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Productivity performance of high- and low-skill intensive industries before and after the crisis in Europe, Japan, Russia and the US

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Abstract

In this paper we explore the differentiated patterns of value added and productivity growth performance (both labour and total factor productivity growth) in four large economies – EU, Japan, Russia and the US – and document the patterns of the widely recognized productivity slowdown (specifically in the period after the global financial crisis). Doing so, we analyse the changes in the various contributions of input factors (hours worked, labour composition, ICT and non-ICT capital) and total factor productivity (TFP) differentiating between high- and low-skill intensive industries. For this exercise we make use of the recent release of Russia KLEMS and the (preliminary results) of the EU KLEMS Release 2019. The descriptive results of this paper enrich the literature on the global productivity slowdown to the most recent years and highlight differences across economies and industries as a base for further analysis. We find that that in all four economies TFP slowdown was particularly biased towards the low-skill intensive industries. The thus increasing role of high-skill intensive sectors in the post-crisis TFP growth performance is a new phenomenon, which deserves more attention. At the same time, the aggregate TFP slowdown continues after the crisis (Japan is an exception). The positive impact of high- skill intensive sector is not strong enough to circumvent an overall productivity slowdown of the low-skill intensive industries. The structural change effect towards a higher share of the skill-intensive industries is negligible and thus not contributing to the overall post crisis performance.

JEL-classification: C14, O47, O57.

Keywords: global productivity slowdown, industry growth accounting, skills intensive industries.

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1. Introduction

Growth rates and productivity performance have markedly changed after the global economy has been hit by the global financial crisis in 2008. It is now widely acknowledged that growth rates – of value added and labour productivity – have been slower in the years after the crisis compared to the pre-crisis performance. At the same time, total factor productivity slowdown started in mid-2000s, or well before the crisis (see, e.g., McGowan et.al. 2015 for OECD countries and Voskoboynikov 2017 for Russia). So, the impact of the global financial crisis on TFP performance remains questionable, mostly due to data shortages and short time series available (for a recent contribution see e.g. Fernald and Inklaar, 2018) or the impact of the crisis on the sectors differentiated by various characteristics.

In this respect, the role of skills in industry and country performance is high on the agenda. Among other causes, McGowan at al. (2015, 24) argue that the slowdown of human capital accumulation and the following shrinkage of the contribution of labour composition in many OECD countries, starting from 2000, led to a productivity slowdown in the longer period.

Skill level of the workforce impact on labour productivity growth not only directly, but also because of higher capacity of a qualified worker to adapt new technologies. This assumes that the shortage of human capital is expected to show up not only in labour composition, but also in the slowdown of total factor productivity (TFP). Further, the impact of worsening of skills allocation can be different for high and low-skills intensive industries, as it was found, e.g., by Conti and Sulis (2016) for OECD economies in 1970-2005 on the basis of EU KLEMS dataset. Focusing on employment protection legislation in EU-14, Conti and Sulis (2016) found that TFP growth rates differentials between high and low human capital intensive sectors is greater in countries with low employment protection legislation, because technology adaption depends on (i) the skills level of work force and on (ii) the capacity of firms to adjust employment as technology changes.

Against this backdrop, this paper aims to draw a picture of the changing levels and patterns of the growth and productivity performance and their underlying factors before and after the crisis distinguishing between high- and low-skill intensive industries. Dealing with this question we combine data for three big OECD economies – EU-10[1], Japan and US- and Russia, using the recently developed EU KLEMS Release 2019 and Russia KLEMS datasets. We split each economy into high-skill and low-skill intensive sectors and consider two periods before (2002-2007) and after (2011-2016) the most severe years of the global financial crisis. For an EU-10 aggregate and the United States we

[1] The EU-10 aggregate in this paper refers the VA weighted average of 10 EU countries (Austria, Czech Republic, Finland, France, Germany, Italy, Netherlands, Spain, Sweden, and the United Kingdom) where we have growth accounting results from 1996-2017. Exceptions are Spain and Sweden where growth accounts are not available in 2017 due to data constraints.

even look at the average 2016-2017 where possible to better understand how output growth is made up in more recent years.

We find that in all four economies before the crisis, the low-skill intensive industries demonstrate higher TFP growth, whereas after the crisis TFP growth in these generally declined while TFP growth in the high-skill intensive industries picked up. However, the latter effects have not been strong enough to compensate the decline of TFP growth in the low-skill intensive industries.

The remainder of this paper is organized as follows. Section 2 provides the general methodological framework before Section 3 addresses the labour productivity slowdown by looking at employment and productivity growth in low and high-skill intensive sectors in all four economies. We present the latest growth accounting results in Section 3. Here we decompose the growth of value added in the periods 2002-2007 and 2011-2016 into the contributions from various sources of growth, including total hours worked and labour composition (i.e., gender, age and skill mix), ICT capital input, non-ICT capital, and the efficiency by which these inputs are used, which is called multifactor productivity. Finally, Section 4 discusses structural changes and TFP slowdown before we conclude in Section 5.

2. Approach and data

In this section the standard growth accounting approach is introduced, including a discussion of the intended treatment of intangible assets in the framework. This follows the standard framework as outlined in Jorgensen et al (2005) and Timmer et al. (2010) and therefore kept short.

