OCTOBER 2019

Research Report 442

Tangible and Intangible Assets in the Growth Performance of the EU, Japan and the US

Amat Adarov and Robert Stehrer

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

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AMAT ADAROV
ROBERT STEHRER

Amat Adarov is Economist at The Vienna Institute for International Economic Studies (wiiw).
Robert Stehrer is Scientific Director at wiiw.

A comparative analysis based on the EU KLEMS Release 2019

The paper is written as part of the project 'Industry level growth and productivity data with special focus on intangible assets' under the Service Contract No. ECFIN-116-2018/SI2.784491 financed by the European Commission, DG ECFIN.

We would like to thank Dale Jorgenson, Ilya Voskoboynikov and participants of the Asian KLEMS conference (14-15 October 2019, Bejing) for useful comments.

Abstract

This paper presents results using the EU KLEMS 2019 Release focussing on the role of ICT and intangibles assets employing a growth accounting framework and an econometric analysis. The EU KLEMS 2019 data covers most EU Member States, the US and Japan, forty detailed industries according to NACE Rev. 2 (ISIC Rev. 4) along with nine aggregated industries and spans over the period 1995-2017. In particular, intangible assets outside the boundaries of the national accounts are taken into account. The data are used to study total factor productivity, labour and capital productivity developments in a comparative cross-country and cross-industry dimension with an emphasis on the role of capital investments. Inter alia, the analysis studies the implications of various asset types and particularly the role of ICT and intangible capital, as well as changes in labour services and the composition thereof, as drivers of value added and labour productivity growth. Significant differences in the underlying growth contributions between the pre-crisis and post-crisis periods in growth performances are highlighted.

Keywords: EU KLEMS, growth accounting, tangible and tangible assets, ICT and non-ICT capital, productivity and growth

JEL classification: C82, D24, O47

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1. Introduction

It is now commonly accepted that the financial crisis which hit the world economy in 2007 has resulted in a long-lasting drag concerning overall GDP and productivity growth rates in many countries – along with the adverse impact on global value chains, trade dynamics and a multitude of other economic effects. However, the factors contributing to this slowdown are still not fully understood with respect to the various drivers of value added and productivity growth, which constitute the main focus of this paper.[1] In the 1990s and early 2000s a number of studies emphasised the role of information and communication technologies (ICT) as drivers of productivity growth in addition to the more traditional ones like investment in tangible assets, upgrading of the composition of labour, research and development (R&D) and total factor productivity (TFP) growth. This has also been triggered by the development of databases (in the European context notably the EU KLEMS project[2] documented in Timmer et al., 2010) for growth and productivity accounts focussing on the role of ICT and non-ICT capital (for a recent analysis see Ark and Jäger, 2017).

Based on the seminal contributions by Corrado et al., 2005, 2009 and Nakamura, 1999, 2001, a related strand of the literature developed emphasising the role of intangible assets which are now, with the implementation of SNA 2008/ESA 2010, partly integrated in the boundaries of the national accounts (e.g. R&D, software and databases), and also include other assets which are still outside the boundaries of national accounts (e.g. design, brand, training, organisational efficiency).[3] In the European context databases this has been investigated in various projects summarised in Corrado et al. 2016, 2018.4 Haskel and Westlake (2018) provide an extensive summary of this strand of research.

This paper draws on the recently revised and updated EU KLEMS dataset — EU KLEMS Release 2019[5]. This newly developed dataset, in addition to assets captured already within the boundaries of national accounts (growth and productivity measures for these are provided in the ‘statistical module’ differentiating ten asset types aggregated to ICT and non-ICT capital services), also integrates measures for intangible assets outside these boundaries drawing on strategies and assumptions developed in the literature mentioned above. The EU KLEMS Release 2019 therefore further provides an ‘analytical module’, which, in addition to the ten asset types already identified in the previous EU KLEMS releases, also captures the role of intangibles outside the boundaries of the national accounts in

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1 Certainly, there is also a notable strand of the literature investigating the macroeconomic dimension and the role of fiscal and monetary policies during and after the crisis, which is however not the subject of this paper.

2 The initial project has been funded by the European Commission under the 6th framework project. Several updates have been undertaken since then (2012, 2016, 2017).

3 Boundaries refer to the items covered or not covered in national accounting.

4 This research and the datasets have been developed in projects (COINVEST and INNODRIVE9 funded by the European Commission under the 7th framework Programme. A related project focussing on the role of intangible assets in the public sector was SPINTAN also funded under the 7th framework project.

5 The update has been funded by the European Commission (DG ECFIN) under service contract ECFIN-116-2018/SI2.784491.

a growth and productivity accounting framework (for details see Stehrer et al. 2019).[6] Furthermore, the EU KLEMS Release 2019 includes a comparable set of indicators for Japan and the US.

This analytical module therefore allows one to investigate the drivers of growth considering various groups of asset types, differentiating between ICT and non-ICT capital services and tangible versus intangible capital services (the asset types are discussed in more detail in Section 2). Therefore, this provides deeper insights into the factors underlying the growth and productivity slowdown in the aftermath of the financial crisis in a comparative manner across countries (EU, Japan and the US) as well as industries.

Results of the growth accounting analysis are broadly in line with the literature. First, the general slowdown of value added and productivity growth after the financial crisis is well reported (with the only exception of Japan). Second, this was only partly due to a slowdown of total factor productivity (TFP) growth, as also contributions of other capital asset types diminished, particularly so of ICT and intangible assets like software and databases. Differently, the contributions to growth of intangibles outside the boundaries of national accounts (innovative properties, economic competencies) – in the way these are measureable - seem to have been more resilient to the crisis; therefore growth contributions of these are more stable. Consequently, there share in the overall growth performance of countries and industries has increased. However, with respect to levels, the contributions of the 'classical inputs' like TFP, labour and its composition, and tangible capital to both value added and productivity growth still account for the predominant sources of growth. Third, with respect to comparisons across countries reveals that the European growth performance has been much less driven by investments in tangible ICT assets (hardware for information and communication technologies) and intangible ICT assets (software and databases), as well as R&D (which a particularly strong difference in the manufacturing industry). However, contributions of these asset types have strongly declined in Japan and the US in recent years. Finally, the results document that the growth slowdown has been more pronounced in the goods producing industries, whereas services industries have been less affected by the crisis or even shows slightly better performance. However, this does not compensate to circumvent the overall growth and productivity slowdown.

Besides introducing the novel features of the new version of EU KLEMS and describing the composition and patterns of capital assets in relation to productivity and growth, the paper zooms in on the economic role of ICT capital and intangibles assets using a growth accounting framework and an econometric analysis at the aggregate country and sectoral levels. Based on the expanded sample of countries relative to the previous EU KLEMS vintages (concerning both the time and the country dimensions) and new differentiation between asset types in line with the literature on intangibles, also hitherto unavailable in internally consistent panel data setup, our analysis confirms the importance of ICT capital and intangibles concerning economic competencies (specifically, advertising and market research assets) as drivers of value added and labour productivity growth at an aggregate country level. The high relevance of economic competencies is also confirmed empirically for the post-crisis period. The analysis also confirms the conjecture of importance of R&D capital for growth and productivity in manufacturing sectors. In this regard, our results are helpful for informing policy discussions and, inter alia, provide empirical support for economic policies facilitating accumulation of intangible assets and ICT capital as integral elements of productivity and competitiveness. The latter is especially critical in light of the ever-

6 The EU KLEMS Release 2019 is available at www.euklems.eu.

changing nature of the world economy increasingly driven nowadays by technological progress and the rise of the intangible economy.

The paper is structured as follows: The next section documents the growth accounting framework and shows how the intangible assets outside the boundaries of the national accounts are included. This section also includes more detailed information about the various groups of tangible (ICT and non-ICT) and intangible capital services. The latter are also split into computerised information, R&D, other innovative property and economic competencies, thereby adapting the capital asset setup developed in the new EU KLEMS framework to the relevant literature on intangibles (Haskel and Westlake, 2018). Section 3 then provides an overview of the growth dynamics and its composition for the total economy and various sub-groups (market economy, manufacturing, business services and public services). Section 4 reviews the results of an econometric analysis focussing on the relevance of the various growth drivers across countries and industries. Summary and conclusions are given in Section 5.

2. Growth accounting approach including intangibles and data

In this section, first, the growth accounting framework is sketched (see Jorgensen et al., 2005, and Timmer et al., 2010 for details) with the focus on how intangible assets that are not part of the national accounts capital data have been included in this framework. Second, information with respect to data and assumptions are summarised and groupings of capital asset types including supplementary intangibles are discussed (details are provided in Stehrer et al., 2019).[7]

2.1. GROWTH ACCOUNTING APPROACH[8] INCLUDING INTANGIBLES

2.1.1. Overall approach

In this section the standard growth accounting approach is introduced including a discussion of the intended treatment of intangible assets in the framework.[9] Let the value added production function[10] be given by

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

where j denotes the industry, Y_j is the measure of (real) value added, and the inputs (in real terms or physical units) are labour (e.g. number of employed persons or hours worked) L_j and the capital stock K_j. T_j denotes the (unobserved) level of total factor productivity. These inputs are 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) which allows us to go further and calculate labour and capital services. Assuming a translog functional form of the production function, total factor productivity growth can be derived as (see Jorgensen et al, 2005)

$$\Delta \ln Y_j = \bar{v}_{CAP,j} \Delta \ln K_j + \bar{v}_{LAB,j} \Delta \ln L_j + \Delta \ln T_j \qquad (1)$$

with $\Delta \ln$ denoting the first-difference of the logarithm of the respective variable, i.e. its growth rate. Nominal input (cost) shares (in value added) are the shares of labour and the share of capital income in value added[11] with $\bar{v}_{CAP,j} + \bar{v}_{LAB,j} = 1$. Here, factor input prices are denoted by $p_{f,j}$ and $p_{Y,j}$ is the price

7 These data are available in the EU KLEMS Release 2019 Analytical Database (euklems.eu) which include growth accounts for the supplementary intangible assets not being part of national accounts capital data.

8 See e.g. Timmer et al, 2010, Chapter 3.

9 Additional aspects which are not yet included are concerning (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.

10 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.

11 The shares correspond to LAB and CAP in the EU KLEMS data.

index of value added, and $\mathrm{Y_j}$ is value added in real terms (chain-linked volumes). Variables $\bar{\mathrm{v}}_{\mathrm{f,j}} = 0.5\left(\mathrm{v_{f,j,t}} + \mathrm{v_{f,j,t-1}}\right)$ are the period average shares ('Divisia index'). By definition it holds that $\sum_{\mathrm{f}} \mathrm{v_{f,j}} = 1$ due to the assumption of constant returns to scale; this also implies that $\sum_{\mathrm{f}} \bar{\mathrm{v}}_{\mathrm{f,j}} = 1$. 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.

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. The construction of these labour and capital services growth rates are discussed in the following subsections.

2.1.2. Labour services

Labour input of type l in industry j is measured in hours worked denoted by $\mathrm{H_{l,j}}$.[12] The measure of (log) growth rate of labour input in industry j, $\Delta \ln \mathrm{L_j}$, 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

$$\Delta \ln \mathrm{L_j} = \sum_{l} \bar{\mathrm{v}}_{\mathrm{L,l,j}} \Delta \ln \mathrm{H_{l,j}} \qquad (2)$$

where $\bar{\mathrm{v}}_{\mathrm{L,l,j}} = (\mathrm{v_{L,l,j,t}} - \mathrm{v_{L,l,j,t-1}})/2$ 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

$$\mathrm{v_{L,l,j}} = \frac{\mathrm{p_{L,l,j} H_{l,j}}}{\sum_{k} \mathrm{p_{L,k,j} H_{k,j}}} \qquad (3)$$

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

The levels of hours worked in each industry j, i.e. $\mathrm{H_j}$, are taken from the national accounts data collected from Eurostat. These are broken down into the respective labour types13 using data from the EU labour force survey (EU LFS). As there is normally no information on hours worked by these categories, these 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, $\mathrm{H_{l,j}}$ with $\sum_{k} \mathrm{H_{k,j}} = \mathrm{H_j}$.

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 $\mathrm{p_{L,l,j}}$, i.e. the price of labour of type l in industry j. This allows us to calculate the respective nominal factor income shares $\mathrm{v_{L,l,j}}$ used 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.

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

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

The evolution of the Törnqvist volume index for labour services can finally be broken down (see Stehrer et al., 2019) into (i) a labour composition effect, and (ii) a change in hours worked effect denoted as

$$\Delta \ln L_j = \Delta \ln LC_j + \Delta \ln H_j \tag{4}$$

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: 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 wouldn'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. [14]

2.1.3. Capital services

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

$$\Delta \ln K_j = \sum_k \bar{v}_{K,k,j} \Delta \ln K_{k,j} \tag{5}$$

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 of 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 $\sum_k \bar{v}_{K,k,j} = 1$.

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 and taken from the EU KLEMS Release 2019. 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[15] is given by

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

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

[15] For a discussion see Jorgenson et al. (2005) for details. Specifically, a geometric pattern of depreciation is using depreciation rates as documented in Stehrer et al. (2019).

where $p_{I,k,j,t}$ is the investment price of asset type k in industry j and δ_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

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

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 chain-linked series volumes.[16]

2.1.4. Taking supplementary intangible assets into account

In the literature (see Haskel and Westlake, 2018) various additional intangible asset types are suggested. For measurement issues (see e.g. Corrado et al. 2018) two types of intangible assets are distinguished: National Account Intangible Assets (NAI) and Non-National Accounts Intangible Assets. The former group is already capitalised in the National Accounts (Software and databases, R&D, Other intellectual property products). The latter group is further differentiated into 'purchased components' and 'own account' components.

The intangible assets which are now accounted for as intermediates (and therefore not yet included in the national accounts capital data) can be capitalised (similarly to R&D in the SNA 2008/ESA 2010) and constitute the 'purchased components'. The information to construct these assets is taken from supply and use tables by defining products which are characterised as constituting assets. In particular these are marketing activities, design, and purchased organisational capital. Having defined this set of products, the construction follows several steps: First, the purchase of such products is defined as being 'gross intangible capital formation' which is available at current prices from the supply and use tables.[17] These products are transformed into chain-linked volumes by applying proper price deflators. The next step is then to apply the perpetual-inventory method (using pre-specified capitalisation factors and deflation rates taken from Corrado et al., 2018) to calculate capital stocks.[18]

As these products are no longer accounted for as intermediates their (current and real) values have to be added to the value added figures (in each industry) such that gross output figures are unchanged. This results in slightly different value added and labour productivity growth rates.[19]

In addition a further set of intangible assets (not included in the national accounts capital data) is suggested which constitutes the 'own account components' (e.g. training, in-house organisational capital). Information for these stems from various surveys (in particular the Vocational Training Survey (CVTS), labour costs survey (EU LCS), Structure of Earnings Survey (EU SES)) from which cost shares are derived which allow us to construct a time series for a proxy of 'investment' in these assets.[20]

16 The capital services price can become negative in which case these are adapted (see Stehrer et al. 2019, for discussion).

17 These supply and use tables have been collected from Eurostat and updated and benchmarked to the National Accounts data in the EU KLEMS Release 2019 according to the SUT-RAS methodology developed in the WIOD project (see Temurshoev and Timmer, 2011).

18 For a detailed discussion concerning the construction of these asset types see Stehrer et al., 2019.

19 The correlation between the official ones and the adapted ones is however beyond a coefficient of 0.95.

20 For details see Stehrer et al., 2019.

Similarly to above, the strategy is to construct a time series of investment in these assets (e.g. training costs), assume a relevant deflator and use this series to construct a capital stock. Differently to the above, it can be assumed that (by definition) these are already part of value added (e.g. training costs as a share of total labour costs) and therefore value added figures would not change.[21]

Having such data available means that one can easily take these additional assets into account in the methodology sketched above. Particularly, the supplementary asset types are taken into account in the construction of capital services as outlined above.

2.1.5. Decomposing value added and labour productivity growth

Finally, the thus compiled data allow calculating the contributions to value added and productivity growth in the standard way. The contributions to (real) value added growth are calculated by inserting the measures for labour services growth (broken down into the labour composition and the hours worked effect) and the capital services growth (broken down into several asset types including intangibles) into Equation (1) resulting in

$$\Delta \ln \mathrm{V_j} = \bar{\mathrm{v}}_{\mathrm{CAP,j}}\left[\textstyle\sum_{\mathrm{k}} \bar{\mathrm{v}}_{\mathrm{K,k,j}} \Delta \ln \mathrm{K_{k,j}}\right] + \bar{\mathrm{v}}_{\mathrm{LAB,j}}\left[\Delta \ln \mathrm{LC_j} + \Delta \ln \mathrm{H_j}\right] + \Delta \ln \mathrm{T_j} \qquad (6)$$

where $\sum_{\mathrm{k}} \bar{\mathrm{v}}_{\mathrm{K,k,j}} \Delta \ln \mathrm{K_{k,j}}$ is the growth rate of capital services (i.e. Törnqvist weighted growth rates of asset types with $\sum_{\mathrm{k}} \bar{\mathrm{v}}_{\mathrm{K,k,j}} = 1$). The shares $\bar{\mathrm{v}}_{\mathrm{CAP,j}}$ and $\bar{\mathrm{v}}_{\mathrm{LAB,j}}$ denote the shares of capital and labour income in value added. In practice, this equation is used to calculate TFP growth, $\Delta \ln \mathrm{T_j}$, as a residual by subtracting capital and labour services growth (appropriately weighted) from real value added growth.

