years; purple: missing years; yellow: sourced from OECD; red: not available;
Source: EU KLEMS Release 2019.

### 3.2.2. Additional data and imputations

Based on these data, additional variables are calculated. First, labour compensation is calculated as

$$\mathrm{LAB} = \frac{\mathrm{H\_EMP}}{\mathrm{H\_EMPE}}\ \mathrm{COMP}$$

which assumes that the self-employed receive the same hourly wage as the employees (in each industry and year). Capital compensation is then calculated as value added minus labour compensation, i.e. $\mathrm{CAP} = \mathrm{VA} - \mathrm{LAB}$.

### 3.2.3. National Accounts data in the 'Statistical Database'

The list of variables and indicators finally provided is unchanged as compared to previous EU KLEMS releases, though labels of variables are slightly changed in some cases. These available indicators are summarised in Table 4.

**Table 4 / National accounts data**

| Variables | |
|---|---|
| **Values** | |
| *VA* | GVA, current prices, NAC mn |
| *GO* | Gross output, current prices, NAC mn |
| *II* | Intermediate inputs, current prices, NAC mn |
| *VA_PYP* | GVA, prev.year prices, NAC mn |
| *GO_PYP* | Gross output, prev.year prices, NAC mn |
| *II_PYP* | Intermediate inputs, prev.year prices, NAC mn |
| *COMP* | Compensation of employees, current prices, NAC mn |
| *EMP* | Number of persons employed, th |
| *EMPE* | Number of employees, th |
| *H_EMP* | Total hours worked by persons engaged, th |
| *H_EMPE* | Total hours worked by employees, th |
| **Prices** | |
| *VA_PI* | GVA, price indices, 2010=100 |
| *GO_PI* | Gross output, price indices, 2010=100 |
| *II_PI* | Intermediate inputs, price indices, 2010=100 |
| **Volumes** | |
| *VA_Q* | GVA, volume 2010 ref.prices, NAC mn |
| *GO_Q* | Gross output, volume 2010 ref.prices, NAC mn |
| *II_Q* | Intermediate inputs, volume 2010 ref.prices, NAC mn |
| *LP_QI* | GVA per hour worked, volume 2010=100 |

Source: EU KLEMS Release 2019.

## 3.3. LABOUR

The second set of information needed is data from which growth in 'labour services' can be calculated. This section therefore discusses the data inputs and methods for calculations of labour inputs. This therefore concerns (i) EU LFS data to calculate a breakdown of employment (hours worked) data, (ii) EU SES data to gather information on hourly wages and cost shares and (iii) data used from previous EU KLEMS releases, which is outlined in this section. Corresponding data for Japan and the US was delivered from national sources.

### 3.3.1. Labour categories and data sources

The labour accounts aim at a breakdown of labour inputs (measured in terms of the number of persons employed and hours worked) and labour compensation and cost shares into the eighteen categories listed in Table 5.

**Table 5 / Breakdown of labour input categories**

| Gender | | Age groups | | Educational attainment | |
|---|---|---|---|---|---|
| 1 | male | 1 | 15-29 | 1 | University graduates (ISCED_5 + 6) |
| 2 | female | 2 | 30-49 | 2 | Intermediate |
| | | 3 | 50 and higher | 3 | No formal qualifications |

Note: These labour types and labelling correspond to previous EU KLEMS releases.
Source: EU KLEMS, Release 2017.

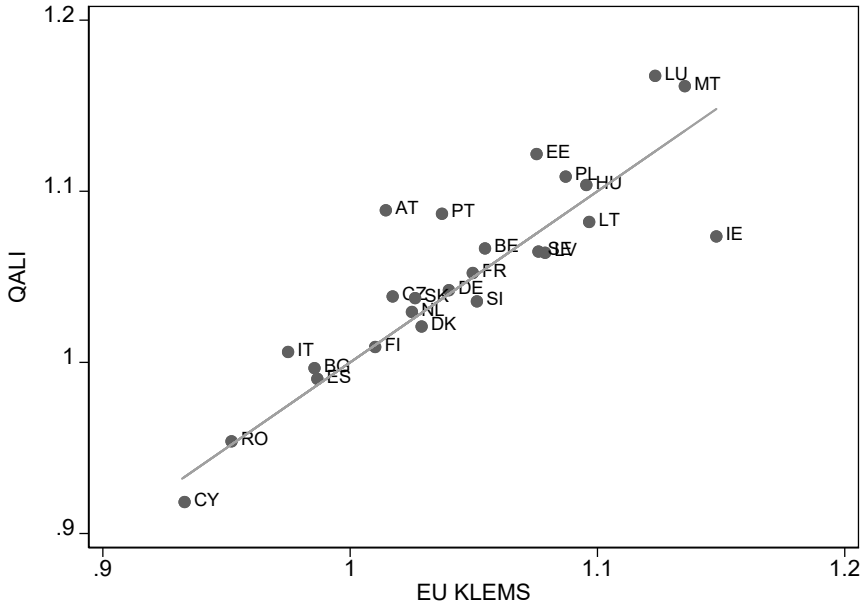
These categories are not part of the National Accounts data and therefore have to be constructed from other sources. There are two main sources for this additional information. First, the EU LFS (microdata) provide information on the number of persons employed in each of the categories listed above (and including industry and time dimensions). Second, the EU SES (microdata, accessed via CD-ROM) data provide information on hourly wages of these groups.[19] These data are now discussed in more detail. An alternative source for such information is the recently published QALI database (see Box 2 for detailed information).

[19] Belgium provided its own input data and growth accounts.

## BOX 2 / EUROSTAT QALI DATABASE

Eurostat has recently provided 'quality adjusted labour input data' over the period 2002-2015 for 21 NACE Rev. 2 industries (see https://ec.europa.eu/eurostat/web/experimental-statistics/qali). In general this follows a very similar methodology as applied in the EU KLEMS approach so far. However, there are also some differences compared to EU KLEMS of which the important ones are: (i) the QALI database does not distinguish workers by gender (the breakdown by age and educational attainment are similar) and (ii) information on earnings, in addition to EU SES, is gathered from EU SILC data. In addition, different imputation and adjustment strategies are applied in both approaches. Despite these differences, a strong correlation between the resulting figures exists in general (though there are some differences in specific countries and industries) as indicated in the figure below. This figure correlates the index (2010=1) of this measure in 2015 (the last year for which QALI is available) for the total economy (the correlation coefficient is 0.87).

**Box Figure 1 / Correlation between EU KLEMS labour services index and QALI**




Note: Indicator used is chQali10; line: QALI = EU KLEMS
Source: Eurostat QALI and EU KLEMS Release 2019.

Though this data would be a valuable alternative source of information in general, it also has some deficiencies for our purposes which were the reasons for us to stick to our own calculations: country coverage is not complete (EL, HR and UK are missing); industry coverage does not go beyond EU KLEMS data; the time period covered is 2002-2015 (compared to the intended coverage 1995-2017); to arrive at the longer time series back to 1995, data on labour services from previous EU KLEMS releases are used which is therefore consistent with the data constructed here.

EU LFS micro-data

The first important source for a breakdown of labour inputs is the EU Labour Force Survey (EU LFS) which provides the necessary details for the breakdown of hours worked by type of labour. These data are available for the period 2008-2016 and report data according to NACE Rev. 2. One limitation however is that data are provided only for NACE Rev. 2 1-digit industries.[20] The industry breakdown (including 20 NACE activities) available[21] is listed in Table 6.

**Table 6 / NACE Rev. 2 1-digit industry classification**

| NACE Rev 2 | Description |
|---|---|
| A | Agriculture, forestry and fishing |
| B | Mining and quarrying |
| C | Manufacturing |
| D | Electricity & gas |
| E | Water and sewerage |
| F | Construction |
| G | Wholesale and retail trade |
| H | Transport and storage |
| I | Hotels & catering |
| J | Information and communication |
| K | Financial intermediation |
| L | Real estate |
| M-N | Professional, scientific, technical, administrative and support service activities |
| O | Public administration and defence; compulsory social security |
| P | Education |
| Q | Health and social work |
| R | Arts, entertainment and recreation |
| S | Other service activities |
| T | Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use |
| U | Activities of extraterritorial organizations and bodies |

*Source*: EU LFS, own elaborations.

To be consistent with the previous EU KLEMS releases, the EU LFS microdata on a quarterly basis are used which are converted into an annual series by computing the respective averages (with these averages being weighted by population provided in the dataset). These data have been adjusted as follows. In some cases (e.g. for smaller industries and some specific employment categories) employment data are not available (due to the small sample size of the LFS). To avoid strange numbers when calculating growth rates of hours worked later on, first the average share over the whole period was calculated and imputed in the cases of missing values. To guarantee that shares by industry sum up to one, the shares have been normalised. Second, in case no breakdown of employment categories in specific industries is available due to non-reporting in these industries, shares of 1/18 are applied to each cell assuring that national accounts levels are preserved (in the cases where employment figures are reported there). The resulting data were cross-checked with the corresponding data in the EU

[20] Data for 2008 are still in NACE Rev. 1; in this case data has been extrapolated or taken from the previous EU KLEMS data. Further, in 2011 there was a change in the ISCED classification (from ISED 1997 to ISED 2011); at this stage, this break is treated as in previous EU KLEMS updates.

[21] Industries M and N are aggregated in accordance with the EU KLEMS 2019 industry list.

KLEMS 2017 Release which in all cases (with the exception of the UK) showed very high correlations.[22] For building the respective aggregates (TOT, TOT_IND, MARKT, O-Q and R_S), employment levels by industry and employment categories based on the adjusted shares were calculated and summed up to the industry aggregates.