2.1 General framework of production and TFP growth

The general value added production function is given by

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

where j denotes the industry, Y_j is the measure of (real) value added, and the inputs for production are labour services L_j and the capital services K_j. T_j denotes the (unobserved) level of technology (total factor productivity). The factor inputs are broken down into several categories as discussed above, i.e. labour into educational attainment levels, age, and gender, and capital into asset types (e.g. ICT and non-ICT capital). As usual, the assumptions in this approach are that (i) product and factor markets are competitive (prices equal marginal costs, factor prices equal marginal product), (ii) inputs are fully utilized (basically due to data constraints) and (iii) production is characterized by constant returns to scale. Assuming a translog functional form of the production function total factor productivity growth is (see Jorgensen et al, 2005)

$$\Delta \ln T_{VA,j} \equiv \Delta \ln V_j - \bar{v}_{K,j} \Delta \ln K_j - \bar{v}_{L,j} \Delta \ln L_j \qquad (1)$$

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

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. In the next section we discuss the calculation of the labour and capital services growth rates in detail.

2.2 Labour services growth

Labour input of type l in industry j is measured in hours worked denoted by $H_{l,j}$[2] The measure of (log) growth rate of labour input in industry j, $\Delta \ln L_j$, is a Törnqvist volume index of the growth of hours worked of type l weighted by its nominal input shares which is referred to as 'labour services'. Formally this is specified as

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

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

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

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

The levels of hours worked in each industry j, i.e. H_j, are broken down into the respective labour types differentiating gender, three age and three educational attainment categories. The number of hours worked in industry j is then the sum of the number of hours worked over labour types l, i.e. $\sum_l H_{l,j} = H_j$.

To calculate the nominal costs shares data on (hourly) wages of the respective labour types for each industry, denoted by $p_{L,l,j}$, i.e. the price of labour of type l in industry j is needed This allows calculating the respective nominal factor income shares $v_{L,l,j}$ stated in equation (3). 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 (2) above.

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

The evolution of the Törnqvist volume index for labour services is then broken down into a labour composition effect, and the change in hours worked effect as follows:

$$\begin{aligned}\Delta \ln L_j &= \sum\nolimits_k \bar{v}_{L,k,j} \Delta \ln H_{k,j} - \Delta \ln H_j + \Delta \ln H_j \\ &= \left(\sum\nolimits_k \bar{v}_{L,k,j} \Delta \ln H_{k,j} - \sum\nolimits_k \bar{v}_{L,k,j} \Delta \ln H_j\right) + \Delta \ln H_j \\ &= \sum\nolimits_l \bar{v}_{L,k,j} \Delta \ln \frac{H_{k,j}}{H_j} + \Delta \ln H_j\end{aligned}$$

resulting in

$$\Delta \ln L_j = \Delta \ln LC_j + \Delta \ln H_j \qquad (4)$$

The first term on the right hand side shows the growth contribution of the composition effect to labour services growth, the second the contribution of changes in hours worked.

2.3 Capital services growth

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

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

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

To calculate the user costs of capital (or the price of capital services or 'rental price') for each asset type the 'user-cost of capital approach' is applied assuming a geometric depreciation profile as outlined in Jorgenson et al. (2005). This is the price at which the investor is indifferent between buying and renting the capital good for one year. The calculation of this requires data on price deflators of gross fixed capital formation by asset type and industry and capital stocks in chain-linked volumes and depreciation rates by asset type and industry to calculate the nominal rate of return for each industry.

In the underlying EU KLEMS database, ten asset types are distinguished which are Törnqvist - aggregated to ICT (computing equipment, communications equipment, and software and databases) and non-ICT capital (residential buildings, other construction, transport equipment, other machinery, R&D, cultivated assets, and other intellectual property products).

2.4 Growth accounting

Having calculated growth rates of ICT and non-ICT capital and labour services (the latter split into the labour composition and hours worked growth), real value added growth is given by

$$\Delta \ln V_j \equiv \bar{v}_{K,j} \sum_{k=ICT,NonICT} \bar{v}_{k,j} \Delta \ln K_{k,j} + \bar{v}_{L,j} \left(\Delta \ln LC_j + \Delta \ln H_j \right) + \Delta \ln T_j \quad (6)$$

where $\Delta \ln T_j$ denotes TFP growth. In practice, this equation is used to calculate TFP growth, $\Delta \ln T_j$, as a residual, i.e.

$$\Delta \ln T_j = \Delta \ln V_j - \bar{v}_{K,j} \sum_{k=ICT,NonICT} \bar{v}_{k,j} \Delta \ln K_{k,j} - \bar{v}_{L,j} \left(\Delta \ln LC_j + \Delta \ln H_j \right) \quad (7)$$

Subtracting the change of hours worked growth from both sides results in the growth rate of labour productivity (value added per hour worked), i.e.

$$\Delta \ln V_j - \Delta \ln H_j \equiv \bar{v}_{K,j} \bar{v}_{K,j} \sum_{k=ICT,NonICT} \bar{v}_{k,j} \Delta \ln K_{k,j} + \bar{v}_{L,j} \Delta \ln LC_j + \bar{v}_{L,j} \Delta \ln H_j + \Delta \ln T_j - \Delta \ln H_j \quad (8)$$

This expression can be manipulated and finally written as

$$\Delta \ln V_j - \Delta \ln H_j \equiv \bar{v}_{K,j}\left(\sum_{k=ICT,NonICT} \bar{v}_{k,j}(\Delta \ln K_{k,j} - \Delta \ln H_j)\right) + \bar{v}_{L,j}\left(\Delta \ln LC_j\right) + \Delta \ln T_j \quad (9)$$

This decomposes value added per hour worked growth into capital services per hour worked growth, the labour composition effect and TFP growth.