When taking the supplementary intangible assets into account a further assumption is needed as to whether these are changing the shares of capital $\bar{\mathrm{v}}_{\mathrm{CAP,j}}$ and labour income $\bar{\mathrm{v}}_{\mathrm{LAB,j}}$ in each industry. Here it is assumed that these shares are unchanged by this.[22]

Subtracting the change of hours worked growth from both sides and manipulating results in (see Stehrer et al. 2019)

$$\Delta \ln \mathrm{V_j} - \Delta \ln \mathrm{H_j} \equiv \bar{\mathrm{v}}_{\mathrm{CAP,j}}\left[\textstyle\sum_{\mathrm{k}}\left(\bar{\mathrm{v}}_{\mathrm{K,k,j}} \Delta \ln \mathrm{K_{k,j}} - \Delta \ln \mathrm{H_j}\right)\right] + \bar{\mathrm{v}}_{\mathrm{LAB,j}} \Delta \ln \mathrm{LC_j} + \Delta \ln \mathrm{T_j} \qquad (7)$$

This decomposes value added per hour worked growth (on the left side) into capital services per hour worked growth, the labour composition effect and TFP growth. Note that TFP growth is unchanged by this.[23]

21 It might be argued that these components could also be in-house deliveries which might be part of the 'diagonal cells' in the input-output or supply-use framework. In such a case these costs should be shifted from the diagonal cells (indicating intra-industry use) to value added resulting in again higher value added figures. This is not done in the results presented here; anyway, given their small share in overall GDP, potential differences are generally small.

22 Some robustness checks suggest that different assumptions only have marginal effects with respect to the contributions to growth.

23 In Stehrer et al. (2019) a further decomposition of labour productivity per person employed growth is shown which is also included in the EU KLEMS Release 2019.

Finally, when considering labour productivity per person employed one has to subtract the change of growth of employed persons from both sides which results in

$$\Delta \ln V_j - \Delta \ln E_j = \bar{v}_{CAP,j}\left[\sum_k \left(\bar{v}_{K,k,j}\Delta \ln K_{k,j} - \Delta \ln E_j\right)\right] + \bar{v}_{LAB,j}\Delta \ln LC_j + \bar{v}_{LAB,j}(\Delta \ln H_j - \Delta \ln E_j) + \Delta \ln T_j$$

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 in addition the growth rate of working hours worked 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. This term therefore indicates the role of hours worked adjustments over the business cycle. In this EU KLEMS 2019 release the effect of growth differentials between hours worked and employment (weighted by the labour share) is stated explicitly.[24]

2.2. DATA: THE EU KLEMS RELEASE 2019

In this section we provide an overview of the most important data and classification issues for the sake of this paper which focusses on the role of various asset types in the growth performance of countries and industries. The new EU KLEMS Release 2019 is based on data downloaded from Eurostat on March 1, 2019[25]. Differently to previous releases, data are collected in current and previous year prices from which chain-linked volumes are calculated (thus there might be small deviations between the officially provided deflators and the ones calculated in the EU KLEMS project[26]). The use of current and previous year prices allows aggregations across industries to be calculated at the initial stage rather than using Törnqvist aggregation. Further, the industry classification has been slightly modified to be more in line with the NACE Rev.2 (ISIC Rev. 4) classification (details are discussed below). As described below in more detail, the 'statistical' module differentiates five asset types (Non-ICT capital, ICT capital, Software and databases, R&D and other intellectual property products). Importantly, comparative data for Japan and the US are collected.

In addition to a 'statistical module' which solely relies on officially available data (subject to some minor adjustments), an 'analytical module' is provided which, in addition, includes intangible assets outside the boundaries of National Accounts (see discussion below). More details concerning coverage and treatment of asset types and capital services are provided in the following subsections.

2.2.1. Country, industry and time coverage

The EU KLEMS Release 2019 has a slightly expanded set of industries and distinguishes 40 NACE Rev. 2 1- and 2-digit industries. Further, results for the total economy (TOT) and 8 aggregates are

24 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 in persons employed included the contribution of changes in hours worked by person employed.

25 Capital data for Romania became available on October 1, 2019 and have been included.

26 This mostly concerns cases when current or previous year price data became zero or negative where some adjustments have been made. This is particularly the case for capital data (and especially for the item Other intellectual property products, OIPP).

provided[27] (for a detailed list, see Appendix Table A.1). However, coverage with respect to detailed industries differs across countries and therefore this study is based on data for the total economy and NACE Rev. 2 1-digit industries as indicated in Table 1. Focus is on the grey shaded industries, i.e. total economy (TOT), the market economy (MARKT), manufacturing (C), business services (J to M_N) and public services (O to Q). Results of the growth accounts for the latter two industry groups have been built by calculating Törnqvist aggregates.[28]

Table 1 / Industry correspondence

Code	Description	Group
TOT	Total economy	
MARKT	Market economy (not including O, P, and Q)	
A	Agriculture, forestry & fishing	
B	Mining & quarrying	
C	Manufacturing	
D_E	Electricity, gas & water supply	
F	Construction	
G	Trade	
H	Transportation & storage	
I	Accommodation & food services	
J	Information and communication	Business services
K	Financial & insurance activities	
L	Real estate activities	
M_N	Professional services	
O	Public administration & defence	Public services
P	Education	
Q	Health & social work	
R	Arts, entertainment & recreation	
S	Other services	

Source: EU KLEMS Release 2019; author's assessment.

The aim of the project has been to include all EU-28 Member States (and potentially Norway) as well as comparable data for Japan and the US. For the descriptive analysis provided in Section 3 and the econometric analysis provided in Section 4, one has to keep in mind that coverage differs across countries and years. As a minimum set of indicators for the growth accounting analysis in this paper, data on value added and productivity growth, growth in labour services and capital services based on all ten asset types within the boundaries of national accounts distinguished in the EU KLEMS database[29] and the asset types (not included in the national accounts) capturing supplementary intangibles are required (these asset types are discussed in detail in the next subsection). Here one has to distinguish between availability of data for the total economy (as some countries report gross fixed capital formation and capital stocks for detailed asset types only at the total economy level) and data at the NACE Rev. 2

27 In addition three aggregates are tracked separately (C20_C21, C26_C27, and D_E) for consistency with the previous EU KLEMS Releases and as some countries are providing data only for these aggregates.

28 MARKT is included in the EU KLEMS industry list and has been built aggregating data in current and previous year prices.

29 An exception is that some countries do not report IT and CT assets separately, which are however included in Other Machinery (OMach). These countries are included.

1-digit level. An indication with respect to the overall availability of data for this report is provided in Table 2 (see Stehrer et al. 2019, for details on data construction).

As one can see, data are available at the total economy level for all countries with the exception of Cyprus, Croatia, Malta and Poland which lack data on gross fixed capital formation and capital stocks. Data are further not available at the 1-digit industry level for Bulgaria, Ireland, and Portugal. In some cases capital stocks had to be estimated using the PIM method (Bulgaria, Romania, Latvia for R&D and OIPP at the 1-digit level). One constraint for many countries (particularly the EU Central and Eastern European economies) are short time series with respect to labour composition. For this reason growth accounts for many countries can only be provided from 2008 on.[30] Data for non-EU countries are available for similar time periods (data for Japan ends in 2015); labour services for Norway have been proxied.[31]

Table 2 / Data coverage

				Growth accounts		Labour services	Gross fixed capital formation		Capital stocks	
				Total economy	1-digit industries	Total economy and 1-digit industries	Total economy	1-digit industries	Total economy	1-digit industries
EU Member States										
EU-15	EA	AT	Austria							
EU-15	EA	BE	Belgium	1998-2017		1998-2017				
EU-CEE		BG	Bulgaria	2008-2017		2008-2017			PIM	
	EA	CY	Cyprus			2008-2017				
EU-CEE		CZ	Czech. Rep.							
EU-15	EA	DE	Germany							
EU-15		DK	Denmark							
EU-CEE	EA	EE	Estonia	2008-2016	2008-2016	2008-2017	1995-2016	1995-2016	2000-2016	2000-2016
EU-15	EA	EL	Greece	2008-2016		2008-2017			1995-2016	1995-2016
EU-15	EA	ES	Spain	1995-2016	1995-2016		1995-2016	1995-2016	1995-2016	1995-2016
EU-15	EA	FI	Finland							
EU-15	EA	FR	France							
EU-CEE		HR	Croatia			2008-2017				
EU-CEE		HU	Hungary	2008-2017	2008-2017	2008-2017	IT, CT n.a.	IT and CT n.a.	IT and CT n.a.	IT and CT n.a.
EU-15	EA	IE	Ireland	2008-2016		2008-2017	1995-2016		1995-2016	
EU-15	EA	IT	Italy							
EU-CEE	EA	LT	Lithuania	2008-2017	2008-2017	2008-2017				
EU-15	EA	LU	Luxembourg	2008-2017	2008.2017	2008-2017				
EU-CEE	EA	LV	Latvia	2008-2017	2008-2017	2008-2017				PIM RD, OIPP
	EA	MT	Malta			2008-2017				
EU-15	EA	NL	Netherlands							
EU-CEE		PL	Poland			2008-2017				
EU-15	EA	PT	Portugal	2008-2016		2008-2017	1995-2016		2000-2016	
EU-CEE		RO	Romania	2008-2016	2008-2016	2008-2017	1995-2016	1995-2016	PIM	PIM
EU-15		SE	Sweden	1995-2016	1995-2016		1995-2016	1995-2016	1995-2016	1995-2016
EU-CEE	EA	SI	Slovenia	2008-2017	2008-2017	2008-2017	2000-2017	2000-2017	2000-2017	2000-2017
EU-CEE	EA	SK	Slovak Rep.	2000-2017	2000-2017		2000-2017	2000-2017	2000-2017	2000-2017
EU-15		UK	United Kingdom							
Other countries										
		JP	Japan	1995-2015	1995-2015		1995-2015	1995-2015	1995-2015	1995-2015
		US	United States	1997-2017	1997-2017	1984-2017	1970-2017	1970-2017	1970-2017	1970-2017

Source: EU KLEMS Release 2019.

[30] In ongoing work growth accounts are recalculated not considering labour composition effects which allow for longer time series.

[31] Data for Japan have been kindly provided by Kyoji Fukao and Kenta Ikeuchi (https://www.rieti.go.jp/en/database/JIP2018/index.html); data for US have been collected by K. Jäger with the help of BEA and BLS.

2.2.2. Capital asset types and intangibles

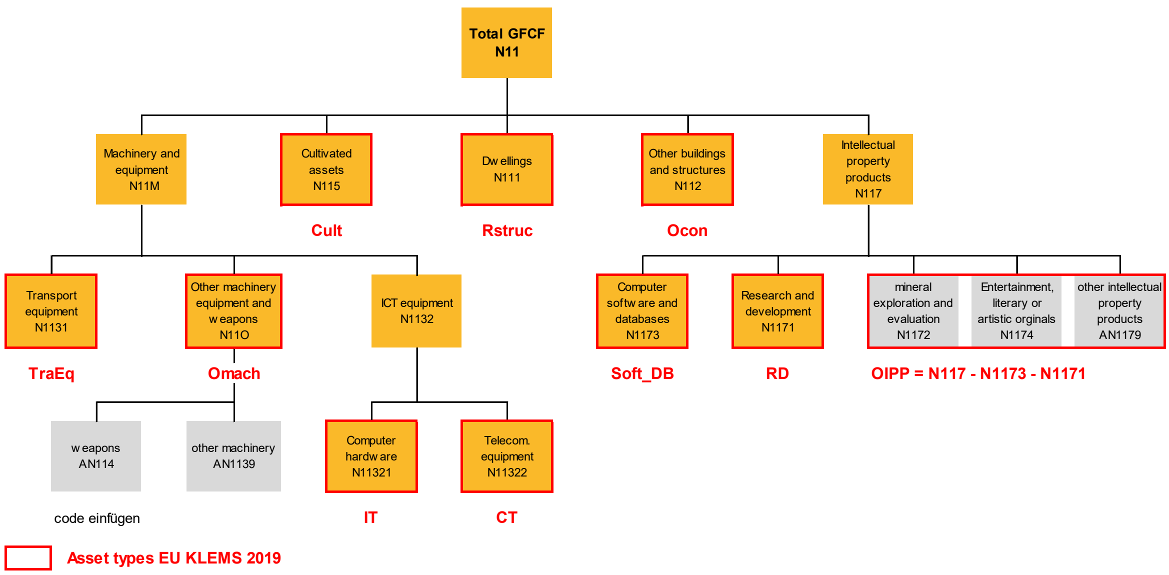
In the EU KLEMS Release 2019 database a number of asset types are distinguished. The list includes ten asset types available from the national accounts capital data which have already been included in the previous release of the EU KLEMS data. These asset types are presented in Figure 1. In addition, supplementary intangible asset types are included in the Analytical Database of the EU KLEMS Release 2019.[32] These include, in accordance with the literature (see Haskel and Westlake, 2018), the following: Advertising and Market Research (AdvMRes), Design (Design), Purchased Organisational Capital (POCap) and Vocational Training (VT).[33] Therefore a total of fourteen asset types are considered in the growth accounting exercise outlined in Subsection 2.1. In the growth accounting exercise (as well as in the econometric results presented in Section 4), however, these are grouped into various categories.

In general, various groupings could be considered. For example, in the previous EU KLEMS releases a distinction between ICT and Non-ICT capital was made:

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

From these the asset types, Software and Databases (Soft_DB), R&D (RD) and Other Intellectual Property Products (OIPP) are considered as intangibles in the recent literature (see the recent book by Haskel and Westlake, 2018), whereas supplementary intangible assets have not been included.

Figure 1 / 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.

32 In the EU KLEMS Release 2019 Statistical Database, only the ten asset types included in the National Accounts capital data are considered.

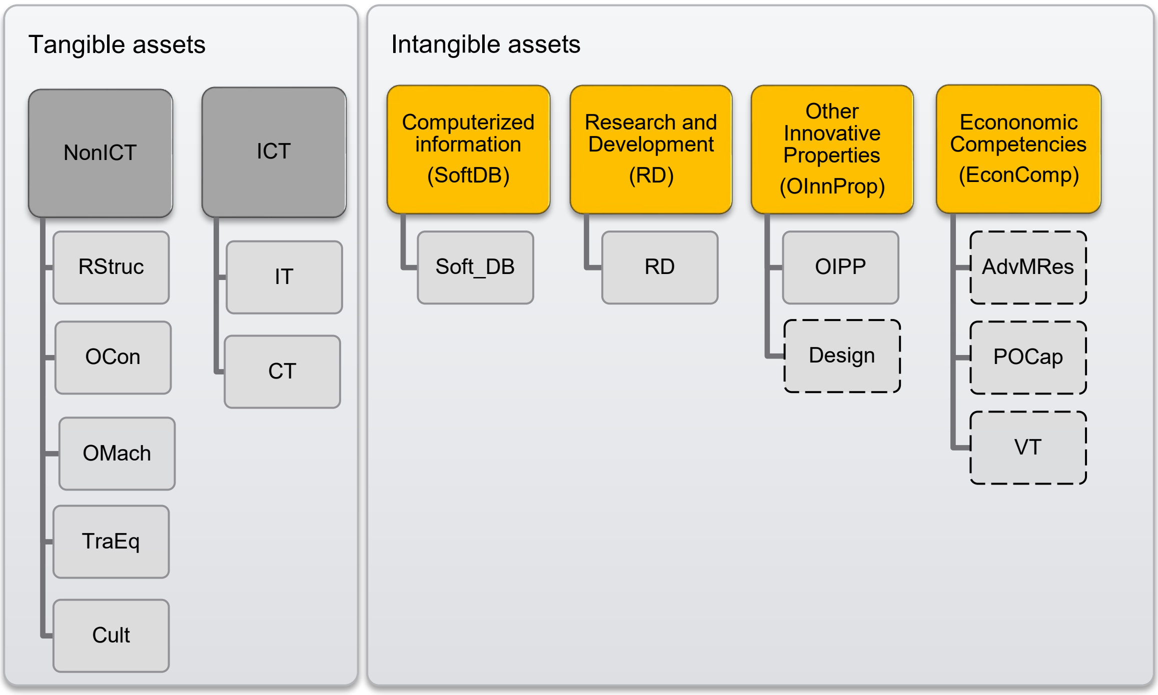
33 A measure for own-account organisational capital (based on information on income shares of managers) has been developed but not integrated into the analytical database and the analysis due to insufficient coverage across countries.

A similar distinction could be made with respect to tangibles and intangible asset types, the latter being distinguished in those already included in the national accounts capital data and those being constructed:

Tangibles:	RStruc, OCon, OMach, TraEq, Cult, IT, CT
Intangibles:	Soft_DB, RD, OIPP
Supplementary intangibles:	AdvMRes, Design, POCap, VT

For the purposes of this paper – as well as in line with the results made available in the EU KLEMS Release 2019 Analytical Database – a slightly more detailed grouping is presented, simultaneously distinguishing, on the one hand, ICT and non-ICT capital and, on the other, tangibles and intangibles. The latter are broken down into the categories of intangible investment in Haskel and Westlake (2018). Therefore, the following six categories, as shown in Figure 2, are considered in the analysis presented in Sections 3 and 4. The left two columns shaded in grey indicate the tangible assets (split into non-ICT and ICT) whereas the yellow-coloured are the intangible assets considered.

Figure 2 / 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).

