

KLEMS growth accounting implemented in Poland¹

Dariusz Kotlewski², Mirosław Błazej³

ABSTRACT

The aim of the article is to present the main body of the KLEMS growth accounting recently implemented in Poland. The works on the KLEMS productivity accounting in Poland started in 2013 and focused on areas such as the development of methodology and the availability and assessment of data. These efforts enabled preparing KLEMS data sets pertaining to the Polish economy and moreover proved that unavailable data can be effectively estimated. Additionally, interesting but complex and debatable results were obtained, such as labour hoarding together with remunerations' freezing around the 2009 crisis, accompanied by a natural drop in the capital contribution growth and an increase in the MFP contribution, which most probably indicated effective reorganizations in the economy. In the years 2012–2014, increasing labour and capital contributions did not fully translate into gross value added growth, which led to negative MFP growths, as these are calculated residually. This, however, changed completely in the last two years of the time span covered by the research, namely in 2015–2016. An industry-level analysis became also possible, showing that the Polish economy was developing dynamically and undergoing intensive modernisation, which was obtained, however, with a debatable contribution of the State. To study the debatable features of the Polish economy in a greater detail, a further decomposition of the labour factor growth into four sub-factor contributions instead of two sub-factor contributions was performed. This additional analysis confirmed that labour hoarding phenomenon specific for Poland contributed to a softer impact of the 2007–09 financial crisis on this country's economy.

Key words: gross value added, decomposition, production factors, KLEMS, productivity.

1. Introduction

The aim of the article is to present KLEMS productivity growth accounting recently being implemented in Poland and discuss it. Although Poland is present in various

¹ Disclaimer: the views presented in this article are those of the authors and do not represent the official standpoint of Statistics Poland.

² Warsaw School of Economics, Dariusz Kotlewski is also an employee in Statistics Poland, Poland.
E-mail: dariusz.kotlewski@gmail.com, dariusz.kotlewski@sgh.waw.pl, d.kotlewski@stat.gov.pl.
ORCID: <https://orcid.org/0000-0003-1059-7114>.

³ Statistics Poland, Poland. E-mail: m.blazej@stat.gov.pl.

releases of EU KLEMS database, no decomposition of gross value added growth or gross output growth into factor contributions and MFP contribution has been ever performed there because of missing input data (with the exception of 2007 EU KLEMS release, presently outdated) – the reason is that no sufficient data are being sent to Eurostat on the one hand (although theoretically they could be sent, which is a matter of co-operation agreements within Eurostat) and on the other hand that there are data which need to be imputed innovatively, since they are not straightforwardly available in Poland too. A growth accounting for Poland with decomposition as above mentioned has been performed by NBP⁴ appointed researchers, based on a slightly different methodology (Gradzewicz et al., 2014, 2018), but not at the sectoral and industry level. As far as the authors of this article know, no one else has ever performed a decomposition of the above-mentioned kind at industry level for Poland (with the exception of the above mentioned release⁵).

The methodology framework based on a gross value added decomposition is outlined in the second section. In the third section, these results are discussed in an attempt to interpret them. In the fourth section a sample analysis at industry level is presented. In the fifth section, a developed labour factor decomposition is advanced allowing for more analytical insights in the Polish economy. Despite the specific data processing hurdles accompanying the works on the Polish KLEMS accounting, ample results of good quality were achieved (presently, they are available on Statistics Poland web page⁶). As they are to a large extent debatable, these outcomes remain open to further analyses and discussion. New avenues for developing KLEMS accounting and the conclusion are presented in the final section. The article is of a wide synthetic nature. It deals both with theoretical matters and technicalities, and presents also the results of KLEMS accounting in Poland with some interpretation.

2. Basic methodology

The basic methodology follows in general the growth accounting methodology developed by Dale W. Jorgenson and associates, as outlined in Jorgenson (1963), Jorgenson & Griliches (1967), Jorgenson, Gollop and Fraumeni (1987), Jorgenson

⁴ The National Bank of Poland which is the Polish Central Bank.

⁵ The EU KLEMS data set release of 2007 includes a decomposition for Poland with labour services' contribution being subdivided into hours worked and labour composition contributions, but with no subdivision of capital services' contribution into ICT and non-ICT capital contributions. This release covers the period of 1996–2004, therefore just preceding the present study time span. For the 2007 EU KLEMS release data were often extensively imputed (Timmer et al., 2007b, pp. 121–29) to a far greater degree than in the present study due to greater data shortages. The possible comparisons between the two studies can possibly be an avenue for further analysis.

⁶ KLEMS Economic Productivity Accounts, <https://stat.gov.pl/en/experimental-statistics/klems-economic-productivity-accounts/>

(1989) and Jorgenson, Ho and Stiroh (2005)⁷. This methodology has been summarized by Timmer et al. (2007), and O'Mahony and Timmer (2009) for the EU KLEMS⁸. For Poland it has been developed and presented in Kotlewski & Błażej (2016, 2018a and 2018b)⁹. Hereinafter, only the basic idea and structure of the accounts is presented. It is based on the standard growth accounting decomposition of output into the contribution of input factors and MFP:

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

where Y is the gross output, X – intermediate consumption, K – capital services¹⁰, L – labour services¹¹ and where A^Y stands for multifactor productivity. These values are subscripted by j for industries and t for years. \bar{v} with appropriate subscripts are average value shares¹² of the individual factors in the gross output (defined in the superscripts by X , K and L) for two discrete time periods $t-1$ and t , which are calculated through linear interpolation as $\bar{v} = (v_{t-1} + v_t)/2$ (for simplicity the subscripts of (1) have been omitted here). Since the growth of A^Y is residually calculated, the equation (1) is always met. As for most of the EU KLEMS countries performing the KLEMS growth accounting, the methodology has been reduced to a gross value added decomposition following the standard equation¹³:

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

⁷ In the preparatory works, the OECD growth accounting methodology was studied as well for possible insights; see: OECD (2001, 2009 and 2013), Wölfl (2007).

⁸ See also the large overview of the subject: Jorgenson, ed. (2009).

⁹ The first of these works is addressed to the Polish audience not fully acquainted with KLEMS accounting, therefore methodological details were amply presented, whereas the second one is more focused on Polish specificities, more essential for the foreign audience. The third of these works presents development of the labour factor decomposition into additional sub-factors.

¹⁰ It is assumed that the values of capital services are proportional to the values of capital stocks if these are separated into different kinds of capital stocks at industry level, which means that although capital stocks and capital services are different entities, their growths are the same at this level. These different kinds of capital stocks are then aggregated with the use of Törnqvist quantity index at industry level. Following: OECD (2001, 61), Timmer et al. (2007a, 32-33), OECD (2009, 60) and Timmer et al. (2010, eq. (3.6)).

¹¹ It is assumed that the values of labour services are proportional to the amounts of physical work engaged (in hours worked) if these are separated into different kinds of labour according to age, education attainment and sex.

¹² All value shares throughout the paper were taken from the national accounts, but they were adjusted for the self-employed before being used in calculations.

¹³ This value added based growth accounting is not neutral to the substitution between intermediate inputs, and the production factors labour and capital, but this problem is considered to be less severe than vertical firm consolidation differences between different countries, when their growth accounting are compared. Moreover, there is the problem of producing intermediate inputs deflators that are required for gross output based growth accounting, which is a quite universal unsolved problem (see: EU KLEMS database). However, a separate methodology has been lastly developed for Poland to address this issue, which allowed to include intermediate inputs according to formula (1). This issue, however, does not contradict the present analysis and could be the subject of a separate paper.

where V is the gross value added and where A^V stands for multifactor productivity (further referred to as MFP¹⁴) in the gross value added based decomposition \bar{w} with appropriate subscripts are average value shares of production factors' services in the gross value added (defined in the superscripts as K and L) for two discrete time periods $t-1$ and t , which are calculated through linear interpolation in a similar way as \bar{v} for the previous formula (1). The other symbols are the same as in equation (1). Replacing the decomposition (1) by (2) eases some data problems and the international comparability of the individual countries¹⁵. In practice the contribution of multifactor productivity $\Delta \ln A_{jt}^V$ is residually calculated as the subtraction between the other values, so the equation (2) is always met, similarly to equation (1). There is no need, therefore, to directly measure the levels of A .

The capital factor contribution (understood as capital services inputs) has been decomposed into two sub-factors contributions as follows:

$$\bar{w}_{jt}^K \Delta \ln K_{jt} = \bar{w}_{jt}^{KIT} \Delta \ln KIT_{jt} + \bar{w}_{jt}^{KNIT} \Delta \ln KNIT_{jt} \quad (3)$$

where KIT stands for ICT capital and $KNIT$ for non-ICT capital services¹⁶, treated as separate factors indeed, which is expressed also by their different shares (appropriately superscripted). In practice one of the three contributions, usually the non-ICT capital one, is residually calculated as the subtraction between the other values in the equation (3), in order to avoid mathematical tool problems (so the equation (3) is always met).

The labour factor contribution (understood in the standard KLEMS methodology as labour services' contribution) has been decomposed somehow differently as follows:

$$\bar{w}_{jt}^L \Delta \ln L_{jt} = \bar{w}_{jt}^H \Delta \ln H_{jt} + \bar{w}_{jt}^Q \Delta \ln Q_{jt} \quad (4)$$

where L stands for the labour factor understood as hours worked aggregated with the use of Törnqvist quantity index on the one hand or compensations aggregated with the use of this index on the other hand¹⁷, H stands for the (straightforward) sum of hours worked on the one hand or hours worked aggregated with the use of Törnqvist quantity index on the other hand¹⁸, and Q for labour quality. The firsts of these options result in

¹⁴It can be considered as a variant of total factor productivity (TFP).

¹⁵Because of the vertical integration of firms of different intensity in different countries, which hinders international comparability of the countries, as far as the intermediate consumption is considered.

¹⁶Symbols taken from Timmer et al. (2007).

¹⁷Over standard KLEMS 18 kinds of labour according to sex, three age groups and three education attainment levels ($2 \times 3 \times 3 = 18$). The first of these options is a standard KLEMS procedure, the second is an option explored additionally in Statistics Poland.

¹⁸As above. Experiments done in Statistics Poland have finally led to a developed procedure for labour factor contribution decomposition presented in more details in Section 4.

labour quality contribution understood as labour composition contribution, whereas the seconds – as labour compensation change contribution. They are all treated as a single factor, which is expressed by their same share \bar{w}_{jt}^L as for L . This difference in comparison with the capital factor decomposition (3) is however of no importance as far as the linear additivity of the sub-factor contributions in the gross value added growth is considered¹⁹. Here the growths of the so-called sub-factors sum up to the growth of the entire labour factor as:

$$\Delta \ln L_{jt} = \Delta \ln H_{jt} + \Delta \ln Q_{jt} \quad (5)$$

In practice, the labour quality related expressions in equations (4) and (5) are residually calculated through subtractions between the expressions related with L and H (this is possible because all expressions are in percentage points). So, there is no need to directly measure the value of Q and therefore the equations (4) and (5) are always met.

All data have been calculated after being converted initially into 2005 prices and presently into 2010 prices²⁰, following the same change in Eurostat transmission tables that happened during the works on Poland KLEMS. This change was found to be only technical and of little impact on the accounts. Information on data processing by other countries was studied for comparison and reference in Gouma and Timmer (2013). During the works the ESA'95 Eurostat system changed also into the ESA 2010 system²¹, but this change was found to be of even lower importance than the above-mentioned one²². The problem of qualitative growth as discussed, e.g. by Diewert (1993), Hausman (2003) and Hulten (2009, 19–21) has been for the time being ignored, which is the general practice in the present KLEMS accounting²³. However, one may argue that quality deflators for ICT capital services are to some extent considered, as the structure

¹⁹ The equation (15) in O'Mahony and Timmer (2009, F378) expresses also this difference, but instead of the term "labour quality" (Q) used here, the terms "labour composition" (LC) was used there, more narrowly defined as only the standard KLEMS procedure. More details are presented in Section 4.

²⁰ This can be done directly comparing each year with the base year or through chaining (see Schreyer (2004) and Milana (2009)). The results of the two methods are slightly different. As in other EU KLEMS countries chaining was applied to establish the base year. Establishing the base year is not necessary to perform KLEMS type growth accounting (pairs of years in the same prices are good enough), but such is the way the other EU KLEMS countries data were processed.

²¹ These are European equivalents of SNA'93 and SNA 2008 systems.

²² It concerns only the ICT capital services where mixed data on productive capital stocks had to be used. A test for shortened time series covering both ESA'95 and ESA 2010 comparing results arising from the use of these two systems showed that differences are negligible.

²³ And there seems to be no perspective to introduce it soon. It is quite controversial to use hedonic quality assessments based on price differentials. High quality growth industries should theoretically expand at the expense of low quality growth industries, but this is not necessarily the case. In the case of ICT industries it might be that prices are falling and product quality rising.

taken from SUT tables (ICT services related with software providing) was used to distribute productive capital stocks by industries²⁴.

The works on Poland KLEMS have a specific feature, which is open for further discussion. All results have been calculated and presented in four versions indicated on the Statistics Poland web page by capital letters A-D:

- A – Capital without residential capital (without dwellings), labour quality understood as labour composition
- B – Capital with residential capital (with dwellings), labour quality understood as labour composition
- C – Capital without residential capital (without dwellings), labour quality understood as labour compensation level
- D – Capital with residential capital (with dwellings), labour quality understood as labour compensation level

The inclusion of residential capital in the Polish KLEMS accounting is controversial because of the still opaque (to be understood as not fully liquid in economic terms) Polish dwelling market. But for international comparison it is preferable because all the other KLEMS countries (which are generally not transformation countries and therefore with well capitalised, liquid and transparent dwelling markets) do include it. Therefore, it was decided to make the calculations in both ways (to satisfy both contenders). There are perceivable difference on graphs, between these two options, although of no decisive importance²⁵.

The other dichotomy is the possibility of different understanding of the labour quality sub-factor, as solely related to labour composition change or, alternatively, as being entirely translatable into changes in labour compensation levels. Here also both ways of calculations have been performed. For international comparisons the versions B is the appropriate one. In Kotlewski & Błażej (2016 and 2018a) and in Kotlewski (2017) details on how data limitations have been overcome are extensively presented.

Figure 1 shows the results at the aggregate level for the above-mentioned four versions A to D. It can be seen that the differences are not of a fundamental nature. However, there are some benefits from doing KLEMS accounting in the four versions. The lower graphs (C and D) show the impact of remuneration level increase on the

²⁴It was, as it seems quite sensibly, assumed that the ICT productive stocks (used to compute ICT capital services' contributions) are proportional to the related ICT services, such as software providing. Both ICT capital assets and related services provided on the market are increasing in quality and decreasing in prices, to some extent in parallel.

²⁵The industry of residential building is usually excluded from market economy, because the output of this industry mostly reflect imputed housing rents instead of firms' production (Timmer et al., 26). Such is the case, e.g. in Germany. However, in Poland the situation is different since houses are generally owned by the users. Excluding housing from market economy is therefore also a controversial issue, although the Statistics Poland's KLEMS database provides also the data for this market economy aggregation. In Poland, houses are rather a kind of product sold in instalments, therefore excluding it from capital stocks finds supporters.

accounts, i.e. the years when this impact was huge can be identified by comparing the differences in the MFP level between these graphs and the graphs A and B situated above. Similarly, the years when the impact of dwellings' growth was huge can be identified by comparing the differences in the MFP level between graphs A and C with graphs B and D.