Again, in practice, this expression can be used to calculate the contribution of TFP growth to labour productivity; note that the contribution of TFP for labour productivity growth is the same as for value added growth.

Thus, in this paper value added growth is decomposed into five factors: TFP growth, ICT and non-ICT capital services growth, change in labour composition and hours worked growth; and labour productivity growth into four factors: TFP growth, ICT and non-ICT capital services per hour worked growth, and change in labour composition.

2.5 Sectoral aggregation, country sample and time period

With respect to sectoral aggregation, we use the direct aggregation approach (Jorgenson et al. 2005, chapter 8), which assumes that aggregated real value added growth is the weighted average of real value added growth in industries, or

$$\Delta \ln V = \sum_j \bar{v}_j \Delta \ln V_j, \quad (10).$$

where $\bar{v}_j$ are time average shares of value added of industry j in total value added. Substituting growth accounting decomposition (1)-(9) for industry j to (10) and making simple transformations we have

$$\Delta \ln V = \sum_j \bar{v}_j \Delta \ln V_j = \sum_j \bar{v}_j \bar{v}_{K,j} \Delta ln\, K_j + \sum_j \bar{v}_j \bar{v}_{L,j} \Delta ln\, L_j + \sum_j \bar{v}_j \bar{v}_{L,j}\left(\Delta ln\, LC_j + \Delta \ln H_j\right) + \sum_j \bar{v}_j \Delta ln\, TFP_{VA,j} \quad (11).$$

This decomposition regards aggregate real value added growth rates as the joint contributions of labour, capital and TFP in each industry.[3]

2.6 Data description

The data on which the analysis is based are the preliminary results from the EU KLEMS Release 2019 which is just underway (this will be documented in an accompanying forthcoming report, see Stehrer et al., 2019).

The second source is the 2019 Russia KLEMS dataset which is a further development of July 2017 release of July 2017 ("Russia KLEMS" 2017). Series are now extended to 2016 with output series already adjusted to SNA 2008. Russia KLEMS 2017 includes series of value added, hours worked, labour and capital shares, as well as capital services for 34 industries in the industrial classicisation corresponding to NACE Rev. 1 starting from 1995. The dataset is nearly consistent with the official Russian National Accounts at the aggregate level for the whole period, and at the industry level starting from 2005. It is also harmonized with similar datasets for other countries within the World KLEMS framework, which makes possible cross-countries comparisons at the level of industries. A more detailed description of the dataset and its construction can be found in Voskoboynikov (2016). The database is currently being transferred to NACE Rev. 2 corresponding to the 2019 EU KLEMS release.

In this paper, we opt for two periods for the analysis, which are pre-crisis years 2002-2007 and the post-crisis period 2011-2016, thus not focusing of growth and productivity performance in the crisis. We exclude years of the crisis to avoid the impact of short-term demand-driven effects on TFP growth. This allows us to focus on the overall longer-term performance before and after the crisis

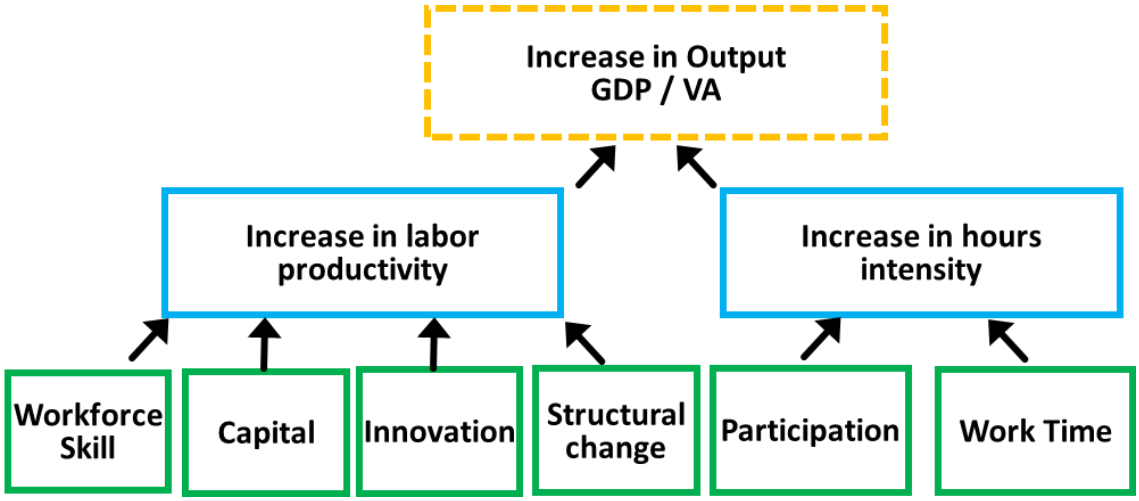
[3] Taking into account that the present study is focused on the link between TFP and skills intensity in industries, we do not consider the contribution of inputs' reallocation to aggregate real value added and labor productivity growth. However, the reallocation effects can be easily integrated in this framework (see e.g. Stiroh, 2002).