*EU-SES data*

For the breakdown of labour compensation, data from the European Structure of Earnings Survey (EU SES) provide detailed information on the average gross hourly wage. However, there are some specific issues with respect to coverage. First, not all EU28 countries are included in the EU SES provided (accessed via CD-ROM); Table 7 indicates the countries available or not available. Second, the industry details available are limited and information in some industries is missing (agriculture, forestry and fishing). Finally, third, EU SES data are only available for the years 2002, 2006, 2010 and 2014.[23] Therefore it was decided to use the wage shares from the previous EU KLEMS Release which assures consistency with previous assessments of labour composition. As a longer time series is now needed, the data are extrapolated to 2017 based on trends of shares.[24]

**Table 7 / Country coverage in EU SES data**

| 2002 | 2006 | 2010 | 2014 |
|---|---|---|---|
| AT | AT | AT | AT |
| BE | BE | BE | BE |
| BG | BG | BG | BG |
| CY | CY | CY | CY |
| CZ | CZ | CZ | CZ |
| DE | DE | DE | DE |
| DK | DK | DK | DK |
| EE | EE | EE | EE |
| EL | EL | EL | EL |
| ES | ES | ES | ES |
| FI | FI | FI | FI |
| FR | FR | FR | FR |
| HR | HR | HR | HR |
| HU | HU | HU | HU |
| IE | IE | IE | IE |
| IT | IT | IT | IT |
| LT | LT | LT | LT |
| LU | LU | LU | LU |
| LV | LV | LV | LV |
| MT | MT | MT | MT |
| NL | NL | NL | NL |
| PL | PL | PL | PL |
| PT | PT | PT | PT |
| RO | RO | RO | RO |
| SE | SE | SE | SE |
| SI | SI | SI | SI |
| SK | SK | SK | SK |
| UK | UK | UK | UK |

Note: Countries marked red are not providing SES data.
Source: Own assessment.

[22] It has been decided to use data from official statistics (available from Eurostat).

[23] Results from the survey 2018 have not yet been published.

[24] In the EU KLEMS 2017 Release, data for 2015 were assumed to be the same as in 2014.

### 3.3.2. Calculation of labour services growth

Using these data sources allows splitting hours worked (or persons employed) by industry taken from the National Accounts data (variables H_EMP or EMP) into these subcategories. (Note that for 2-digit subcategories of a specific 1-digit industry, the shares of the respective 1-digit industry are applied). This provides the number of hours worked (or employed persons) by type of labour, industry and years 2008-2017 for each country. This is combined with the wage shares for each employment type by industry and year to calculate shares in labour compensation which finally allows us to calculate the labour volume growth by industry as outlined in Section 2.

EU KLEMS data

The data inputs just described (employment shares and hourly wages) are generally available over the period 2008-2017. For the years prior to 2008 (i.e. 1995-2007), labour services growth rates for each industry were taken from the EU KLEMS 2017 Release. Specifically, growth rates from variable LAB_QI (labour services, volume indices, 2010 = 100) backwards from 2008 were used and linked to the data calculated for the period 2008-2017 which thus extends the time series for labour services growth back to 1995. For doing so, a correspondence table between the industry classification in EU KLEMS 2017 and the industry classification applied in this Release was used (see Appendix Table A.1).

### 3.3.3. Coverage

These calculations result in time series for hours worked and labour services as indicated in Table 8 (the time spans refer to the resulting index figures). The time series are available for twelve countries for the whole period 1995-2017 and for thirteen countries for the period 2008-2017 (though specific industries are missing in some cases)[25]. Data for Hungary are only available from 2010 on (due to missing data on hours worked before) and Malta from 2008; for this country only total economy is available. Data for Belgium (delivered from national sources) are available from 1999 on. Coverage with respect to hours worked is generally better with 22 countries providing data since 1995, Belgium since 1999, Poland and Latvia since 2000, Croatia and Malta since 2008 and Hungary since 2010.

With respect to industries in some countries, figures for detailed wholesale and retail trade industries or transport and storage industries are missing. Data for specific manufacturing industries are not available in a few countries due to a lack of data on figures for hours worked (and detailed manufacturing data are completely missing for Latvia). Further, some specific adjustments were made; particularly in the case of Hungary where growth rates from hours worked were taken to calculate labour services from 2008-2010. Additionally, some countries report even more detailed data underlying the calculation of labour services (e.g. Belgium or Japan) whereas, e.g. in the US, although a more detailed breakdown is used, it is only available at the total economy level (i.e. applied to all industries). Table 9 provides an overview of which cases labour services can be calculated.

[25] In a few cases some time series for hours worked (by country and detailed industry) were discarded due to either very high and/or volatile growth rates or data gaps within the time series (i.e. missing years).

**Table 8 / Coverage with respect to hours worked and labour services growth**

| | Hours worked | Labour services | Industries for which data are not available |
|---|---|---|---|
| AT | 1995-2017 | 1995-2017 | |
| BE | 1999-2017 | 1999-2017 | G45-G47; H49-H53 |
| BG | 1995-2017 | 2008-2017 | G45-G47; H49-H53, T |
| CY | 1995-2017 | 2008-2017 | |
| CZ | 1995-2017 | 1995-2017 | |
| DE | 1995-2017 | 1995-2017 | G45-G47; H49-H53 |
| DK | 1995-2017 | 1995-2017 | |
| EE | 1995-2017 | 2008-2017 | C19; C21; H51 |
| EL | 1995-2017 | 2008-2017 | |
| ES | 1995-2017 | 1995-2017 | |
| FI | 1995-2017 | 1995-2017 | |
| FR | 1995-2017 | 1995-2017 | G45-G47; H49-H53 |
| HR | 2008-2017 | 2008-2017 | |
| HU | 2008-2017 | 2008-2017 | |
| IE | 1995-2017 | 2008-2017 | |
| IT | 1995-2017 | 1995-2017 | G45-G47; H49-H53 |
| LT | 1995-2017 | 2008-2017 | G45-G47; H49-H53 |
| LU | 1995-2017 | 2008-2017 | C19; C21; C24_C25 to C31_C33; J62_J63 |
| LV | 2000-2017 | 2008-2017 | C10-12 to C31-C33; G45-G47; H49-H53; J58-J60 to J62_J63 |
| MT | 2008-2017 | 2008-2017 | 2-digit industries n.a. |
| NL | 1995-2017 | 1995-2017 | |
| PL | 2000-2017 | 2008-2017 | |
| PT | 1995-2017 | 2008-2017 | G45-G47; H49-H53 |
| RO | 1995-2017 | 2008-2017 | |
| SE | 1995-2017 | 1995-2017 | C20, C21; H52, H53 |
| SI | 1995-2017 | 2008-2017 | |
| SK | 1995-2017 | 1995-2017 | |
| UK | 1995-2017 | 1995-2017 | G45-G47; H49-H53 |
| | | | |
| JP | 1995-2017 | 1995-2017 | |
| US | 1997-2017 | 1997-2017 | C21, G45, H53, J61, T |

Note: '*for C29-C30 since 2004.
Source: EU KLEMS Release 2019; own elaborations.

**Table 9 / Coverage with respect to labour services**

| Labour services | | Total economy | 1-digit level | 2-digit level |
|---|---|---|---|---|
| AT | Austria | | | |
| BE | Belgium* | 1999-2017 | 1999-2017 | 1999-2017; G. H n.a. |
| BG | Bulgaria | 2008-2017 | 2008-2017, T | 2008-2017; G, H n.a. |
| CY | Cyprus | 2008-2017 | 2008-2017 | 2008-2017 |
| CZ | Czech Republic | | | |
| DE | Germany | | | G, H n.a. |
| DK | Denmark | | | |
| EE | Estonia | 2008-2017 | 2008-2017 | 2008-2017 |
| EL | Greece | 2008-2017 | 2008-2017 | 2008-2017 |
| ES | Spain | | | |
| FI | Finland | | | |
| FR | France | | | G, H n.a. |
| HR | Croatia | 2008-2017 | 2008-2017 | 2008-2017; H n.a. |
| HU | Hungary | 2008-2017 | 2008-2017 | 2008-2017 |
| IE | Ireland | 2008-2017 | 2008-2017 | 2008-2017 |
| IT | Italy | | | G,H n.a. |
| LT | Lithuania | 2008-2017 | 2008-2017 | 2008-2017, G, H n.a. |
| LU | Luxembourg | 2008-2017 | 2008-2017 | 2008-2017* |
| LV | Latvia | 2008-2017 | 2008-2017 | 2008-2017; C, G, H, J n.a. |
| MT | Malta | 2008-2017 | * | |
| NL | Netherlands | | | |
| PL | Poland | 2008-2017 | 2008-2017 | 2008-2017 |
| PT | Portugal | 2008-2017 | 2008-2017 | 2008-2017, G, H. n.a. |
| RO | Romania | 2008-2017 | 2008-2017 | 2008-2017 |
| SE | Sweden | | | C20,C21, H52, H53 n.a. |
| SI | Slovenia | 2008-2017 | 2008-2017 | 2008-2017 |
| SK | Slovak Republic | | | |
| UK | United Kingdom | | | G, H n.a. |
| | | | | |
| JP | Japan | | | |
| US | United States | | | C21, G45, H53, J61, T |

Note: * various industries missing; red indicates that data are not available.
Source: EU KLEMS Release 2019; own assessment.

### 3.3.4. Labour accounts in the 'Statistical Database'

The underlying data for calculating labour services are reported in the 'Labour' files of the Statistical Database. These include the shares of hours worked (H_shares) and income (W_shares) of the eighteen types of workers for the years 2008-2017. Data for hours worked are reported in the 'Basic Data'. Finally, the index of labour services calculated from the growth rates of labour services (LAB_QI) is reported in the 'Growth accounting results'.

## 3.4. CAPITAL ACCOUNTS

### 3.4.1. Data on gross fixed capital formation and stocks

The measures for capital inputs are provided in the capital files. As in previous versions of the EU KLEMS database, ten asset types – according to National Accounts – are distinguished as shown in Figure 2. With the exception of the category 'other intellectual property products' (OIPP), data for the asset types are (generally) directly available. OIPP is calculated as the difference between intellectual property product (N117) and computer software and databases (Soft_DB) and research and development (RD).