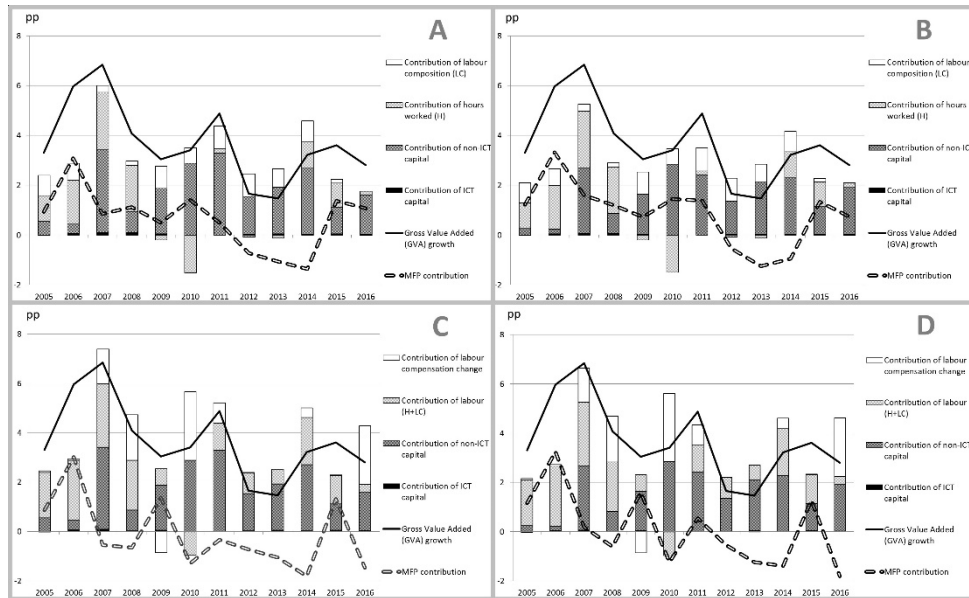


Figure 1. Decomposition of aggregate value added growth in Poland in four versions

Source: Statistics Poland web page.

3. Preliminary interpretation of aggregate results

The general picture of the Polish economy in the light of the present KLEMS accounting methodology, which is in line with other countries performing KLEMS productivity accounting (version B as indicated in section 2.), is presented in Figure 2. What can be seen is that the peaks of MFP contribution in 2006 and 2010 precede the peaks of aggregate gross value added growth in 2007 and 2011, which suggests at first that the increase in productivity due to some reorganizations or modernizations in the economy led to profit margin increases, launching forward the economy and that these impulses remained active for some time after.

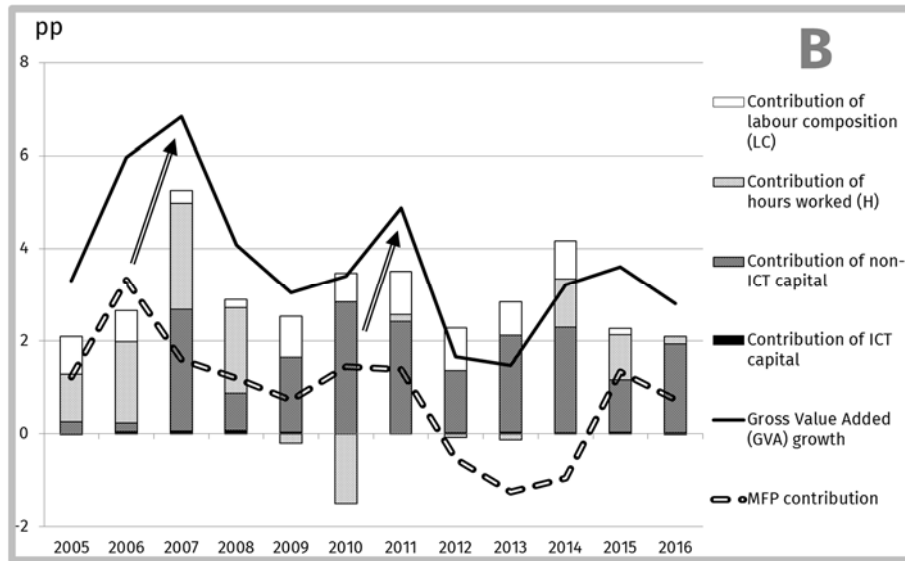


Figure 2. Decomposition of aggregate value added growth in Poland – version B conformable with EU KLEMS

Source: Own contribution based on Statistics Poland web page.

However, the evolution of the gross value added growth in Poland is also not in contradiction to its evolutions in some other economies, i.e. there was a slump around the year 2009 during the trough of the world-wide financial crisis, and the above-mentioned peaks before and after are somehow correlated with the world's economy as well, which suggests rather a business cycle effect. The mentioned slowdown has not, however, led the Polish economy into recession, which is its distinctive feature. These results correspond well with the results presented, e.g. in Havik, Leitner, Stehrer (2012) as far as the time series do overlap each other, but additionally MFP data are provided. Since yearly representations of growth accounting can be misleading, because it might be difficult to focus on long run effects only and eliminate the short-term demand effects, a cumulative growth analysis is provided in the fifth section. Exact quantitative yearly data are available on the Statistics Poland website²⁶.

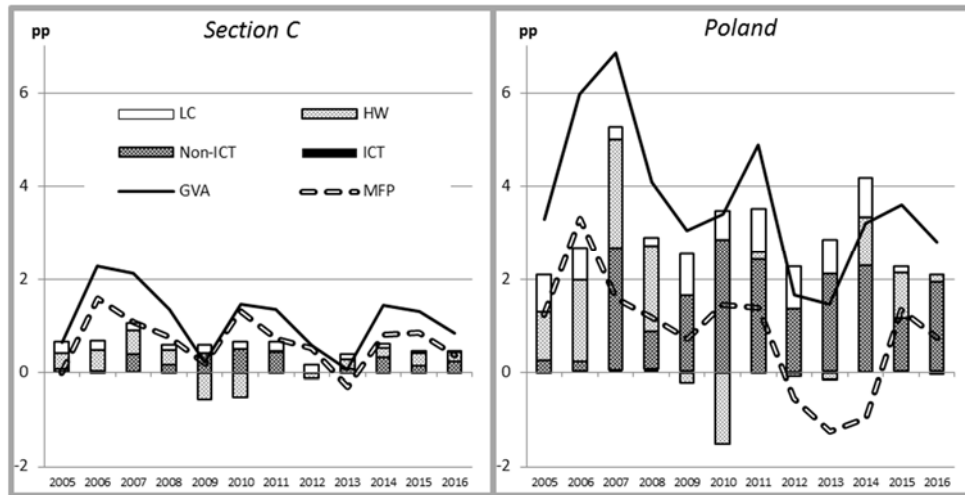
For the years 2012–2014 it can be observed that MFP contribution is negative. The possible explanation of this fact may be that the direct contribution to gross value added growth of growing capital stocks (at industry level and therefore capital services at the aggregate level within KLEMS methodology as explained before) is in relation with the growing demand for capital goods, which in Poland are largely imported. The increase in investments has led to “demand evasion” abroad through increased net imports of

²⁶KLEMS Economic Productivity Accounts, <https://stat.gov.pl/en/experimental-statistics/klems-economic-productivity-accounts/>.

that capital goods, therefore we have a growth of capital contribution in the accounts, not accompanied, however, by a parallel domestic growth of demand for domestic capital goods – the contribution of capital services temporarily raises but with no additional raise in gross value added. This fact may be reflected in lower and even negative MFP contribution, because it is computed residually in the KLEMS methodology. This process was facilitated in those years by the fact that the Polish trade balance improved and even reached positive numbers in 2015, so the economy had finance to invest domestically and of course some role in increasing investments can be attributed to EU funds as well. In the light of developing KLEMS accounting this phenomenon could be better explained using the concept of Global Value Chains (GVC), which would allow to trace exactly and unequivocally (Timmer et al., 2013) the “migration” of gross value added growth together with some part of the residual contribution of MFP between the countries. This effect can also be considered as a tool problem or short-run demand disturbance (if MFP contribution was not calculated residually but computed somehow directly, it would not occur probably).

The last two years of the covered span of time show a huge increase in the contribution of MFP to gross value added growth, which is difficult to be explained solely by the business cycle upturn. It can be observed, however, that this phenomenon is accompanied by a fall in the contribution of the labour factor, i.e. both labour composition and hours worked, which is being offset, as far as its possible negative impact on economic growth is considered, by a surge in productivity growth represented by the MFP contribution.

KLEMS economic productivity accounting allows also to undertake an analysis of the contributions of industry aggregations to aggregate gross value added growth and to decompose this contribution into factor contributions as defined in KLEMS accounting. It can be observed that the NACE 2 classification industries, of which the contribution to aggregate gross value added growth is generally the most important, are industries belonging to section C (manufacturing) of this classification. Its evolution and the evolutions of its contributing factors, as shown in Figure 3 (left-hand side graph), exhibit a similar pattern to the pattern of evolutions observed for the aggregate economy (right-hand side graph).



Legend: ICT – ICT capital contribution, Non-ICT – non-ICT capital contribution, HW – hours worked contribution, LC – labour composition contribution, GVA – gross value added growth, MFP – multifactor productivity contribution.

Figure 3. Contribution of GVA growth of section C and its decomposition compared to GVA growth decomposition for the aggregate Polish economy

Source: Own contribution based on Statistics Poland web page data.

However, the falling trends of gross value added growth, particularly of MFP contribution in section C, are less conspicuous than for the aggregate economy. This indicates that section C supports economic growth. The role of manufacturing seems to strengthen particularly as far as MFP in section C is considered, since its contribution to section C growth is relatively much greater in comparison with the other factors' contributions than for the aggregate economy. This goes in line with the concept that reindustrialization of the Polish economy is on its way.

A lot of interest is due to the labour market, which in Poland has behaved very specifically in comparison with the other countries that have performed KLEMS accounting, as shown in Figure 2, and some argue that this fact lies behind the good comportment of the Polish economy during the trough of the world's financial crisis in 2009. This, of course, is very debatable.

However, we can imply that this is also due to a labour hoarding phenomenon of a both rational and psychological origin and it is caught by the right-hand side graph of Figure 6 later on in the article. The general government and firms refrained from laying off employees until the onslaught of the financial crisis passed away²⁷. At the same time

²⁷ Although typical (see: Timmer et al., Spring 2011, 9–10), this labour hoarding lasted in Poland until 2010, that is about a year longer than in the other EU KLEMS countries.

the highest remunerations were curbed down in the Government administration. From 2008 wage increases in the Government administration were also officially frozen because of the regulations on budget deficit and debt that are in force in Poland²⁸. In the next year (2010) the low base helped to reach a high labour quality contribution growth, when the labour market was freed again to some degree.

The data on KLEMS accounting posted on the Statistics Poland web page indicate that the NACE 2 sections C, G, J, K, L and M-N can be considered as trend settlers for the labour market. The sections O-U (representing mainly the wide public sector entities) contribute to some degree to the entire economy labour productivity evolution.

As far as the capital factor contribution to aggregate gross value added growth is considered, it can be seen in Figure 4 that it generally follows the evolution of the entire economy (i.e. the business cycle), but its relative contribution share increased in the long run and became prevalent in the years 2013–2014. In some countries this led to reduced capital productivity²⁹, but not in Poland. From some other analyses it is known that the ratio of residual capital income³⁰ to capital stock value is continuously (over the period of this analysis) and still growing. Following the standard theory, as long as the “golden rule”³¹ shall be maintained there should not be any decrease in capital productivity. However, the relative role of capital contribution to gross value added growth decreased importantly in the years 2015v2016, which leads to a possible conclusion that a similar process of substitution happened to labour factor contribution substitution by MFP contribution. Generally, a decrease in factor contributions seems to be largely offset by an outstanding MFP contribution increase, much greater than expected to be induced solely by the business cycle itself.

²⁸Timmer et al. (Spring 2011, 9) mention about a productivity going up together with massive layoffs. In Poland, instead of layoffs, remunerations were slashed in 2009.

²⁹In other emerging markets the economic growth was similarly to Poland „increasingly investment driven with negative TFP”, (see: Bart van Ark, 2016).

³⁰Calculated by subtracting labour total compensation from gross value added (Lewandowski et al., 2015).

³¹According to the neoclassical theory of economic growth, an economy should invest about 20% of its GDP.

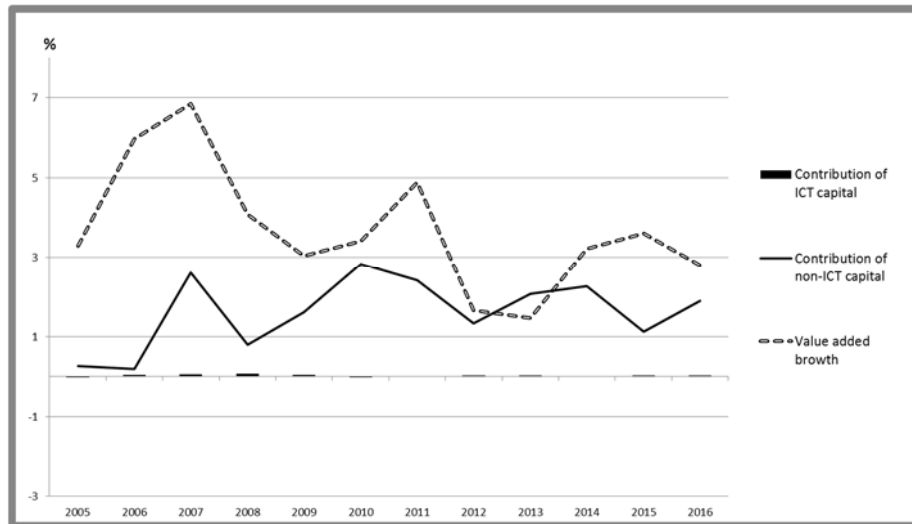


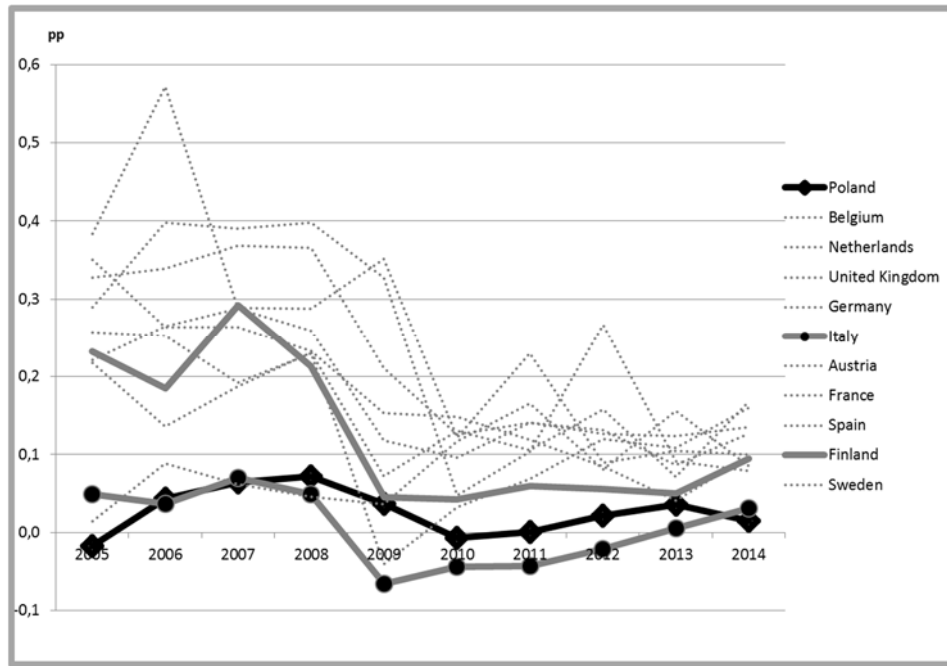
Figure 4. Capital sub-factors' contributions to aggregate GVA growth in Poland

Source: Own calculations based on Statistics Poland web page data.

However, this positive feature in general (with the exception of uncertain last two years 2015–2016), concerning the non-ICT capital services and therefore also the entire capital services as understood in KLEMS accounting, does not concern the ICT capital services, of which the contribution is almost imperceptible (see Figure 4). In comparison with some other countries this could be explained also by the fact that Poland is rather an importer of ICT goods (although Poland is an exporter of quite many ICT components and some software). But there can be also some other explanations that will be examined in Figure 5, where the scale on the vertical axis has been magnified to ease the observations.

As it can be seen in Figure 5, the ten countries that traditionally perform a decomposition of the KLEMS growth accounting type (presented on the EU KLEMS internet platform) greatly differ in the contribution of ICT capital to aggregate gross value added growth, although these are all developed and similar Western European economies, which suggests the possibility of a methodological problem³².

³²This has been discussed in Timmer et al. (2007a and 2007b), the definition of ICT capital is very different in the mentioned countries. The ICT capital can be solely consisting of computers and software, and some top telecommunication devices, or include many peripheral components and infrastructure that is related.



Note: 2015–2016 data for countries other than Poland are not entirely available presently, therefore the graph ends in 2014.