3. Patterns of the productivity slowdown in EU, Japan, Russia and US

3.1 Labour productivity and hours worked growth

Before turning to the detailed growth accounting results for the EU-10, United States, Japan, and Russia we document the productivity slowdown by zooming in on the relative contributions of productivity and hours worked growth for the total economy and its split in high-skill and low-skill intensive industries as classified above. Figure 1 shows the conceptual framework for this exercise: an increase in GDP - alternatively value added – results from productivity growth and an increase in hours worked.

Figure 1: Factors of wealth creation



Source: Author's elaboration.

As this simple framework shows, productivity growth provides an important foundation for value added growth that originates from various sources: skill intensity of the workforce, investment, innovation and structural change. This lowers prices and raises real wage income. In addition, an increase in the number of hours worked brings additional positive demand effects that provide incentives for businesses to expand and create more value added. The number of hours worked itself depends on participation of the work force in the labour market and the time actual hours worked

Labour productivity provides a simple but powerful indicator of economic efficiency. Labour productivity measures how much output is obtained per hour of work and provides a connection to living standards as measured by per capita income—the higher the relative level of productivity, the higher per capita income is, and the greater the chance for economic expansion. Moreover, labour

productivity (measured in a broader sense) is a principal source of economic growth (note that labour productivity times total hours worked in the economy equals (real) GDP).

Figure 2 presents the performance of the four countries in the period before the crisis (2002-2007) and after the crisis (2011-2016 and 2016-2017) for the total economy, as well as high-skill and low-skill intensive industries. It should be emphasized that most EU countries and the Eurozone as a whole experienced another recession in 2011/2012, which is included in the second period[4]. Given the high interest in of the growth performance of very recent years, we also add the 2016-2017 average for the EU-10 aggregate and the United States.

Labour productivity growth has been an important driver of US growth prior until 2007 – in the high-skill intensive industries, and even more so in the low-skill intensive industries. The picture has however changed in the period after 2011, where the output recovery after the financial crisis has been largely driven by a recovery in hours worked across all industries. Labour productivity growth was lower than hours worked growth from 2011-2016, but in this period 9-fold higher in high-skill intensive industries compared to low-skill intensive industries. Even though the proportions of productivity and hours worked growth in value added growth remained broadly constant in 2016-2017 compared to the longer period in the US economy, there is evidence that productivity growth is slightly catching up in low-skilled industries in recent years.

Before the crisis, a similar pattern is found for the EU-10, i.e. labour productivity growth has been higher in the low-skill intensive industries. Overall labour productivity growth in the EU-10 recovered after the collapse during the crisis years to 0,7 percent on average from 2011-2017 in the total economy, largely driven by the strong productivity growth in low-skilled industries (and therefore somewhat different to the patterns in the US). In these industries, hours worked growth contributed negatively to value added growth in 2002-2007, marginally negative in 2011-2016 and are gaining in importance in the two recent years. In the high-skill intensive industries labour productivity growth remained largely constant, however growth in working hours declined substantially.

The composition of value added growth in Japan is straightforward and does not show any reversing patterns over time. Value added growth is entirely driven by labour productivity growth in the total economy prior and after the financial crises. The ratios of growth rates in hours worked and labour productivity are roughly constant in high-skilled and low-skilled industries over both periods. Importantly, while value added growth in high-skilled industries is strongly driven by hours worked growth with an even negative impact of labour productivity growth, the picture is the complete opposite in low-skilled industries.

[4] For a further discussion of trends in Europe's Output and Productivity Growth in Europe up to 2015, see also van Ark and Jäger (2017) and van Ark et al. (2018).

Figure 2: Decomposition of value added growth into contributions of labour productivity and hours worked (p.p.)

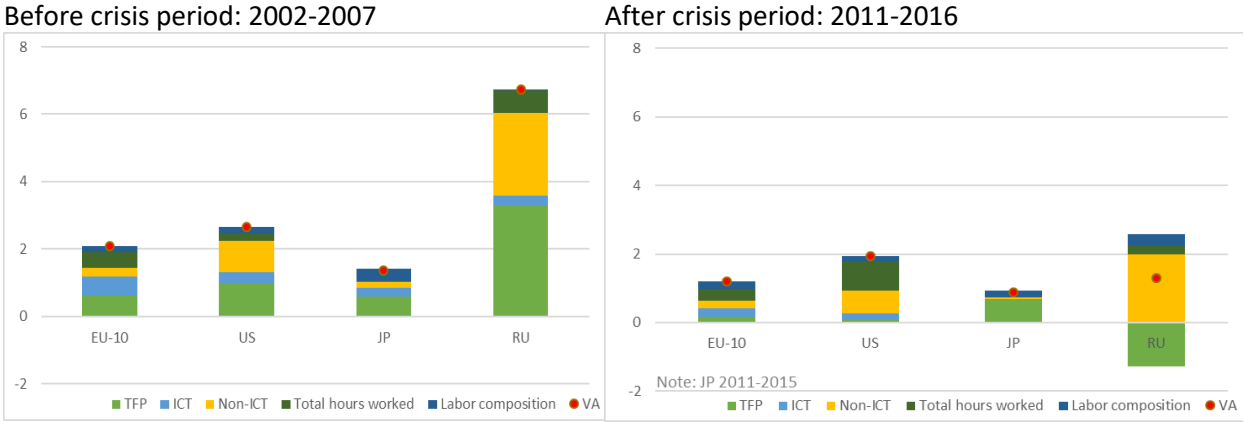
Sources: EU KLEMS 2019 (preliminary), Russia KLEMS 2019 (preliminary)
Note: See Appendix for the composition of high-skills- and low-skills intensive sectors

Finally, Russia has experienced remarkably high labour productivity growth prior to the crisis with relatively low growth rates in hours worked (note the different scales in the graph). However, the country by far did not manage to bring back productivity growth anywhere in the range of pre-crisis levels. Productivity growth declined from 5,9 per cent from 2002-2007 to just 1,3 per cent in 2011-2016 with virtually no growth in hours. With respect to sectoral patterns, productivity growth rates before the crises have been slightly higher in the low-skill-intensive industries. This pattern however reversed in the period 2011-2016 with the high-skill intensive industries performing productivity growth rates twice as high than the low-skill intensive industries (though at a much lower level compared to the pre-crisis period as mentioned above).