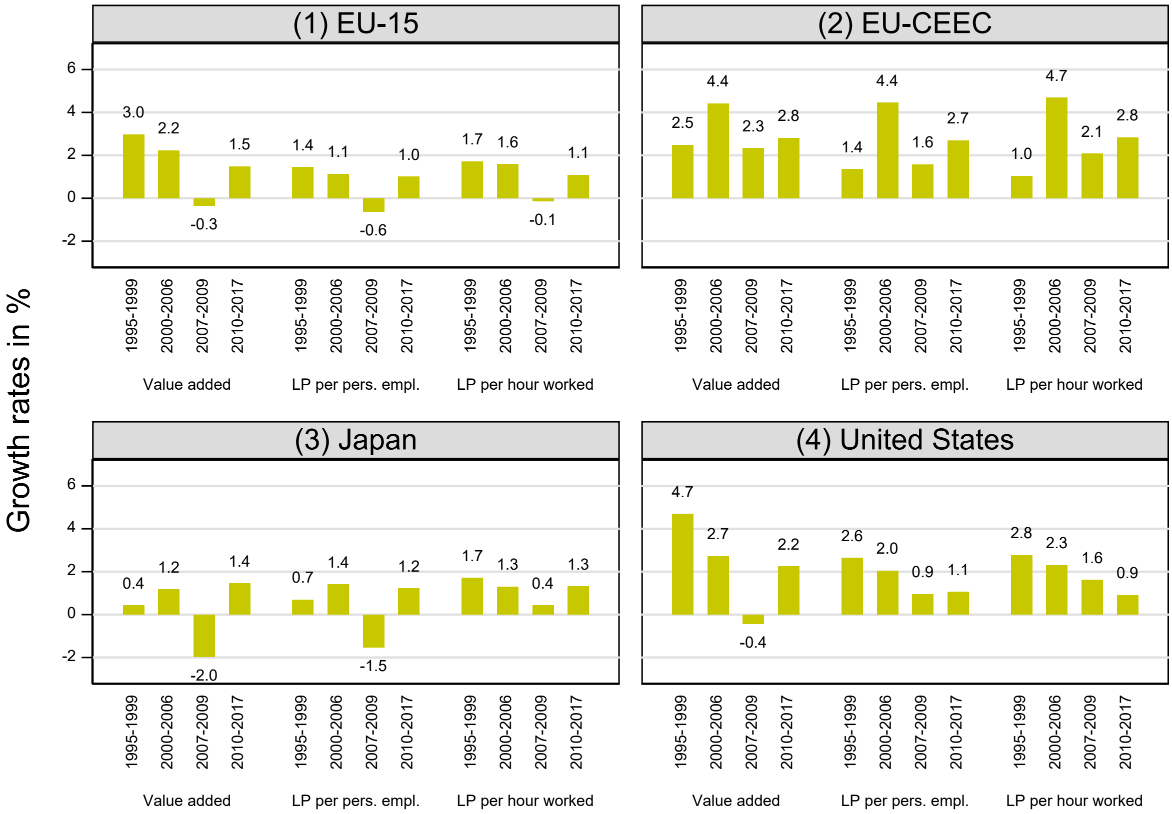
3. Growth accounting results

In this section, the growth performance of the two European country groups - the countries which have been EU Members already since 1995 (EU-15) and the Central and Eastern European countries which joined later (EU-CEEC) - and Japan and the US are considered.

3.1. TOTAL ECONOMY

Let us first discuss the performance of these countries at the total economy level. In Figure 3 four time periods are considered: 1995-1999, the years 2000-2006 before the crisis, the crisis period 2007-2011 and the phase after the crisis 2012-2017. Growth rates are Törnqvist aggregates using nominal value added at current exchange rates with arithmetic means over the periods considered.

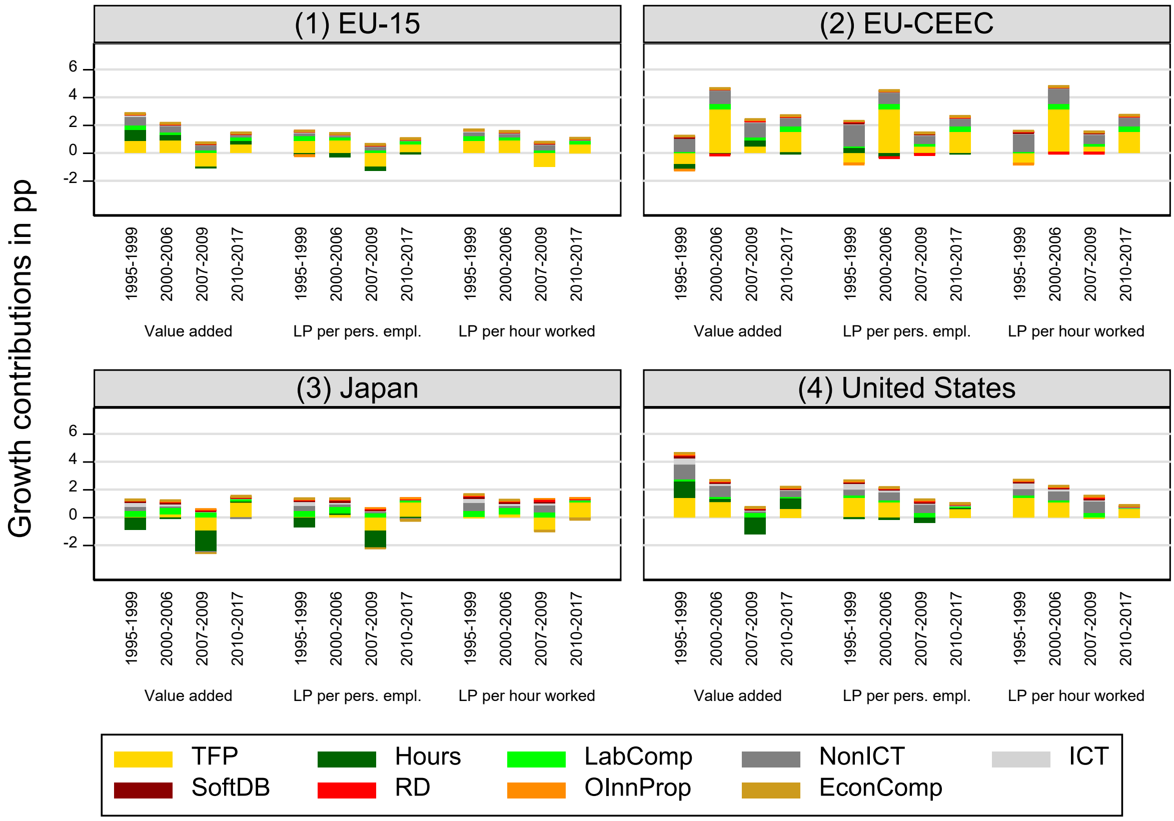
Figure 3 / Value added and labour productivity growth rates in %, total economy



Note: For Japan, only period 2011-2015 is considered.
Source: EU KLEMS Release 2019 (Analytical Database).

Focussing on the pre- and post-crisis period, one can find a slowdown of both value added and productivity growth in all countries, though less pronounced in Japan which however anyway experienced slower growth rates over the whole period considered. Comparing EU Member States and the US, it is interesting to note that while value added growth picked up after the crisis in both countries, labour productivity growth did so only in the EU Member States and not in the US. Finally, comparing the EU-15 Member states (comprised of those countries being EU Members since 1995 or before) and the Central and Eastern European countries, one finds similar dynamic patterns, but growth rates are much higher (between one to two percentage points) in the EU-CEE countries. In particular, this pattern remained intact after the crisis.

Figure 4 / Contributions to value added and labour productivity growth, total economy



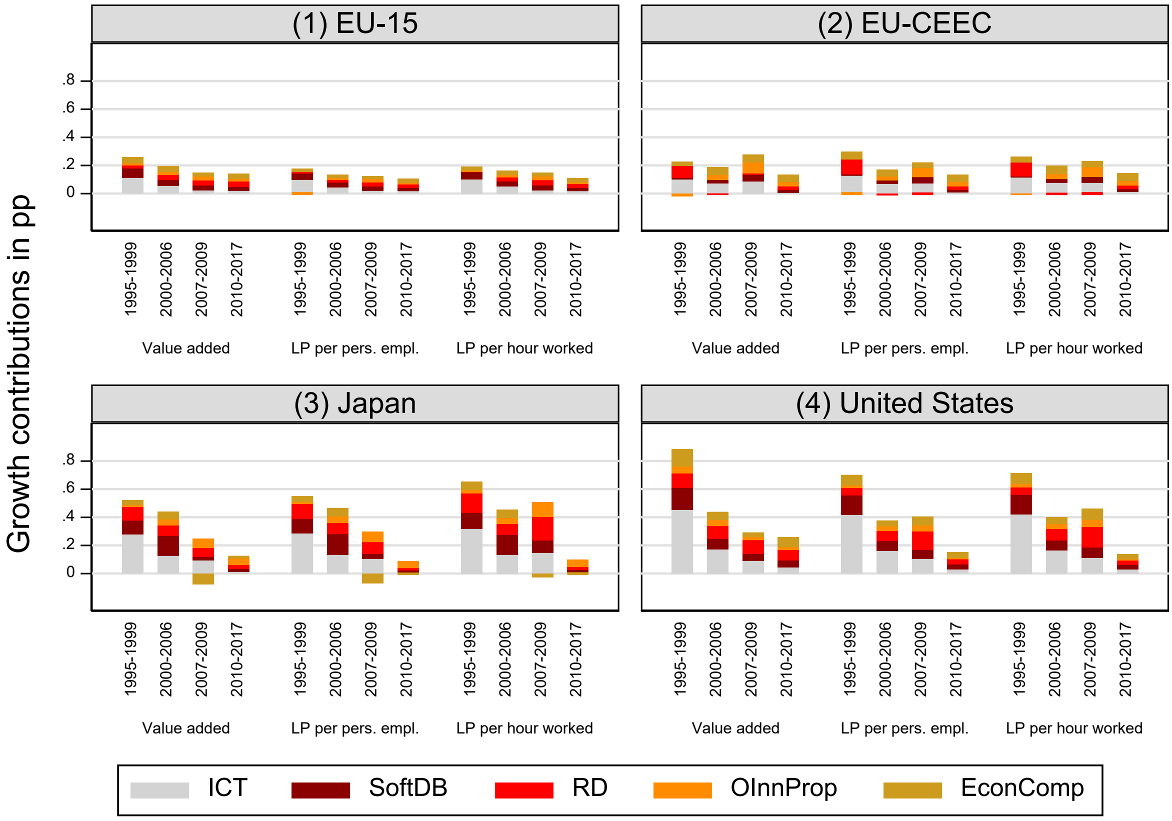
Source: EU KLEMS Release 2019 (Analytical Database).

The focus of this paper is however on the growth components. Figure 4 therefore reports the growth decomposition outlined in Section 2.[34] The broad picture suggests that growth before the crisis in the EU-15, the EU-CEE countries and the US was largely driven by total factor productivity (TFP) growth. Hours worked and labour composition contributed relatively more in the EU countries compared to the US. Further, investment in tangible assets (in particularly Non-ICT capital) played a significant role, especially in the EU-CEE economies. Non-ICT capital also contributed more to growth in the US as compared to the EU-15 Member States. Growth of intangible assets played only a minor role, though showing positive contributions in all country groups. Differently, growth in Japan before the crisis was mostly driven by labour composition changes, ICT capital and, intangible assets (particularly software and databases).

34 Note that the country sample for EU-15 and EU-CEE differs as growth accounting is not possible for all countries (see discussion above).

The growth performance after the crisis shows a significant decline in the contribution of total factor productivity in the EU-15, the EU-CEE and the US, whereas TFP growth picked up in Japan.[35] Contributions of changes in labour composition remained relatively stable (with the exception of Japan). Growth of Non-ICT capital still played an important role in the EU-CEE countries and the US, but less so in the other two.

Figure 5 / Contributions of ICT and intangible assets to growth, total economy

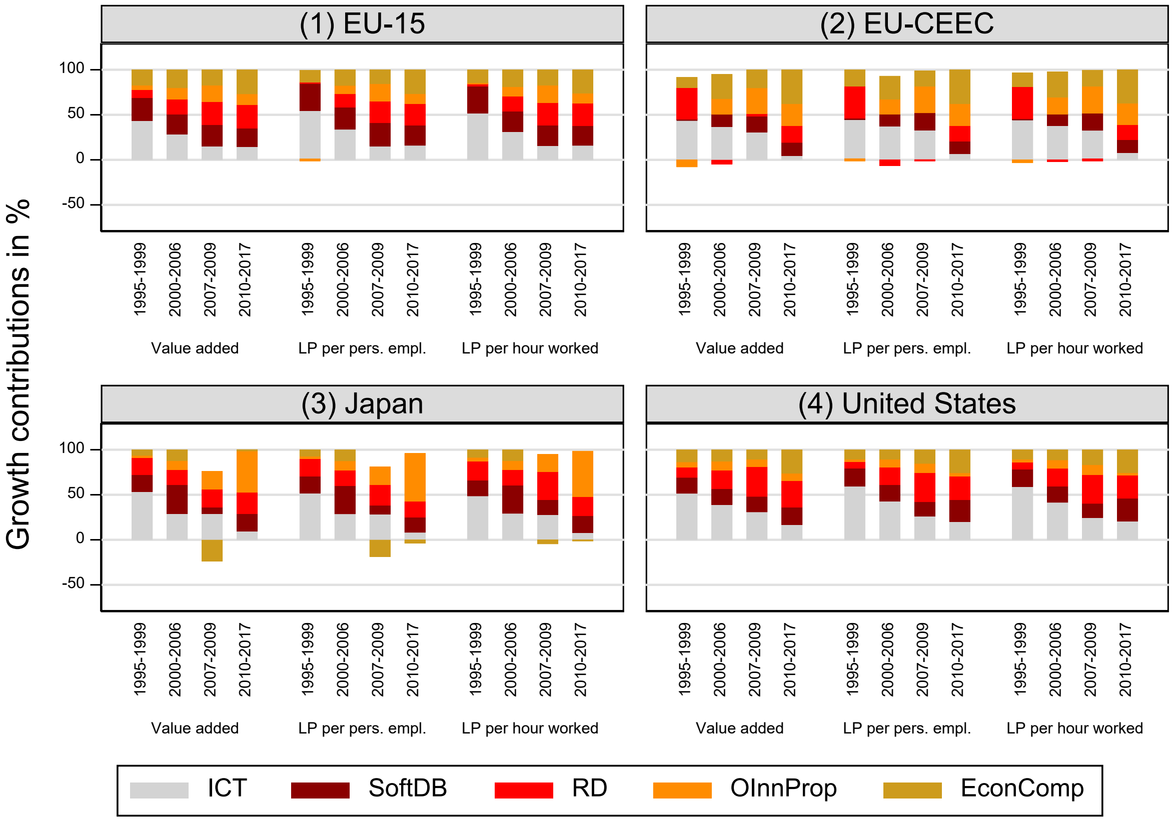


Source: EU KLEMS Release 2019 (Analytical Database).

To focus on the role of ICT capital and intangible assets, their contributions to growth are presented in Figure 5. First, one can see that before the crisis ICT and intangible assets significantly contributed to growth in Japan with about 0.5 percentage points, and also the US with about 0.4 percentage points. Contributions of these assets were much smaller in the EU countries with about 0.2 percentage points. This is particularly important for the EU-CEE countries which experienced double as high growth rates compared to the EU-15. Second, one finds that the contribution of ICT and intangible assets to growth significantly declined in Japan in and after the crisis period as well as (though less pronounced) in the US. In particular, the contributions of ICT investments shrank considerably. Similar trends - at the already lower level as mentioned above - are also observed for the EU-15 countries, whereas the contributions of ICT and intangible assets remained relatively stable in the EU-CEE countries (though again the contribution of ICT capital being on the decline).

[35] In a companion paper Jäger et al. (2019) study the sectoral contributions to these overall productivity changes.

Figure 6 / Structure of ICT and intangibles' growth contribution, total economy



Source: EU KLEMS Release 2019 (Analytical Database).

The changing structure of these contributions can better be seen in Figure 6 which shows the contributions of ICT and the intangible assets considered in percent of their overall contributions to growth. The declining role of ICT assets to growth as already discussed above is particularly prominent across all countries considered. Second, the contribution of R&D is fairly robust in Japan and the US, though seems to increase in the EU-15 and the EU-CEE countries after the crisis. The role of other innovative properties (including design) was relatively stable before and after the crisis in the EU countries, whereas it became much more important in Japan and vanished in the US. Finally, intangibles concerning economic competencies (advertising and market research, purchased organisational capital and training) have become relatively more important in all countries except Japan.

3.2. PRODUCTIVITY PERFORMANCE BY BROAD INDUSTRY GROUPS

Such trends can also be analysed at the more detailed industry level. The EU KLEMS 2019 Release distinguishes 40 individual industries (according to NACE Rev. 2/ISIC Rev. 4) and various aggregates.[36] In Annex B the corresponding graphs to Figure 3 to Figure 6 are presented for (i) the market economy (comprising industries A to N and Q to S), (ii) total manufacturing, (iii) business services (J to N) and (iv) public services (industries O, P and Q) are considered. The latter two groups were built using Törnqvist aggregates (over industries) as these are not included in the EU KLEMS Release 2019 industry list.

36 Aggregates have been built using data in current and previous year prices.

When considering the market economy only, patterns are similar to those described for the total economy. As expected, the recession affected the market economy more than the total economy resulting in a stronger decline in the crisis period. However, other growth rates – and particularly the labour productivity growth rate – are generally higher when considering the market economy on its own. Differences are only minor when considering growth components, however.

When looking at the manufacturing industry on its own, one finds a much stronger impact of the crisis on growth resulting in value added and labour productivity growth rates between -3 and -5%. In the years before and after the crisis productivity seems to have been even more driven by TFP growth. Again, growth in non-ICT capital services has been more important for the EU-CEE countries compared to the others. However, the most striking difference is that labour productivity growth is strongly driven by intangible assets, notably R&D services. Intangible ICT (i.e. software and databases) again are more important contributors to growth in the US and Japan as compared to the EU-15. Interestingly growth contributions of intangible ICT has been relatively important in the EU-CEE countries, mostly due to lower starting values.

Business services are characterised by lower productivity growth rates in general and were less affected by the crisis. However, there are striking differences in the labour productivity growth performance which is much larger in the US compared to the EU countries (where these have been more volatile and much lower). Particularly, TFP growth in the US has been much more important compared to the other countries. Further, there is a striking difference with respect to the role of tangible ICT and intangible ICT (software and databases) where EU countries show significantly lower contributions. However, these contributions are steadily declining in Japan and the US. This pattern is also found for public services albeit slightly less pronounced. Labour composition change is also a more important component of growth in public services in the EU countries compared to the others.

4. Contributions on the margin: evidence from econometric analysis

This section discusses the results of an econometric analysis complementing the growth accounting exercise to examine the drivers of value added growth and labour productivity[37] with an emphasis on the differences between tangible and intangible capital, as well as ICT and non-ICT capital analogous to the descriptive growth accounting evidence presented in Section 3. The analysis is based on the EU KLEMS sample of countries, however dropping outlier countries (Cyprus, Luxembourg and Malta), which amounts to 23 countries observed over the period 2000-2017.[38] One should also note that the panel is unbalanced and the available data differs significantly across countries, particularly for different capital asset types (see Section 2).