Figure 5. Comparisons of the contribution of ICT capital to aggregate value added growth between Poland and some other countries performing KLEMS accounting

Source: Own contribution based on Statistics Poland website data for Poland and EU KLEMS data for other countries.

Poland seems to be a “non-ICT country” just as Italy is, but this could be the result of narrow definitions of ICT capital used in these countries. The narrow definition of ICT capital in Poland was adopted because it can be assessed in this way from the supply and use tables (SUT), thanks to the structure of software services (see: Kotlewski & Błażej, 2016 and 2018a) and this technique cannot be reliably used if the ICT capital is defined widely³³. At the same time, however, the case of Finland, where we have seen the fall of Nokia impacting the entire ICT industry in this country, suggests that there is some rationale behind the figures (after the fall of Nokia Finland became relatively a non-ICT country as can be seen on the graph).

³³As Timmer et al. (2007a, 38) summarize it: The definitions of IT and CT assets have not been completely harmonized to date. In some countries IT has been defined broadly as office and computing equipment (CPA 30), whereas others have used the more narrowly defined category CPA 3002 computers only. Similarly, CT ...etc.

The EU KLEMS site does not provide more information (e.g. on constant quality indices) about the countries represented on this site that could shed more light on this issue, but the results for Finland suggest some degree of credibility of these comparisons between the countries. It is possible, therefore, that not all countries do benefit from the explosive growth of productivity of ICT technologies (as suggested, e.g. in: Jorgenson, Ho, Stiroh (2005) and Ark, O'Mahony, Timmer (2008)).

The final observation presented here is that there are some premises to think that Poland in the long run is subject to *secular stagnation* just as the remaining world is (as observed through the EU KLEMS performing countries). The long-run trend, as can be seen on all the figures presented here, is a decreasing one. But the concept of *secular stagnation* does not take into consideration that qualitative growth may be replacing quantitative growth now³⁴. In an environment of slowing down demographics, accompanied by a pressure on reducing fuel and material consumption and on shrinking sizes and weights of all end-user machinery, it might be that qualitative growth has become prevalent. This, however, remains debatable³⁵.

4. Preliminary interpretation of results at industry level

To carry on an analysis at industry level, a wide industry approach at NACE 2 classification sections has been applied here. Section A (agriculture, forestry and fishing) has been omitted because the KLEMS methodology is considered to be controversial for this economic activity. Also, NACE 2 sections not belonging to the so-called 'market economy' according to the standard approach (which includes sections L, O, P and Q) have been omitted. Because of their little importance, section T and U have been omitted too. However, NACE sections representing commercialized activities, but under strong public control or with heavy sovereign supports have been included (sections B, D, E, H and R). Industries represented by these sections have huge investment outlays, which are directly or indirectly sovereign supported, and which do not necessarily translate into gross value added growth.

In section B (mining and quarrying) we can observe a negative gross value added growth related to the process of mining industry restructuring carried out under sovereign control, so despite some investments the residual MFP contribution value is negative. In sections D (electricity, gas, steam and air conditioning supply) and E (water supply, sewerage, waste management and remediation activities) that concern network

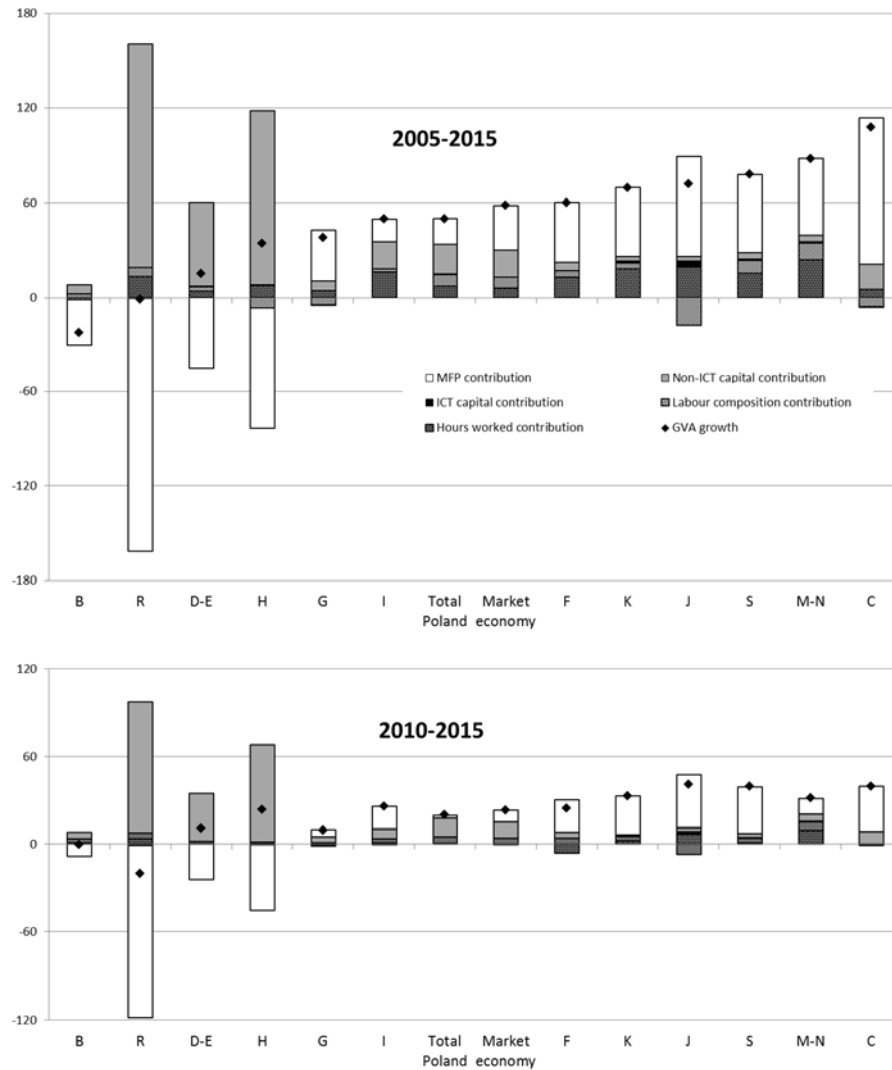
³⁴A discussion about how to measure it and the possibility to use hedonic quality measures is discussed in Hulten (2009), among others.

³⁵One may think that in the light of Krugman (2014, 61-68), the only way to combat secular stagnation is to appropriately reward qualitative growth, thanks to a monetary expansion that would allow prices to grow as an equivalent for improved quality of goods, but near zero policy interest rates do not give room for that. Perhaps only quantitative easing remains, which, however, remains scary for monetary economists.

services there are important upgrading outlays (probably necessary) that are not accompanied by substantial output growth, therefore here as well the contribution of residually computed MFP is negative. To some degree it is the same with section H (transportation and storage) in which also important public outlays are only partly accompanied by an increase in transport services – therefore we also observe a negative MFP contribution. Also a capital public support for section R (arts, entertainment and recreation) does not directly lead to production increase, which inevitably leads to negative MFP contribution.

Those negative MFP contributions are compensated by positive ones in the other industries included in the analysis, therefore the results for total Poland on the graph from Figure 6, are in the middle. Sections not included in the market economy contribute also negatively to the overall MFP contribution and that is why this category is situated to the right from total Poland.

One important observation in Figure 6 is that NACE 2 section C representing a group of industries related to manufacturing has the highest MFP cumulative contribution in the 2005–2016 period. Because this section is the largest in the Polish economy it weighs very importantly on the total economy MFP contribution in a situation where its level within the section is high as well. As they are very technical (as manufacturing generally is), it can be asserted that industries from this section have in general the greatest technological progress (with some possible but not numerous exceptions). It



Note: on the first graph (2005–2015) the NACE 2 classification sections are in order of growing cumulative gross value added growth from the left side to the right-hand side; on the second graph (2010–2015) this order has been maintained.

Figure 6. Decomposition of cumulative gross value added growth into factor and MFP contributions at selected NACE 2 classification sections in the light of KLEMS growth accounting (in pp).

Source: Own contribution based on Statistics Poland website data for Poland.

should translate to an important contribution of MFP into gross value added growth in this section, but the fact that this contribution dominates entirely over other

contributions is an important novelty observation. This suggests that manufacturing is being intensively upgraded (modernized) in Poland, and this is happening regardless of whether this upgrading is replicative (through imitation and acquiring of foreign technologies) or innovative. This upgrading seems to be the basic growth engine for the industries in this section, rather than new capital outlays. Section C in relative terms has the highest growth between all NACE 2 sections. This implies that a reindustrialization process is under way in Poland.

The second NACE 2 classification section that distinguishes itself by its high MFP contribution is section J (information and communication). In the period 2005-2016 the cumulative gross value added growth and the cumulative MFP contribution to that growth in that section was only a little lower than in section C, but in the second half of that period (2010–2016) as shown on the lower graph of Figure 6 it becomes the leader in both of these categories. Sections I (accommodation and food service activities) and S (other service activities) also have increased their importance thanks mainly to MFP contributions. In general we can observe that in all growth supporting activities it is MFP contribution that dominates. Therefore, MFP can be considered as the main *growth engine* in the economy and this domination remains in the second half of the analysed period (2010–2016). However, at the total economy level this important MFP contribution is being levelled by industries from the above-mentioned sections, which do not contribute importantly or positively to gross value added growth and this effect even strengthened in the 2010–2016 period.

The more general implication is that the Polish economy is developing well and intensively modernizing, particularly in industries from the well growing sections as shown in Figure 6 on the one hand. On the other hand, the share of the other industries that are not greatly contributing to gross value added growth or contributing negatively is to large (which would be a *government failure* paradigm supporters' view). However, some contenders might assert that there is no trouble at all since in general the MFP negative contributions of industries from some sections are well counterbalanced by MFP positive contributions of industries from other sections (which would be rather a *market failure* paradigm supporters' preferable interpretation).

The possible analyses at industry level are very numerous (by far trespassing the size of this article), so only a sample is provided here.

5. Developed labour factor decomposition

One of the key idea presented in this article is the possibility to further analyse the labour factor contribution by dividing it into three (and even four as shown latter on) instead of two sub-contributions. Considering KLEMS decomposition at industry

levels, this seems to open new possibilities for analysing the business cycle and the labour market itself, and can lead to promising linkages to other studies.

The standard KLEMS decomposition of the labour factor contribution (called labour services' contribution) into two sub-contributions is:

$$\bar{w}_{jt}^l \Delta \ln L_{jt} = \bar{w}_{jt}^l \Delta \ln LC_{jt} + \bar{w}_{jt}^l \Delta \ln H_{jt} \quad (6)$$

This formula is the same as formula (4) in section 2, but labour quality (Q) is understood here as labour composition (LC) solely, and is therefore calculated through a subtraction between hours worked H_{jt} for labour kinds l growths aggregated with the use of the Törnqvist quantity index over industry j and hours worked H_{jt} growths simply added up for the given industry j :

$$\Delta \ln LC_{jt} = \sum_l \bar{v}_{l,jt} \Delta \ln H_{l,jt} - \Delta \ln H_{jt} \quad (7)$$

In the above-mentioned formulae \bar{w}_{jt}^l stands for the average share of the labour factor remuneration (labour compensation together with the self-employed) in gross value added of industry j for two discrete periods ($t-1$) and t . $\Delta \ln L_{jt}$ stands for the relative growth of the labour factor, understood in the standard KLEMS accounting as labour services, in industry j between two discrete periods ($t-1$) and t ; and $\Delta \ln H_{jt}$ for the relative growth of the number of hours worked in industry j , between these two discrete periods. $\Delta \ln LC_{jt}$ stands for the relative change in the so-called labour composition (otherwise called labour quality in standard KLEMS accounting) in industry j between two discrete periods ($t-1$) and t , understood as an effect of the change in the share structure of the labour factor by different labour kinds l . $\Delta \ln H_{l,jt}$ stands for the relative growth of the number of hours worked in industry j between two discrete periods ($t-1$) and t of different labour kinds l , whereas $\bar{v}_{l,jt}$ are average shares of labour kinds l in labour compensation in industry j between two discrete periods ($t-1$) and t . As seen from equations (6) and (7), only data on the hours worked and value shares are needed for the accounts (all data are according to the National Accounts).

In this way the traditionally understood (Solow, 1956 and 1957) contribution of the labour factor to economic growth as the contribution of hours worked solely is complemented in standard KLEMS accounting by the contribution of labour composition (otherwise called labour quality), which was contained before in the so-called Solow residual. Following this change, the labour inputs have been renamed as labour services' inputs in the standard KLEMS accounting. As mentioned before, in the KLEMS accounting 18 kinds of labour are defined, which arises from divisions into sexes, three age groups and three education attainment levels. Labour composition change is understood, therefore, as the effect of the change in the relative remuneration

shares of different 18 labour kinds at industry level (within industries)³⁶. This effect is as conspicuous as the different labour kinds l are differently remunerated by hour.

This analysis of the labour factor contribution (labour services' contribution in standard KLEMS accounting) can be deepened further, however. The contribution of hours worked growth in formula (6) can be decomposed by changing this formula into:

$$\bar{w}_{jt}^L \Delta \ln L_{jt} = \bar{w}_{jt}^L \Delta \ln LC_{jt} + \bar{w}_{jt}^L \Delta \ln M_{jt} + \bar{w}_{jt}^L \Delta \ln H_{Mjt} \quad (8)$$

where:

$$\Delta \ln H_{Mjt} = \Delta \ln H_{jt} - \Delta \ln M_{jt} \quad (9)$$

In the above-mentioned formulae $\Delta \ln H_{Mjt}$ is the relative growth of hours worked H per employee M in industry j between two discrete periods ($t-1$) and t . In practice, it is calculated residually by subtracting the relative growth of the number of employees, i.e. $\Delta \ln M_{jt}$, from the relative growth of hours worked, i.e. $\Delta \ln H_{jt}$ in industry j between two discrete periods ($t-1$) and t . This technique of residual calculations is the reason why the above formulae are always met in practice and is therefore a better technique for the accounts than to divide the number of hours by the number of employees and observe the changes of this ratio. More generally, the rationale behind this procedure is that the growth of hours worked at a given aggregation can be the result of two distinct processes. One is the possibility that the number of employees is increasing, the other is the possibility that the number of hours per employee is increasing, and it is assumed that these processes may not have exactly the same consequences.

A more detailed decomposition of hours worked contribution into the contributions of the number of employees and the number of hours per employee can be of some not negligible importance for using KLEMS results in analyses oriented at economic policy. In the case of a negative shock, the economy reacts usually by reducing the total number of hours worked. However, the case of reduced number of employees with stabilization (or even increase) of the number of hours per employees is well different from the case when the economic adjustment takes the shape of a decreased number of hours per employee with little employee reduction. In the first case, the social consequences are more severe, which results in reduced household consumption (a contagion alike consumer spending reduction effect) and the eventuality of high costs of bringing back the previous employment level (because of a hysteresis effect). In the second case, the social consequences are milder, which results in a lower decrease of the household consumption level and its quicker restauration

³⁶ The contribution of labour reallocation between industries with different levels of productivity can also be taken into account in theory (Timmer et al. 2010, 153, eq. (5.4)).

(because consumers tend to maintain their spending levels when their incomes decrease moderately).