3.2 Growth accounting results and TFP growth

The "growth accounting" model explained above (see Section 2) results in a more sophisticated productivity measure called total-factor productivity (TFP). This represents output on top of all inputs in the production process, not just labour. Thus, TFP growth measures the growth in output that is not accounted for by the joint contribution of capital and labour[5] and is considered as a reasonably good proxy of the "real" efficiency of the production process, looking at output "quantities" over input "quantities".[6]

Figure 3 - Contributions to gross value added growth, total economy



Source: EU KLEMS 2019 release (preliminary version); Russia KLEMS 2019 release (preliminary version).

One main focus of the paper is to reveal to what extent the global productivity slowdown can be attributed to changes in the patterns of productivity growth in the industries differentiated by skill-intensities. To complement the picture from the previous section, we look at the contributions of the various factors (i.e. hours worked, labour composition, capital and TFP growth). Figures 3 to 5 provide these growth accounting results that decompose the growth of value added into the contributions from various sources of growth (capital, labour and total factor productivity growth) for the total economy (Figure 3) as well as high-skill and low-skill intensive industries (Figures 4 and 5) as laid out in the previous section. While the broad trends of the TFP slowdown and sluggish recovery

[5] Further energy, materials and services are taken into account when gross output growth is considered.

[6] These may also be called "real" cost reductions, and may be contrasted to "nominal" efficiency measures, which are used more regularly in business, that simply look at cost over sales or margins. For example, an increase in output value, adjusted for inflation, relative to the rise in the numbers of workers, is a real cost reduction. In contrast a cut in wages, without a change in the real numbers of workers, is a nominal efficiency gain but does not represent a productivity increase.

after the crisis are widely documented in the literature, there are important cross-country differences (and different patterns between high-skill and low-skill industries).[7]

TFP growth explained similar shares of value added growth in EU-10, Japan's and the US total economy at about 30-40 per cent from 2002-2007. TFP growth rates in Europe have recovered to positive territory in 2011-2016 (however accounting just for 10 per cent of value added growth) Japan managed to almost double the portion in value added growth stemming from TFP in the same period (accounting for 75 per cent of value added growth). Interestingly, in the US TFP growth has not recovered at all after the crisis. Value added in Russia grew at 6,7 percent on average in the total economy in the period 2002-2007 and was boosted to about 50 percent by TFP growth.

Before the crisis, growth in ICT capital services have been rather important in the EU-10 compared to the other economies whereas growth in non-ICT capital services have been less important in the EU-10 but taken a high share in the US and Russia. After the crisis, the contribution of ICT capital services has declined strongly, though still slightly positive in the EU-10 and the US whereas invisible in Japan and Russia. For the latter country and to a lesser extent the US, non-ICT capital services growth is the most important component.

Figure 3 also indicate that changes in labour composition contributed at roughly equal rates at 0,2 percentage points to output growth in the total economies in the EU-10 and the United States during 2002-2007. The growth rate of labour composition in Japan was only slightly below total capital input growth and close to zero per cent in Russia at the same time. This contribution in absolute numbers reached pre-crisis levels in Europe from 2011-2016 and halved in the United States Japan at the same time. Russia is seeing a relatively strong impact of labour composition change in 2011-2016 with a 0,3 percent contribution to the 1,3 per cent growth of value added of the total economy. Even though this contribution is often smaller across countries and skill levels than that of other sources of growth, its positive sign implies that the process of transformation of the labour force to higher skills has proceeded.

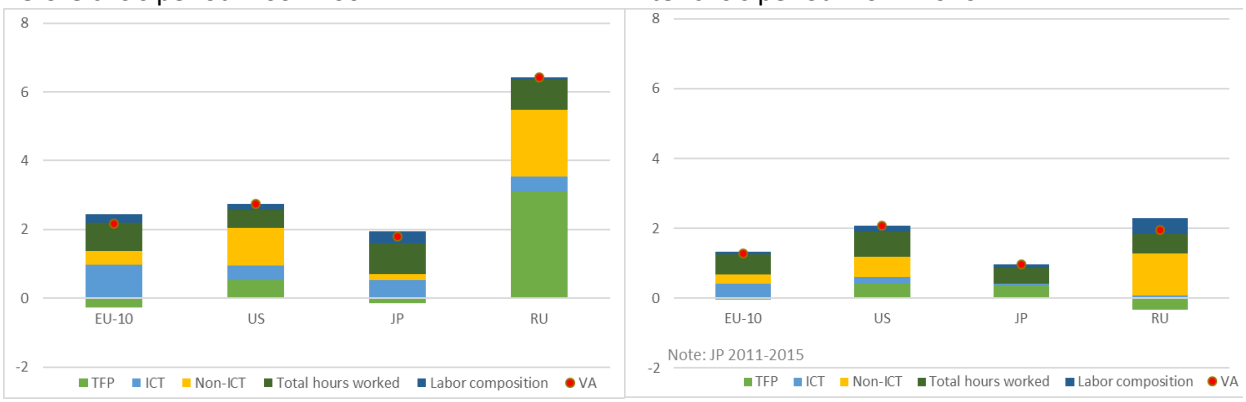
Finally, hours worked growth contributed relatively strong before the crisis in the EU-10 and Russia which declined strongly in the period after the crisis. Only in the US, a more significant share of growth is accounted for to growth in hours worked.