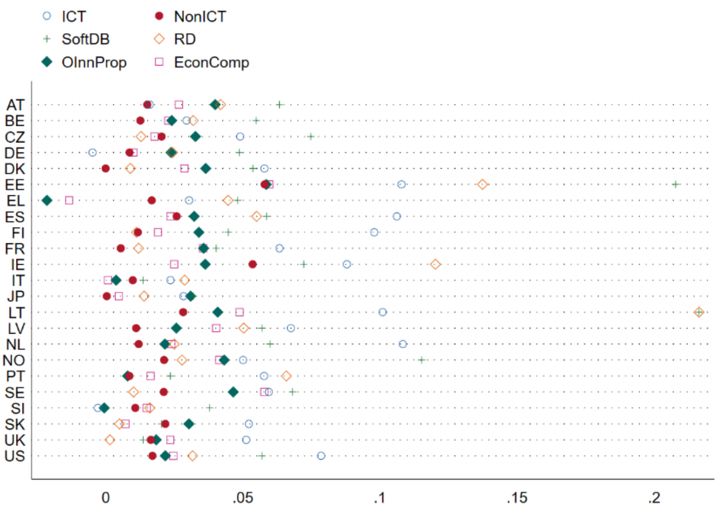
As discussed in the previous section, in line with Haskel and Westlake (2018) capital asset types that are based on the new EU KLEMS classification are aggregated into six broader groups: tangible assets, including tangible ICT (ICT) and tangible non-ICT (Non-ICT) groups, and intangible assets, including ICT software and databases (SoftDB), R&D (RD), other innovative property (OInnProp) and economic competencies (EconComp) groups. Summary statistics for the effective sample used in the analysis are listed in Appendix C. In addition, Figure 7 and Figure 8 show the average growth rate over the entire period analysed (2000-2017), the pre-crisis (2000-2006) and post-crisis (2010-2017) periods for aggregate country-level data. In Figure 9 and Figure 10, capital aggregates are juxtaposed against labour productivity and value added (all in log-differenced form, aggregate country-level panel data) as a preliminary evidence of statistical association between capital assets and economic outcomes.

[37] Throughout the analysis labour productivity and value added refer to real labour productivity and real value added (i.e. values adjusted using appropriate deflators at aggregate or sectoral levels).

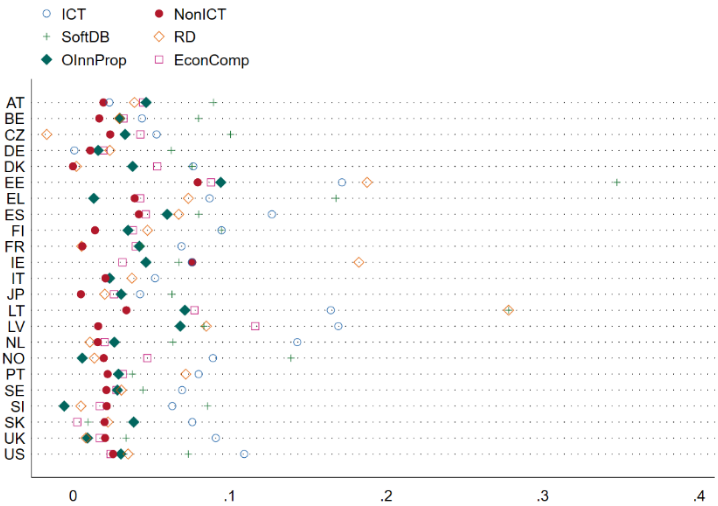
[38] The sample includes the following countries: AT, BE, CZ, DE, DK, EE, EL, ES, FI, FR, IE, IT, JP, LT, LV, NL, NO, PT, SE, SI, SK, UK, US.

Figure 7 / Capital aggregates: average growth rates

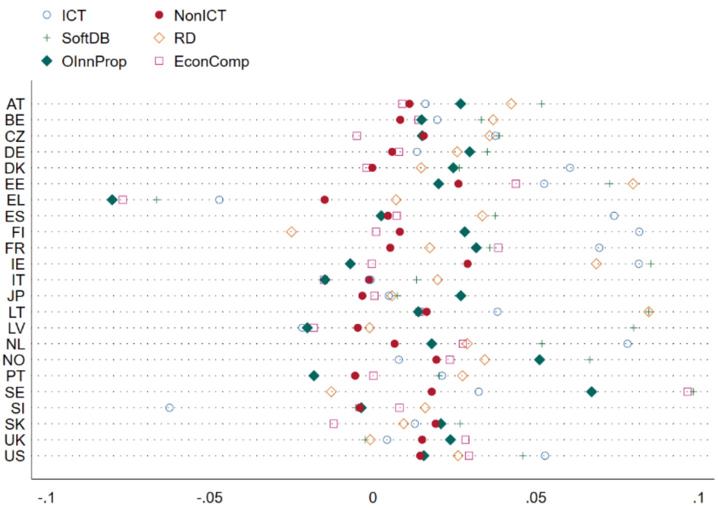
A) Period: 2000-2017



B) Period: 2000-2006



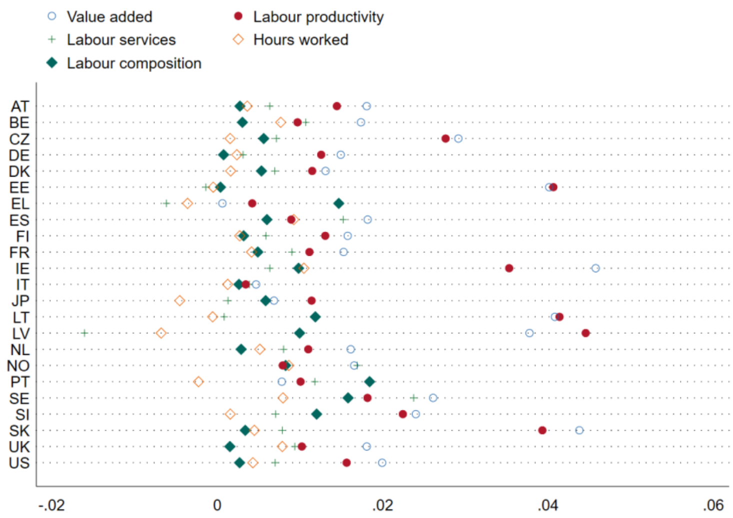
C) Period: 2010-2017



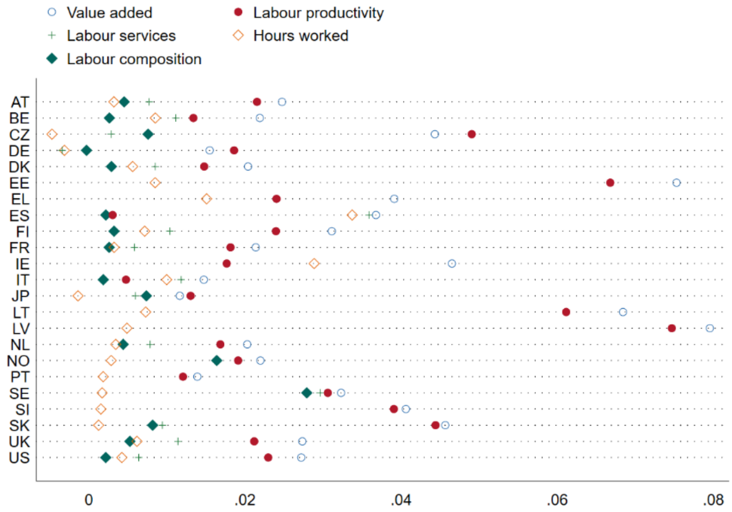
Source: EU KLEMS 2019 release; own elaboration.

Figure 8 / Value added and labour market variables: average growth rates

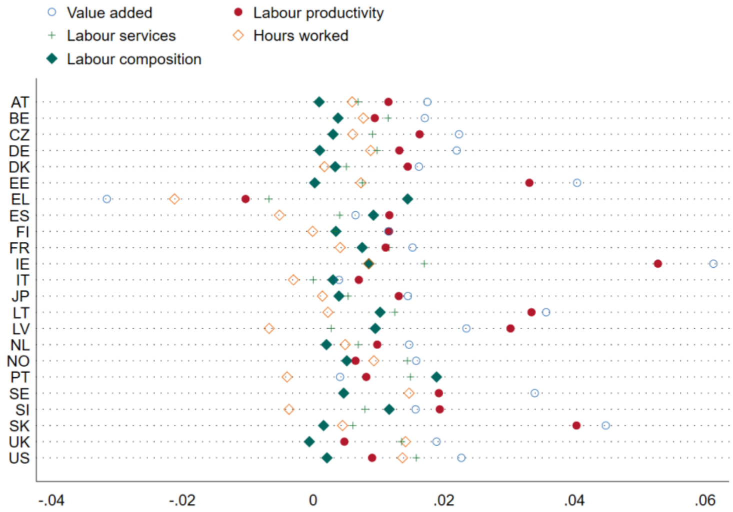
A) Period: 2000-2017



B) Period: 2000-2006

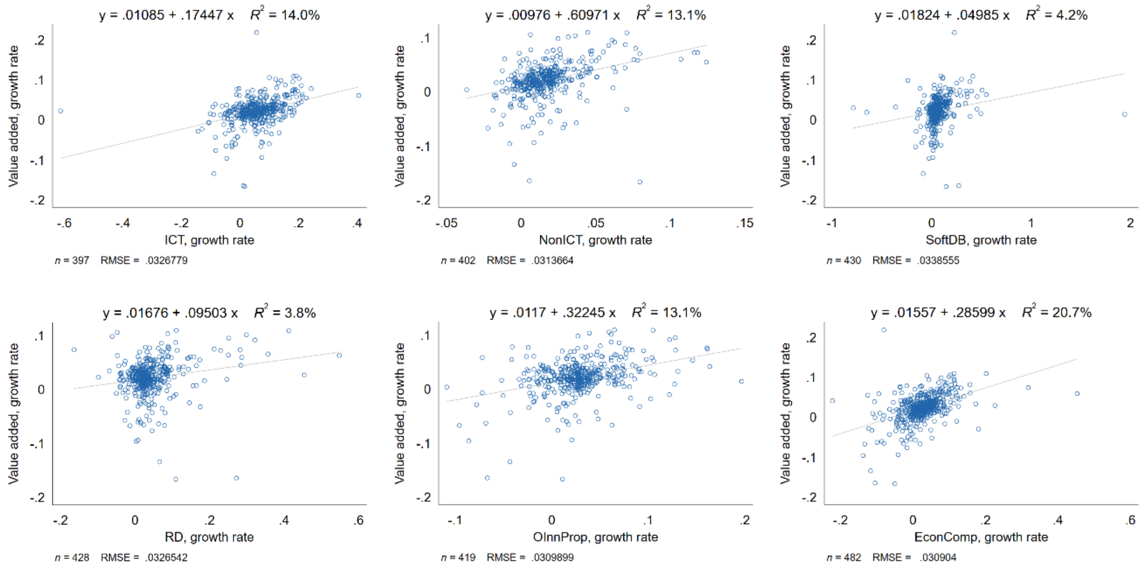


C) Period: 2010-2017



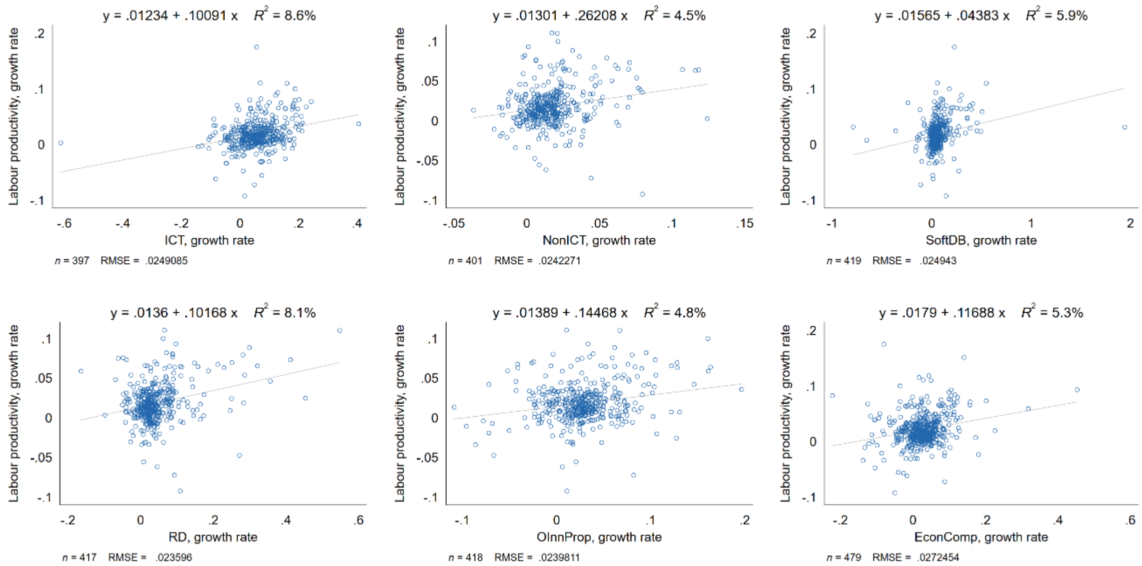
Source: EU KLEMS 2019 release; own elaboration.

Figure 9 / Scatterplots: value added growth vs growth of capital aggregates



Source: EU KLEMS 2019 release; own elaboration.

Figure 10 / Scatterplots: labour productivity growth vs growth of capital aggregates



Source: EU KLEMS 2019 release; own elaboration.

The econometric analysis employs panel data estimation techniques. The specification is based on the log-differenced version of the Cobb-Douglas production function, which, in its basic form, explains real value added growth $\Delta \ln Y_{cjt}$ as a function of the growth of real capital inputs ($\Delta \ln K_{cjt}$), growth of labour inputs ($\Delta \ln L_{cjt}$) and the TFP growth term ($\Delta \ln A_{cjt}$), calculated as a residual:

$$\Delta \ln Y_{cjt} = \alpha \, \Delta \ln L_{cjt} + \beta \Delta \ln K_{cjt} + \Delta \ln A_{cjt}$$

For the purposes of econometric analysis, this specification is further expanded to incorporate the set Q = {SoftDB; NonICT; ICT; RD; OInnProp; EconComp} comprising capital asset groups (in terms of capitals services growth) and the labour input measured as the growth rate of labour services:

$$\Delta \ln Y_{cjt} = \alpha \Delta \ln L_{cjt} + \sum_{q \in Q} \beta_q \Delta \ln K_{qcjt} + \Delta \ln A_{cjt} \tag{8}$$

Alternative specifications also include hours worked and labour composition instead of labour services (as discussed above, the labour composition variable in the baseline specification is decomposed as $\Delta \ln L_{cjt} = \Delta \ln LC_{cjt} + \Delta \ln H_{cjt}$). In addition to the baseline model involving the six outlined capital asset aggregates, the model is estimated with the 14 asset types as defined in the new EU KLEMS (analytical module) for further insights, adjusting accordingly the set Q in the specification. In order to control for unobserved heterogeneity at the country and sector levels and alleviate potential omitted variable issues we also include fixed effects (country, sector, year fixed effects or their interaction, depending on the specification).

Table 3 / Aggregate country analysis: estimation results for value added growth

Dependent variable:	2000-2017				2000-2006	2010-2017
Value added	FE	FE	POLS	System GMM	FE	FE
	1	2	3	4	5	6
Labour services	0.573***		0.485***	0.609***	0.163	0.569***
	(0.087)		(0.079)	(0.104)	(0.094)	(0.155)
Hours worked		0.623***				
		(0.092)				
Labour composition		-0.049				
		(0.176)				
ICT	0.042***	0.036***	0.037**	0.058***	-0.005	0.042***
	(0.012)	(0.010)	(0.014)	(0.013)	(0.021)	(0.011)
NonICT	-0.152	-0.246	0.209	-0.264	0.122	0.066
	(0.212)	(0.205)	(0.205)	(0.238)	(0.140)	(0.224)
SoftDB	0.003	0.003	0.005	0.004	0.020	0.005
	(0.004)	(0.004)	(0.005)	(0.004)	(0.015)	(0.004)
RD	-0.010	-0.003	-0.044	-0.016	0.027	-0.038
	(0.040)	(0.038)	(0.043)	(0.038)	(0.062)	(0.040)
OInnProp	0.016	-0.003	0.051	-0.020	-0.010	-0.151*
	(0.044)	(0.041)	(0.045)	(0.039)	(0.033)	(0.077)
EconComp	0.123***	0.102***	0.093**	0.149***	0.154*	0.112*
	(0.043)	(0.035)	(0.044)	(0.050)	(0.081)	(0.058)
Value added, lag				0.121*		
				(0.072)		
Constant	0.022***	0.032***	0.017***	-0.006	0.027***	0.024***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.002)
Year FE	yes	yes	yes	yes	yes	yes
Observations	335	335	335	320	111	169
R-squared	0.764	0.784	0.718		0.697	0.546

Note: All variables are included in log-differences. Standard errors clustered by country are included in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1 percent levels respectively.
Source: EU KLEMS Release 2019, own results.

The model is first estimated using country-level aggregates via fixed effects ("FE") as the baseline estimator, and the pooled OLS ("POLS") and Arellano-Bover / Blundell-Bond system GMM ("System GMM") are also reported as alternatives for comparison (see Table 3 for value added growth results and

Table 4 for labour productivity growth results). The results however remain consistent across estimations.