This analysis can be a contribution to explaining the reasons of different reactions of the EU economies against the 2007–2009 crisis and of different paces of growth restauration. Some initial studies carried for some chosen EU economies according to a simplified methodology seem to demonstrate these different reactions in accordance with the rationale presented here (CSO Poland³⁷, 2014). This could be also interesting when regional (by provinces of the given country) growth decompositions will be performed³⁸. On the right hand, in the side graph of Figure 7 we can see that in 2009 the contribution of hours per employee was negative, and thanks to that the contribution of the number of employees³⁹ remained positive even in the situation where the total number of hours worked decreased. This explains presumably why consumer spending did not decrease importantly in Poland in comparison with the other countries in that year. Obviously,

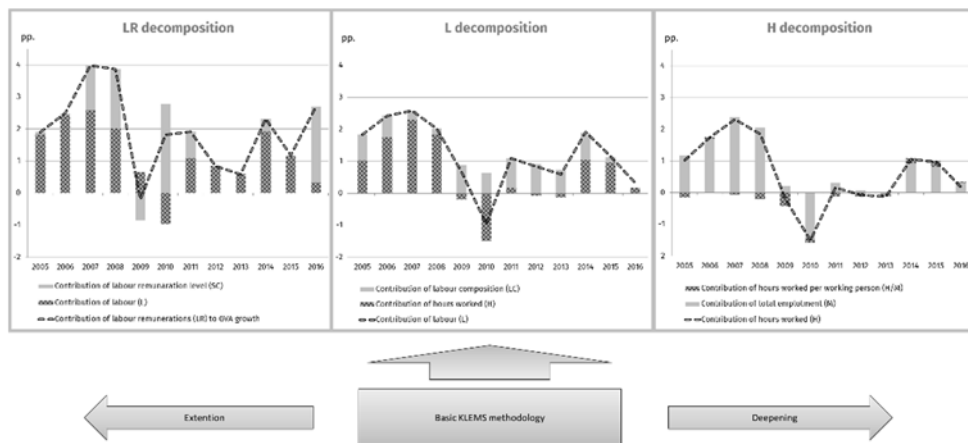


Figure 7. Developed labour factor decomposition

Source: Own contribution based on Statistics Poland web page.

although it helps to understand why Poland avoided recession in that year, it is certainly not the only reason for this wishful behaviour of the economy⁴⁰.

We have also a general wage increase phenomenon, which by a margin can be different than labour factor (L), understood as above, increase. In real terms (deflated)

³⁷ Actually Statistics Poland.

³⁸ As Spain did. In China it has been done also, see: Kang and Peng (2013).

³⁹ In the entire article employees are considered as including the self-employed.

⁴⁰ The other well identified reason is a floating currency that allowed for a betterment of the balance of payments to a large degree.

and marginally, including it should help to completely reflect labour quality growth, understood as marginal labour productivity growth. The resulting conclusion is that in an ideal situation the total labour quality effect should include the wage effect from formula (10) below. The analysis of the labour factor can be therefore extended. If the contribution of labour factor (L) growth, calculated as above-mentioned, is subtracted from the contribution of labour compensation (LR) growth then we receive the contribution of the change in the relative level of remunerations (SC – *soft composition*⁴¹) according to the following formula:

$$\bar{w}_{jt}^L \Delta \ln SC_{jt} = \bar{w}_{jt}^L \Delta \ln LR_{jt} - \bar{w}_{jt}^L \Delta \ln L_{jt} \quad (10)$$

and here as well (according to a technique often used in KLEMS accounting) we do not need to establish the value of SC directly, because the value of its contribution, i.e. the left-hand side of the equation (10), can be calculated residually from the other variables as the subtraction between their contributions (the value of labour compensation (LR – *labour remuneration*⁴²) is available from the National Accounts). In such a case the contributions of all the above-mentioned four labour factor's sub-factors can be joined in a single formula:

$$\bar{w}_{jt}^L \Delta \ln LR_{jt} = \bar{w}_{jt}^L \Delta \ln SC_{jt} + \bar{w}_{jt}^L \Delta \ln LC_{jt} + \bar{w}_{jt}^L \Delta \ln M_{jt} + \bar{w}_{jt}^L \Delta \ln H_{Mjt} \quad (11)$$

In the KLEMS accounting labour composition LC is interpreted as the main manifestation of labour efficiency in the long run⁴³, which only to some degree translates into the actual remunerations' level. The remaining remunerations' level change SC can be attributed to the actual labour usage that mostly can be related with the business cycle but also with a reallocation effect between industries⁴⁴.

For clarity, on the Statistics Poland website the Excel tables concerning this developed decomposition of the labour factor are presented in a hierarchical way following the equation (11) divided into three equations:

$$\begin{aligned} \bar{w}_{jt}^L \Delta \ln LR_{jt} &= \bar{w}_{jt}^L \Delta \ln SC_{jt} + \bar{w}_{jt}^L \Delta \ln L_{jt} \\ \bar{w}_{jt}^L \Delta \ln L_{jt} &= \bar{w}_{jt}^L \Delta \ln LC_{jt} + \bar{w}_{jt}^L \Delta \ln H_{jt} \\ \bar{w}_{jt}^L \Delta \ln H_{jt} &= \bar{w}_{jt}^L \Delta \ln M_{jt} + \bar{w}_{jt}^L \Delta \ln H_{Mjt} \end{aligned} \quad (12)$$

⁴¹ Own designation.

⁴² Own designation – must be different from LC (labour composition) already used.

⁴³ The neoclassical premise is that labour is being remunerated according to its marginal productivity.

⁴⁴ This reallocation effect has been discussed in Stiroh (2002). Here, it is contained within SC .

They represent the three stages of the labour factor decomposition presented in Figure 7. It can be seen that a drop in remunerations' contribution in 2009 shown on the left-hand side graph probably delayed the trough in labour contribution to gross value added growth in 2010 shown on the middle graph, which was accompanied by some labour hoarding in 2009 shown on the right-hand side graph in the form of a negative hours per employee growth level.

6. Conclusions and a look into the future

To conclude, the KLEMS accounting methodology applied in Poland, although not solving all economic analysis dilemmas, is a valuable tool for economic ex post observation, which can provide non-negligible findings, also for the decision makers. It does not respond to similar Keynesian findings and controversies, but the processed final KLEMS data can possibly be used also for that purpose in some cases, although mainly applicable to similar neoclassical analyses oriented rather towards the long run economic paradigm.

The main findings are:

- 1) that missing data can be effectively assessed up to the level allowing to build up KLEMS type data sets of sufficient quality;
- 2) that the labour factor can be decomposed further, which is conducive to more informed analysis;
- 3) that during the 2009 crisis trough MFP contribution increased, resulting perhaps from some effective reorganisations in the economy undertaken to combat the crisis both at the aggregate level and at firms levels;
- 4) that a specific labour hoarding phenomenon was present in the economy during the 2009 onslaught of the crisis on the Polish economy, which prevented largely the incidence of huge demand slump;
- 5) that the industry level analysis exhibits an even more optimistic feature of the Polish economy than at the aggregate level – it shows that the Polish economy has strong sectoral fundamentals and that only the role of the State is an issue.

Some of these findings, i.e. four of the five above-mentioned items, have already been published in previous publications (Kotlewski & Błażej 2016, 2018a and 2018b), but here they were explained more extensively. Item 4) was only signalled in (Kotlewski & Błażej 2018b), whereas here it was well explained. Item 5) is a first time result publication.

The KLEMS accounting performed in Poland can be developed. One obvious possibility is to bring to live not only the gross value added growth decomposition but also the gross output growth decomposition, which includes intermediate consumption

contribution. The theoretical KLEMS methodology⁴⁵ includes a decomposition of intermediate consumption contribution into the contributions of its three sub-components, i.e. energy, materials and services inputs. As we know from the last release of National Accounts for Poland, the deflators for intermediate consumption by industries are now available⁴⁶, so the main obstacle standing against this procedure has been almost lifted (what remains is the issue to attribute the appropriate deflators to the three kinds of intermediate consumption, i.e. energy, materials and services). The international comparability problem, arising from differences in vertical integration of firms between the countries, will remain. But, performing gross output decomposition could be useful for intra-country analyses of energy and material footprints, and the scale of services' outsourcing also by industries. Lastly (June 2019), on Statistics Poland website gross output growth decomposition has been published, although without the subdivision into the above-mentioned three categories of intermediate inputs. This partial progress can lead, however, to some new analyses⁴⁷.

Considerably more important and complex is the idea to perform KLEMS accounting not only for the entire economy at the aggregate level and by industries, but also regionally, i.e. by individual Polish sixteen voivodships. This could allow to make analytical comparisons between voivodship regional economies (as some Polish voivodships are as large as some small European countries), also in relation to the aggregate economy as a whole, and could happen to become an important supporting tool for economic analyses oriented at regional economic policy.

REFERENCES

- ARK BART VAN, (2016). Are Emerging Markets Still Emerging?, Forth World KLEMS Conference, Madrid 2016.
- ARK BART VAN, O'MAHONY, M., TIMMER MARCEL P., (2008). The productivity gap between Europe and the United States, *Journal of Economic Perspectives*, 22(1), pp. 25–44.
- BHAGWATI JAGHDISH N., (1982). Directly Unproductive Profit-seeking (DUP) Activities, *Journal of Political Economy*, Vol. 90, No. 5.
- DIEWERT W., EDWIN, (1993). The Early History of Price Index Research, in: Diewert W.E., Nakamura A.O. (1993), *Essays in Index Number Theory*, Elsevier, B.V.

⁴⁵ Particularly comprehensively explained in O'Mahony and Timmer (2009).

⁴⁶ They are different as the price inflation for intermediate goods is different than for final goods.

⁴⁷ A paper about this issue is under elaboration.

- GOUMA REITZE, MARCEL P. TIMMER, (2013a). EU KLEMS Growth and Productivity Accounts – 2013 update, Groningen Growth and Development Centre.
- GOUMA, REITZE, MARCEL P. TIMMER, (2013b). WORLD KLEMS Growth and Productivity Accounts – 2013 update, Groningen Growth and Development Centre.
- GRADZEWICZ, M., GROWIEC, J., KOLASA, M., POSTEK, Ł., STRZELECKI, P., (2014). Poland's Exceptional Growth Performance During the World Economic Crisis: New Growth Accounting Evidence. Working Paper, No. 186. NBP.
- GRADZEWICZ, M., GROWIEC, J., KOLASA, M., POSTEK, Ł., STRZELECKI, P. (2018). Poland's Uninterrupted Growth Performance: new growth accounting evidence, in: *Post-Communist Economies*, Vol. 30, No. 2, pp. 238–272.
- HAUSMAN, J., (2003). Sources of Bias and Solutions to Bias in the Consumer Price Index, *Journal of Economic Perspective*, Vol. 17, No. 1, pp. 23–44.
- HAVLIK P., LEITNER, S., STEHRER, R. (2012). Growth Resurgence, Productivity Catching-up and Labor Demand in Central and Eastern European Countries, in: Matilde Mas, Robert Stehrer (Ed.), *Industrial Production in Europe. Growth and Crisis*, Edward Elgar, pp. 219–263.
- HULTEN, C. R., (2009). Growth Accounting, NBER Working Paper 15341.
- JORGENSEN, D. W., (1963). Capital Theory and Investment Behavior, *American Economic Review*, 53(2), pp. 247–259.
- JORGENSEN, D. W., (1989). Productivity and Economic Growth, in Ernst R. Berndt and Jack E. Triplett (eds.), *Fifty Years of Economic Measurement*, University of Chicago Press.
- JORGENSEN, D. W., (2012). The World KLEMS Initiative, *International Productivity Monitor*.
- JORGENSEN, D. W., ZWI GRILICHES, (1967). The explanation of Productivity Change, *Review of Economic Studies*, 34, pp. 249–83.
- JORGENSEN, D. W., ed., (2009). *The Economics of Productivity*, Edward Elgar Publishing.
- JORGENSEN, D. W., FRANK M. GOLLOP, BARBARA M. FRAUMENI, (1987). *Productivity and U.S. Economic Growth*, Cambridge, MA: Harvard University Press.

- JORGENSON, D. W., MUN S. HO, KEVIN J. STIROH, (2005). *Information Technology and the American Growth Resurgence*, Cambridge, MA: The MIT Press.
- JORGENSON, D. W., MUN S. HO, JON D. SAMUELS, (2014). *Long-term Estimates of U.S. Productivity and Growth*, Third World KLEMS Conference paper.
- KANG LILI, FEI PENG, (October 2013). *Growth Accounting in China 1978-2009*, MPRA Paper No. 50827.
- KOTLEWSKI, D., C. (2017). *Problem cen w regionalnym rachunku produktywności*, *Wiadomości Statystyczne* 12/2017.
- KOTLEWSKI, D., BŁAŻEJ, M., (2016). *Metodologia rachunku produktywności KLEMS i jego implementacja w warunkach polskich*, *Wiadomości Statystyczne* 9/2016.
- KOTLEWSKI, D., BŁAŻEJ, M., (2018a). *Implementation of KLEMS economic productivity accounts in Poland*, Lodz University Publication, *Folia Oeconomica* 2/2018.
- KOTLEWSKI, D., BŁAŻEJ, M., (2018b). *KLEMS Productivity Accounts – Poland 2005-2016*, Statistics Poland.
- KLEMS Economic Productivity Accounts, <https://stat.gov.pl/en/experimental-statistics/klems-economic-productivity-accounts/>
- KOTLEWSKI, D., BŁAŻEJ, M., (updated regularly every year or every two years), *KLEMS Economic Productivity Accounts*, Statistics Poland, <https://stat.gov.pl/en/experimental-statistics/klems-economic-productivity-accounts/methodology-of-decomposition-in-klems-productivity-accounts-for-the-polish-economy,2,1.html>
- KRUGMAN, P., (2014). *Four observations on secular stagnation in Coen Teulings and Richard Baldwin, eds., Secular Stagnation: Facts, Causes, and Cures*, CEPR Press, pp. 61–68.
- LEWANDOWSKI, M., BANAS, M., KOTLEWSKI, D., KULCZYCKA, J., DONIEC, D., WITKOWSKI, G., and others, (2015). *Metoda dekompozycji Produktu Krajowego Brutto (PKB) oraz Wartości Dodanej Brutto (WDB) w zastosowaniu do analizy struktury różnic regionalnych*, Statistics Poland, <http://stat.gov.pl/statystyka-regionalna/statystyka-dla-polityki-spojnosci/realizacja-prac-metodologicznych-analiz-ekspertyz-oraz-prac-badawczych-na-potrzeby-polityki-spojnosci/dezagregacja-wskaznikow-z-obszaru-rachunkow-narodowych-i-regionalnych> .

- MILANA, C., (2009). Solving the Index-Number Problem in a Historical perspective, EU KLEMS Working Paper 43.
- O'MAHONY, MARY and MARCEL, P., TIMMER, (2009) Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database, *The Economic Journal*, 119 (June), F374-F403.
- OECD, (2001) *Measuring Productivity*, OECD Manual.
- OECD, (2009) *Measuring Capital*, OECD Manual.
- OECD, (2013) *OECD Compendium of Productivity Indicators 2013*, OECD Publishing.
- SCHREYER, P., (2004). Chain Index Number Formulae in the National Accounts, 8th OECD – NBS Workshop on National Accounts.
- SOLOW R., .M. (1956). A Contribution to the Theory of Economic Growth, *Quarterly Journal of Economics*, Vol. 70, No. 1, pp. 65–70.
- SOLOW R., M. (1957). Technical Change and the Aggregate Production Function, *Review of Economics and Statistics*, Vol. 39, No. 3, pp. 312–320.
- STATISTICS POLAND (2014). *Macroeconomic Situation in Poland in 2013 in the Context of the World Economic Processes*, a yearly report.
- STIROH, K., J., (2002). Information Technology and the U.S. Productivity Revival: What Do the Industry data Say? *American Economic Review*, 92(5), pp. 1559–76.
- TIMMER M. P., MARY O'MAHONY, BART VAN ARK, (2011). Productivity and Economic Growth in Europe: A Comparative Industry Perspective, *International Productivity Monitor*.
- TIMMER MARCEL P., INKLAAR, R., O'MAHONY, M., ARK BART VAN, (2010). *Economic Growth in Europe*, Cambridge University Press.
- TIMMER, MARCEL P., ABDUL AZEEZ ERUMBAN, BART LOS, ROBERT STEHRER, GAAITZEN J. DE VRIES, (2013). Slicing Up Global Value Chains, *Journal of Economic Perspectives*, Vol. 28, No. 2, pp. 99–118.
- TIMMER, MARCEL P., TON VAN MOERGASTEL, EDWIN STUIVENWOLD, GERARD YPMA, (Groningen Growth and Development Centre) and Mary O'Mahony, and Mari Kangasniemi (National Institute of Economic and Social Research) (March 2007a) *EU KLEMS Growth and Productivity Accounts – Methodology*, EU KLEMS Consortium.

TIMMER, MARCEL P., TON VAN MOERGASTEL, EDWIN STUIVENWOLD, GERARD YPMA, (Groningen Growth and Development Centre) and MARY O'MAHONY, and MARI KANGASNIEMI (National Institute of Economic and Social Research), (2007b). EU KLEMS Growth and Productivity Accounts – Sources by country, EU KLEMS Consortium.

WÖLFL, ANITA and DANA HAJKOVA, (2007) Measuring multifactor productivity growth, STI Working Paper 2007/5, OECD.