Figures 4 and 5 now split the growth accounting results into the high-skill intensive and low-skill intensive industries.

[7] The upcoming 2019 EU KLEMS release comprises growth accounting results for 10 EU countries as well as the United States up to 2017. Given the general interest in recent sources of growth analysis we present a short summary of these results in Appendix Figure A.2. To get rid of the impact of the second recession in the Euro Area in 2011-2012 and to make use of the 2016-2017 results, we include the latter average in Appendix Table A.2.

Figure 4 - Contributions to gross value added growth, high-skill intensive industries

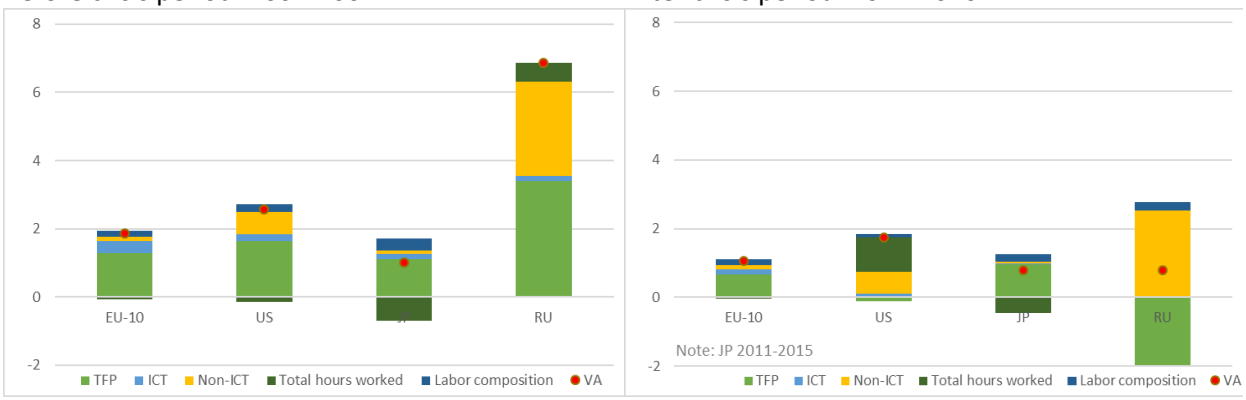
Before crisis period: 2002-2007 | After crisis period: 2011-2016



Source: EU KLEMS 2019 release (preliminary version); Russia KLEMS 2019 release (preliminary version).

Figure 5 - Contributions to gross value added growth, low-skill intensive industries

Before crisis period: 2002-2007 | After crisis period: 2011-2016



Source: EU KLEMS 2019 release (preliminary version); Russia KLEMS 2019 release (preliminary version).

TFP growth before the crisis has been very strong in Europe in the low-skill intensive industries, whereas being nil (even slightly negative) in the high-skill intensive industries. TFP growth in low-skill intensive industries remained the main driver of Europe's growth after the crisis. Further, the relative contributions of the factors of growth haven't changed much in the EU-10.

A slightly different pattern can be observed for the United States where the dominant positive contribution of TFP to value added growth in low-skilled industries strongly declined after the crisis, whereas remained roughly constant in the high-skill intensive industries. The role of the non-ICT capital services remained relatively strong in both industry groups, whereas the contribution of ICT capital services growth declined (though still somewhat stronger in the high-skill intensive industries). The contribution of total hours worked growth has increased in the US after the crisis, particularly so in the low-skill intensive industries.

A rather similar patterns concerning the growth contributions before and after the crisis (though at a lower level) is observed in Japan.

Finally, TFP growth declined strongly in Russia and even turned into negative, particularly strongly in the low-skill intensive industries. The weak TFP performance is therefore mainly caused by Russian low-skill economies. The most prominent factor of remains growth non-ICT capital services which contributes particularly strong in the low-skill intensive industries.

4. A closer look: structural change and the slowdown in TFP growth

Because of the expected higher capacity of qualified workers for technology adaptation, the reaction of TFP growth in high-skill intensive industries to a global shock is expected to be different from the reaction of low-skill intensive ones. The following analysis is focused on the issue, if this difference is observed in the big four economies in question. Assume that the economy consists of two sectors (groups of industries): high-skill intensive (HS) and lowskill intensive (LS). Then in accordance to (10)-(11), aggregate TFP growth can be represented as

$$\Delta \ln TFP = \bar{v}^{HS} \cdot \Delta \ln TFP^{HS} + \bar{v}^{LS} \cdot \Delta \ln TFP^{LS}, \qquad \bar{v}^{HS} + \bar{v}^{LS} = 1, \qquad (12)$$

where $\bar{v}^{\cdot}$ are time averages of value added shares. Equation (12) can be transformed to the following form by addition and subtraction of $\bar{v}^{HS} \cdot \Delta \ln TFP^{HS}$ to the right side of the equation. As a result, we have

$$\Delta \ln TFP = \bar{v}^{HS} \cdot (\Delta \ln TFP^{HS} - \Delta \ln TFP^{LS}) + \Delta \ln TFP^{LS}, \qquad (13)$$

which shows that three effects can impact on aggregate TFP growth: (i) a change in the economic structure ($\bar{v}^{HS}$), (ii) the TFP growth rates differential ($\Delta \ln TFP^{HS} - \Delta \ln TFP^{LS}$) and (iii) TFP growth in the low-skills intensive sector.