Table 4 / Aggregate country analysis: estimation results for labour productivity growth

Dependent variable:	2000-2017				2000-2006	2010-2017
Labour productivity	FE	FE	POLS	System GMM	FE	FE
	1	2	3	4	5	6
Labour services	-0.353***		-0.403***	-0.332***	-0.498***	-0.460**
	(0.092)		(0.101)	(0.085)	(0.093)	(0.164)
Hours worked		-0.377***				
		(0.092)				
Labour composition		-0.049				
		(0.176)				
ICT	0.033***	0.036***	0.031**	0.039***	-0.022	0.038***
	(0.010)	(0.010)	(0.014)	(0.010)	(0.017)	(0.009)
NonICT	-0.291	-0.246	0.108	-0.354	-0.038	0.002
	(0.192)	(0.205)	(0.204)	(0.232)	(0.220)	(0.182)
SoftDB	0.003	0.003	0.007	0.002	0.033*	0.004
	(0.004)	(0.004)	(0.007)	(0.003)	(0.018)	(0.004)
RD	-0.000	-0.003	-0.024	-0.016	-0.035	-0.019
	(0.036)	(0.038)	(0.039)	(0.033)	(0.060)	(0.038)
OInnProp	-0.012	-0.003	-0.006	0.041	0.016	-0.123
	(0.042)	(0.041)	(0.050)	(0.039)	(0.031)	(0.075)
EconComp	0.092**	0.102***	0.086*	0.113**	0.088	0.099*
	(0.037)	(0.035)	(0.043)	(0.046)	(0.113)	(0.057)
Labour productivity, lag				0.096		
				(0.084)		
Constant	0.037***	0.032***	0.028***	0.002	0.039***	0.031***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.006)	(0.002)
Year FE	yes	yes	yes	yes	yes	yes
Observations	335	335	335	320	111	169
R-squared	0.487	0.498	0.380		0.386	0.469

Note: All variables are included in log-differences. Standard errors clustered by country are included in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1 percent levels respectively.
Source: EU KLEMS Release 2019, own results.

As expected, growth of labour services, particularly its hours worked component, contributes positively to real value added growth with high statistical significance and the marginal impact of about 0.6, implying that a 1-percentage point change in the growth of labour services is associated with a 0.6-percentage point change in value added growth. The negative coefficient associated with the estimated contribution of labour services and hours worked to labour productivity reflects decreasing marginal returns.

Notably, the results reveal a significant role that tangible ICT and intangible economic competencies play in facilitating both value added growth and labour productivity growth. For instance, a 1-pp increase in the growth of the economic competencies assets translates to about 0.1-pp growth of labour productivity and value added. The marginal contribution of tangible ICT, while also statistically significant, is lower — 0.03-0.04 for labour productivity growth and 0.04-0.06 for value added growth. The results from the detailed analysis by 14 asset types (see Appendix C) attribute the impact largely to CT and AdvMRes capital.

When splitting the sample into the pre-crisis and post-crisis periods (Columns 5 and 6 of Table 3 and

Table 4), only intangible economic competencies asset group remains statistically significant across both periods with the magnitude of the effect decreasing only slightly. At the same time, the impact of tangible ICT only manifests in the post-crisis period with the marginal effect of about 0.04 for both labour productivity and value added growth.

Since informative variation in output, productivity and capital asset dynamics may be lost as a result of country-level aggregation, the analysis is complemented by a range of additional exercises focussing on (i) the manufacturing sector only, (ii) pooling sectors at the 1-digit NACE level (sections) in a single panel dataset and augmenting the specification with sector and country fixed effects, and (iii) distinguishing the market economy, the business services and the public services clusters.

Table 5 / Estimation results for the manufacturing sector

Dependent variable:	Value added				Labour productivity			
	FE	FE	POLS	System GMM	FE	FE	POLS	System GMM
	1	2	3	4	5	6	7	8
Labour services	0.714***		0.781***	0.890***	-0.212		-0.128	-0.092
	(0.156)		(0.180)	(0.220)	(0.194)		(0.217)	(0.212)
Hours worked		0.731***				-0.269		
		(0.167)				(0.167)		
Labour composition		0.506*				0.506*		
		(0.242)				(0.242)		
ICT	0.045	0.046	0.053**	0.062	0.049	0.046	0.051*	0.063
	(0.029)	(0.030)	(0.023)	(0.043)	(0.031)	(0.030)	(0.024)	(0.040)
NonICT	-0.228	-0.264	0.448**	-0.070	-0.388	-0.264	0.353*	-0.255
	(0.357)	(0.380)	(0.153)	(0.288)	(0.373)	(0.380)	(0.175)	(0.323)
SoftDB	-0.009	-0.009	-0.014	-0.012	-0.008	-0.009	-0.011	-0.006
	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)	(0.010)	(0.011)	(0.011)
RD	0.102*	0.101*	0.025	0.132**	0.101*	0.101*	0.029	0.144***
	(0.048)	(0.048)	(0.045)	(0.058)	(0.049)	(0.048)	(0.058)	(0.050)
OInnProp	-0.041	-0.038	0.030	-0.049	-0.028	-0.038	0.027	-0.038
	(0.032)	(0.034)	(0.063)	(0.036)	(0.043)	(0.034)	(0.061)	(0.032)
EconComp	0.045	0.043	0.011	0.015	0.038	0.043	0.017	0.023
	(0.049)	(0.050)	(0.074)	(0.049)	(0.059)	(0.050)	(0.077)	(0.057)
Value added, lag				-0.002				
				(0.064)				
Labour productivity, lag								0.109*
								(0.057)
Constant	0.060***	0.063***	0.038***	0.040***	0.073***	0.063***	0.049***	0.038***
	(0.011)	(0.011)	(0.011)	(0.010)	(0.012)	(0.011)	(0.012)	(0.010)
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	209	209	209	199	209	209	209	199
R-squared	0.791	0.792	0.750		0.547	0.572	0.468	

Note: The table shows the results of the estimation for value added and labour productivity growth for the manufacturing sector (NACE rev. 2 section C). All variables are included in log-differences. Standard errors clustered by country are included in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1 percent levels respectively.
Source: EU KLEMS Release 2019, own results.

Estimations carried out separately for the manufacturing sector (see Table 5) suggest two major differences from the aggregate country-level results. First, R&D capital manifests as an important driver of both labour productivity and value added growth for the manufacturing sector. In both cases the magnitudes are similar: an increase in R&D capital growth rate by 1 pp induces an increase in the growth rate of productivity or output by about 0.1 pp. At the same time, tangible ICT capital and intangible economic competencies are not statistically significant[39] (the impact is nevertheless positive). Second, in contrast to the aggregate country-level results, for the manufacturing sector, labour composition signifies an important driver of output growth and labour productivity with the estimated marginal effect of 0.5.

Table 6 / Estimation results for pooled sectors: value added

Dependent variable:	2000-2017			2000-2006			2010-2017		
Value added	1	2	3	4	5	6	7	8	9
Labour services	0.185***	0.185***	0.199***	0.222***	0.222***	0.252***	0.154***	0.154***	0.160***
	(0.038)	(0.038)	(0.040)	(0.074)	(0.074)	(0.080)	(0.038)	(0.038)	(0.040)
ICT	0.011	0.011	0.007	0.000	0.000	-0.009	0.004	0.004	0.003
	(0.009)	(0.009)	(0.010)	(0.016)	(0.016)	(0.019)	(0.016)	(0.016)	(0.016)
NonICT	-0.029	-0.029	-0.056	0.043	0.043	-0.008	-0.047	-0.047	-0.025
	(0.055)	(0.055)	(0.057)	(0.052)	(0.052)	(0.056)	(0.067)	(0.067)	(0.079)
SoftDB	0.008*	0.008*	0.010	0.017	0.017	0.015	0.001	0.001	0.001
	(0.005)	(0.005)	(0.007)	(0.011)	(0.011)	(0.013)	(0.005)	(0.005)	(0.007)
RD	0.010*	0.010*	0.011*	0.014	0.014	0.014	0.010	0.010	0.009
	(0.005)	(0.005)	(0.006)	(0.014)	(0.014)	(0.015)	(0.007)	(0.007)	(0.006)
OInnProp	-0.002	-0.002	0.000	-0.060**	-0.060**	-0.067	0.006	0.006	0.008
	(0.007)	(0.007)	(0.010)	(0.027)	(0.027)	(0.046)	(0.006)	(0.006)	(0.007)
EconComp	0.047	0.047	0.012	0.017	0.017	-0.015	0.062***	0.062***	0.044
	(0.030)	(0.030)	(0.031)	(0.074)	(0.074)	(0.090)	(0.024)	(0.024)	(0.027)
Constant	0.028***	0.028***	0.029***	0.028***	0.028***	0.031***	0.013***	0.013***	0.029***
	(0.005)	(0.005)	(0.003)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.003)
Country, sector, year FE	yes			yes			yes		
Country-sector, year FE		yes			yes			yes	
Country-year, sector FE			yes			yes			yes
Observations	3,506	3,506	3,506	1,278	1,278	1,278	1,640	1,640	1,640
R-squared	0.129	0.129	0.198	0.058	0.058	0.101	0.082	0.082	0.158

Note: The table shows the results of the fixed effects estimations for value added growth pooling all sectors NACE rev. 2 A-S). All variables are included in log-differences. Standard errors clustered at the country-sector level are included in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1 percent levels respectively.
Source: EU KLEMS Release 2019, own results.

Complementing aggregate country-level analysis, value added and labour productivity drivers are further assessed using a pooled sector-level sample: NACE rev.2 1-digit level sections A-S are pooled together to form a significantly more heterogeneous panel dataset. In order to address the associated technical challenges, the baseline specification is tested with varying combinations of dummy variables comprising the vector of fixed effects: (i) country, sector and year fixed effects; (ii) country*sector and year fixed effects and (iii) country*year and sector fixed effects. In addition to the full period spanning 2000-2017, the estimations are carried out for the pre-crisis and post-crisis periods. Regression results for value added and labour productivity are reported in Table 6 and Table 7 respectively.[40]

39 Only in pooled OLS estimations for labour productivity and value added growth tangible and intangible ICT aggregates remain marginally statistically significant. However, pooled OLS estimations do not control for cross-country unobserved heterogeneity and the results are thus not robust.

40 Additional results employing other estimators, decomposing labour services into hours worked and labour composition at the sectoral level, as well as the vector of detailed asset types are available on request from the authors. In order to address strong heterogeneity across country-sectors we also estimate the model with outliers (observations at the country-sector-year level for which value added growth and labour productivity growth exceeds 5 standard deviations

Table 7 / Estimation results for pooled sectors: labour productivity

Dependent variable:	2000-2017			2000-2006			2010-2017		
Labour productivity	1	2	3	4	5	6	7	8	9
Labour services	-0.400***	-0.400***	-0.371***	-0.405***	-0.405***	-0.358***	-0.448***	-0.448***	-0.436***
	(0.048)	(0.048)	(0.054)	(0.087)	(0.087)	(0.090)	(0.061)	(0.061)	(0.066)
ICT	0.000	0.000	-0.004	-0.010	-0.010	-0.021	0.001	0.001	-0.002
	(0.009)	(0.009)	(0.010)	(0.015)	(0.015)	(0.018)	(0.017)	(0.017)	(0.017)
NonICT	-0.029	-0.029	-0.034	0.036	0.036	-0.012	-0.018	-0.018	0.018
	(0.055)	(0.055)	(0.054)	(0.052)	(0.052)	(0.061)	(0.076)	(0.076)	(0.086)
SoftDB	0.007	0.007	0.006	0.006	0.006	0.006	0.004	0.004	0.001
	(0.005)	(0.005)	(0.007)	(0.013)	(0.013)	(0.014)	(0.007)	(0.007)	(0.007)
RD	0.010*	0.010*	0.011*	0.009	0.009	0.010	0.011	0.011	0.010
	(0.006)	(0.006)	(0.007)	(0.015)	(0.015)	(0.015)	(0.007)	(0.007)	(0.007)
OInnProp	0.002	0.002	0.003	-0.067***	-0.067***	-0.066*	0.006	0.006	0.006
	(0.006)	(0.006)	(0.009)	(0.023)	(0.023)	(0.039)	(0.006)	(0.006)	(0.007)
EconComp	0.015	0.015	-0.015	-0.056	-0.056	-0.090	0.053**	0.053**	0.034
	(0.027)	(0.027)	(0.031)	(0.074)	(0.074)	(0.090)	(0.021)	(0.021)	(0.024)
Constant	0.027***	0.027***	0.006*	0.031***	0.031***	0.030***	0.018***	0.018***	0.001
	(0.005)	(0.005)	(0.003)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Country, sector, year FE	yes			yes			yes		
Country-sector, year FE		yes			yes			yes	
Country-year, sector FE			yes			yes			yes
Observations	3,506	3,506	3,506	1,278	1,278	1,278	1,640	1,640	1,640
R-squared	0.131	0.131	0.186	0.075	0.075	0.124	0.200	0.200	0.249

Note: The table shows the results of the fixed effects estimations for labour productivity growth pooling all sectors NACE rev. 2 A-S). All variables are included in log-differences. Standard errors clustered at the country-sector level are included in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1 percent levels respectively.
Source: EU KLEMS Release 2019, own results.

The results differ in a number of ways from the aggregate country-level estimates, yet remain robust to the inclusion of alternative fixed effects vectors and are consistent with the results obtained for the manufacturing sector discussed above. While ICT capital does not manifest itself as a statistically significant factor in the pooled sectoral estimations, intangible R&D is statistically significant (at the 10% level) and the magnitude of 0.01 (for both labour productivity and value added growth results). At the same time, in the pre-crisis period other innovative property assets (OInnProp) contribute negatively to labour productivity and value added (for the full sample and post-crisis estimations it remains statistically insignificant). In the post-crisis period, the intangible economic competencies asset group (EconComp) gains statistical significance, confirming the findings from the aggregate country-level analysis.

Turning to the evidence from the fixed effects estimations based on pooled sectors grouped by market activity types — that is, distinguishing the “market economy”, which excludes public services (NACE sections O, P and Q), the “public services” sectors (NACE sections O, P, and Q) and the “business services” sectors (NACE sections J-N) — generally does not yield statistically significant results for the capital asset types (see Table 8). The notable exception is the public services sector group, for which a robust impact of tangible non-ICT capital and intangible R&D on labour productivity and value added growth is identified. In comparison with estimates for other sector groups, the magnitude of the non-ICT

from the respective sectoral period average) dropped from the sample, which however does not significantly alter the results.

capital effect is also relatively high (0.13 for labour productivity and 0.16 for value added), albeit statistically significant only at the 10-percent level. In contrast, the marginal effect of R&D capital is highly statistically significant, but small in magnitude (0.03).

Given that the sample of countries is relatively small, a range of further robustness checks were carried out in addition to the reported results. In particular, other periods were checked (for instance, post-2013 period instead of the reported post-2010 period, which also excludes the 'double-dip' recession in Europe that some countries experienced; this, however, comes at the expense of losing observations for an already small panel), sensitivity checks to sample composition and outliers (for instance, dropping observations with the growth rate above and below 5 standard deviation from the respective sectoral mean for the key variables of interest, depending on the specification — an issue particularly relevant for pooled sectoral estimations as some country-sectors exhibit high volatility in some variables, including labour productivity and value added growth) and consecutive inclusion of capital asset types to counteract possible mutual influences.

Table 8 / Estimation results for pooled sectors by activity type

Dep. variable:	Value added				Labour productivity			
NACE sections:	all sectors A-S	market economy A-S ex. O,P,Q	business services J-N	public services O,P,Q	all sectors A-S	market economy A-S ex. O,P,Q	business services J-N	public services O,P,Q
	1	2	3	4	5	6	7	8
Labour services	0.185***	0.189***	0.027	0.133*	-0.400***	-0.406***	-0.478***	-0.323***
	(0.038)	(0.040)	(0.041)	(0.072)	(0.048)	(0.050)	(0.086)	(0.110)
ICT	0.011	0.008	-0.010	0.017	0.000	-0.002	-0.014	0.014
	(0.009)	(0.010)	(0.013)	(0.011)	(0.009)	(0.010)	(0.012)	(0.010)
NonICT	-0.029	-0.048	0.032	0.159*	-0.029	-0.039	0.016	0.129*
	(0.055)	(0.063)	(0.111)	(0.090)	(0.055)	(0.062)	(0.100)	(0.068)
SoftDB	0.008*	0.007	-0.001	-0.000	0.007	0.006	-0.000	-0.002
	(0.005)	(0.005)	(0.008)	(0.013)	(0.005)	(0.006)	(0.012)	(0.012)
RD	0.010*	0.008	0.017	0.032***	0.010*	0.009	0.019	0.033***
	(0.005)	(0.005)	(0.013)	(0.011)	(0.006)	(0.006)	(0.013)	(0.008)
OInnProp	-0.002	-0.003	-0.004	0.005	0.002	0.004	0.003	-0.008
	(0.007)	(0.008)	(0.009)	(0.016)	(0.006)	(0.007)	(0.007)	(0.018)
EconComp	0.047	0.042	0.078*	0.036	0.015	0.013	0.037	0.009
	(0.030)	(0.032)	(0.043)	(0.031)	(0.027)	(0.029)	(0.051)	(0.029)
Constant	0.028***	0.033***	0.053***	0.008**	0.027***	0.029***	0.033***	0.014***
	(0.005)	(0.006)	(0.008)	(0.004)	(0.005)	(0.006)	(0.010)	(0.004)
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	3,506	2,881	835	625	3,506	2,881	835	625
R-squared	0.129	0.149	0.135	0.155	0.131	0.140	0.173	0.215

Note: The table shows the results of fixed effects estimations based on the full panel data sample for value added and labour productivity growth. The columns indicate estimates: pooling all sectors (NACE rev. 2 sections A-S), market economy (all sections excluding public services sectors O-Q), business services (J-N) and public services (O-Q). All variables are included in log-differences. Standard errors clustered at the country-sector level are included in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1 percent levels respectively.
Source: EU KLEMS Release 2019, own results.

5. Conclusion

The paper introduces the key features of the new EU KLEMS 2019 Release and, based on the new data emphasises the economic role of ICT capital and intangibles assets using a growth accounting framework and an econometric analysis. The new approach delineating intangible assets and distinguishing simultaneously ICT and non-ICT capital allows one to understand better their significance for economic growth and productivity — in light of the fast-paced technological progress driving the world economy today and the differences between the pre-crisis and post-crisis economic stance. The latter is especially important taking into account the notable slowdown in the growth of value added and productivity, including labour productivity and TFP as also documented in the study.