KLEMS growth accounting implemented in Poland¹

Dariusz Kotlewski², Mirosław Błazej³

ABSTRACT

The aim of the article is to present the main body of the KLEMS growth accounting recently implemented in Poland. The works on the KLEMS productivity accounting in Poland started in 2013 and focused on areas such as the development of methodology and the availability and assessment of data. These efforts enabled preparing KLEMS data sets pertaining to the Polish economy and moreover proved that unavailable data can be effectively estimated. Additionally, interesting but complex and debatable results were obtained, such as labour hoarding together with remunerations' freezing around the 2009 crisis, accompanied by a natural drop in the capital contribution growth and an increase in the MFP contribution, which most probably indicated effective reorganizations in the economy. In the years 2012–2014, increasing labour and capital contributions did not fully translate into gross value added growth, which led to negative MFP growths, as these are calculated residually. This, however, changed completely in the last two years of the time span covered by the research, namely in 2015–2016. An industry-level analysis became also possible, showing that the Polish economy was developing dynamically and undergoing intensive modernisation, which was obtained, however, with a debatable contribution of the State. To study the debatable features of the Polish economy in a greater detail, a further decomposition of the labour factor growth into four sub-factor contributions instead of two sub-factor contributions was performed. This additional analysis confirmed that labour hoarding phenomenon specific for Poland contributed to a softer impact of the 2007–09 financial crisis on this country's economy.

Key words: gross value added, decomposition, production factors, KLEMS, productivity.

1. Introduction

The aim of the article is to present KLEMS productivity growth accounting recently being implemented in Poland and discuss it. Although Poland is present in various

¹ Disclaimer: the views presented in this article are those of the authors and do not represent the official standpoint of Statistics Poland.

² Warsaw School of Economics, Dariusz Kotlewski is also an employee in Statistics Poland, Poland.
E-mail: dariusz.kotlewski@gmail.com, dariusz.kotlewski@sgh.waw.pl, d.kotlewski@stat.gov.pl.
ORCID: <https://orcid.org/0000-0003-1059-7114>.

³ Statistics Poland, Poland. E-mail: m.blazej@stat.gov.pl.

releases of EU KLEMS database, no decomposition of gross value added growth or gross output growth into factor contributions and MFP contribution has been ever performed there because of missing input data (with the exception of 2007 EU KLEMS release, presently outdated) – the reason is that no sufficient data are being sent to Eurostat on the one hand (although theoretically they could be sent, which is a matter of co-operation agreements within Eurostat) and on the other hand that there are data which need to be imputed innovatively, since they are not straightforwardly available in Poland too. A growth accounting for Poland with decomposition as above mentioned has been performed by NBP⁴ appointed researchers, based on a slightly different methodology (Gradzewicz et al., 2014, 2018), but not at the sectoral and industry level. As far as the authors of this article know, no one else has ever performed a decomposition of the above-mentioned kind at industry level for Poland (with the exception of the above mentioned release⁵).

The methodology framework based on a gross value added decomposition is outlined in the second section. In the third section, these results are discussed in an attempt to interpret them. In the fourth section a sample analysis at industry level is presented. In the fifth section, a developed labour factor decomposition is advanced allowing for more analytical insights in the Polish economy. Despite the specific data processing hurdles accompanying the works on the Polish KLEMS accounting, ample results of good quality were achieved (presently, they are available on Statistics Poland web page⁶). As they are to a large extent debatable, these outcomes remain open to further analyses and discussion. New avenues for developing KLEMS accounting and the conclusion are presented in the final section. The article is of a wide synthetic nature. It deals both with theoretical matters and technicalities, and presents also the results of KLEMS accounting in Poland with some interpretation.

2. Basic methodology

The basic methodology follows in general the growth accounting methodology developed by Dale W. Jorgenson and associates, as outlined in Jorgenson (1963), Jorgenson & Griliches (1967), Jorgenson, Gollop and Fraumeni (1987), Jorgenson

⁴ The National Bank of Poland which is the Polish Central Bank.

⁵ The EU KLEMS data set release of 2007 includes a decomposition for Poland with labour services' contribution being subdivided into hours worked and labour composition contributions, but with no subdivision of capital services' contribution into ICT and non-ICT capital contributions. This release covers the period of 1996–2004, therefore just preceding the present study time span. For the 2007 EU KLEMS release data were often extensively imputed (Timmer et al., 2007b, pp. 121–29) to a far greater degree than in the present study due to greater data shortages. The possible comparisons between the two studies can possibly be an avenue for further analysis.

⁶ KLEMS Economic Productivity Accounts, <https://stat.gov.pl/en/experimental-statistics/klems-economic-productivity-accounts/>

(1989) and Jorgenson, Ho and Stiroh (2005)⁷. This methodology has been summarized by Timmer et al. (2007), and O'Mahony and Timmer (2009) for the EU KLEMS⁸. For Poland it has been developed and presented in Kotlewski & Błażej (2016, 2018a and 2018b)⁹. Hereinafter, only the basic idea and structure of the accounts is presented. It is based on the standard growth accounting decomposition of output into the contribution of input factors and MFP:

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

where Y is the gross output, X – intermediate consumption, K – capital services¹⁰, L – labour services¹¹ and where A^Y stands for multifactor productivity. These values are subscripted by j for industries and t for years. \bar{v} with appropriate subscripts are average value shares¹² of the individual factors in the gross output (defined in the superscripts by X , K and L) for two discrete time periods $t-1$ and t , which are calculated through linear interpolation as $\bar{v} = (v_{t-1} + v_t)/2$ (for simplicity the subscripts of (1) have been omitted here). Since the growth of A^Y is residually calculated, the equation (1) is always met. As for most of the EU KLEMS countries performing the KLEMS growth accounting, the methodology has been reduced to a gross value added decomposition following the standard equation¹³:

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

⁷ In the preparatory works, the OECD growth accounting methodology was studied as well for possible insights; see: OECD (2001, 2009 and 2013), Wölfl (2007).

⁸ See also the large overview of the subject: Jorgenson, ed. (2009).

⁹ The first of these works is addressed to the Polish audience not fully acquainted with KLEMS accounting, therefore methodological details were amply presented, whereas the second one is more focused on Polish specificities, more essential for the foreign audience. The third of these works presents development of the labour factor decomposition into additional sub-factors.

¹⁰ It is assumed that the values of capital services are proportional to the values of capital stocks if these are separated into different kinds of capital stocks at industry level, which means that although capital stocks and capital services are different entities, their growths are the same at this level. These different kinds of capital stocks are then aggregated with the use of Törnqvist quantity index at industry level. Following: OECD (2001, 61), Timmer et al. (2007a, 32-33), OECD (2009, 60) and Timmer et al. (2010, eq. (3.6)).

¹¹ It is assumed that the values of labour services are proportional to the amounts of physical work engaged (in hours worked) if these are separated into different kinds of labour according to age, education attainment and sex.

¹² All value shares throughout the paper were taken from the national accounts, but they were adjusted for the self-employed before being used in calculations.

¹³ This value added based growth accounting is not neutral to the substitution between intermediate inputs, and the production factors labour and capital, but this problem is considered to be less severe than vertical firm consolidation differences between different countries, when their growth accounting are compared. Moreover, there is the problem of producing intermediate inputs deflators that are required for gross output based growth accounting, which is a quite universal unsolved problem (see: EU KLEMS database). However, a separate methodology has been lastly developed for Poland to address this issue, which allowed to include intermediate inputs according to formula (1). This issue, however, does not contradict the present analysis and could be the subject of a separate paper.

where V is the gross value added and where A^V stands for multifactor productivity (further referred to as MFP¹⁴) in the gross value added based decomposition \bar{w} with appropriate subscripts are average value shares of production factors' services in the gross value added (defined in the superscripts as K and L) for two discrete time periods $t-1$ and t , which are calculated through linear interpolation in a similar way as \bar{v} for the previous formula (1). The other symbols are the same as in equation (1). Replacing the decomposition (1) by (2) eases some data problems and the international comparability of the individual countries¹⁵. In practice the contribution of multifactor productivity $\Delta \ln A_{jt}^V$ is residually calculated as the subtraction between the other values, so the equation (2) is always met, similarly to equation (1). There is no need, therefore, to directly measure the levels of A .

The capital factor contribution (understood as capital services inputs) has been decomposed into two sub-factors contributions as follows:

$$\bar{w}_{jt}^K \Delta \ln K_{jt} = \bar{w}_{jt}^{KIT} \Delta \ln KIT_{jt} + \bar{w}_{jt}^{KNIT} \Delta \ln KNIT_{jt} \quad (3)$$

where KIT stands for ICT capital and $KNIT$ for non-ICT capital services¹⁶, treated as separate factors indeed, which is expressed also by their different shares (appropriately superscripted). In practice one of the three contributions, usually the non-ICT capital one, is residually calculated as the subtraction between the other values in the equation (3), in order to avoid mathematical tool problems (so the equation (3) is always met).

The labour factor contribution (understood in the standard KLEMS methodology as labour services' contribution) has been decomposed somehow differently as follows:

$$\bar{w}_{jt}^L \Delta \ln L_{jt} = \bar{w}_{jt}^H \Delta \ln H_{jt} + \bar{w}_{jt}^Q \Delta \ln Q_{jt} \quad (4)$$

where L stands for the labour factor understood as hours worked aggregated with the use of Törnqvist quantity index on the one hand or compensations aggregated with the use of this index on the other hand¹⁷, H stands for the (straightforward) sum of hours worked on the one hand or hours worked aggregated with the use of Törnqvist quantity index on the other hand¹⁸, and Q for labour quality. The firsts of these options result in

¹⁴It can be considered as a variant of total factor productivity (TFP).

¹⁵Because of the vertical integration of firms of different intensity in different countries, which hinders international comparability of the countries, as far as the intermediate consumption is considered.

¹⁶Symbols taken from Timmer et al. (2007).

¹⁷Over standard KLEMS 18 kinds of labour according to sex, three age groups and three education attainment levels ($2 \times 3 \times 3 = 18$). The first of these options is a standard KLEMS procedure, the second is an option explored additionally in Statistics Poland.

¹⁸As above. Experiments done in Statistics Poland have finally led to a developed procedure for labour factor contribution decomposition presented in more details in Section 4.

labour quality contribution understood as labour composition contribution, whereas the seconds – as labour compensation change contribution. They are all treated as a single factor, which is expressed by their same share \bar{w}_{jt}^L as for L . This difference in comparison with the capital factor decomposition (3) is however of no importance as far as the linear additivity of the sub-factor contributions in the gross value added growth is considered¹⁹. Here the growths of the so-called sub-factors sum up to the growth of the entire labour factor as:

$$\Delta \ln L_{jt} = \Delta \ln H_{jt} + \Delta \ln Q_{jt} \quad (5)$$

In practice, the labour quality related expressions in equations (4) and (5) are residually calculated through subtractions between the expressions related with L and H (this is possible because all expressions are in percentage points). So, there is no need to directly measure the value of Q and therefore the equations (4) and (5) are always met.

All data have been calculated after being converted initially into 2005 prices and presently into 2010 prices²⁰, following the same change in Eurostat transmission tables that happened during the works on Poland KLEMS. This change was found to be only technical and of little impact on the accounts. Information on data processing by other countries was studied for comparison and reference in Gouma and Timmer (2013). During the works the ESA'95 Eurostat system changed also into the ESA 2010 system²¹, but this change was found to be of even lower importance than the above-mentioned one²². The problem of qualitative growth as discussed, e.g. by Diewert (1993), Hausman (2003) and Hulten (2009, 19–21) has been for the time being ignored, which is the general practice in the present KLEMS accounting²³. However, one may argue that quality deflators for ICT capital services are to some extent considered, as the structure

¹⁹ The equation (15) in O'Mahony and Timmer (2009, F378) expresses also this difference, but instead of the term "labour quality" (Q) used here, the terms "labour composition" (LC) was used there, more narrowly defined as only the standard KLEMS procedure. More details are presented in Section 4.

²⁰ This can be done directly comparing each year with the base year or through chaining (see Schreyer (2004) and Milana (2009)). The results of the two methods are slightly different. As in other EU KLEMS countries chaining was applied to establish the base year. Establishing the base year is not necessary to perform KLEMS type growth accounting (pairs of years in the same prices are good enough), but such is the way the other EU KLEMS countries data were processed.

²¹ These are European equivalents of SNA'93 and SNA 2008 systems.

²² It concerns only the ICT capital services where mixed data on productive capital stocks had to be used. A test for shortened time series covering both ESA'95 and ESA 2010 comparing results arising from the use of these two systems showed that differences are negligible.

²³ And there seems to be no perspective to introduce it soon. It is quite controversial to use hedonic quality assessments based on price differentials. High quality growth industries should theoretically expand at the expense of low quality growth industries, but this is not necessarily the case. In the case of ICT industries it might be that prices are falling and product quality rising.

taken from SUT tables (ICT services related with software providing) was used to distribute productive capital stocks by industries²⁴.

The works on Poland KLEMS have a specific feature, which is open for further discussion. All results have been calculated and presented in four versions indicated on the Statistics Poland web page by capital letters A-D:

- A – Capital without residential capital (without dwellings), labour quality understood as labour composition
- B – Capital with residential capital (with dwellings), labour quality understood as labour composition
- C – Capital without residential capital (without dwellings), labour quality understood as labour compensation level
- D – Capital with residential capital (with dwellings), labour quality understood as labour compensation level

The inclusion of residential capital in the Polish KLEMS accounting is controversial because of the still opaque (to be understood as not fully liquid in economic terms) Polish dwelling market. But for international comparison it is preferable because all the other KLEMS countries (which are generally not transformation countries and therefore with well capitalised, liquid and transparent dwelling markets) do include it. Therefore, it was decided to make the calculations in both ways (to satisfy both contenders). There are perceivable difference on graphs, between these two options, although of no decisive importance²⁵.

The other dichotomy is the possibility of different understanding of the labour quality sub-factor, as solely related to labour composition change or, alternatively, as being entirely translatable into changes in labour compensation levels. Here also both ways of calculations have been performed. For international comparisons the versions B is the appropriate one. In Kotlewski & Błażej (2016 and 2018a) and in Kotlewski (2017) details on how data limitations have been overcome are extensively presented.

Figure 1 shows the results at the aggregate level for the above-mentioned four versions A to D. It can be seen that the differences are not of a fundamental nature. However, there are some benefits from doing KLEMS accounting in the four versions. The lower graphs (C and D) show the impact of remuneration level increase on the

²⁴It was, as it seems quite sensibly, assumed that the ICT productive stocks (used to compute ICT capital services' contributions) are proportional to the related ICT services, such as software providing. Both ICT capital assets and related services provided on the market are increasing in quality and decreasing in prices, to some extent in parallel.

²⁵The industry of residential building is usually excluded from market economy, because the output of this industry mostly reflect imputed housing rents instead of firms' production (Timmer et al., 26). Such is the case, e.g. in Germany. However, in Poland the situation is different since houses are generally owned by the users. Excluding housing from market economy is therefore also a controversial issue, although the Statistics Poland's KLEMS database provides also the data for this market economy aggregation. In Poland, houses are rather a kind of product sold in instalments, therefore excluding it from capital stocks finds supporters.

accounts, i.e. the years when this impact was huge can be identified by comparing the differences in the MFP level between these graphs and the graphs A and B situated above. Similarly, the years when the impact of dwellings' growth was huge can be identified by comparing the differences in the MFP level between graphs A and C with graphs B and D.