Table 2 represents aggregate yearly average growth rates before and after the global financial crisis in the four economies, which could be explained, among other factors, by the slowdown of human capital accumulation and the following shrinkage of the contribution of labour composition in many OECD countries, starting from 2000, noticed by McGowan at al. (2015, 24). All economies, except Japan, experienced a TFP slowdown being strongest in the US. In this country, average growth rates in 2011-2016 fall by 0,78 p.p. in comparison with the pre-crisis five-years period. In contrast, TFP growth rates in Japan grew by 0,14 p.p. Taking into account the decomposition (13) it is interesting to identify some common features of this variation.

Table 2. Yearly average TFP growth rates for total economy, in %

		EU-10	Japan	Russia	US
1	**2002-2007**	0,46	0,55	3,18	0,98
2	**2011-2016**	0,27	0,69	-1,04	0,20
3	**Increment (2-1)**	-0,19	0,14	3,18	-0,78

Source: EU KLEMS 2019 release (preliminary version); Russia KLEMS 2019 release (preliminary version).

We therefore explain changes in TFP growth rates in these economies after the global financial crisis by interactions of the differential in TFP growth rates and the change of TFP growth rates in the low-skill intensive sectors amid insignificant structural change.

Table 3. Value added shares of high-skills sector (%)

		EE-10	Japan	Russia	US
1	**2002-2007**	52,9	45,5	64,2	57,8
2	**2011-2016**	55,4	47,6	57,8	60,8
3	**Increment (2–1)**	2,5	2,1	-6,3	2,9

Source: EU KLEMS 2019 release (preliminary version); Russia KLEMS 2019 release (preliminary version).

As can be seen in Table 3, the value added share of the high-skill intensive sectors of three of the four economies (not in Russia) demonstrates the slow expansion with an average increment just above 2 percentage points. One remarkable exception is Russia, where the skill intensive sector shrinks by more than 6 percentage points.[8] Overall, changes in the sectoral shares seem relatively small however.

A much more important contribution can be found in changes of TFP growth rates, represented in Table 4. In 2002-2007 (line 3) TFP growth in high-skill industries is lower than in the low-skill industries in all cases, i.e. there is a strong negative differential in all economies except Russia. A

[8] This is not surprising, taking into account expanding informal economy, mostly because of informal labour inflow to trade and construction (Voskoboynikov 2019, fig. 2).

possible explanation is the pre-crisis slowdown of accumulation of knowledge-based capital and a faster recovery of investments to knowledge-based capital after the crisis, reported by (McGowan, Andrews, and Nicoletti 2015, 29).[9]

This picture changes after the crisis for two economies: the high-skill intensive sector moves TFP growth forward in Japan and the US, but not so in the EU-10 and Russia.

Overall, the change growth differential between low- and high-skill intensive industries the crisis is visible (line 9) in all four economies. This highlights the increasing role of high-skill intensive industries in the post-crisis TFP growth performance in all four economies. At the same time, aggregate TFP growth slowdown continues after the crisis (Japan is an exception) because the positive impact of high-skill intensive sector is not strong enough to circumvent overall productivity slowdown of the negative impact of a low-skill intensive sector. The small change in value added shares of high skill intensive sectors $\bar{v}^{HS}$ (table 2) suggests that the structural change effect is small and negligible; thus overall productivity performance is driven by changes in the TFP growth rates of the high- and low-skill intensive industries.

[9] Investments to knowledge-based capital include development of firm-specific skills along with R&D, organizational know-how, etc. One of the features of the global financial crises was that investments to skills in OECD economies during the crisis were more resilient in comparison, e.g., with the investments to tangibles. Investments in R&D and worker training divert resources from current production but only generate future benefits, their opportunity costs are likely to be lower during downturns because there is potentially less revenue to be forgone from normal productive activities than otherwise (McGowan, Andrews, and Nicoletti 2015, 29).

Table 4. Yearly average TFP growth rates in high-skill and low-skill intensive sectors

		EU-10	Japan	Russia	US
	2002-2007				
1	High-skill intensive industries	-0.26	-0.14	3.10	0.52
2	Low-skill intensive industries	1.28	1.11	3.39	1.63
3	Differential (1-2)	-1.54	-1.25	-0.29	-1.11
	2011-2016				
4	High-skill intensive industries	-0.04	0.38	-0.34	0.41
5	Low-skill intensive industries	0.66	0.97	-1.97	-0.11
6	Differential (4-5)	-0.70	-0.60	1.63	0.51
	Increment				
7	High-skill intensive industries (4-1)	0.22	0.52	-3.44	-0.11
8	Low-skill intensive industries (5-2)	-0.62	-0.14	-5.36	-1.74
9	Differential (7-8)	0.84	0.66	1.92	1.63

Source: EU KLEMS 2019 release (preliminary version); Russia KLEMS 2019 release (preliminary version).