As outlined in Section 2, for the calculation of capital services data (by industry and asset type) on the price deflators of investments, data on capital stocks in chain-linked volumes by industry and asset type are needed. For these, first, data on investment in current and previous year prices and the derived values for chain-linked volumes and the price indices are available. Second, data for capital stocks in current and previous year prices as well as the capital stocks in chain-linked volumes are presented. Industry aggregates (not included in the NACE Rev. 2 classification (i.e. TOT_IND, MARKT and R_S) are calculated by summing up data in current and previous year prices from which chain-linked volume series and the corresponding price deflators are calculated. Analogously, data on capital stocks are collected at current replacement prices and previous year replacement prices from which chain-linked capital stock series (reference year 2010) are calculated.

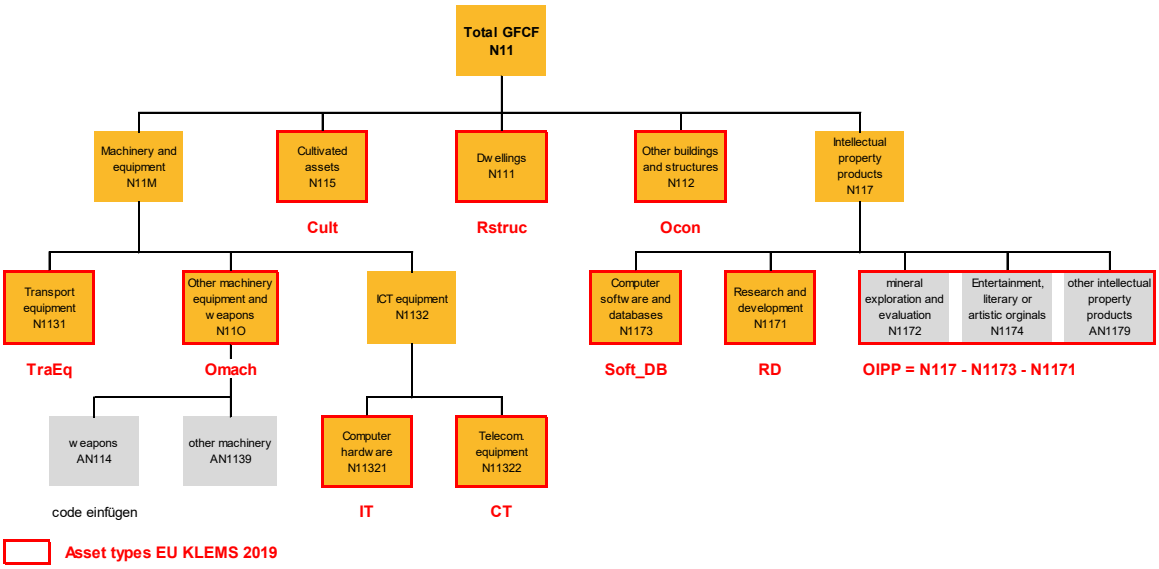
This procedure however is not without problems, particularly in the case of gross fixed capital formation. The reason is that investment can become negative (very small, or are reported as zero or missing) as happened in many cases in the crisis years. Particularly in some countries and industries and for some asset types, data in current and previous year prices are not fully aligned (for example, these values show different signs, or magnitudes differ by a large factor, etc.). In various cases this resulted in strange deflators which might become negative, show very high numbers or are missing (due to the sequential calculation of the chain-linked volumes). As the price deflator for gross fixed capital formation plays an important role in the calculation of capital services, a number of cross-checks and adjustments (e.g. interpolation of figures for one year, etc.) were undertaken to arrive at smoother and more complete time series for deflators.[26]

This issue is particularly relevant for asset type OIPP as this is calculated as a difference. In this case, very small values (lower than 0.001 in absolute terms) which are likely to be the result of rounding errors are set to zero. Second, negative values which popped up only in single years are interpolated. Third, to avoid bumpy series which popped up in some cases, current and previous year prices are set to zero in cases where the median of OIPP (in current prices) accounted for less than one percent of the upper aggregate N117. Finally, fourth, as the time series of deflators in cases of small values, data are smoothed (using a 3-year moving average). This careful procedure was important as OIPP is reported as a single asset type in the growth accounts.[27]

[26] Some checks indicate that in such cases procedures to circumvent such unreliable deflators across countries differ.

[27] In the previous versions of the EU KLEMS database, OIPP was included in non-ICT capital.

**Figure 2 / National Accounts asset breakdown**




Note: Asset types are based on ESA 2010 definition. Those with a code are available at Eurostat (yellow/orange), others not (grey).
Source: EU KLEMS Release 2019.

### 3.4.2. Groups of asset types and capital services

For the growth accounting exercise, these asset types are lumped together into five categories of which the first group constitutes tangible assets and the second group intangible assets (based on National Accounts data) as shown in Figure 3.

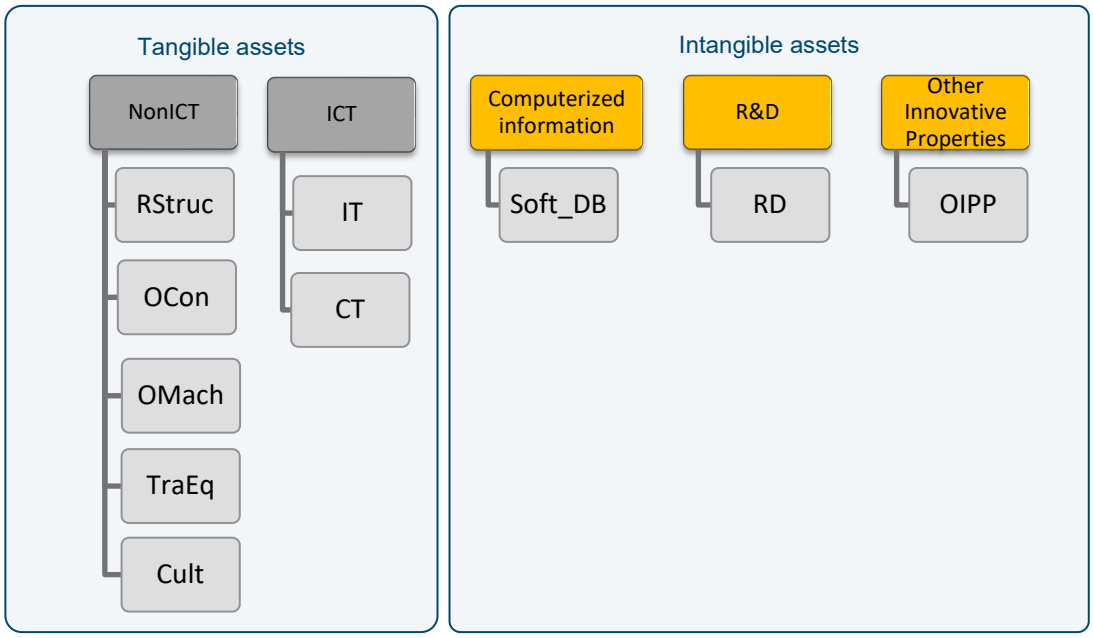
This provides more detailed information compared to the previous EU KLEMS releases which – in the growth accounts – made a distinction between ICT and Non-ICT capital according to the following groupings:

› ICT capital including asset types IT, CT and Soft_DB
› Non-ICT capital including asset types RStruc, OCon, OMach, TraEq, Cult, RD and OIPP.

In the recent literature emphasising the role of intangible assets (see Haskel and Westlake, 2018), the asset types Software and Databases (Soft_DB), R&D (RD) and Other Intellectual Property Products (OIPP) are considered as intangibles (see the recent book by Haskel and Westlake, 2018). The refined grouping of asset types provided in the EU KLEMS Release 2019 distinguishes between tangible ICT investments and stocks ('hardware') and intangible ICT ('software and databases') which were lumped together as ICT in the previous EU KLEMS releases. Further, the important asset type of RD investments and stocks is reported separately (see Figure 3).

The growth rates of these capital services are calculated as outlined in Section 2 (according to EU KLEMS methodology) by calculating the nominal interest rate and the user-cost of capital from which growth in capital services can be derived. The depreciation rates which were assumed are listed in Appendix Table A.2.

**Figure 3 / Aggregates of capital services includig tangible and intangible assets**




Source: own elaboration based on Haskel and Westlake (2018).

### 3.4.3. Coverage

Appendix Table A.3 provides an overview of the coverage by year, industry and asset types for data on gross fixed capital formation. Analogous information is provided in Appendix Table A.4 concerning capital stocks. This coverage is based on specific adjustments and imputations which are reported in the country specific notes. At the total economy level, data on gross fixed capital formation are not, or insufficiently, available for four countries (Cyprus, Croatia, Malta and Poland). This is also the case for Bulgaria, Greece, Ireland and Portugal at the 1-digit level. Data at the 2-digit industry level are missing for even more countries; in some countries information at the level of 2-digit industries is missing only for some sectors (mostly G and H). Finally, time coverage starts from 1995 in many countries (though some provide data from 2000 only) and ends in most cases in 2017 (though in 2016 in some cases).

Coverage with respect to capital stocks is very similar. The most important exception is Greece which provides a full series of capital stock data, also for detailed industries. To be able to provide growth accounts, gross fixed capital formation data could be used in some cases to create a capital stock by the PIM method These are Bulgaria (total economy level), Latvia (for RD and OIPP at the 1-digit industry level) and Romania. These capital stocks created by PIM are not reported but are used in the growth accounting analysis.

Data for Belgium and Spain were collected form country-specific sources while in some other cases country-specific information allowed us to break down the data into more details (e.g. Germany, Italy). Data for non-European countries are almost fully available (except for only Japan where the series ends

in 2015). Finally, in the case of Hungary, information on IT and CT is included in the asset type 'other machinery' (OMach).[28]

The combination of data on capital income (CAP) by industry from the National Accounts, the price index for gross fixed capital formation by industry and asset type and the growth rates of capital stocks (in chain-linked volumes) allow us to calculate capital services which is an important input in the growth accounts. The broad coverage with respect to capital services is presented in Table 10.