Results of the growth accounting analysis suggests a general slowdown of value added and productivity growth after the financial crisis; only Japan weathered the crisis better, but started from much lower growth rates. Contributions of total factor productivity (TFP) growth and other capital asset types diminished (particularly tangible ICT and intangible assets like software and databases). The contributions to growth of intangibles outside the boundaries of national accounts (innovative properties, economic competencies) have been more resilient to the crisis. Consequently, these have become more prominent in their contributions to overall growth rates. However, overall growth contributions of the 'classical inputs' like TFP, labour and its composition, and tangible capital still account for the predominant sources of growth. Cross-country comparisons reveal that the European growth performance has been to a much lower extent driven by investments in tangible ICT assets (hardware for information and communication technologies) and intangible ICT assets (software and databases), as well as R&D (which a particularly strong difference in the manufacturing industry). However, there is strong evidence that contributions of these asset types have strongly declined in Japan and the US in recent years. Finally, the results document that the growth slowdown has been more pronounced in the goods producing industries, whereas services industries have been less affected by the crisis or even shows slightly better performance. However, this does not compensate to circumvent the overall growth and productivity slowdown.

Based on the new data at aggregate and sectoral levels for European countries, the USA and Japan, the econometric estimations confirm the importance of ICT capital and intangibles concerning economic competencies (specifically, advertising and market research assets) as drivers of output and labour productivity growth. Notably, the impact of economic competencies intangibles remains significant in the post-crisis period. R&D capital is found to be an important factor facilitating growth and productivity in manufacturing sectors. Therefore, the results highlight the importance of economic policies facilitating accumulation of intangible assets and ICT capital as integral elements of productivity and competitiveness.

While the present study provides an initial analysis of the relationship between economic outcomes and capital stock composition with an emphasis on intangibles and ICT assets, further work is needed to unravel specific effects for individual sectors as the impact is likely to differ across sectors. In this regard of particular interest is the analysis focussing on technologically intensive manufacturing and service sectors for which the implications of intangibles are likely to differ. From a policy perspective also of much interest is a deeper investigation into specific structural factors and economic policies that facilitate intangible capital formation and concentration in specific sectors and countries, and, as a closely related matter, the allocative efficiency of intangible ICT and non-ICT capital in a comparative perspective across sectors and countries.

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Appendix A - EU KLEMS Release 2019 industry list

Table A.1 / EU KLEMS Release 2019 industry list

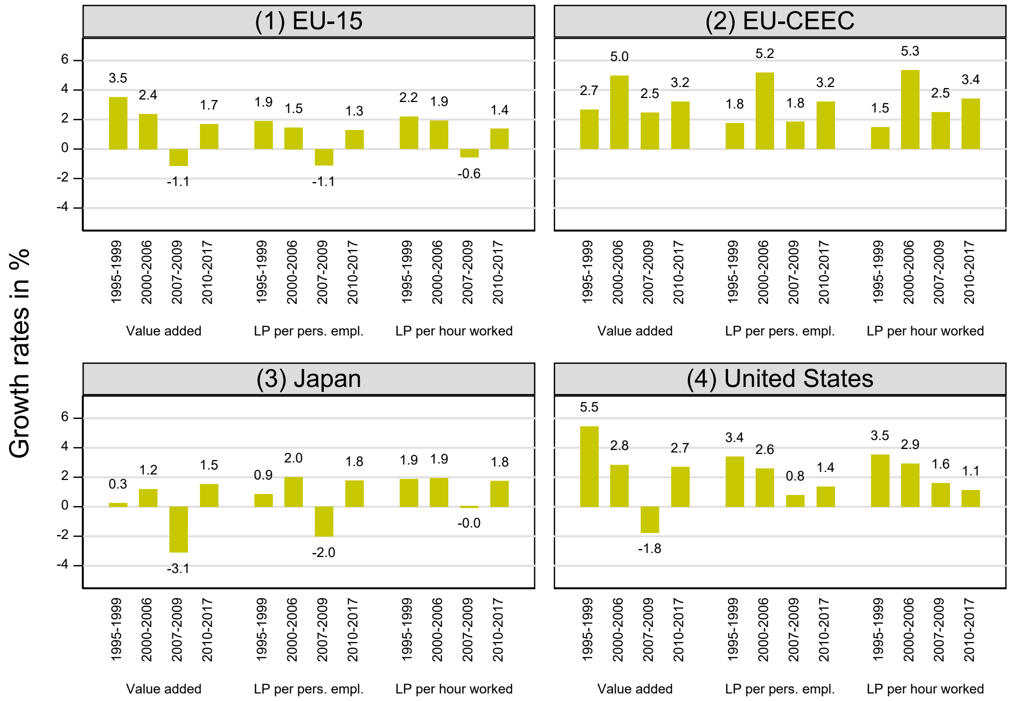
Sort_ID	IndNr	Code	Description
1	Agg	TOT	Total economy (A-U)
2	*Agg	TOT_IND	Total industries (A-S)
3	*Agg	MARKT	Market economy (all industries excluding L, O, P, Q, T and U)
4	1	A	Agriculture, forestry and fishing
5	2	B	Mining and quarrying
6	Agg	C	Total manufacturing
7	3	C10-C12	...Food products, beverages and tobacco
8	4	C13-C15	...Textiles, wearing apparel, leather and related products
9	5	C16-C18	...Wood and paper products; printing and reproduction of recorded media
10	6	C19	...Coke and refined petroleum products
11	7	C20	...Chemicals and chemical products
12	8	C21	...Basic pharmaceutical products and pharmaceutical preparations
13	9	C22_C23	...Rubber and plastics products, and other non-metallic mineral products
14	10	C24_C25	...Basic metals and fabricated metal products, except machinery and equipment
15	11	C26	...Computer, electronic and optical products
16	12	C27	...Electrical equipment
17	13	C28	...Machinery and equipment n.e.c.
18	14	C29_C30	...Transport equipment
19	15	C31-C33	...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	G45	...Wholesale and retail trade and repair of motor vehicles and motorcycles
25	20	G46	...Wholesale trade, except of motor vehicles and motorcycles
26	21	G47	...Retail trade, except of motor vehicles and motorcycles
27	Agg	H	Transportation and storage
28	22	H49	...Land transport and transport via pipelines
29	23	H50	...Water transport
30	24	H51	...Air transport
31	25	H52	...Warehousing and support activities for transportation
32	26	H53	...Postal and courier activities
33	27	I	Accommodation and food service activities
34	Agg	J	Information and communication
35	28	J58-J60	...Publishing, audio-visual and broadcasting activities
36	29	J61	...Telecommunications
37	30	J62_J63	...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: The industry list is based on the NACE Rev. 2/ISIC Rev. 4 economic activity classification; Agg denotes aggregates with more detailed subindustries; *Agg denotes aggregates not defined in National Accounts NACE Rev. 2 classification.
Source: EU KLEMS Release 2019.

Appendix B – Growth accounts for selected industry groups

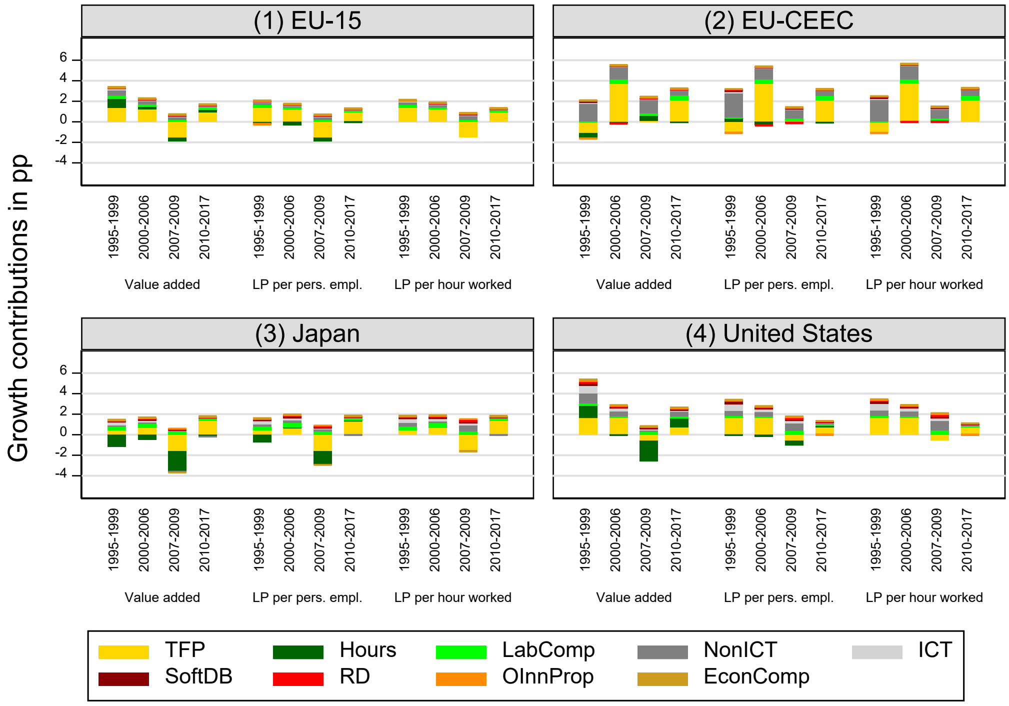
B.1 MARKET ECONOMY

Figure B.1.1 / Value added and labour productivity growth rates in %, market economy



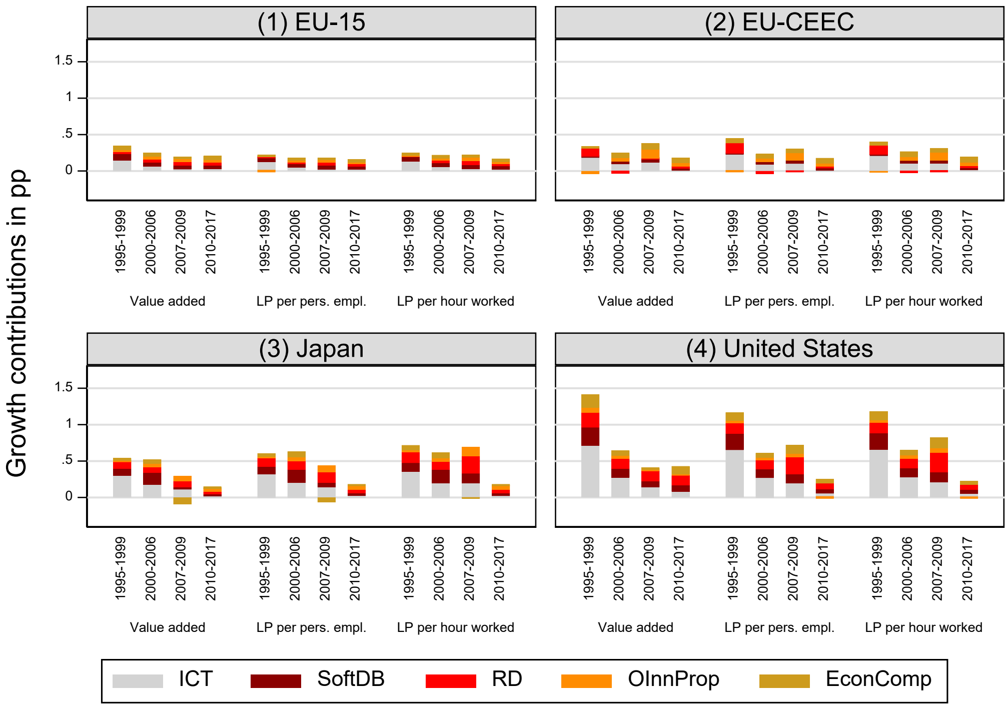
Source: EU KLEMS Release 2019 (Analytical Database).

Figure B.1.2 / Contribution to value added and labour productivity growth, market economy



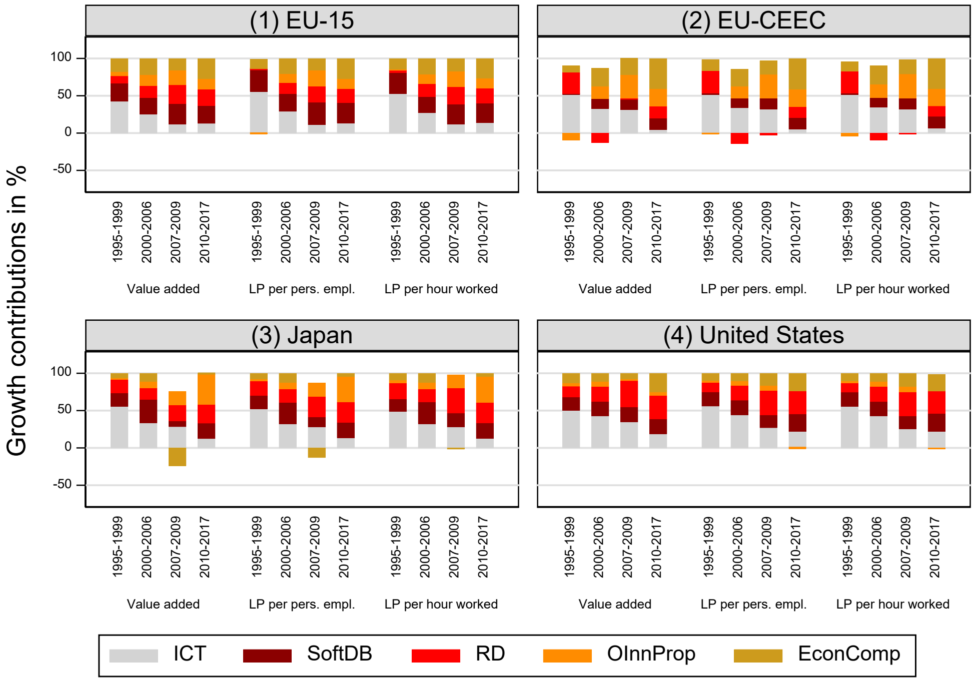
Source: EU KLEMS Release 2019 (Analytical Database).

Figure B.1.3 / Contributions of ICT and intangible assets to growth, market economy



Source: EU KLEMS Release 2019 (Analytical Database).

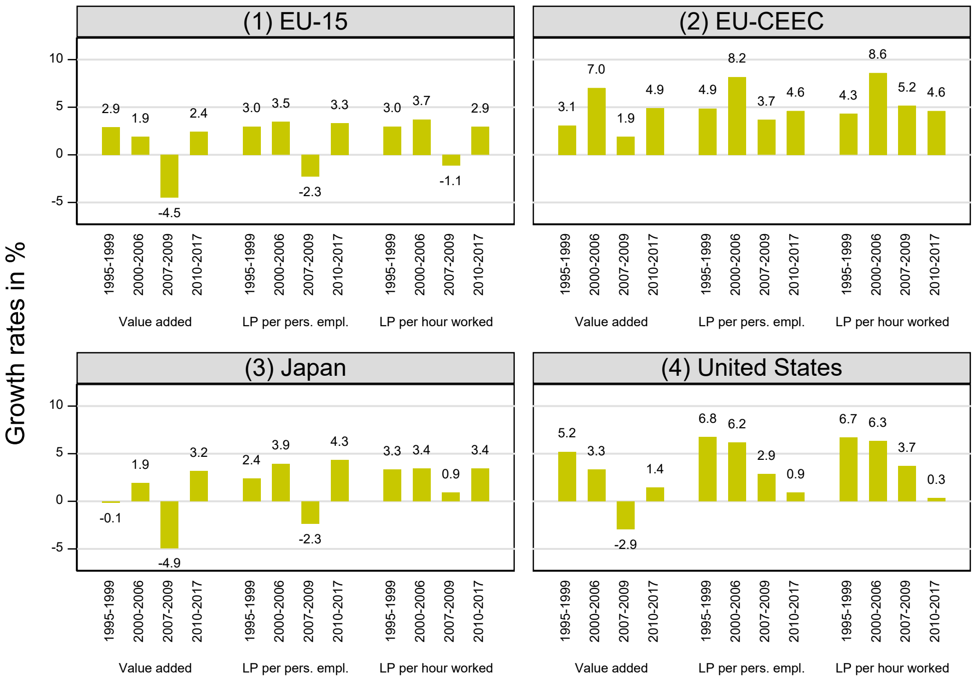
Figure B.1.4 / Structure of ICT and intangibles' growth contribution, market economy



Source: EU KLEMS Release 2019 (Analytical Database).