5. Conclusion

The paper discussed – based on a growth accounting approach – the productivity slowdown that most countries experienced after the global financial crisis for four economies: the EU-10, Japan, Russia and the US based on the (preliminary) data from the 2019 EU KLEMS release and the Russia KLEMS database. The productivity and growth slowdown is documented in all economies, except Japan, with differences across countries and industries – grouped into high-and low-skill intensive industries.

Specifically, the change of the TFP growth differential after the crisis in direction of the high-skill intensive industries is documented in all four economies. In other words, TFP slowdown was much less sound in high skill intensive industries, than in low skill ones. This might highlight the increasing role of high-skill intensive sectors (and growth performance in high-skill intensive services) in the post-crisis TFP growth performance in all four economies. This is a new phenomenon, which deserves are more detailed explanation in future research. Thus, the aggregate TFP growth slowdown continues after the crisis (Japan is an exception) because the positive impact of high-skill intensive sector is not strong enough to circumvent an overall productivity slowdown in the low-skill intensive sector. Finally, the structural change effect (towards a higher share of the skill-intensive industries) is small and negligible and thus not contributing to the overall explanation of the productivity growth performances.

References

Conti, Maurizio, and Giovanni Sulis. 2016. "Human Capital, Employment Protection and Growth in Europe." *Journal of Comparative Economics* 44 (2): 213–30. https://doi.org/10.1016/j.jce.2015.01.007.

Fernald, John and Robert Inklaar. 2018. "Does Disappointing European Productivity Growth Reflect a Slowing Trend? Weighing the Evidence and Assessing the Future". 35th IARIW General Conference Copenhagen, Denmark, August 20-25, 2018.

Jorgenson, Dale W., Mun S. Ho, and Kevin J. Stiroh. 2005. *Information Technology and the American Growth Resurgence*. Vol. 3. Cambridge, MA: The MIT Press.

McGowan, Müge Adalet, Dan Andrews, and Giuseppe Nicoletti. 2015. *The Future of Productivity*. OECD. http://www.oecd.org/eco/OECD-2015-The-future-of-productivity-book.pdf.

"Russia KLEMS." 2017. National Research University Higher School of Economics; Groningen Growth and Development Centre. http://www.worldklems.net/data/basic/RUS_wk_march_2017.xlsx.

Stehrer, R, A. Bykova, K. Jäger, O. Reiter, and M. Schwarzhappel. 2019. Industry level growth and productivity data with special focus on intangible assets, Technical Report for EU KLEMS 2019 release, work in progress.

Stiroh, Kevin J. 2002. "Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?" *American Economic Review* 92 (5): 1559–76.

Syverson, Chad. 2011. "What Determines Productivity?" *Journal of Economic Literature* 49 (2): 326–65.

Timmer, M.P., R. Inklaar, M. O'Mahony and B. van Ark (2010), Economic Growth in Europe – A comparative Industry Perspective, Cambridge: CUP.

Timmer, Marcel P., and Ilya B. Voskoboynikov. 2016. "Is Mining Fuelling Long-Run Growth in Russia? Industry Productivity Growth Trends in 1995-2012." In *Growth and Stagnation in the World Economy*, edited by Dale W. Jorgenson, Kyoji Fukao, and Marcel P. Timmer, 281–318. Cambridge University Press.

http://www.cambridge.org/ru/academic/subjects/economics/economic-development-and-growth/world-economy-growth-or-stagnation?format=HB&isbn=9781107143340#dp60CqVsDlAh7fCX.97.

van Ark, Bart, and Kirsten Jäger. 2017. Recent Trends in Europe's Output and Productivity Growth Performance at the Sector Level, 2002-2015, *International Productivity Monitor*, Number 33, Fall 2017.

van Ark, Bart, Klaas de Vries and Kirsten Jäger. 2018. Is Europe's Productivity Glass Half Full or Half Empty?, *Intereconomics* 53 (2), pp. 53-58.

Voskoboynikov, Ilya B. 2017. "Sources of Long Run Economic Growth in Russia before and after the Global Financial Crisis." *Russian Journal of Economics* 3 (4): 348–65. https://doi.org/10.1016/j.ruje.2017.12.003.

Voskoboynikov, Ilya B. 2019. "Structural Change, Expanding Informality and Labor Productivity Growth in Russia." *Review of Income and Wealth* forthcoming. https://doi.org/10.1111/roiw.12417.

Appendix.

Table A.1: Classification of NACE Rev. 2 industries into high-skilled and low-skilled industries

NACE code	Description	High-skill intensive	Low-skill intensive
A	Agriculture, Forestry and Fishing		X
B	Mining and quarrying		X
C	Manufacturing		X
D	Electricity & gas	X	
E	Water and sewerage		X
F	Construction		X
G	Wholesale and retail trade		X
H	Transport and Storage		X
I	Hotels & catering		X
J	Information and Communication	X	
K	Financial intermediation	X	
L	Real Estate	X	
M_N	Professional, scientific, technical, administrative and support service activities	X	
O	Public administration and defence; compulsory social security	X	
P	Education	X	
Q	Health and social work	X	
R	Arts, Entertainment and Recreation	X	
S	Other service activities		X
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use		X
U	Activities of extraterritorial organizations and bodies		X

Note: In case of Russia until 2016 the official national accounts data is available in NACE Revision 1 only. Bridging of data for Russia to NACE Revision 2 should be considered as preliminary.