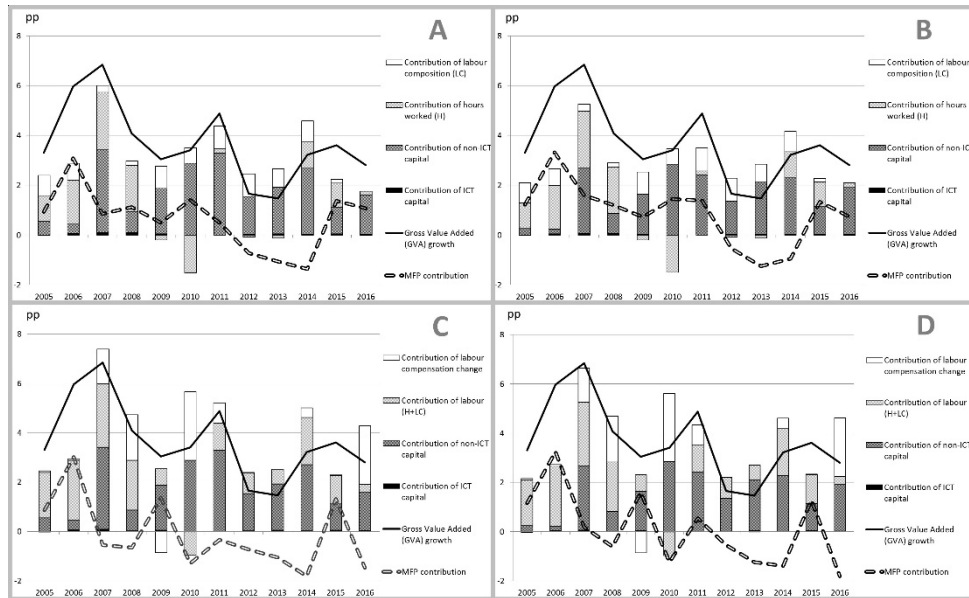


Figure 1. Decomposition of aggregate value added growth in Poland in four versions

Source: Statistics Poland web page.

3. Preliminary interpretation of aggregate results

The general picture of the Polish economy in the light of the present KLEMS accounting methodology, which is in line with other countries performing KLEMS productivity accounting (version B as indicated in section 2.), is presented in Figure 2. What can be seen is that the peaks of MFP contribution in 2006 and 2010 precede the peaks of aggregate gross value added growth in 2007 and 2011, which suggests at first that the increase in productivity due to some reorganizations or modernizations in the economy led to profit margin increases, launching forward the economy and that these impulses remained active for some time after.

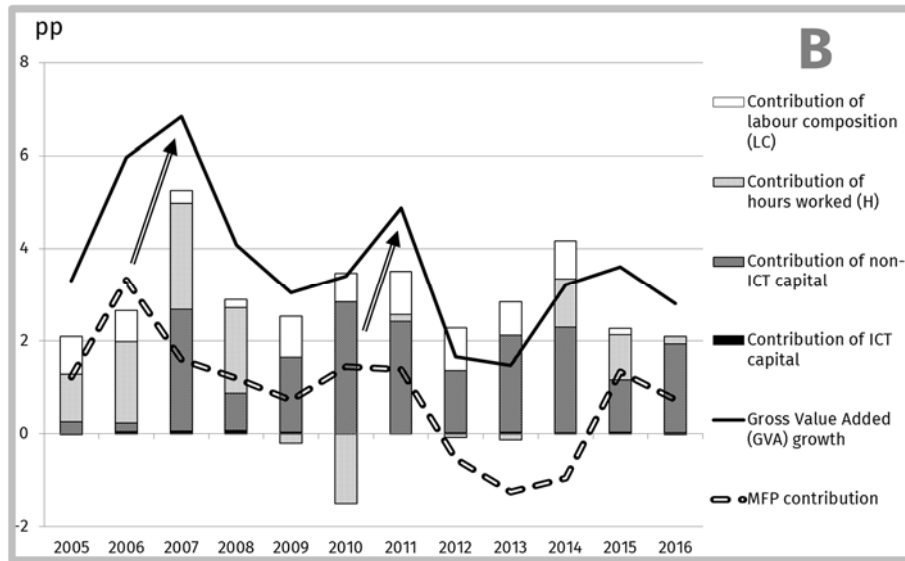


Figure 2. Decomposition of aggregate value added growth in Poland – version B conformable with EU KLEMS

Source: Own contribution based on Statistics Poland web page.

However, the evolution of the gross value added growth in Poland is also not in contradiction to its evolutions in some other economies, i.e. there was a slump around the year 2009 during the trough of the world-wide financial crisis, and the above-mentioned peaks before and after are somehow correlated with the world's economy as well, which suggests rather a business cycle effect. The mentioned slowdown has not, however, led the Polish economy into recession, which is its distinctive feature. These results correspond well with the results presented, e.g. in Havik, Leitner, Stehrer (2012) as far as the time series do overlap each other, but additionally MFP data are provided. Since yearly representations of growth accounting can be misleading, because it might be difficult to focus on long run effects only and eliminate the short-term demand effects, a cumulative growth analysis is provided in the fifth section. Exact quantitative yearly data are available on the Statistics Poland website²⁶.

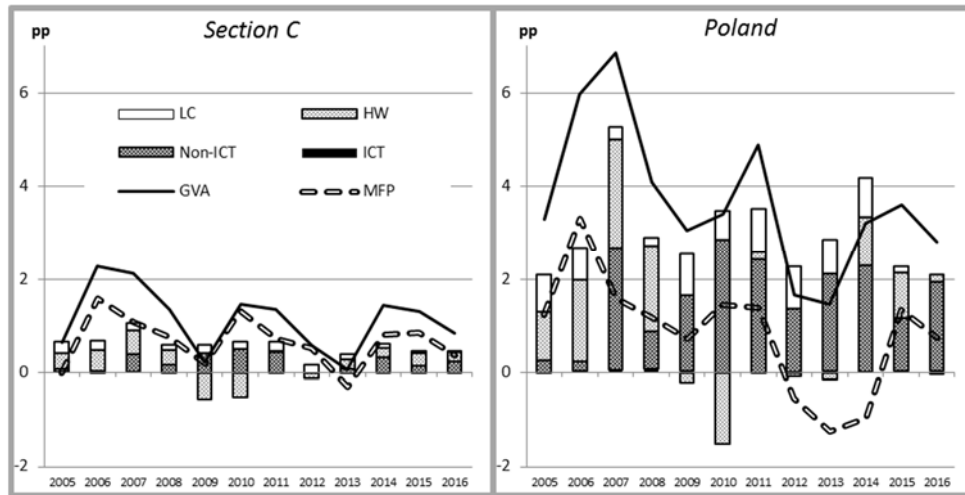
For the years 2012–2014 it can be observed that MFP contribution is negative. The possible explanation of this fact may be that the direct contribution to gross value added growth of growing capital stocks (at industry level and therefore capital services at the aggregate level within KLEMS methodology as explained before) is in relation with the growing demand for capital goods, which in Poland are largely imported. The increase in investments has led to “demand evasion” abroad through increased net imports of

²⁶KLEMS Economic Productivity Accounts, <https://stat.gov.pl/en/experimental-statistics/klems-economic-productivity-accounts/>.

that capital goods, therefore we have a growth of capital contribution in the accounts, not accompanied, however, by a parallel domestic growth of demand for domestic capital goods – the contribution of capital services temporarily raises but with no additional raise in gross value added. This fact may be reflected in lower and even negative MFP contribution, because it is computed residually in the KLEMS methodology. This process was facilitated in those years by the fact that the Polish trade balance improved and even reached positive numbers in 2015, so the economy had finance to invest domestically and of course some role in increasing investments can be attributed to EU funds as well. In the light of developing KLEMS accounting this phenomenon could be better explained using the concept of Global Value Chains (GVC), which would allow to trace exactly and unequivocally (Timmer et al., 2013) the “migration” of gross value added growth together with some part of the residual contribution of MFP between the countries. This effect can also be considered as a tool problem or short-run demand disturbance (if MFP contribution was not calculated residually but computed somehow directly, it would not occur probably).

The last two years of the covered span of time show a huge increase in the contribution of MFP to gross value added growth, which is difficult to be explained solely by the business cycle upturn. It can be observed, however, that this phenomenon is accompanied by a fall in the contribution of the labour factor, i.e. both labour composition and hours worked, which is being offset, as far as its possible negative impact on economic growth is considered, by a surge in productivity growth represented by the MFP contribution.

KLEMS economic productivity accounting allows also to undertake an analysis of the contributions of industry aggregations to aggregate gross value added growth and to decompose this contribution into factor contributions as defined in KLEMS accounting. It can be observed that the NACE 2 classification industries, of which the contribution to aggregate gross value added growth is generally the most important, are industries belonging to section C (manufacturing) of this classification. Its evolution and the evolutions of its contributing factors, as shown in Figure 3 (left-hand side graph), exhibit a similar pattern to the pattern of evolutions observed for the aggregate economy (right-hand side graph).



Legend: ICT – ICT capital contribution, Non-ICT – non-ICT capital contribution, HW – hours worked contribution, LC – labour composition contribution, GVA – gross value added growth, MFP – multifactor productivity contribution.

Figure 3. Contribution of GVA growth of section C and its decomposition compared to GVA growth decomposition for the aggregate Polish economy

Source: Own contribution based on Statistics Poland web page data.

However, the falling trends of gross value added growth, particularly of MFP contribution in section C, are less conspicuous than for the aggregate economy. This indicates that section C supports economic growth. The role of manufacturing seems to strengthen particularly as far as MFP in section C is considered, since its contribution to section C growth is relatively much greater in comparison with the other factors' contributions than for the aggregate economy. This goes in line with the concept that reindustrialization of the Polish economy is on its way.

A lot of interest is due to the labour market, which in Poland has behaved very specifically in comparison with the other countries that have performed KLEMS accounting, as shown in Figure 2, and some argue that this fact lies behind the good comportment of the Polish economy during the trough of the world's financial crisis in 2009. This, of course, is very debatable.

However, we can imply that this is also due to a labour hoarding phenomenon of a both rational and psychological origin and it is caught by the right-hand side graph of Figure 6 later on in the article. The general government and firms refrained from laying off employees until the onslaught of the financial crisis passed away²⁷. At the same time

²⁷ Although typical (see: Timmer et al., Spring 2011, 9–10), this labour hoarding lasted in Poland until 2010, that is about a year longer than in the other EU KLEMS countries.

the highest remunerations were curbed down in the Government administration. From 2008 wage increases in the Government administration were also officially frozen because of the regulations on budget deficit and debt that are in force in Poland²⁸. In the next year (2010) the low base helped to reach a high labour quality contribution growth, when the labour market was freed again to some degree.

The data on KLEMS accounting posted on the Statistics Poland web page indicate that the NACE 2 sections C, G, J, K, L and M-N can be considered as trend settlers for the labour market. The sections O-U (representing mainly the wide public sector entities) contribute to some degree to the entire economy labour productivity evolution.

As far as the capital factor contribution to aggregate gross value added growth is considered, it can be seen in Figure 4 that it generally follows the evolution of the entire economy (i.e. the business cycle), but its relative contribution share increased in the long run and became prevalent in the years 2013–2014. In some countries this led to reduced capital productivity²⁹, but not in Poland. From some other analyses it is known that the ratio of residual capital income³⁰ to capital stock value is continuously (over the period of this analysis) and still growing. Following the standard theory, as long as the “golden rule”³¹ shall be maintained there should not be any decrease in capital productivity. However, the relative role of capital contribution to gross value added growth decreased importantly in the years 2015v2016, which leads to a possible conclusion that a similar process of substitution happened to labour factor contribution substitution by MFP contribution. Generally, a decrease in factor contributions seems to be largely offset by an outstanding MFP contribution increase, much greater than expected to be induced solely by the business cycle itself.

²⁸Timmer et al. (Spring 2011, 9) mention about a productivity going up together with massive layoffs. In Poland, instead of layoffs, remunerations were slashed in 2009.

²⁹In other emerging markets the economic growth was similarly to Poland „increasingly investment driven with negative TFP”, (see: Bart van Ark, 2016).

³⁰Calculated by subtracting labour total compensation from gross value added (Lewandowski et al., 2015).

³¹According to the neoclassical theory of economic growth, an economy should invest about 20% of its GDP.

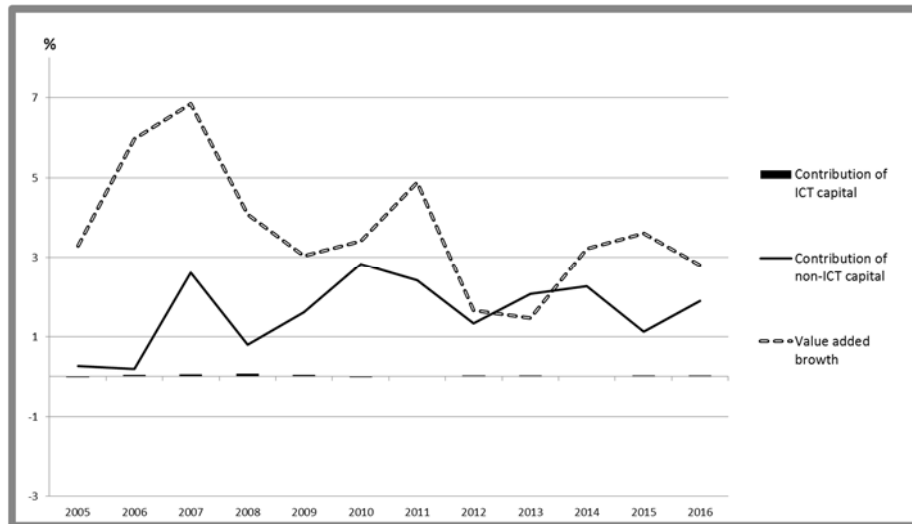


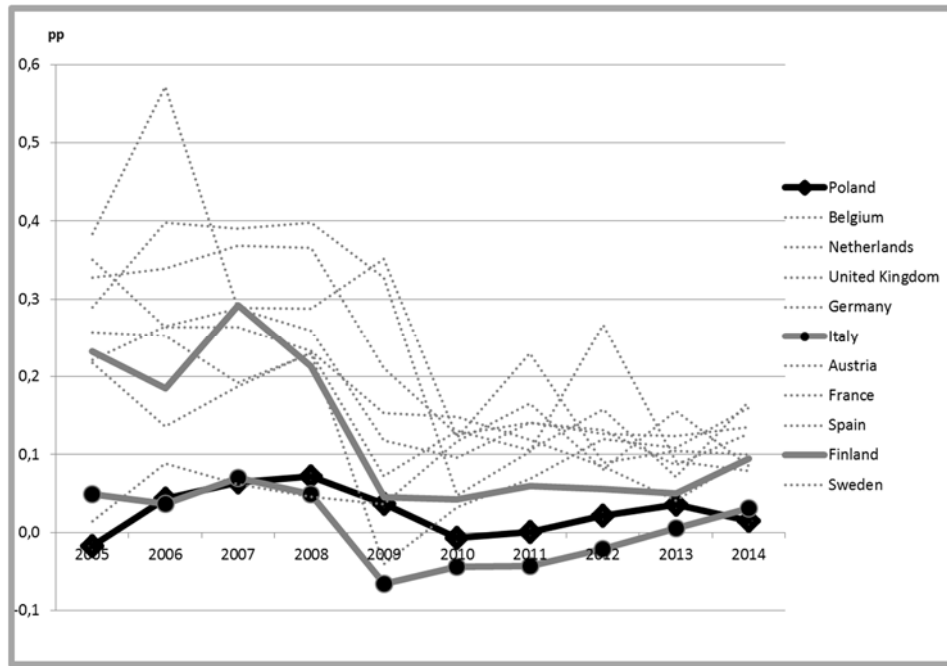
Figure 4. Capital sub-factors' contributions to aggregate GVA growth in Poland

Source: Own calculations based on Statistics Poland web page data.

However, this positive feature in general (with the exception of uncertain last two years 2015–2016), concerning the non-ICT capital services and therefore also the entire capital services as understood in KLEMS accounting, does not concern the ICT capital services, of which the contribution is almost imperceptible (see Figure 4). In comparison with some other countries this could be explained also by the fact that Poland is rather an importer of ICT goods (although Poland is an exporter of quite many ICT components and some software). But there can be also some other explanations that will be examined in Figure 5, where the scale on the vertical axis has been magnified to ease the observations.

As it can be seen in Figure 5, the ten countries that traditionally perform a decomposition of the KLEMS growth accounting type (presented on the EU KLEMS internet platform) greatly differ in the contribution of ICT capital to aggregate gross value added growth, although these are all developed and similar Western European economies, which suggests the possibility of a methodological problem³².

³²This has been discussed in Timmer et al. (2007a and 2007b), the definition of ICT capital is very different in the mentioned countries. The ICT capital can be solely consisting of computers and software, and some top telecommunication devices, or include many peripheral components and infrastructure that is related.



Note: 2015–2016 data for countries other than Poland are not entirely available presently, therefore the graph ends in 2014.