**Table 10 / Data on capital services**

| Capital stocks | | Total economy | 1-digit level | 2-digit level |
|---|---|---|---|---|
| AT | Austria | | | |
| BE | Belgium | | | G, H n.a. |
| BG | Bulgaria | | | |
| CY | Cyprus | 1995-2009 | | |
| CZ | Czech Rep. | | | |
| DE | Germany | | | |
| DK | Denmark | | | |
| EE | Estonia | 2000-2016 | 2000-2016 | |
| EL | Greece | 1995-2016 | | |
| ES | Spain | 1995-2016 | 1995-2016 | 1995-2016; G, H n.a.* |
| FI | Finland | | | |
| FR | France | | | G, H n.a. |
| HR | Croatia | | | |
| HU | Hungary | IT, CT n.a. | IT, CT n.a. | |
| IE | Ireland | 1995-2016 | | |
| IT | Italy | | | G and H n.a. |
| LT | Lithuania | | | |
| LU | Luxembourg | | | # ind n.a. |
| LV | Latvia | 1995-2016 | 1999-2016 | |
| MT | Malta | | | |
| NL | Netherlands | | | G, H n.a. |
| PL | Poland | | | |
| PT | Portugal | 2000-2016 | | |
| RO | Romania | 1995-2016 | 1995-2016 | 1995-2016 |
| SE | Sweden | 1995-2016 | 1995-2016 | 1995-2016** |
| SI | Slovenia | 2000-2017 | 2000-2017 | |
| SK | Slovak Rep. | 2000-2017 | 2000-2017 | 2000-2017 |
| UK | United Kingdom | | | |
| JP | Japan | 1995-2015 | 1995-2015 | 1995-2015 |
| US | United States | 1970-2017 | 1970-2017 | 1970-2017**** |

Note: *C20, C21, C26, C27, D, E, R and S n.a.; * C20, C21, H52, H53 n.a.; *** various asset types missing; **** C15, C21, C33, G45, J61 n.a.; T and U are not included.
Source: EU KLEMS Release 2019.

[28] This is also the case for Germany in which case however country-specific information was used to split it out.

### 3.4.4. Capital accounts in the statistical database

Table 11 and Table 12 list the variables provided; these include data in current and previous year prices, chain-linked volumes and the price index (for gross fixed capital formation) for the ten individual asset types.

**Table 11 / Capital stock variables**

| Variables | |
|---|---|
| **Capital stock net, curr.replac.costs, NAC mn** | |
| K_IT | Computing equipment |
| K_CT | Communications equipment |
| K_Soft_DB | Computer software and databases |
| K_TraEq | Transport Equipment |
| K_OMach | Other Machinery and Equipment |
| K_OCon | Total Non-residential investment |
| K_RStruc | Residential structures |
| K_Cult | Cultivated assets |
| K_RD | Research and development |
| K_OIPP | Other IPP assets |
| K_GFCF | All assets |
| **Capital stock net, prev.year replac.costs, NAC mn** | |
| Kpyp_IT | Computing equipment |
| Kpyp_CT | Communications equipment |
| Kpyp_Soft_DB | Computer software and databases |
| Kpyp_TraEq | Transport Equipment |
| Kpyp_OMach | Other Machinery and Equipment |
| Kpyp_OCon | Total Non-residential investment |
| Kpyp_RStruc | Residential structures |
| Kpyp_Cult | Cultivated assets |
| Kpyp_RD | Research and development |
| Kpyp_OIPP | Other IPP assets |
| Kpyp_GFCF | All assets |
| **Capital stock net, volume 2010 ref.prices, NAC mn** | |
| Kq_IT | Computing equipment |
| Kq_CT | Communications equipment |
| Kq_Soft_DB | Computer software and databases |
| Kq_TraEq | Transport Equipment |
| Kq_OMach | Other Machinery and Equipment |
| Kq_OCon | Total Non-residential investment |
| Kq_RStruc | Residential structures |
| Kq_Cult | Cultivated assets |
| Kq_RD | Research and development |
| Kq_OIPP | Other IPP assets |
| Kq_GFCF | All assets |

*Source*: own assessment.

**Table 12 / Gross fixed capital formation variables**

| Variables | |
|---|---|
| **GFCF, current prices, NAC mn** | |
| I_IT | Computing equipment |
| I_CT | Communications equipment |
| I_Soft_DB | Computer software and databases |
| I_TraEq | Transport Equipment |
| I_OMach | Other Machinery and Equipment |
| I_OCon | Total Non-residential investment |
| I_RStruc | Residential structures |
| I_Cult | Cultivated assets |
| I_RD | Research and development |
| I_OIPP | Other IPP assets |
| I_GFCF | All assets |
| **GFCF, prev.year prices, NAC mn** | |
| Ipyp_IT | Computing equipment |
| Ipyp_CT | Communications equipment |
| Ipyp_Soft_DB | Computer software and databases |
| Ipyp_TraEq | Transport Equipment |
| Ipyp_OMach | Other Machinery and Equipment |
| Ipyp_OCon | Total Non-residential investment |
| Ipyp_RStruc | Residential structures |
| Ipyp_Cult | Cultivated assets |
| Ipyp_RD | Research and development |
| Ipyp_OIPP | Other IPP assets |
| Ipyp_GFCF | All assets |
| **GFCF, volume 2010 ref.prices, NAC mn** | |
| Ig_IT | Computing equipment |
| Ig_CT | Communications equipment |
| Ig_Soft_DB | Computer software and databases |
| Ig_TraEq | Transport Equipment |
| Ig_OMach | Other Machinery and Equipment |
| Ig_OCon | Total Non-residential investment |
| Ig_RStruc | Residential structures |
| Ig_Cult | Cultivated assets |
| Ig_RD | Research and development |
| Ig_OIPP | Other IPP assets |
| Ig_GFCF | All assets |
| **GFCF, price indices, 2010=100** | |
| Ip_IT | Computing equipment |
| Ip_CT | Communications equipment |
| Ip_Soft_DB | Computer software and databases |
| Ip_TraEq | Transport Equipment |
| Ip_OMach | Other Machinery and Equipment |
| Ip_OCon | Total Non-residential investment |
| Ip_RStruc | Residential structures |
| Ip_Cult | Cultivated assets |
| Ip_RD | Research and development |
| Ip_OIPP | Other IPP assets |
| Ip_GFCF | All assets |

*Source*: own assessment.

## 3.5. GROWTH ACCOUNTS IN THE STATISTICAL DATABASE

The growth accounts can be calculated based on these data as outlined in Section 2. Three sets of growth accounts are provided: value added growth, labour productivity per hour worked growth and labour productivity per employed person growth. The respective variables provided in the statistical database are listed in Table 13.

**Table 13 / Variables in growth accounts**

| Variables | |
|---|---|
| **Labour and capital services growth** | |
| LAB | Labour compensation, NAC mn |
| CAP | Capital compensation, NAC mn |
| LAB_QI | Labour services, volume indices, 2010=100 |
| CAP_QI | Capital services, volume indices, 2010=100 |
| CAPIT_QI | ICT capital services, volume indices, 2010=100 |
| CAPNIT_QI | Non-ICT capital services, volume indices, 2010=100 |
| CAPTang_QI | Tangible capital services, volume indices, 2010=100 |
| CAPIntang_QI | Intangible capital services, volume indices, 2010=100 |
| **Contributions to value added growth** | |
| VA_G | Growth rate of value added volume, %, log |
| VAConH | Hours worked, p.p. |
| VAConLC | Labour composition change, p.p. |
| VAConTangNICT | Tangible non-ICT capital services, p.p. |
| VAConTangICT | Tangible ICT capital services, p.p. |
| VAConIntangSoftDB | Intangible Software and databases capital services, p.p. |
| VAConIntangRD | Intangible R&D capital services, p.p. |
| VAConIntangOIPP | Intangible other intellectual property products (OIPP) capital services, p.p. |
| VAConTFP | TFP, p.p. |
| VATFP_I | TFP index, 2010=100 |
| **Contributions to value added per hour worked growth** | |
| LP1_G | Growth rate of value added per hour worked, %, log |
| LP1ConLC | Labour composition change, p.p. |
| LP1ConTangNICT | Tangible non-ICT capital services, p.p. |
| LP1ConTangICT | Tangible ICT capital services, p.p. |
| LP1ConIntangSoftDB | Intangible Software and databases capital services, p.p. |
| LP1ConIntangRD | Intangible R&D capital services, p.p. |
| LP1ConIntangOIPP | Intangible other intellectual property products (OIPP) capital services, p.p. |
| LP1ConTFP | TFP, p.p. |
| LP1TFP_I | TFP index, 2010=100 |
| **Contributions to value added per person employed growth** | |
| LP2_G | Growth rate of value added per person employed, %, log |
| LP2ConLHE | Hours worked per person employed, p.p. |
| LP2ConLC | Labour composition change, p.p. |
| LP2ConTangNICT | Tangible non-ICT capital services, p.p. |
| LP2ConTangICT | Tangible ICT capital services, p.p. |
| LP2ConIntangSoftDB | Intangible Software and databases capital services, p.p. |
| LP2ConIntangRD | Intangible R&D capital services, p.p. |
| LP2ConIntangOIPP | Intangible other intellectual property products (OIPP) capital services, p.p. |
| LP2ConTFP | TFP, p.p. |
| LP2TFP_I | TFP index, 2010=100 |

*Source*: EU KLEMS Release 2019.

In each of these growth accounts the contribution of labour composition and hours worked (if applicable) are reported. In the case of labour productivity per person employed, the contribution of hours worked

per person employed is now reported separately.[29] Further, the contributions of the defined five groups of asset types are shown together with the contribution of TFP to growth and the TFP index is provided.