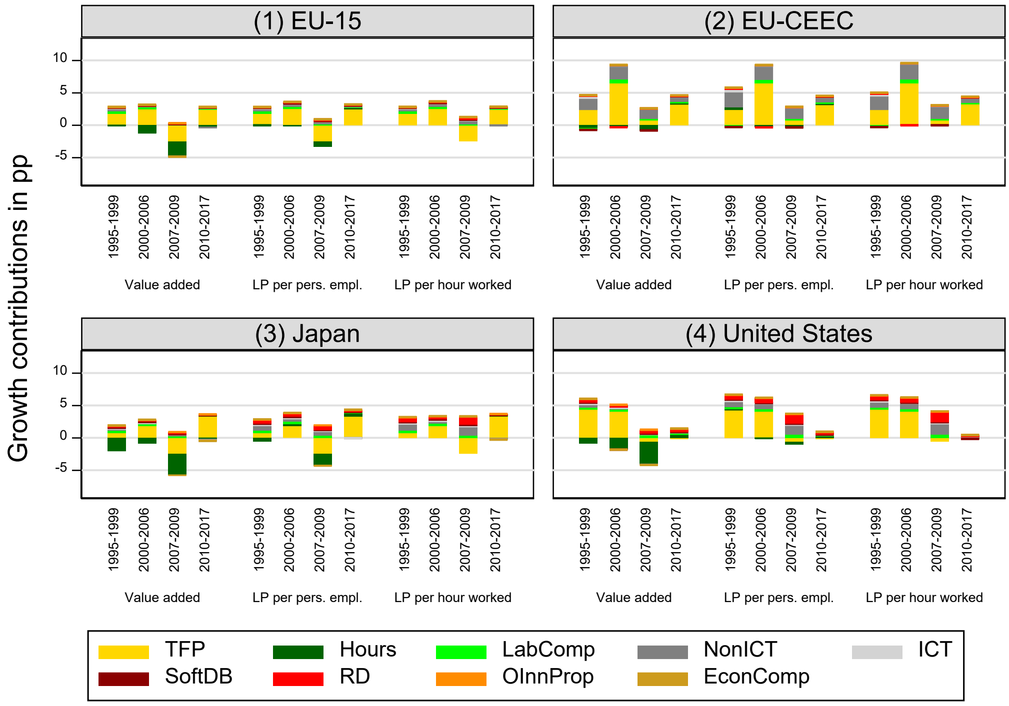
B.2 MANUFACTURING (C)

Figure B.2.1 / Value added and labour productivity growth rates in %, manufacturing



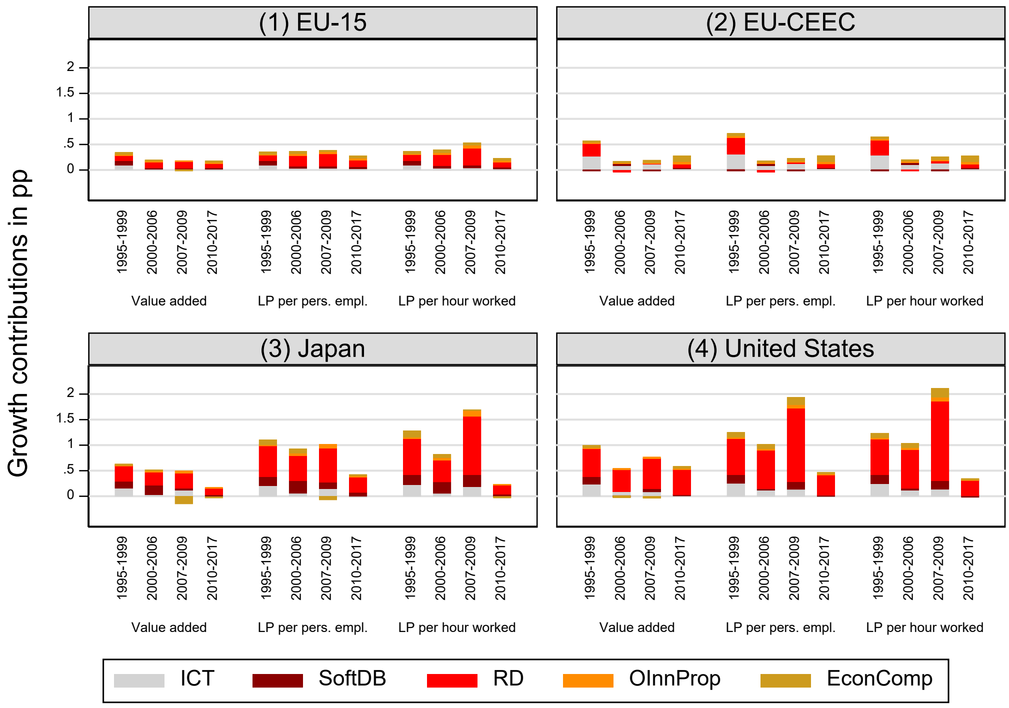
Source: EU KLEMS Release 2019 (Analytical Database).

Figure B.2.2 / Contributions to value added and labour productivity growth, manufacturing



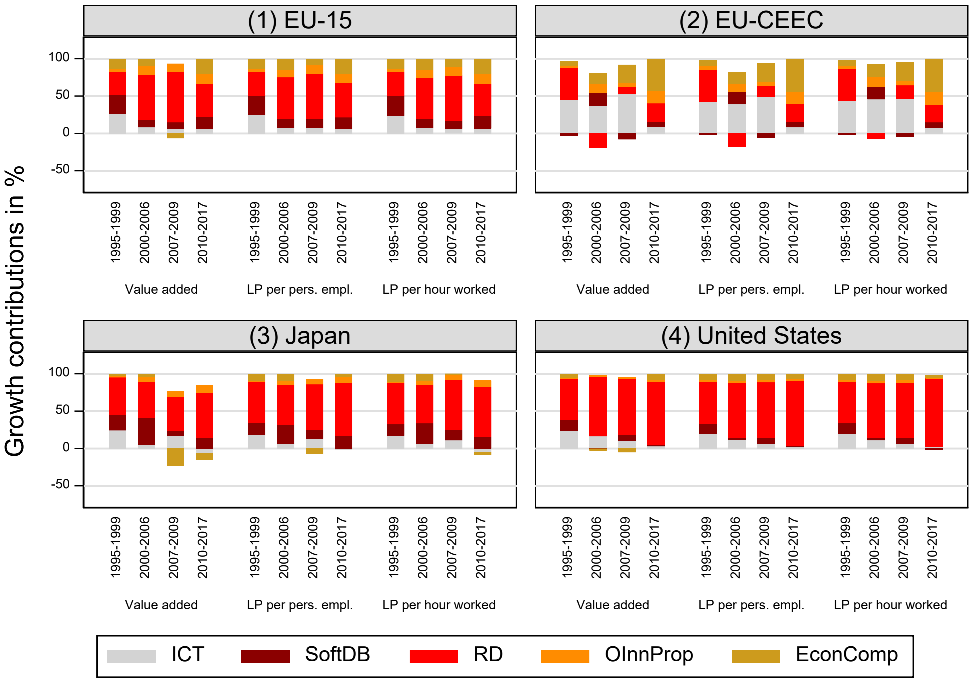
Source: EU KLEMS Release 2019 (Analytical Database).

Figure B.2.3 / Contributions of ICT and intangible assets to growth, manufacturing



Source: EU KLEMS Release 2019 (Analytical Database).

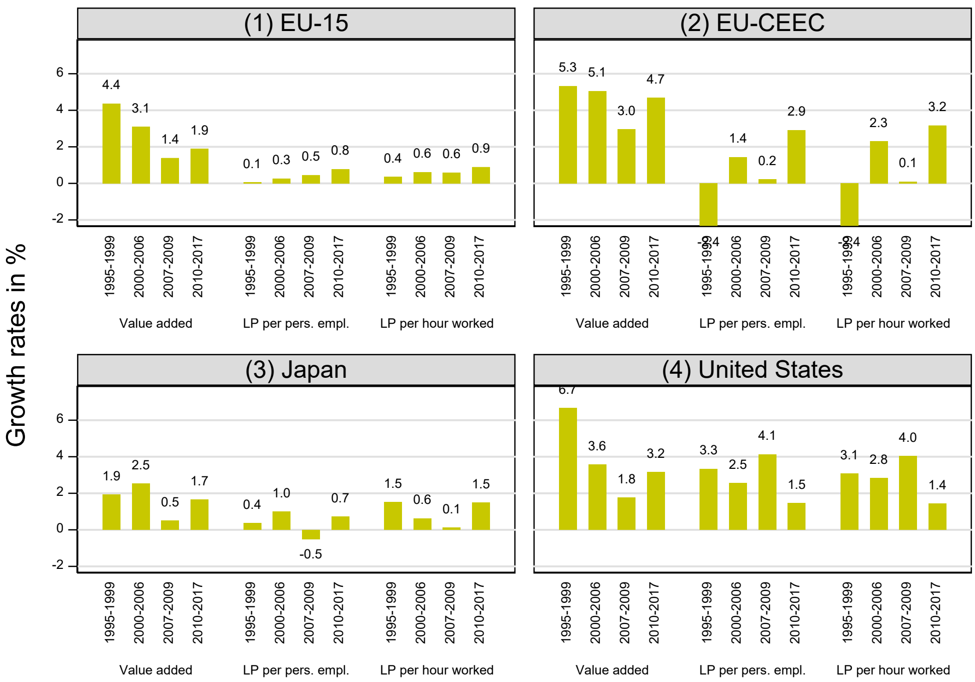
Figure B.2.4 / Structure of ICT and intangibles‘ growth contribution, manufacturing



Source: EU KLEMS Release 2019 (Analytical Database).

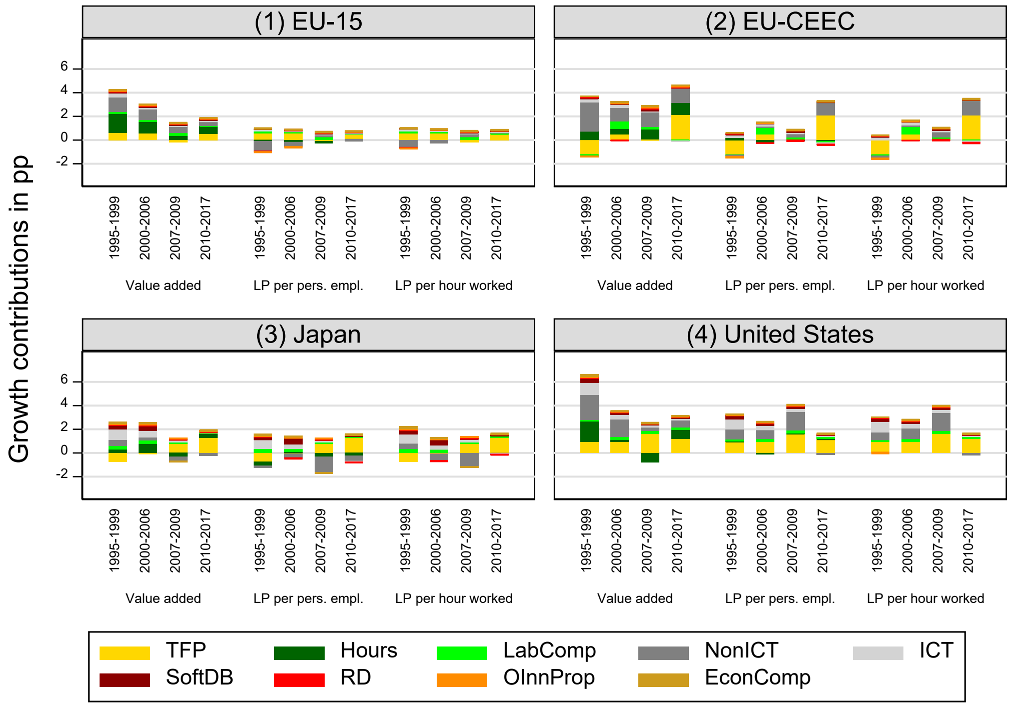
B.3 BUSINESS SERVICES

Figure B.3.1 / Value added and labour productivity growth rates in %, business services



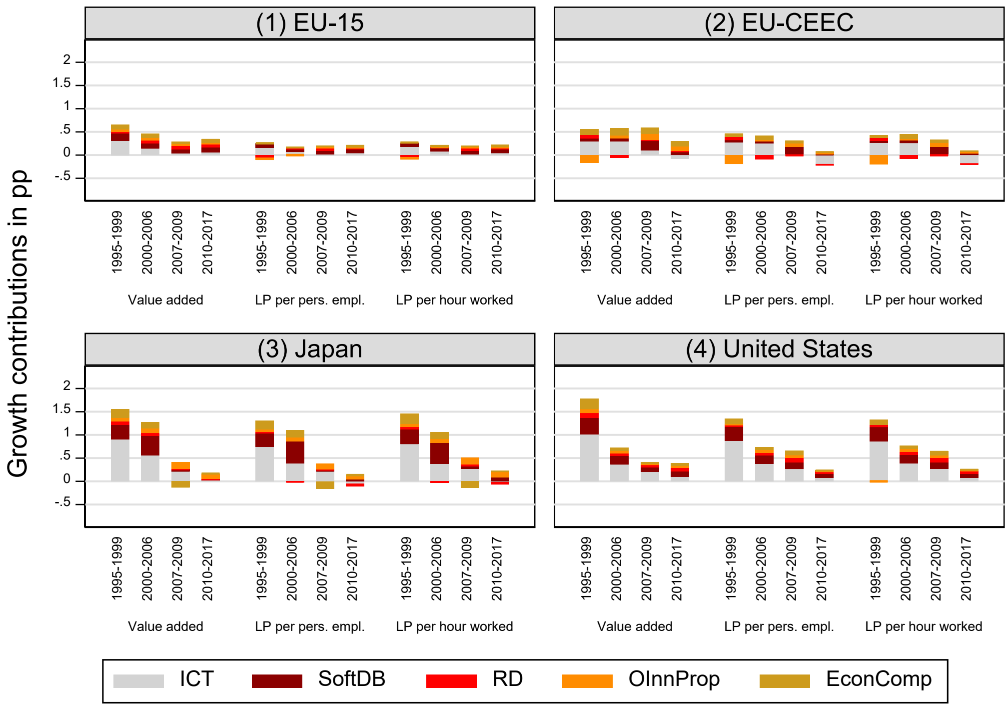
Source: EU KLEMS Release 2019 (Analytical Database).

Figure B.3.2 / Contributions to value added and labour productivity growth, business services



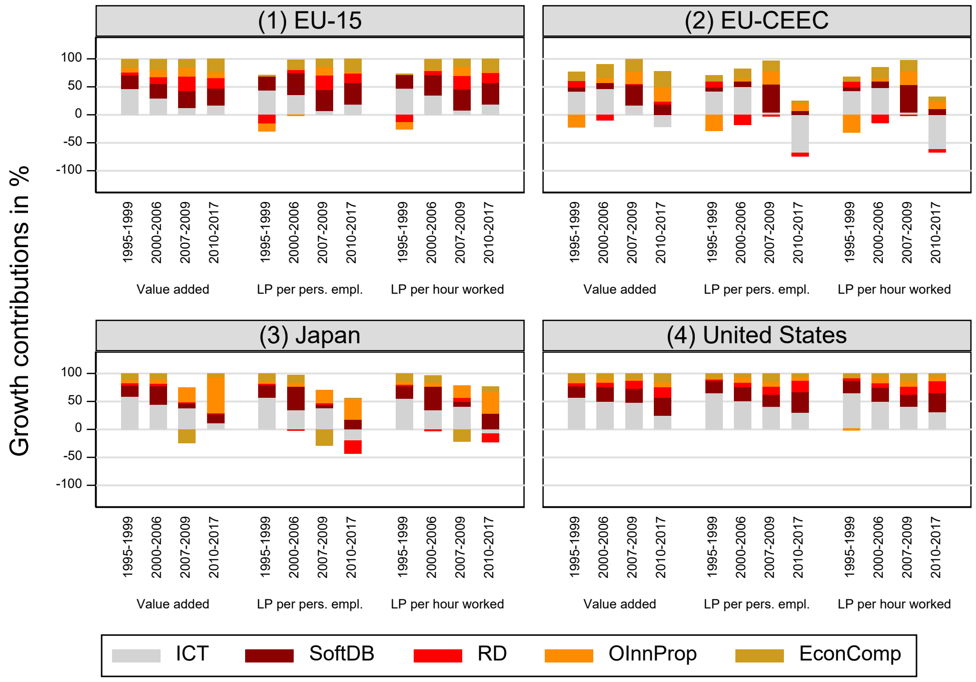
Source: EU KLEMS Release 2019 (Analytical Database).

Figure B.3.3 / Contributions of ICT and intangible assets to growth, business services



Source: EU KLEMS Release 2019 (Analytical Database).

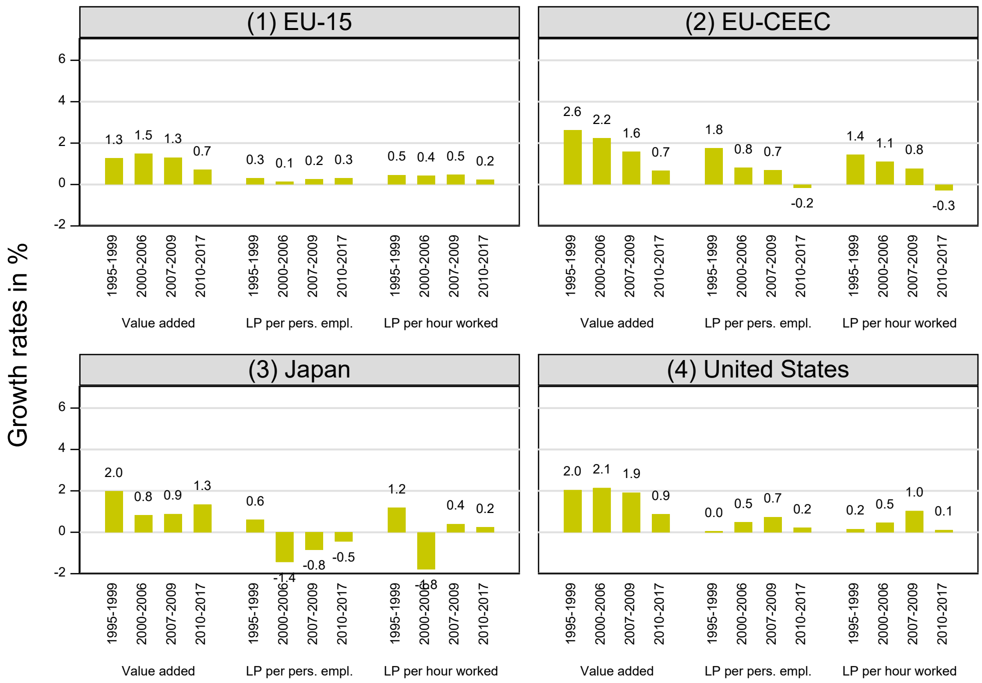
Figure B.3.4 / Structure of ICT and intangibles‘ growth contribution, business services



Source: EU KLEMS Release 2019 (Analytical Database).