Figure 5. Comparisons of the contribution of ICT capital to aggregate value added growth between Poland and some other countries performing KLEMS accounting

Source: Own contribution based on Statistics Poland website data for Poland and EU KLEMS data for other countries.

Poland seems to be a “non-ICT country” just as Italy is, but this could be the result of narrow definitions of ICT capital used in these countries. The narrow definition of ICT capital in Poland was adopted because it can be assessed in this way from the supply and use tables (SUT), thanks to the structure of software services (see: Kotlewski & Błażej, 2016 and 2018a) and this technique cannot be reliably used if the ICT capital is defined widely³³. At the same time, however, the case of Finland, where we have seen the fall of Nokia impacting the entire ICT industry in this country, suggests that there is some rationale behind the figures (after the fall of Nokia Finland became relatively a non-ICT country as can be seen on the graph).

³³As Timmer et al. (2007a, 38) summarize it: The definitions of IT and CT assets have not been completely harmonized to date. In some countries IT has been defined broadly as office and computing equipment (CPA 30), whereas others have used the more narrowly defined category CPA 3002 computers only. Similarly, CT ...etc.

The EU KLEMS site does not provide more information (e.g. on constant quality indices) about the countries represented on this site that could shed more light on this issue, but the results for Finland suggest some degree of credibility of these comparisons between the countries. It is possible, therefore, that not all countries do benefit from the explosive growth of productivity of ICT technologies (as suggested, e.g. in: Jorgenson, Ho, Stiroh (2005) and Ark, O'Mahony, Timmer (2008)).

The final observation presented here is that there are some premises to think that Poland in the long run is subject to *secular stagnation* just as the remaining world is (as observed through the EU KLEMS performing countries). The long-run trend, as can be seen on all the figures presented here, is a decreasing one. But the concept of *secular stagnation* does not take into consideration that qualitative growth may be replacing quantitative growth now³⁴. In an environment of slowing down demographics, accompanied by a pressure on reducing fuel and material consumption and on shrinking sizes and weights of all end-user machinery, it might be that qualitative growth has become prevalent. This, however, remains debatable³⁵.

4. Preliminary interpretation of results at industry level

To carry on an analysis at industry level, a wide industry approach at NACE 2 classification sections has been applied here. Section A (agriculture, forestry and fishing) has been omitted because the KLEMS methodology is considered to be controversial for this economic activity. Also, NACE 2 sections not belonging to the so-called 'market economy' according to the standard approach (which includes sections L, O, P and Q) have been omitted. Because of their little importance, section T and U have been omitted too. However, NACE sections representing commercialized activities, but under strong public control or with heavy sovereign supports have been included (sections B, D, E, H and R). Industries represented by these sections have huge investment outlays, which are directly or indirectly sovereign supported, and which do not necessarily translate into gross value added growth.

In section B (mining and quarrying) we can observe a negative gross value added growth related to the process of mining industry restructuring carried out under sovereign control, so despite some investments the residual MFP contribution value is negative. In sections D (electricity, gas, steam and air conditioning supply) and E (water supply, sewerage, waste management and remediation activities) that concern network

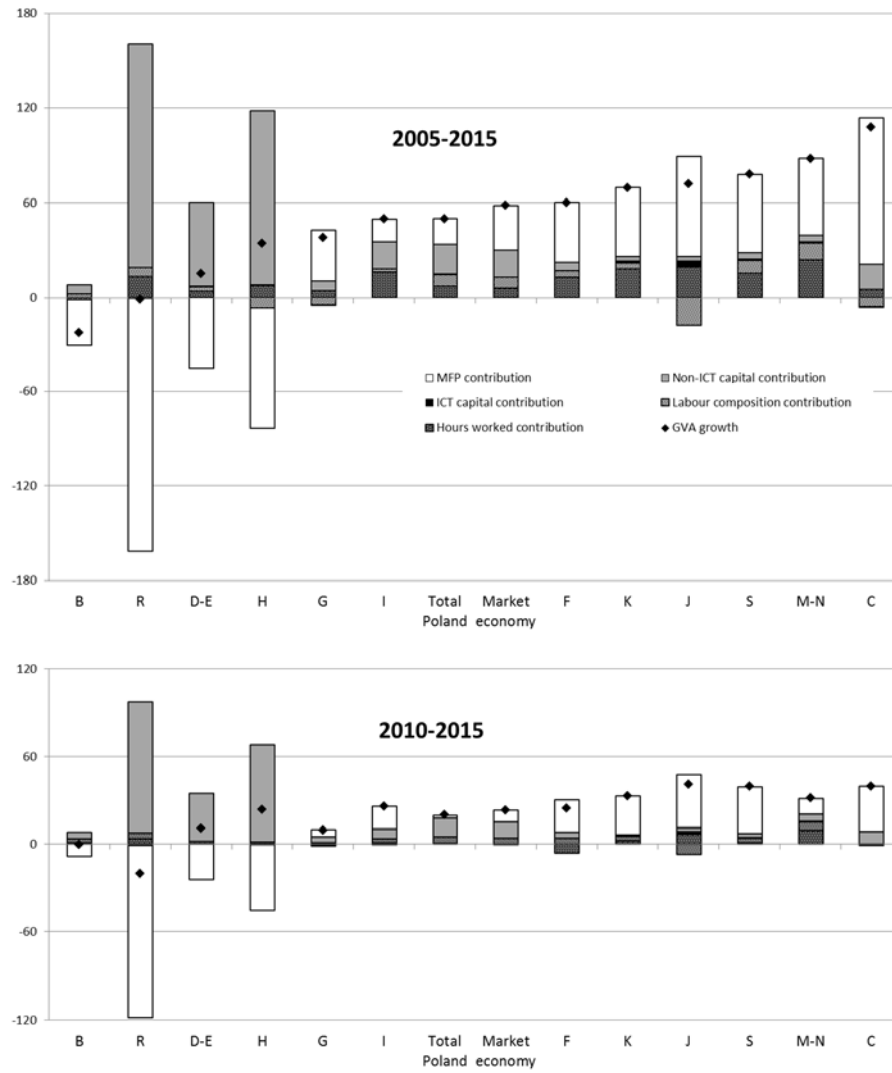
³⁴A discussion about how to measure it and the possibility to use hedonic quality measures is discussed in Hulten (2009), among others.

³⁵One may think that in the light of Krugman (2014, 61-68), the only way to combat secular stagnation is to appropriately reward qualitative growth, thanks to a monetary expansion that would allow prices to grow as an equivalent for improved quality of goods, but near zero policy interest rates do not give room for that. Perhaps only quantitative easing remains, which, however, remains scary for monetary economists.

services there are important upgrading outlays (probably necessary) that are not accompanied by substantial output growth, therefore here as well the contribution of residually computed MFP is negative. To some degree it is the same with section H (transportation and storage) in which also important public outlays are only partly accompanied by an increase in transport services – therefore we also observe a negative MFP contribution. Also a capital public support for section R (arts, entertainment and recreation) does not directly lead to production increase, which inevitably leads to negative MFP contribution.

Those negative MFP contributions are compensated by positive ones in the other industries included in the analysis, therefore the results for total Poland on the graph from Figure 6, are in the middle. Sections not included in the market economy contribute also negatively to the overall MFP contribution and that is why this category is situated to the right from total Poland.

One important observation in Figure 6 is that NACE 2 section C representing a group of industries related to manufacturing has the highest MFP cumulative contribution in the 2005–2016 period. Because this section is the largest in the Polish economy it weighs very importantly on the total economy MFP contribution in a situation where its level within the section is high as well. As they are very technical (as manufacturing generally is), it can be asserted that industries from this section have in general the greatest technological progress (with some possible but not numerous exceptions). It



Note: on the first graph (2005–2015) the NACE 2 classification sections are in order of growing cumulative gross value added growth from the left side to the right-hand side; on the second graph (2010–2015) this order has been maintained.

Figure 6. Decomposition of cumulative gross value added growth into factor and MFP contributions at selected NACE 2 classification sections in the light of KLEMS growth accounting (in pp).

Source: Own contribution based on Statistics Poland website data for Poland.

should translate to an important contribution of MFP into gross value added growth in this section, but the fact that this contribution dominates entirely over other

contributions is an important novelty observation. This suggests that manufacturing is being intensively upgraded (modernized) in Poland, and this is happening regardless of whether this upgrading is replicative (through imitation and acquiring of foreign technologies) or innovative. This upgrading seems to be the basic growth engine for the industries in this section, rather than new capital outlays. Section C in relative terms has the highest growth between all NACE 2 sections. This implies that a reindustrialization process is under way in Poland.

The second NACE 2 classification section that distinguishes itself by its high MFP contribution is section J (information and communication). In the period 2005-2016 the cumulative gross value added growth and the cumulative MFP contribution to that growth in that section was only a little lower than in section C, but in the second half of that period (2010–2016) as shown on the lower graph of Figure 6 it becomes the leader in both of these categories. Sections I (accommodation and food service activities) and S (other service activities) also have increased their importance thanks mainly to MFP contributions. In general we can observe that in all growth supporting activities it is MFP contribution that dominates. Therefore, MFP can be considered as the main *growth engine* in the economy and this domination remains in the second half of the analysed period (2010–2016). However, at the total economy level this important MFP contribution is being levelled by industries from the above-mentioned sections, which do not contribute importantly or positively to gross value added growth and this effect even strengthened in the 2010–2016 period.

The more general implication is that the Polish economy is developing well and intensively modernizing, particularly in industries from the well growing sections as shown in Figure 6 on the one hand. On the other hand, the share of the other industries that are not greatly contributing to gross value added growth or contributing negatively is to large (which would be a *government failure* paradigm supporters' view). However, some contenders might assert that there is no trouble at all since in general the MFP negative contributions of industries from some sections are well counterbalanced by MFP positive contributions of industries from other sections (which would be rather a *market failure* paradigm supporters' preferable interpretation).

The possible analyses at industry level are very numerous (by far trespassing the size of this article), so only a sample is provided here.

5. Developed labour factor decomposition

One of the key idea presented in this article is the possibility to further analyse the labour factor contribution by dividing it into three (and even four as shown latter on) instead of two sub-contributions. Considering KLEMS decomposition at industry

levels, this seems to open new possibilities for analysing the business cycle and the labour market itself, and can lead to promising linkages to other studies.

The standard KLEMS decomposition of the labour factor contribution (called labour services' contribution) into two sub-contributions is:

$$\bar{w}_{jt}^l \Delta \ln L_{jt} = \bar{w}_{jt}^l \Delta \ln LC_{jt} + \bar{w}_{jt}^l \Delta \ln H_{jt} \quad (6)$$

This formula is the same as formula (4) in section 2, but labour quality (Q) is understood here as labour composition (LC) solely, and is therefore calculated through a subtraction between hours worked H_{jt} for labour kinds l growths aggregated with the use of the Törnqvist quantity index over industry j and hours worked H_{jt} growths simply added up for the given industry j :

$$\Delta \ln LC_{jt} = \sum_l \bar{v}_{l,jt} \Delta \ln H_{ljt} - \Delta \ln H_{jt} \quad (7)$$

In the above-mentioned formulae \bar{w}_{jt}^l stands for the average share of the labour factor remuneration (labour compensation together with the self-employed) in gross value added of industry j for two discrete periods ($t-1$) and t . $\Delta \ln L_{jt}$ stands for the relative growth of the labour factor, understood in the standard KLEMS accounting as labour services, in industry j between two discrete periods ($t-1$) and t ; and $\Delta \ln H_{jt}$ for the relative growth of the number of hours worked in industry j , between these two discrete periods. $\Delta \ln LC_{jt}$ stands for the relative change in the so-called labour composition (otherwise called labour quality in standard KLEMS accounting) in industry j between two discrete periods ($t-1$) and t , understood as an effect of the change in the share structure of the labour factor by different labour kinds l . $\Delta \ln H_{ljt}$ stands for the relative growth of the number of hours worked in industry j between two discrete periods ($t-1$) and t of different labour kinds l , whereas $\bar{v}_{l,jt}$ are average shares of labour kinds l in labour compensation in industry j between two discrete periods ($t-1$) and t . As seen from equations (6) and (7), only data on the hours worked and value shares are needed for the accounts (all data are according to the National Accounts).

In this way the traditionally understood (Solow, 1956 and 1957) contribution of the labour factor to economic growth as the contribution of hours worked solely is complemented in standard KLEMS accounting by the contribution of labour composition (otherwise called labour quality), which was contained before in the so-called Solow residual. Following this change, the labour inputs have been renamed as labour services' inputs in the standard KLEMS accounting. As mentioned before, in the KLEMS accounting 18 kinds of labour are defined, which arises from divisions into sexes, three age groups and three education attainment levels. Labour composition change is understood, therefore, as the effect of the change in the relative remuneration

shares of different 18 labour kinds at industry level (within industries)³⁶. This effect is as conspicuous as the different labour kinds l are differently remunerated by hour.

This analysis of the labour factor contribution (labour services' contribution in standard KLEMS accounting) can be deepened further, however. The contribution of hours worked growth in formula (6) can be decomposed by changing this formula into:

$$\bar{w}_{jt}^L \Delta \ln L_{jt} = \bar{w}_{jt}^L \Delta \ln LC_{jt} + \bar{w}_{jt}^L \Delta \ln M_{jt} + \bar{w}_{jt}^L \Delta \ln H_{Mjt} \quad (8)$$

where:

$$\Delta \ln H_{Mjt} = \Delta \ln H_{jt} - \Delta \ln M_{jt} \quad (9)$$

In the above-mentioned formulae $\Delta \ln H_{Mjt}$ is the relative growth of hours worked H per employee M in industry j between two discrete periods ($t-1$) and t . In practice, it is calculated residually by subtracting the relative growth of the number of employees, i.e. $\Delta \ln M_{jt}$, from the relative growth of hours worked, i.e. $\Delta \ln H_{jt}$ in industry j between two discrete periods ($t-1$) and t . This technique of residual calculations is the reason why the above formulae are always met in practice and is therefore a better technique for the accounts than to divide the number of hours by the number of employees and observe the changes of this ratio. More generally, the rationale behind this procedure is that the growth of hours worked at a given aggregation can be the result of two distinct processes. One is the possibility that the number of employees is increasing, the other is the possibility that the number of hours per employee is increasing, and it is assumed that these processes may not have exactly the same consequences.

A more detailed decomposition of hours worked contribution into the contributions of the number of employees and the number of hours per employee can be of some not negligible importance for using KLEMS results in analyses oriented at economic policy. In the case of a negative shock, the economy reacts usually by reducing the total number of hours worked. However, the case of reduced number of employees with stabilization (or even increase) of the number of hours per employees is well different from the case when the economic adjustment takes the shape of a decreased number of hours per employee with little employee reduction. In the first case, the social consequences are more severe, which results in reduced household consumption (a contagion alike consumer spending reduction effect) and the eventuality of high costs of bringing back the previous employment level (because of a hysteresis effect). In the second case, the social consequences are milder, which results in a lower decrease of the household consumption level and its quicker restauration

³⁶ The contribution of labour reallocation between industries with different levels of productivity can also be taken into account in theory (Timmer et al. 2010, 153, eq. (5.4)).

(because consumers tend to maintain their spending levels when their incomes decrease moderately).