To complement the values for labour and capital compensation, and six volume indices are presented. The latter include the indices for labour and capital services, the latter differentiated by indices for capital services of tangible and intangible assets and ICT versus non-ICT capital services.

[29] This was included in TFP growth in the previous EU KLEMS versions.

# 4. Including supplementary intangible assets (the 'analytical database')

Based on the statistical database, an analytical database is provided that includes supplementary intangible assets (outside the boundaries of National Accounts).[30] In this section therefore the construction of these assets is documented.

## 4.1. INTANGIBLE ASSETS: AN OVERVIEW

The literature (e.g. Haskel and Westlake, 2018) defines three types of intangible assets:

› Computerised information (Soft_DB):

- Purchased and own-account software
- Databases

› Innovative property:

- R&D (RD)
- Mineral exploitation, and Artistic originals (OIPP)
- Design[31]

› Economic competencies:

- Advertising (brand) and market research
- Purchased and own account organisational capital
- Training.

As one can see, some of these items are already included in the National Accounts data and therefore captured in the statistical database in this EU KLEMS Release. These include computerised information which is captured by asset type software and databases (N1173), R&D (N1171) and mineral exploitation and artistic originals captured by the residual category OIPP (i.e. N117-N1173-N1171) in the statistical database. A second group comprises expenditures which are accounted for as intermediary products, i.e. design, advertising, marketing research and purchased organisational capital. Information on these expenditures is available in the supply and use tables (or input-output tables) and is constructed using such data. A third group of intangible assets is more challenging with respect to data and mostly relies on information from various surveys which are combined with National Accounts data. The construction of these assets is discussed in more detail in the following section.

[30] It should be emphasised that in an older version of the EU KLEMS database, the 'analytical' database was based on capital stocks constructed using the perpetual inventory method (PIM). However, as most countries already provide data on stocks, the main aim of the 'analytical' database in the EU KLEMS Release 2019 is therefore to include intangible assets outside the boundaries of national accounts.

[31] Further financial innovation is mentioned in the literature, which is not considered here.

## 4.2. CONSTRUCTION OF SUPPLEMENTARY INTANGIBLE ASSETS

As outlined above, one distinguishes between 'purchased intangible assets' and 'own account intangible assets' with respect to the underlying data and construction issues. The construction of these asset types requires a number of steps and inputs which will be described below. It should be emphasised that this approach draws heavily on the efforts in the seminal research documented in Corrado et al (2005, 2009, 2017, 2018) and, to a large extent, relies on the assumptions recommended there. The approach for constructing these data applied in this project are less sophisticated than in this literature in some cases in order to assure a broader coverage across countries and industries.[32] In part, the approach applied here therefore might be a slightly more 'conservative' one than that in the existing literature and data.[33]

### 4.2.1. Purchased intangible assets

This first group of asset types is constructed by using information on expenditures on intermediary inputs taken from supply and use tables which are capitalised (assuming that investment in such items has longer-term impacts). These supplementary assets, which can be constructed based on information from supply and use tables, include design, advertising and market research and purchased organisational capital. For the construction of these, one has first to select the relevant expenditure items of intermediary inputs (i.e. the relevant CPA codes), second, to define a capitalisation factor indicating the share of these expenditures which are capitalised, third, to assume a proper deflator for these investments, and fourth, to assume a depreciation rate to construct capital stocks. Following the existing literature (Corrado et al., 2016 and 2018), data and assumptions for the construction of these items are provided in Table 14.[34]

**Table 14 / Assumptions underlying the construction of purchased intangible assets**

| Intangible asset | Intermediary product (CPA) | Deflator (NACE) | Capitalisation factor | Depreciation rate |
|---|---|---|---|---|
| Design | M71 | M71 | 0.5 | 0.20 |
| Advertising and market research | M73 | M73 | 0.6 | 0.55 |
| Purchased organisational capital | M69_M70 | M69_M70 | 0.8 | 0.40 |

*Source:* Corrado, C. et al. (2016); http://www.intaninvest.net/; own elaborations.

To get a decent time series, the supply and use tables existing for European countries were updated and aligned with the most recent National Accounts data using the SUT-RAS procedure developed in Temurshoev and Timmer (2011) for the period 1995-2017.[35] (One should be aware that in Corrado et al. (2016, 2018) and the corresponding INTAN-INVEST data, a different procedure was applied).

[32] See http://www.intaninvest.net

[33] Therefore a strict comparison of the results requires a careful assessment of assumptions and methodologies concerning data construction which will be a worthwhile and fruitful undertaking in future research.

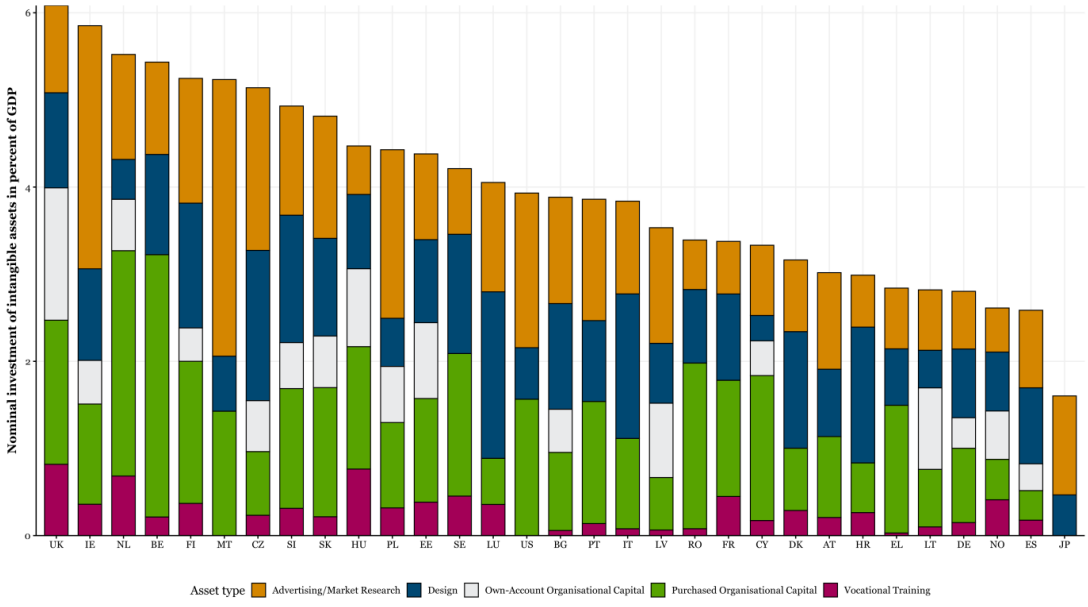
[34] In Corrado et al. (2016, 2018) and the intangible data provided at http://www.intaninvest.net/ a more sophisticated approach was undertaken by also including information from SBS data (M741) in design activities. For the broad set of countries and industries covered here, such information is not in all cases available (or reliable) and is therefore not included here.

[35] This procedure has also been used in the construction of the world input-output database (WIOD); see www.wiod.org.

### 4.2.2. Own account intangible assets

The remaining supplementary asset types, including own-account organisational capital and training, are captured in the following way. First, vocational training was proxied by using information from the EU labour costs survey (EU LCS) which provides data for the years 2000, 2004, 2008, 2012 and 2016 and comprises business industries only.[36] These data provide the share of vocational training in total labour costs.[37] A couple of data issues emerge of which the most important are: data before 2008 are according to NACE Revision 1 so there is no breakdown into 2-digit industries and not all countries provide data for all years. Therefore a rough correspondence between NACE Revision 1 and NACE Revision 2 was applied: expenditure shares for 2-digit industries were assumed to be the same as for the parent industry at the 1-digit level and the years between surveys were interpolated (the same shares as in 2000 were assumed before 2000 and no specific linear trends were imposed). Having constructed such a time series of shares on vocational training in total labour costs, these shares were applied to compensation which resulted in a time series of expenditures. The deflator assumed was the one from industry P (education) while the capitalisation factor applied was 1 and the depreciation rate was assumed to be 0.4 (both in accordance with the existing literature).

**Figure 4 / Gross fixed capital formation of supplementary intangible assets in % of GDP (current prices), average 1995-2017**




Source: EU KLEMS 2019; analytical database.

Finally, own-account organisational capital was constructed by using information from the EU Structure of Earnings Survey (EU SES), specifically the number of employees classified as managers (ISCO 08)

[36] Not included are agriculture (A) and public services (NACE industries O to Q) and other services (NACE industries R to U).

[37] Another potential source of information is the Continuing vocational training (CVT) survey which provides similar information on training activities financed by firms. This survey was conducted in 1995, 2005, 2010 and 2015 and poses similar challenges on coverage and data availability as the labour costs survey. A rough comparison suggests that the shares of expenditures spent on training in percent of labour costs (direct costs) are similar to those of the labour cost survey.

and their mean annual earnings (again according to NACE Rev. 1 and Rev. 2 1-digit industries). Having these data allows one to calculate the expenditures on managerial activities and capitalise them. For this item, the same deflator as for purchased organisational capital (i.e. industry M69_M70) was applied; the capitalisation factor assumed is 0.1 and the depreciation rate 0.4 (again both in accordance with the literature). However, as data coverage across countries is rather patchy, these data are provided in the EU KLEMS Release but not further used in the growth accounting exercise including these supplementary assets (to assure a better comparability across countries).

Based on these results, Figure 4 presents the share of these expenditures on this supplementary gross fixed capital formation in percent of GDP. As one can see, this ranges between 2 and 6%. It also shows that data on own account organisational capital are available for a few countries only; further data on vocational training for the US and Japan are not included.

### 4.2.3. Supplementary intangibles in the analytical database

The information collected on these supplementary intangibles and provided in the analytical database is listed in Table 15. Analogous to the other capital accounts, these include the constructed series of gross fixed capital formation in current and previous year prices from which chain linked volumes and the price index are calculated.