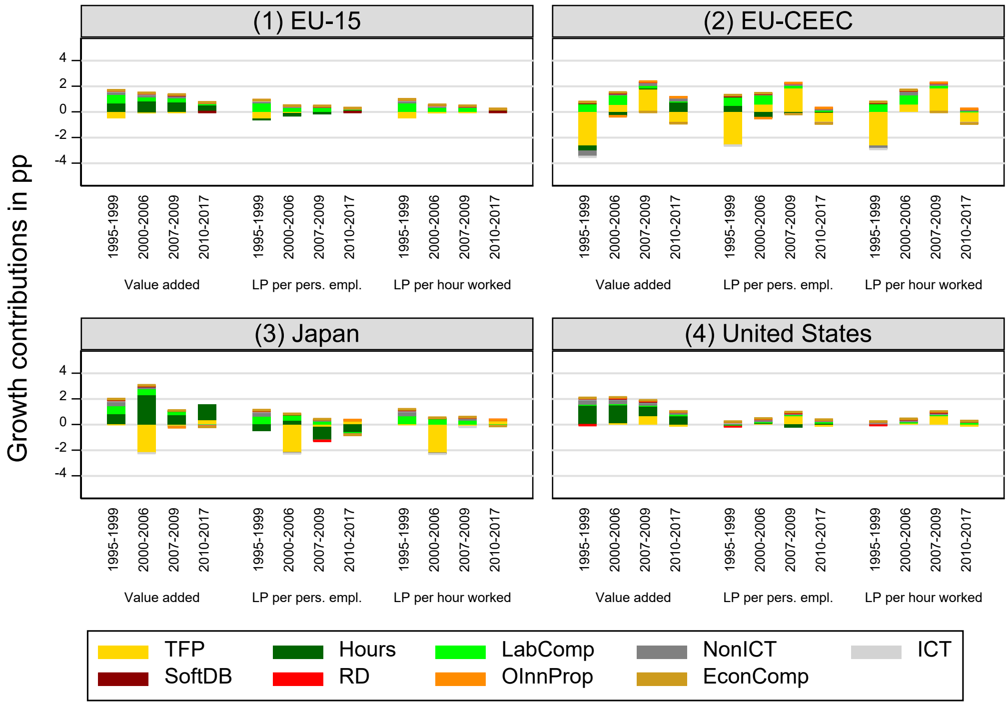
B.4 PUBLIC SERVICES

Figure B.4.1 / Value added and labour productivity growth rates in %, public services



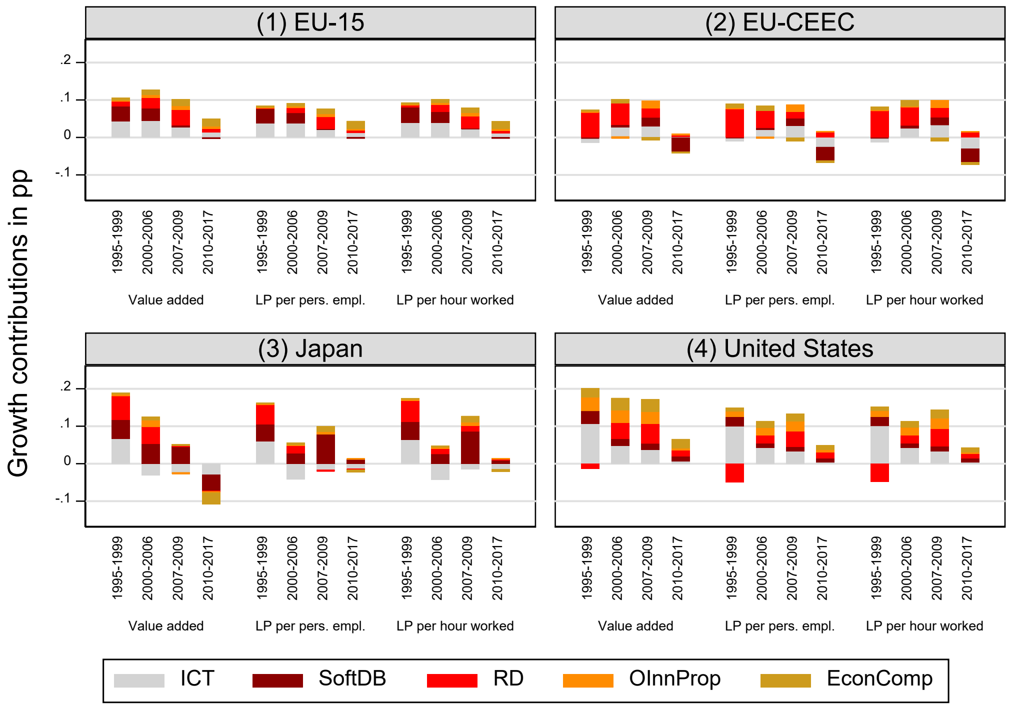
Source: EU KLEMS Release 2019 (Analytical Database).

Figure B.4.2 / Contributions to value added and labour productivity growth, public services



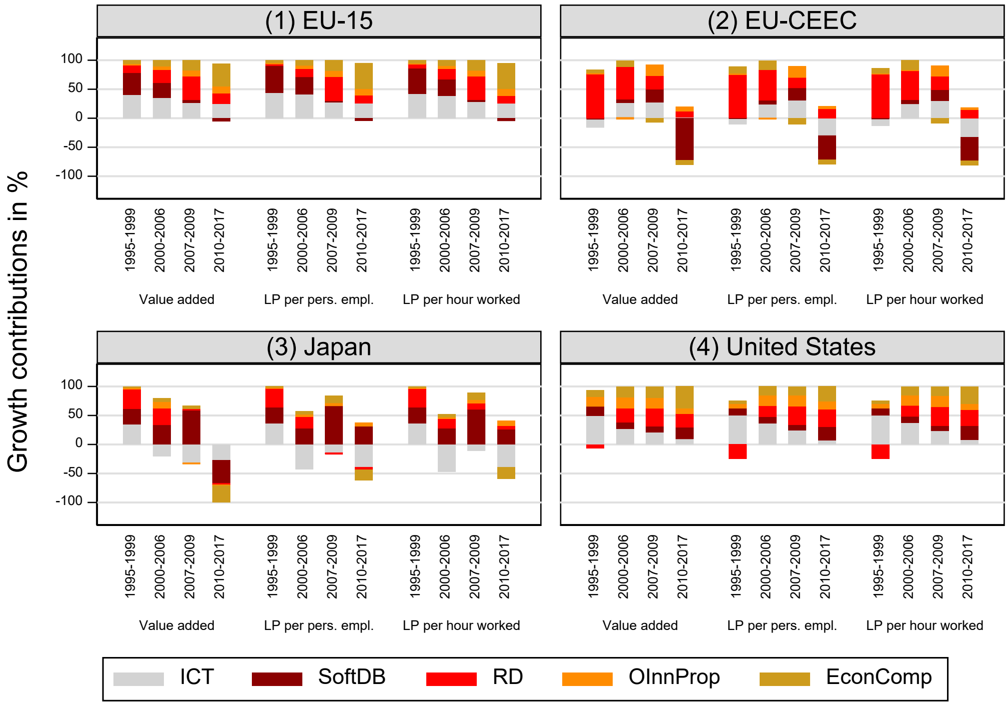
Source: EU KLEMS Release 2019 (Analytical Database).

Figure B.4.3 / Growth contributions of ICT and intangible assets, public services



Source: EU KLEMS Release 2019 (Analytical Database).

Figure B.4.4 / Structure of ICT and intangibles' growth contribution, public services



Source: EU KLEMS Release 2019 (Analytical Database).

Appendix C – Summary statistics and additional regression results

Table C.1 / Aggregate country analysis: estimation results for value added growth with detailed capital asset types

Dependent variable:	2000-2017						2000-2006	2010-2017
Labour productivity	FE	FE	POLS	POLS	System GMM	System GMM	FE	FE
	1	2	3	4	5	6	7	8
Labour services	0.521***		0.434***		0.559***		0.167**	0.555***
	(0.077)		(0.082)		(0.085)		(0.072)	(0.131)
Hours worked		0.581***		0.497***		0.607***		
		(0.078)		(0.103)		(0.086)		
Labour composition		-0.080		0.001		-0.226		
		(0.177)		(0.164)		(0.269)		
RStruc	-0.104	-0.151	-0.107	-0.163	-0.258*	-0.272*	0.427**	-0.291*
	(0.118)	(0.113)	(0.130)	(0.140)	(0.154)	(0.139)	(0.198)	(0.166)
OCon	-0.125	-0.143	-0.005	0.007	-0.074	-0.091	-0.082	0.074
	(0.149)	(0.143)	(0.158)	(0.159)	(0.138)	(0.139)	(0.092)	(0.118)
OMach	-0.020	-0.051	0.178**	0.157**	-0.058	-0.076*	-0.001	-0.101*
	(0.050)	(0.048)	(0.077)	(0.074)	(0.053)	(0.046)	(0.080)	(0.050)
TraEq	0.016	0.005	0.029	0.026	0.010	0.006	0.008	0.057
	(0.039)	(0.036)	(0.041)	(0.044)	(0.059)	(0.053)	(0.069)	(0.046)
IT	0.020	0.012	0.014	0.014	0.038**	0.022	0.002	0.024
	(0.015)	(0.013)	(0.016)	(0.015)	(0.017)	(0.015)	(0.012)	(0.018)
CT	0.034***	0.034***	0.036***	0.033***	0.034***	0.032***	-0.005	0.014
	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.022)	(0.008)
Cult	0.005	0.008	0.001	-0.000	-0.005	0.001	0.011	-0.021**
	(0.007)	(0.006)	(0.009)	(0.009)	(0.009)	(0.008)	(0.018)	(0.008)
RD	-0.006	-0.005	-0.031	-0.023	-0.012	-0.002	0.044	-0.015
	(0.038)	(0.036)	(0.037)	(0.035)	(0.032)	(0.031)	(0.067)	(0.040)
Soft_DB	0.004	0.003	0.008	0.009	0.004	0.004	0.017	0.002
	(0.005)	(0.005)	(0.007)	(0.007)	(0.005)	(0.005)	(0.015)	(0.006)
OIPP	0.009	0.007	0.027**	0.023**	0.008	0.005	-0.018*	-0.035
	(0.012)	(0.010)	(0.011)	(0.011)	(0.008)	(0.008)	(0.009)	(0.030)
AdvMRes	0.121***	0.098***	0.073**	0.057*	0.146***	0.122***	0.032	0.122**
	(0.029)	(0.029)	(0.030)	(0.032)	(0.042)	(0.038)	(0.050)	(0.047)
Design	-0.017	0.008	0.015	0.004	-0.053	-0.025	0.159	-0.079
	(0.076)	(0.077)	(0.064)	(0.061)	(0.095)	(0.087)	(0.100)	(0.125)
POCap	0.006	-0.009	0.028	0.033	0.009	0.004	0.031	-0.037
	(0.045)	(0.048)	(0.031)	(0.035)	(0.054)	(0.056)	(0.048)	(0.051)
VT	0.036*	0.025	0.029*	0.024	0.040***	0.032**	0.023	0.041***
	(0.017)	(0.015)	(0.014)	(0.015)	(0.015)	(0.013)	(0.040)	(0.014)
Value added, lag					0.085	0.044		
					(0.085)	(0.087)		
Constant	0.021***	0.032***	0.015***	0.021***	-0.004	0.002	0.021***	0.025***
	(0.004)	(0.005)	(0.004)	(0.004)	(0.006)	(0.006)	(0.005)	(0.003)
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	335	335	335	335	320	320	111	169
R-squared	0.779	0.797	0.746	0.759			0.744	0.600

Note: All variables are included in log-differences. Standard errors clustered by country are included in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1 percent levels respectively.
Source: EU KLEMS Release 2019, own results.

Table C.2 / Aggregate country analysis: estimation results for labour productivity growth with detailed capital asset types

Dependent variable:	2000-2017						2000-2006	2010-2017
Labour productivity	FE	FE	POLS	POLS	System GMM	System GMM	FE	FE
	1	2	3	4	5	6	7	8
Labour services	-0.388***		-0.440***		-0.388***		-0.456***	-0.456***
	(0.078)		(0.109)		(0.072)		(0.081)	(0.135)
Hours worked		-0.419***		-0.213**		-0.403***		
		(0.078)		(0.092)		(0.071)		
Labour composition		-0.080		0.157		-0.168		
		(0.177)		(0.192)		(0.219)		
RStruc	-0.175	-0.151	-0.219	-0.112	-0.335**	-0.329**	0.394	-0.234
	(0.111)	(0.113)	(0.128)	(0.173)	(0.141)	(0.146)	(0.263)	(0.145)
OCon	-0.152	-0.143	0.019	-0.140	-0.128	-0.132	-0.063	0.058
	(0.142)	(0.143)	(0.158)	(0.129)	(0.147)	(0.146)	(0.116)	(0.107)
OMach	-0.067	-0.051	0.135*	0.111	-0.051	-0.048	-0.113	-0.125**
	(0.046)	(0.048)	(0.078)	(0.098)	(0.055)	(0.054)	(0.067)	(0.051)
TraEq	-0.000	0.005	0.023	0.035	0.003	0.007	-0.026	0.029
	(0.036)	(0.036)	(0.048)	(0.048)	(0.044)	(0.045)	(0.077)	(0.043)
IT	0.008	0.012	0.014	0.027	0.016	0.019	-0.009	0.015
	(0.013)	(0.013)	(0.015)	(0.019)	(0.018)	(0.017)	(0.011)	(0.017)
CT	0.033***	0.034***	0.030***	0.038***	0.030***	0.031***	0.027	0.016*
	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.025)	(0.008)
Cult	0.009	0.008	-0.001	-0.005	-0.004	-0.005	0.037	-0.014*
	(0.007)	(0.006)	(0.009)	(0.010)	(0.007)	(0.006)	(0.024)	(0.007)
RD	-0.005	-0.005	-0.014	-0.016	-0.016	-0.018	0.024	-0.010
	(0.036)	(0.036)	(0.034)	(0.032)	(0.027)	(0.028)	(0.056)	(0.041)
Soft_DB	0.003	0.003	0.010	0.016**	0.001	0.002	0.018	-0.000
	(0.004)	(0.005)	(0.008)	(0.006)	(0.005)	(0.005)	(0.015)	(0.005)
OIPP	0.005	0.007	0.019	0.021	0.018*	0.019*	-0.013	-0.039
	(0.010)	(0.010)	(0.012)	(0.016)	(0.010)	(0.010)	(0.009)	(0.025)
AdvMRes	0.086**	0.098***	0.040	0.133***	0.108***	0.115***	-0.066	0.106**
	(0.034)	(0.029)	(0.035)	(0.038)	(0.025)	(0.025)	(0.053)	(0.041)
Design	0.020	0.008	-0.006	-0.163**	0.061	0.048	0.256**	-0.019
	(0.085)	(0.077)	(0.062)	(0.059)	(0.078)	(0.077)	(0.105)	(0.119)
POCap	-0.016	-0.009	0.039	0.030	-0.013	-0.010	0.074	-0.044
	(0.052)	(0.048)	(0.038)	(0.048)	(0.050)	(0.048)	(0.070)	(0.056)
VT	0.020	0.025	0.019	0.016	0.038***	0.040***	-0.044	0.029**
	(0.014)	(0.015)	(0.015)	(0.020)	(0.013)	(0.013)	(0.049)	(0.013)
Labour productivity, lag					0.095	0.098		
					(0.084)	(0.086)		
Constant	0.038***	0.032***	0.028***	0.013***	0.001	0.000	0.029***	0.031***
	(0.005)	(0.005)	(0.005)	(0.003)	(0.005)	(0.005)	(0.006)	(0.003)
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	335	335	335	335	320	320	111	169
R-squared	0.517	0.528	0.437	0.158			0.519	0.526

Note: All variables are included in log-differences. Standard errors clustered by country are included in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1 percent levels respectively.
Source: EU KLEMS Release 2019, own results.

Table C.3 / Summary statistics

	obs.	mean	median	std. dev.	min	max
Labour productivity	335	0.0142	0.0128	0.0213	-0.0926	0.1102
Value added	335	0.0153	0.0185	0.0317	-0.1669	0.1055
Labour services	335	0.0069	0.0103	0.0222	-0.1666	0.0673
Hours worked	335	0.0011	0.0057	0.0239	-0.1801	0.0469
Labour composition	335	0.0059	0.0044	0.0083	-0.0206	0.0569
ICT	335	0.0462	0.0496	0.0735	-0.6134	0.4054
NonICT	335	0.0127	0.0126	0.0137	-0.0367	0.0795
SoftDB	335	0.0487	0.0425	0.1412	-0.7904	1.9424
RD	335	0.0257	0.0232	0.0397	-0.1637	0.2719
OInnProp	335	0.0226	0.0259	0.0334	-0.1089	0.1635
EconComp	335	0.0173	0.0204	0.0438	-0.1382	0.3177
RStruc	335	0.0104	0.0120	0.0153	-0.0482	0.0806
OCon	335	0.0119	0.0116	0.0175	-0.0823	0.1471
OMach	335	0.0136	0.0140	0.0273	-0.1844	0.1104
TraEq	335	0.0183	0.0195	0.0450	-0.1408	0.2524
IT	335	0.0505	0.0520	0.0811	-0.2585	0.2638
CT	335	0.0398	0.0386	0.0952	-1.0460	0.8528
Cult	335	0.0078	-0.0021	0.1339	-0.4363	1.8216
RD	335	0.0257	0.0232	0.0397	-0.1637	0.2719
Soft_DB	335	0.0487	0.0425	0.1412	-0.7904	1.9424
OIPP	335	0.0092	0.0002	0.0786	-0.2144	0.7618
AdvMRes	335	0.0128	0.0179	0.0500	-0.2423	0.2833
Design	335	0.0259	0.0275	0.0294	-0.0783	0.1612
POCap	335	0.0268	0.0298	0.0500	-0.1315	0.3983
VT	335	-0.0019	0.0035	0.0702	-0.5108	0.4647

Note: The table shows descriptive statistics for aggregate country-level variables for the effective panel data sample used in estimations. The variables are expressed in log-differenced form. Summary statistics for individual sectors and the full sample (database) are available on request from the authors.
Source: EU KLEMS Release 2019, own results.

IMPRESSUM

Herausgeber, Verleger, Eigentümer und Hersteller:
Verein „Wiener Institut für Internationale Wirtschaftsvergleiche“ (wiiw),
Wien 6, Rahlgasse 3

ZVR-Zahl: 329995655

Postanschrift: A 1060 Wien, Rahlgasse 3, Tel: [+431] 533 66 10, Telefax: [+431] 533 66 10 50
Internet Homepage: www.wiiw.ac.at

Offenlegung nach § 25 Mediengesetz: Medieninhaber (Verleger): Verein "Wiener Institut für Internationale Wirtschaftsvergleiche", A 1060 Wien, Rahlgasse 3. Vereinszweck: Analyse der wirtschaftlichen Entwicklung der zentral- und osteuropäischen Länder sowie anderer Transformationswirtschaften sowohl mittels empirischer als auch theoretischer Studien und ihre Veröffentlichung; Erbringung von Beratungsleistungen für Regierungs- und Verwaltungsstellen, Firmen und Institutionen.

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