**Table 15 / Supplementary intangibles – gross fixed capital formation**

| Variables | |
|---|---|
| **GFCF, current prices, NAC mn** | |
| *I_AdvMRes* | Advertising, market research and branding |
| *I_Design* | Design and other product developments |
| *I_POCap* | Purchased organisational capital |
| *I_VT* | Vocational training |
| *I_OOCap* | Own-account organisational capital |
| **GFCF, prev.year prices, NAC mn** | |
| *Ipyp_AdvMRes* | Advertising, market research and branding |
| *Ipyp_Design* | Design and other product developments |
| *Ipyp_POCap* | Purchased organisational capital |
| *Ipyp_VT* | Vocational training |
| *Ipyp_OOCap* | Own-account organisational capital |
| **GFCF, volume 2010 ref.prices, NAC mn** | |
| *Iq_AdvMRes* | Advertising, market research and branding |
| *Iq_Design* | Design and other product developments |
| *Iq_POCap* | Purchased organisational capital |
| *Iq_VT* | Vocational training |
| *Iq_OOCap* | Own-account organisational capital |
| **GFCF, price indices, 2010=100** | |
| *Ip_AdvMRes* | Advertising, market research and branding |
| *Ip_Design* | Design and other product developments |
| *Ip_POCap* | Purchased organisational capital |
| *Ip_VT* | Vocational training |
| *Ip_OOCap* | Own-account organisational capital |

*Source*: EU KLEMS Release 2019, analytical database.

Concerning capital stocks, these are again provided in current and previous year prices (calculated from the respective investment series) from which chain-linked volumes are calculated.

**Table 16 / Supplementary intangibles – capital stocks**

| Variables | |
|---|---|
| **Capital stock net, curr.replac.costs, NAC mn** | |
| *K_AdvMRes* | Advertising, market research and branding |
| *K_Design* | Design and other product developments |
| *K_POCap* | Purchased organisational capital |
| *K_VT* | Vocational training |
| *K_OOCap* | Own-account organisational capital |
| **Capital stock net, prev.year replac.costs, NAC mn** | |
| *Kpyp_AdvMRes* | Advertising, market research and branding |
| *Kpyp_Design* | Design and other product developments |
| *Kpyp_POCap* | Purchased organisational capital |
| *Kpyp_VT* | Vocational training |
| *Kpyp_OOCap* | Own-account organisational capital |
| **Capital stock net, volume 2010 ref.prices, NAC mn** | |
| *Kq_AdvMRes* | Advertising, market research and branding |
| *Kq_Design* | Design and other product developments |
| *Kq_POCap* | Purchased organisational capital |
| *Kq_VT* | Vocational training |
| *Kq_OOCap* | Own-account organisational capital |

*Source*: EU KLEMS Release 2019, analytical database.

## 4.3. GROWTH ACCOUNTING INCLUDING SUPPLEMENTARY INTANGIBLE ASSETS

Having constructed investment flows and stocks of these supplementary assets, one can include them into the growth accounting framework which is briefly discussed in this section. Note that this does not impose fundamental changes in the underlying equations discussed in Section 2 and therefore only a non-technical description is provided.

### 4.3.1. Intangible assets already included in the National Accounts

National Accounts Intangible Assets are capital asset types which are already available in the National Accounts capital data, for example R&D investments and capital stocks. Therefore, in this case, just a more detailed disaggregation of asset types considered in the growth accounting framework is needed. The classification of asset types in the EU KLEMS 2019 Release was discussed in Section 3 and is implemented in the 'statistical database'.

### 4.3.2. Intangible assets – purchased components

The second kind of intangible assets are purchased components, i.e. products which are now accounted for as intermediates but which should be capitalised (similarly to R&D in the new SNA/ESA). Such information can be taken from input-output tables (or use tables) and requires defining products (CPA

classification) which are characterised as 'intangible assets – purchased components' (these include e.g. marketing, design, brand and purchased organisational capital).

The construction follows several steps after having defined these products. First, the purchases of such products (i.e. the intermediary inputs) are defined as being 'gross intangible capital formation' which are available at current prices. One can transform them into chain-linked volumes by applying proper price deflators for these products (e.g. from the corresponding industries). The next step is then to apply the PIM method (using pre-specified deflation rates) and construct nominal and real capital stocks. These additional asset types are then included to recalculate nominal returns and user costs as for national accounts asset types.

As these products are no longer accounted for as intermediates, the (current and previous-year-price) values have to be added to the value added figures for each industry, thus resulting in revised (nominal and previous-year-price) value added figures $\overline{V}_j$. The chain-linked volumes can be calculated from these new figures. Having arrived at this stage, growth accounting proceeds as outlined above.

### 4.3.3. Intangible assets – own account components

The third kind of intangible assets are the own-account components (e.g. in-house organisational capital). By definition, that should already be part of value added (e.g. salaries to these managers) and thus part of labour income. Thus, creating figures for gross fixed capital formation and stocks for these asset types might not change the value added figures.[38] Having capitalised these costs, the resulting asset types can be taken into account in the growth accounting framework analogously to above.[39]

### 4.3.4. Growth accounts including the supplementary intangible assets

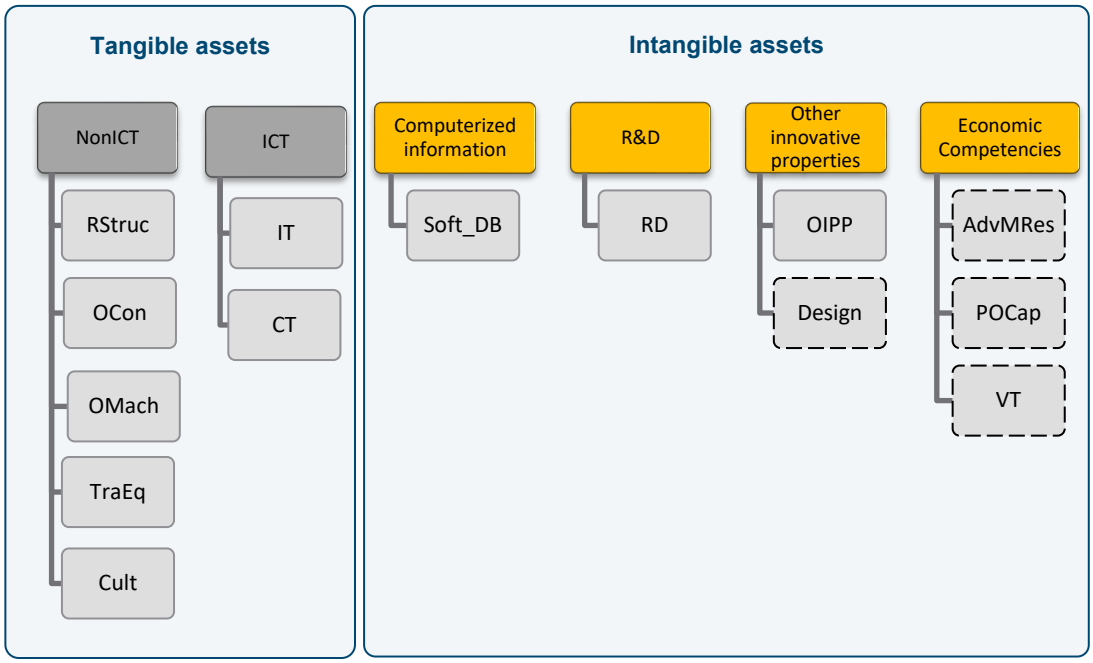
These supplementary intangible assets were included in the growth accounts and the results presented in the following way as outlined in Figure 5. The design activities asset group, which is interpreted as innovative activity, is lumped together with the already included asset, other intellectual property products, constituting the intangible group of other innovative properties in the analytical database. Further, an additional asset group was added comprising 'economic competencies' which includes advertising and market research (AdvMRes), purchased organisational capital (POCap) and vocational training (VT).[40]

[38] A second possibility is to argue that these components are in-house deliveries which are thus – in the input-output or supply-use framework – part of the 'diagonal cells'. In such a case these costs are to be shifted from the diagonal cells to value added similar to the purchased components.

[39] A further assumption is that the share of labour and capital income is not changed by including these additional asset types.

[40] As mentioned above, own account organisational capital has not been included due to lack of decent coverage.

**Figure 5 / Aggregates of capital services including tangible and intangible assets**




Note: Dashed lines indicate asset types outside the boundaries of National Accounts.
Source: own elaboration based on Haskel and Westlake (2018).

According to this definition of broad asset types, the following variables are provided in the growth accounts in the 'analytical database' and listed in Table 17.

Compared to the statistical database, the growth contributions of 'Intangible economic competences capital services' is therefore also reported; further, the group 'Intangible other innovative property capital services' now includes design activities. The other reported contributions are comprised of the same asset types as in the statistical database. However, contributions of these are (slightly) different because value added growth and labour productivity growth rates and the underlying shares (calculated from the user costs of capital) had to be recalculated. For these reasons, the volume indices concerning capital services and TFP contributions might also differ. The volume index for intangible capital services now also includes the supplementary intangible asset types (i.e. design, advertising and market research, purchased organisational capital and vocational training).

**Table 17 / Growth accounting variables in the analytical database of the EU KLEMS Release 2019**

| Variables | |
|---|---|
| **Labour and capital services growth** | |
| *LAB* | Labour compensation, NAC mn |
| *CAP* | Capital compensation, NAC mn |
| *LAB_QI* | Labour services, volume indices, 2010=100 |
| *CAP_QI* | Capital services, volume indices, 2010=100 |
| *CAPIT_QI* | ICT capital services, volume indices, 2010=100 |
| *CAPNIT_QI* | Non-ICT capital services, volume indices, 2010=100 |
| *CAPTang_QI* | Tangible capital services, volume indices, 2010=100 |
| *CAPIntang_QI* | Intangible capital services, volume indices, 2010=100 |
| **Contributions to value added growth** | |
| *VA_G* | Growth rate of value added volume, %, log |
| *VAConH* | Hours worked, p.p. |
| *VAConLC* | Labour composition change, p.p. |
| *VAConTangNICT* | Tangible non-ICT capital services, p.p. |
| *VAConTangICT* | Tangible ICT capital services, p.p. |
| *VAConIntangSoftDB* | Intangible Software and databases capital services, p.p. |
| *VAConIntangRD* | Intangible R&D capital services, p.p. |
| *VAConIntangOInnProp* | Intangible other innovative property capital services, p.p. |
| *VAConIntangEconComp* | Intangible economic competences capital services, p.p. |
| *VAConTFP* | TFP, p.p. |
| *VATFP_I* | TFP index, 2010=100 |
| **Contributions to value added per hour worked growth** | |
| *LP1_G* | Growth rate of value added per hour worked, %, log |
| *LP1ConLC* | Labour composition change, p.p. |
| *LP1ConTangNICT* | Tangible non-ICT capital services, p.p. |
| *LP1ConTangICT* | Tangible ICT capital services, p.p. |
| *LP1ConIntangSoftDB* | Intangible Software and databases capital services, p.p. |
| *LP1ConIntangRD* | Intangible R&D capital services, p.p. |
| *LP1ConIntangOInnProp* | Intangible other innovative property capital services, p.p. |
| *LP1ConIntangEconComp* | Intangible economic competences capital services, p.p. |
| *LP1ConTFP* | TFP, p.p. |
| *LP1TFP_I* | TFP index, 2010=100 |
| **Contributions to value added per person employed growth** | |
| *LP2_G* | Growth rate of value added per person employed, %, log |
| *LP2ConLHE* | Hours worked per person employed, p.p. |
| *LP2ConLC* | Labour composition change, p.p. |
| *LP2ConTangNICT* | Tangible non-ICT capital services, p.p. |
| *LP2ConTangICT* | Tangible ICT capital services, p.p. |
| *LP2ConIntangSoftDB* | Intangible Software and databases capital services, p.p. |
| *LP2ConIntangRD* | Intangible R&D capital services, p.p. |
| *LP2ConIntangOInnProp* | Intangible other innovative property capital services, p.p. |
| *LP2ConIntangEconComp* | Intangible economic competences capital services, p.p. |
| *LP2ConTFP* | TFP, p.p. |
| *LP2TFP_I* | TFP index, 2010=100 |

*Source*: EU KLEMS Release 2019, analytical database.

# 5. Summary

This report provides an overview of methods and data challenges related to the EU KLEMS Release 2019 database. First, it outlined the changes in the industry classification and some improvements concerning methodological aspects (making use of the availability of more and better data). Second, the ways intangible assets are considered in the growth accounting framework are discussed and we show how these are implemented in it. In particular, this concerns the inclusion of intangible assets outside the boundaries of National Accounts which poses major challenges from conceptual, methodological and data points of view. Nonetheless, the data collected in this project and made available at euklems.eu should provide further insights in measuring the importance of intangible assets in conjunction with other assets such as information and communication technologies (ICT) and other intangibles.

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# Appendix

## Appendix Table A.1/ Industry correspondence

| EU KLEMS 2019 | EU KLEMS 2017 industries | |
|---|---|---|
| TOT | TOT | TOTAL INDUSTRIES |
| TOT_IND | TOT | TOTAL INDUSTRIES |
| MARKT | MARKT | MARKET ECONOMY |
| A | A | AGRICULTURE, FORESTRY AND FISHING |
| B | B | MINING AND QUARRYING |
| C | C | TOTAL MANUFACTURING |
| …10-12 | 10-12 | Food products, beverages and tobacco |
| …13-15 | 13-15 | Textiles, wearing apparel, leather and related prodcuts |
| …16-18 | 16-18 | Wood and paper products; printing and reproduction of recorded media |
| …19 | 19 | Coke and refined petroleum products |
| …20 | 20-21 | Chemicals and chemical products |
| …21 | 20-21 | Chemicals and chemical products |
| …22-23 | 22-23 | Rubber and plastics products, and other non-metallic mineral products |
| …24-25 | 24-25 | Basic metals and fabricated metal products, except machinery and equipment |
| …26 | 26-27 | Electrical and optical equipment |
| …27 | 26-27 | Electrical and optical equipment |
| …28 | 28 | Machinery and equipment n.e.c. |
| …29-30 | 29-30 | Transport equipment |
| …31-33 | 31-33 | Other manufacturing; repair and installation of machinery and equipment |
| D | D-E | ELECTRICITY, GAS AND WATER SUPPLY |
| E | D-E | ELECTRICITY, GAS AND WATER SUPPLY |
| F | F | CONSTRUCTION |
| G | G | WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES |
| …45 | 45 | Wholesale and retail trade and repair of motor vehicles and motorcycles |
| …46 | 46 | Wholesale trade, except of motor vehicles and motorcycles |
| …47 | 47 | Retail trade, except of motor vehicles and motorcycles |
| H | H | TRANSPORTATION AND STORAGE |
| …49 | 49-52 | Transport and storage |
| …50 | 49-52 | Transport and storage |
| …51 | 49-52 | Transport and storage |
| …52 | 49-52 | Transport and storage |
| …53 | 53 | Postal and courier activities |
| I | I | ACCOMMODATION AND FOOD SERVICE ACTIVITIES |
| J | J | INFORMATION AND COMMUNICATION |
| …58-60 | 58-60 | Publishing, audiovisual and broadcasting activities |
| …61 | 61 | Telecommunications |
| …62-63 | 62-63 | IT and other information services |
| K | K | FINANCIAL AND INSURANCE ACTIVITIES |
| L | L | REAL ESTATE ACTIVITIES |
| M-N | M-N | PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE & SUPPORT SERVICE ACTIVITIES |
| O-Q | O-U | COMMUNITY SOCIAL AND PERSONAL SERVICES |
| O | O | Public administration and defence; compulsory social security |
| P | P | Education |
| Q | Q | Health and social work |
| R-S | R-S | ARTS, ENTERTAINMENT, RECREATION AND OTHER SERVICE ACTIVITIES |
| R | R | Arts, entertainment and recreation |
| S | S | Other service activities |
| T | T | Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use |
| U | U | Activities of extraterritorial organizations and bodies |

*Note:* For description of EU KLEMS Release 2019 industries see Table 1.
*Source*: EU KLEMS Release 2017; own assessment.

## Appendix Table A.2 / Depreciation rates

| Sort_ID | indnr | code | IT | CT | Soft_DB | TraEq | OMach | OCon | RStruc | OIPP | Cult | RD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Agg | TOT | 0.315 | 0.115 | 0.315 | 0.189 | 0.131 | 0.032 | 0.011 | 0.131 | 0.200 | 0.200 |
| 2 | *Agg | TOT_IND | 0.315 | 0.115 | 0.315 | 0.191 | 0.129 | 0.031 | 0.011 | 0.129 | 0.201 | 0.200 |
| 3 | *Agg | MARKT | 0.315 | 0.115 | 0.315 | 0.185 | 0.126 | 0.034 | 0.011 | 0.126 | 0.193 | 0.200 |
| 4 | 1 | A | 0.315 | 0.115 | 0.315 | 0.170 | 0.129 | 0.024 | 0.011 | 0.129 | 0.151 | 0.200 |
| 5 | 2 | B | 0.315 | 0.115 | 0.315 | 0.170 | 0.129 | 0.024 | 0.011 | 0.129 | 0.207 | 0.200 |
| 6 | Agg | C | 0.315 | 0.115 | 0.315 | 0.174 | 0.108 | 0.033 | 0.011 | 0.108 | 0.207 | 0.200 |
| 7 | 3 | …10-12 | 0.315 | 0.115 | 0.315 | 0.168 | 0.109 | 0.033 | 0.011 | 0.109 | 0.207 | 0.200 |
| 8 | 4 | …13-15 | 0.315 | 0.115 | 0.315 | 0.184 | 0.109 | 0.033 | 0.011 | 0.109 | 0.207 | 0.200 |
| 9 | 5 | …16-18 | 0.315 | 0.115 | 0.315 | 0.173 | 0.106 | 0.033 | 0.011 | 0.106 | 0.207 | 0.200 |
| 10 | 6 | …19 | 0.315 | 0.115 | 0.315 | 0.154 | 0.110 | 0.032 | 0.011 | 0.110 | 0.207 | 0.200 |
| 11 | 7 | …20 | 0.315 | 0.115 | 0.315 | 0.181 | 0.104 | 0.033 | 0.011 | 0.104 | 0.207 | 0.200 |
| 12 | 8 | …21 | 0.315 | 0.115 | 0.315 | 0.181 | 0.104 | 0.033 | 0.011 | 0.104 | 0.207 | 0.200 |
| 13 | 9 | …22-23 | 0.315 | 0.115 | 0.315 | 0.191 | 0.112 | 0.033 | 0.011 | 0.112 | 0.207 | 0.200 |
| 14 | 10 | …24-25 | 0.315 | 0.115 | 0.315 | 0.166 | 0.108 | 0.033 | 0.011 | 0.108 | 0.207 | 0.200 |
| 15 | 11 | …26 | 0.315 | 0.115 | 0.315 | 0.166 | 0.108 | 0.033 | 0.011 | 0.108 | 0.207 | 0.200 |
| 16 | 12 | …27 | 0.315 | 0.115 | 0.315 | 0.166 | 0.108 | 0.033 | 0.011 | 0.108 | 0.207 | 0.200 |
| 17 | 13 | …28 | 0.315 | 0.115 | 0.315 | 0.170 | 0.107 | 0.033 | 0.011 | 0.107 | 0.207 | 0.200 |
| 18 | 14 | …29-30 | 0.315 | 0.115 | 0.315 | 0.167 | 0.109 | 0.033 | 0.011 | 0.109 | 0.207 | 0.200 |
| 19 | 15 | …31-33 | 0.315 | 0.115 | 0.315 | 0.193 | 0.113 | 0.033 | 0.011 | 0.113 | 0.207 | 0.200 |
| 20 | 16 | D | 0.315 | 0.115 | 0.315 | 0.191 | 0.094 | 0.023 | 0.011 | 0.094 | 0.207 | 0.200 |
| 21 | 17 | E | 0.315 | 0.115 | 0.315 | 0.191 | 0.094 | 0.023 | 0.011 | 0.094 | 0.207 | 0.200 |
| 22 | 18 | F | 0.315 | 0.115 | 0.315 | 0.195 | 0.139 | 0.034 | 0.011 | 0.139 | 0.195 | 0.200 |
| 23 | Agg | G | 0.315 | 0.115 | 0.315 | 0.216 | 0.134 | 0.030 | 0.011 | 0.134 | 0.188 | 0.200 |
| 24 | 19 | …45 | 0.315 | 0.115 | 0.315 | 0.229 | 0.121 | 0.031 | 0.011 | 0.121 | 0.188 | 0.200 |
| 25 | 20 | …46 | 0.315 | 0.115 | 0.315 | 0.204 | 0.143 | 0.031 | 0.011 | 0.143 | 0.188 | 0.200 |
| 26 | 21 | …47 | 0.315 | 0.115 | 0.315 | 0.215 | 0.137 | 0.027 | 0.011 | 0.137 | 0.188 | 0.200 |
| 27 | Agg | H | 0.315 | 0.115 | 0.315 | 0.114 | 0.114 | 0.028 | 0.011 | 0.114 | 0.188 | 0.200 |
| 28 | 22 | …49 | 0.315 | 0.115 | 0.315 | 0.092 | 0.118 | 0.028 | 0.011 | 0.118 | 0.188 | 0.200 |
| 29 | 23 | …50 | 0.315 | 0.115 | 0.315 | 0.092 | 0.118 | 0.028 | 0.011 | 0.118 | 0.188 | 0.200 |
| 30 | 24 | …51 | 0.315 | 0.115 | 0.315 | 0.092 | 0.118 | 0.028 | 0.011 | 0.118 | 0.188 | 0.200 |
| 31 | 25 | …52 | 0.315 | 0.115 | 0.315 | 0.092 | 0.118 | 0.028 | 0.011 | 0.118 | 0.188 | 0.200 |
| 32 | 26 | …53 | 0.315 | 0.115 | 0.315 | 0.201 | 0.096 | 0.027 | 0.011 | 0.096 | 0.188 | 0.200 |
| 33 | 27 | I | 0.315 | 0.115 | 0.315 | 0.203 | 0.140 | 0.028 | 0.011 | 0.140 | 0.188 | 0.200 |
| 34 | Agg | J | 0.315 | 0.115 | 0.315 | 0.176 | 0.115 | 0.035 | 0.011 | 0.115 | 0.214 | 0.200 |
| 35 | 28 | …58-60 | 0.315 | 0.115 | 0.315 | 0.173 | 0.106 | 0.033 | 0.011 | 0.106 | 0.214 | 0.200 |
| 36 | 29 | …61 | 0.315 | 0.115 | 0.315 | 0.201 | 0.096 | 0.027 | 0.011 | 0.096 | 0.214 | 0.200 |
| 37 | 30 | …62-63 | 0.315 | 0.115 | 0.315 | 0.155 | 0.144 | 0.044 | 0.011 | 0.144 | 0.214 | 0.200 |
| 38 | 31 | K | 0.315 | 0.115 | 0.315 | 0.187 | 0.149 | 0.044 | 0.011 | 0.149 | 0.160 | 0.200 |
| 39 | 32 | L | 0.315 | 0.115 | 0.315 | 0.227 | 0.147 | 0.027 | 0.011 | 0.147 | 0.218 | 0.200 |
| 40 | 33 | M-N | 0.315 | 0.115 | 0.315 | 0.155 | 0.144 | 0.044 | 0.011 | 0.144 | 0.215 | 0.200 |
| 41 | Agg | O-Q | 0.315 | 0.115 | 0.315 | 0.202 | 0.140 | 0.035 | 0.011 | 0.140 | 0.207 | 0.200 |
| 42 | 34 | O | 0.315 | 0.115 | 0.315 | 0.173 | 0.138 | 0.025 | 0.011 | 0.138 | 0.235 | 0.200 |
| 43 | 35 | P | 0.315 | 0.115 | 0.315 | 0.173 | 0.138 | 0.025 | 0.011 | 0.138 | 0.235 | 0.200 |
| 44 | 36 | Q | 0.315 | 0.115 | 0.315 | 0.225 | 0.149 | 0.027 | 0.011 | 0.149 | 0.235 | 0.200 |
| 45 | *Agg | R-S | 0.315 | 0.115 | 0.315 | 0.223 | 0.136 | 0.051 | 0.011 | 0.136 | 0.186 | 0.200 |
| 46 | 37 | R | 0.315 | 0.115 | 0.315 | 0.223 | 0.136 | 0.051 | 0.011 | 0.136 | 0.186 | 0.200 |
| 47 | 38 | S | 0.315 | 0.115 | 0.315 | 0.223 | 0.136 | 0.051 | 0.011 | 0.136 | 0.186 | 0.200 |
| 48 | 39 | T | 0.315 | 0.115 | 0.315 | 0.198 | 0.140 | 0.032 | 0.011 | 0.140 | 0.186 | 0.200 |
| 49 | 40 | U | 0.315 | 0.115 | 0.315 | 0.198 | 0.140 | 0.032 | 0.011 | 0.140 | 0.186 | 0.200 |

*Source*: EU KLEMS, own assessment.

## Appendix Table A.3 / Data coverage for gross fixed capital formation

| Gross fixed capital formation | | Total economy | 1-digit level | 2-digit level |
|---|---|---|---|---|
| AT | Austria | | | |
| BE | Belgium* | | | . |
| BG | Bulgaria | | | |
| CY | Cyprus** | 1995-2009 | | |
| CZ | Czech Rep. | | | |
| DE | Germany | | | |
| DK | Denmark | | | |
| EE | Estonia | 1995-2016 | 1995-2016 | |
| EL | Greece | | various asset types n.a | various asset types n.a |
| ES | Spain* | 1995-2016 | 1995-2016; D, E n.a. | 1995-2016; G, H n.a. |
| FI | Finland | | | |
| FR | France | | | G, H n.a. |
| HR | Croatia | | | |
| HU | Hungary | IT, CT incl. in OMach | IT, CT incl. in OMach | IT, CT incl in OMach |
| IE | Ireland | 1995-2016 | various asset types n.a. | various asset types n.a. |
| IT | Italy | | | G, H est. |
| LT | Lithuania | | | |
| LU | Luxembourg | | | various industries n.a. |
| LV | Latvia | | | |
| MT | Malta | | | |
| NL | Netherlands | | | G,H n.a. |
| PL | Poland | | | |
| PT | Portugal | 1995-2016 | various asset types n.a. | various asset types n.a. |
| RO | Romania | 1995-2016 | 2010-2016 | 2010-2016 |
| SE | Sweden | 1995-2016 | 1995-2016 | 1995-2016 |
| SI | Slovenia | 2000-2017 | 2000-2017 | |
| SK | Slovak Rep. | 2000-2017 | 2000-2017 | 2000-2017 |
| UK | United Kingdom | | | |
| | | | | |
| JP | Japan* | 1995-2015 | 1995-2015 | 1995-2015 |
| US | United States* | 1970-2017 | 1970-2017 | 1970-2017*** |

Note: * Data delivered from national sources; for BE data are not made publically available; for ES C20,C21, C26, C27 n.a. ***; C15, C21, C33, G45, J61 n.a.
*Source*: EU KLEMS Release 2019.

## Appendix Table A.4 / Data on capital stocks

| Capital stocks | | Total economy | 1-digit level | 2-digit level |
|---|---|---|---|---|
| AT | Austria | | | |
| BE | Belgium* | | | G, H n.a. |
| BG | Bulgaria | PIM | | |
| CY | Cyprus** | 1995-2009 | | |
| CZ | Czechia | | | |
| DE | Germany | | | |
| DK | Denmark | | | |
| EE | Estonia | 2000-2016 | 2000-2016 | |
| EL | Greece | 1995-2016 | 1995-2016 | 1995-2016 |
| ES | Spain* | 1995-2016 | 1995-2016 | 1995-2016; G, H n.a. |
| FI | Finland | | | |
| FR | France | | | G, H n.a. |
| HR | Croatia | | | |
| HU | Hungary | IT, CT incl. in OMach | IT, CT incl. in OMach | |
| IE | Ireland | 1995-2016 | various asset types n.a. | various asset types n.a. |
| IT | Italy | | | G, H est. |
| LT | Lithuania | | | |
| LU | Luxembourg | | | various industries n.a. |
| LV | Latvia | | PIM RD andOIPP | |
| MT | Malta | | | |
| NL | Netherlands | | | G, H n.a. |
| PL | Poland | | | |
| PT | Portugal | 2000-2016 | | |
| RO | Romania | PIM: 1995-2016 | PIM: 1995-2016 | PIM: 1995-2016 |
| SE | Sweden | 1995-2016 | 1995-2016 | 1995-2016. |
| SI | Slovenia | 2000-2017 | 2000-2017 | |
| SK | Slovak Rep. | 2000-2017 | 2000-2017 | 2000-2017 |
| UK | United Kingdom | | | |
| | | | | |
| JP | Japan | 1995-2015 | 1995-2015 | 1995-2015 |
| US | United States | 1970-2017 | 1970-2017 | 1970-2017**** |

Note: * Data delivered from national sources; for BE data are not made publically available; for ES C20,C21, C26, C27 n.a. ***; C15, C21, C33, G45, J61 n.a.
*Source*: EU KLEMS Release 2019.

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