This analysis can be a contribution to explaining the reasons of different reactions of the EU economies against the 2007–2009 crisis and of different paces of growth restauration. Some initial studies carried for some chosen EU economies according to a simplified methodology seem to demonstrate these different reactions in accordance with the rationale presented here (CSO Poland³⁷, 2014). This could be also interesting when regional (by provinces of the given country) growth decompositions will be performed³⁸. On the right hand, in the side graph of Figure 7 we can see that in 2009 the contribution of hours per employee was negative, and thanks to that the contribution of the number of employees³⁹ remained positive even in the situation where the total number of hours worked decreased. This explains presumably why consumer spending did not decrease importantly in Poland in comparison with the other countries in that year. Obviously,

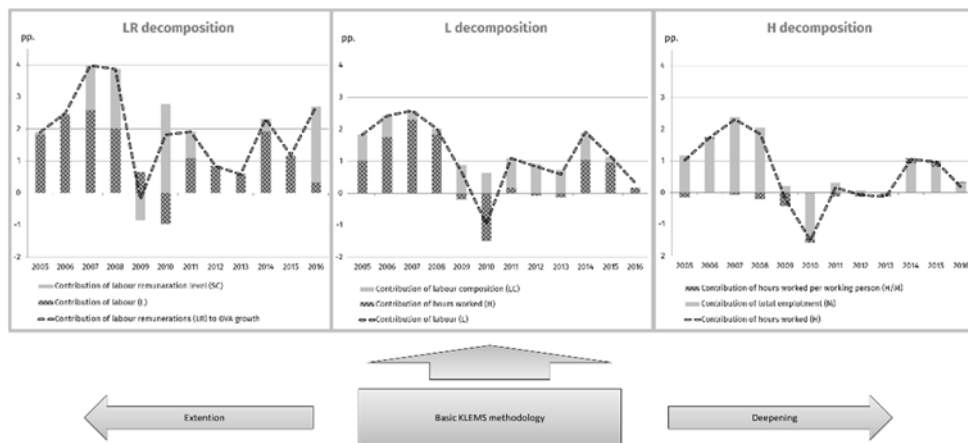


Figure 7. Developed labour factor decomposition

Source: Own contribution based on Statistics Poland web page.

although it helps to understand why Poland avoided recession in that year, it is certainly not the only reason for this wishful behaviour of the economy⁴⁰.

We have also a general wage increase phenomenon, which by a margin can be different than labour factor (L), understood as above, increase. In real terms (deflated)

³⁷ Actually Statistics Poland.

³⁸ As Spain did. In China it has been done also, see: Kang and Peng (2013).

³⁹ In the entire article employees are considered as including the self-employed.

⁴⁰ The other well identified reason is a floating currency that allowed for a betterment of the balance of payments to a large degree.

and marginally, including it should help to completely reflect labour quality growth, understood as marginal labour productivity growth. The resulting conclusion is that in an ideal situation the total labour quality effect should include the wage effect from formula (10) below. The analysis of the labour factor can be therefore extended. If the contribution of labour factor (L) growth, calculated as above-mentioned, is subtracted from the contribution of labour compensation (LR) growth then we receive the contribution of the change in the relative level of remunerations (SC – *soft composition*⁴¹) according to the following formula:

$$\bar{w}_{jt}^L \Delta \ln SC_{jt} = \bar{w}_{jt}^L \Delta \ln LR_{jt} - \bar{w}_{jt}^L \Delta \ln L_{jt} \quad (10)$$

and here as well (according to a technique often used in KLEMS accounting) we do not need to establish the value of SC directly, because the value of its contribution, i.e. the left-hand side of the equation (10), can be calculated residually from the other variables as the subtraction between their contributions (the value of labour compensation (LR – *labour remuneration*⁴²) is available from the National Accounts). In such a case the contributions of all the above-mentioned four labour factor's sub-factors can be joined in a single formula:

$$\bar{w}_{jt}^L \Delta \ln LR_{jt} = \bar{w}_{jt}^L \Delta \ln SC_{jt} + \bar{w}_{jt}^L \Delta \ln LC_{jt} + \bar{w}_{jt}^L \Delta \ln M_{jt} + \bar{w}_{jt}^L \Delta \ln H_{Mjt} \quad (11)$$

In the KLEMS accounting labour composition LC is interpreted as the main manifestation of labour efficiency in the long run⁴³, which only to some degree translates into the actual remunerations' level. The remaining remunerations' level change SC can be attributed to the actual labour usage that mostly can be related with the business cycle but also with a reallocation effect between industries⁴⁴.

For clarity, on the Statistics Poland website the Excel tables concerning this developed decomposition of the labour factor are presented in a hierarchical way following the equation (11) divided into three equations:

$$\begin{aligned} \bar{w}_{jt}^L \Delta \ln LR_{jt} &= \bar{w}_{jt}^L \Delta \ln SC_{jt} + \bar{w}_{jt}^L \Delta \ln L_{jt} \\ \bar{w}_{jt}^L \Delta \ln L_{jt} &= \bar{w}_{jt}^L \Delta \ln LC_{jt} + \bar{w}_{jt}^L \Delta \ln H_{jt} \\ \bar{w}_{jt}^L \Delta \ln H_{jt} &= \bar{w}_{jt}^L \Delta \ln M_{jt} + \bar{w}_{jt}^L \Delta \ln H_{Mjt} \end{aligned} \quad (12)$$

⁴¹ Own designation.

⁴² Own designation – must be different from LC (labour composition) already used.

⁴³ The neoclassical premise is that labour is being remunerated according to its marginal productivity.

⁴⁴ This reallocation effect has been discussed in Stiroh (2002). Here, it is contained within SC .

They represent the three stages of the labour factor decomposition presented in Figure 7. It can be seen that a drop in remunerations' contribution in 2009 shown on the left-hand side graph probably delayed the trough in labour contribution to gross value added growth in 2010 shown on the middle graph, which was accompanied by some labour hoarding in 2009 shown on the right-hand side graph in the form of a negative hours per employee growth level.

6. Conclusions and a look into the future

To conclude, the KLEMS accounting methodology applied in Poland, although not solving all economic analysis dilemmas, is a valuable tool for economic ex post observation, which can provide non-negligible findings, also for the decision makers. It does not respond to similar Keynesian findings and controversies, but the processed final KLEMS data can possibly be used also for that purpose in some cases, although mainly applicable to similar neoclassical analyses oriented rather towards the long run economic paradigm.

The main findings are:

- 1) that missing data can be effectively assessed up to the level allowing to build up KLEMS type data sets of sufficient quality;
- 2) that the labour factor can be decomposed further, which is conducive to more informed analysis;
- 3) that during the 2009 crisis trough MFP contribution increased, resulting perhaps from some effective reorganisations in the economy undertaken to combat the crisis both at the aggregate level and at firms levels;
- 4) that a specific labour hoarding phenomenon was present in the economy during the 2009 onslaught of the crisis on the Polish economy, which prevented largely the incidence of huge demand slump;
- 5) that the industry level analysis exhibits an even more optimistic feature of the Polish economy than at the aggregate level – it shows that the Polish economy has strong sectoral fundamentals and that only the role of the State is an issue.

Some of these findings, i.e. four of the five above-mentioned items, have already been published in previous publications (Kotlewski & Błażej 2016, 2018a and 2018b), but here they were explained more extensively. Item 4) was only signalled in (Kotlewski & Błażej 2018b), whereas here it was well explained. Item 5) is a first time result publication.

The KLEMS accounting performed in Poland can be developed. One obvious possibility is to bring to live not only the gross value added growth decomposition but also the gross output growth decomposition, which includes intermediate consumption

contribution. The theoretical KLEMS methodology⁴⁵ includes a decomposition of intermediate consumption contribution into the contributions of its three sub-components, i.e. energy, materials and services inputs. As we know from the last release of National Accounts for Poland, the deflators for intermediate consumption by industries are now available⁴⁶, so the main obstacle standing against this procedure has been almost lifted (what remains is the issue to attribute the appropriate deflators to the three kinds of intermediate consumption, i.e. energy, materials and services). The international comparability problem, arising from differences in vertical integration of firms between the countries, will remain. But, performing gross output decomposition could be useful for intra-country analyses of energy and material footprints, and the scale of services' outsourcing also by industries. Lastly (June 2019), on Statistics Poland website gross output growth decomposition has been published, although without the subdivision into the above-mentioned three categories of intermediate inputs. This partial progress can lead, however, to some new analyses⁴⁷.

Considerably more important and complex is the idea to perform KLEMS accounting not only for the entire economy at the aggregate level and by industries, but also regionally, i.e. by individual Polish sixteen voivodships. This could allow to make analytical comparisons between voivodship regional economies (as some Polish voivodships are as large as some small European countries), also in relation to the aggregate economy as a whole, and could happen to become an important supporting tool for economic analyses oriented at regional economic policy.

REFERENCES

- ARK BART VAN, (2016). Are Emerging Markets Still Emerging?, Forth World KLEMS Conference, Madrid 2016.
- ARK BART VAN, O'MAHONY, M., TIMMER MARCEL P., (2008). The productivity gap between Europe and the United States, *Journal of Economic Perspectives*, 22(1), pp. 25–44.
- BHAGWATI JAGHDISH N., (1982). Directly Unproductive Profit-seeking (DUP) Activities, *Journal of Political Economy*, Vol. 90, No. 5.
- DIEWERT W., EDWIN, (1993). The Early History of Price Index Research, in: Diewert W.E., Nakamura A.O. (1993), *Essays in Index Number Theory*, Elsevier, B.V.

⁴⁵ Particularly comprehensively explained in O'Mahony and Timmer (2009).

⁴⁶ They are different as the price inflation for intermediate goods is different than for final goods.

⁴⁷ A paper about this issue is under elaboration.

- GOUMA REITZE, MARCEL P. TIMMER, (2013a). EU KLEMS Growth and Productivity Accounts – 2013 update, Groningen Growth and Development Centre.
- GOUMA, REITZE, MARCEL P. TIMMER, (2013b). WORLD KLEMS Growth and Productivity Accounts – 2013 update, Groningen Growth and Development Centre.
- GRADZEWICZ, M., GROWIEC, J., KOLASA, M., POSTEK, Ł., STRZELECKI, P., (2014). Poland's Exceptional Growth Performance During the World Economic Crisis: New Growth Accounting Evidence. Working Paper, No. 186. NBP.
- GRADZEWICZ, M., GROWIEC, J., KOLASA, M., POSTEK, Ł., STRZELECKI, P. (2018). Poland's Uninterrupted Growth Performance: new growth accounting evidence, in: *Post-Communist Economies*, Vol. 30, No. 2, pp. 238–272.
- HAUSMAN, J., (2003). Sources of Bias and Solutions to Bias in the Consumer Price Index, *Journal of Economic Perspective*, Vol. 17, No. 1, pp. 23–44.
- HAVLIK P., LEITNER, S., STEHRER, R. (2012). Growth Resurgence, Productivity Catching-up and Labor Demand in Central and Eastern European Countries, in: Matilde Mas, Robert Stehrer (Ed.), *Industrial Production in Europe. Growth and Crisis*, Edward Elgar, pp. 219–263.
- HULTEN, C. R., (2009). Growth Accounting, NBER Working Paper 15341.
- JORGENSEN, D. W., (1963). Capital Theory and Investment Behavior, *American Economic Review*, 53(2), pp. 247–259.
- JORGENSEN, D. W., (1989). Productivity and Economic Growth, in Ernst R. Berndt and Jack E. Triplett (eds.), *Fifty Years of Economic Measurement*, University of Chicago Press.
- JORGENSEN, D. W., (2012). The World KLEMS Initiative, *International Productivity Monitor*.
- JORGENSEN, D. W., ZWI GRILICHES, (1967). The explanation of Productivity Change, *Review of Economic Studies*, 34, pp. 249–83.
- JORGENSEN, D. W., ed., (2009). *The Economics of Productivity*, Edward Elgar Publishing.
- JORGENSEN, D. W., FRANK M. GOLLOP, BARBARA M. FRAUMENI, (1987). *Productivity and U.S. Economic Growth*, Cambridge, MA: Harvard University Press.

- JORGENSON, D. W., MUN S. HO, KEVIN J. STIROH, (2005). *Information Technology and the American Growth Resurgence*, Cambridge, MA: The MIT Press.
- JORGENSON, D. W., MUN S. HO, JON D. SAMUELS, (2014). *Long-term Estimates of U.S. Productivity and Growth*, Third World KLEMS Conference paper.
- KANG LILI, FEI PENG, (October 2013). *Growth Accounting in China 1978-2009*, MPRA Paper No. 50827.
- KOTLEWSKI, D., C. (2017). *Problem cen w regionalnym rachunku produktywności*, *Wiadomości Statystyczne* 12/2017.
- KOTLEWSKI, D., BŁAŻEJ, M., (2016). *Metodologia rachunku produktywności KLEMS i jego implementacja w warunkach polskich*, *Wiadomości Statystyczne* 9/2016.
- KOTLEWSKI, D., BŁAŻEJ, M., (2018a). *Implementation of KLEMS economic productivity accounts in Poland*, Lodz University Publication, *Folia Oeconomica* 2/2018.
- KOTLEWSKI, D., BŁAŻEJ, M., (2018b). *KLEMS Productivity Accounts – Poland 2005-2016*, Statistics Poland.
- KLEMS Economic Productivity Accounts, <https://stat.gov.pl/en/experimental-statistics/klems-economic-productivity-accounts/>
- KOTLEWSKI, D., BŁAŻEJ, M., (updated regularly every year or every two years), *KLEMS Economic Productivity Accounts*, Statistics Poland, <https://stat.gov.pl/en/experimental-statistics/klems-economic-productivity-accounts/methodology-of-decomposition-in-klems-productivity-accounts-for-the-polish-economy,2,1.html>
- KRUGMAN, P., (2014). *Four observations on secular stagnation in Coen Teulings and Richard Baldwin, eds., Secular Stagnation: Facts, Causes, and Cures*, CEPR Press, pp. 61–68.
- LEWANDOWSKI, M., BANAS, M., KOTLEWSKI, D., KULCZYCKA, J., DONIEC, D., WITKOWSKI, G., and others, (2015). *Metoda dekompozycji Produktu Krajowego Brutto (PKB) oraz Wartości Dodanej Brutto (WDB) w zastosowaniu do analizy struktury różnic regionalnych*, Statistics Poland, <http://stat.gov.pl/statystyka-regionalna/statystyka-dla-polityki-spojnosci/realizacja-prac-metodologicznych-analiz-ekspertyz-oraz-prac-badawczych-na-potrzeby-polityki-spojnosci/dezagregacja-wskaznikow-z-obszaru-rachunkow-narodowych-i-regionalnych> .

- MILANA, C., (2009). Solving the Index-Number Problem in a Historical perspective, EU KLEMS Working Paper 43.
- O'MAHONY, MARY and MARCEL, P., TIMMER, (2009) Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database, *The Economic Journal*, 119 (June), F374-F403.
- OECD, (2001) *Measuring Productivity*, OECD Manual.
- OECD, (2009) *Measuring Capital*, OECD Manual.
- OECD, (2013) *OECD Compendium of Productivity Indicators 2013*, OECD Publishing.
- SCHREYER, P., (2004). Chain Index Number Formulae in the National Accounts, 8th OECD – NBS Workshop on National Accounts.
- SOLOW R., .M. (1956). A Contribution to the Theory of Economic Growth, *Quarterly Journal of Economics*, Vol. 70, No. 1, pp. 65–70.
- SOLOW R., M. (1957). Technical Change and the Aggregate Production Function, *Review of Economics and Statistics*, Vol. 39, No. 3, pp. 312–320.
- STATISTICS POLAND (2014). *Macroeconomic Situation in Poland in 2013 in the Context of the World Economic Processes*, a yearly report.
- STIROH, K., J., (2002). Information Technology and the U.S. Productivity Revival: What Do the Industry data Say? *American Economic Review*, 92(5), pp. 1559–76.
- TIMMER M. P., MARY O'MAHONY, BART VAN ARK, (2011). *Productivity and Economic Growth in Europe: A Comparative Industry Perspective*, *International Productivity Monitor*.
- TIMMER MARCEL P., INKLAAR, R., O'MAHONY, M., ARK BART VAN, (2010). *Economic Growth in Europe*, Cambridge University Press.
- TIMMER, MARCEL P., ABDUL AZEEZ ERUMBAN, BART LOS, ROBERT STEHRER, GAAITZEN J. DE VRIES, (2013). Slicing Up Global Value Chains, *Journal of Economic Perspectives*, Vol. 28, No. 2, pp. 99–118.
- TIMMER, MARCEL P., TON VAN MOERGASTEL, EDWIN STUIVENWOLD, GERARD YPMA, (Groningen Growth and Development Centre) and Mary O'Mahony, and Mari Kangasniemi (National Institute of Economic and Social Research) (March 2007a) *EU KLEMS Growth and Productivity Accounts – Methodology*, EU KLEMS Consortium.

TIMMER, MARCEL P., TON VAN MOERGASTEL, EDWIN STUIVENWOLD, GERARD YPMA, (Groningen Growth and Development Centre) and MARY O'MAHONY, and MARI KANGASNIEMI (National Institute of Economic and Social Research), (2007b). EU KLEMS Growth and Productivity Accounts – Sources by country, EU KLEMS Consortium.

WÖLFL, ANITA and DANA HAJKOVA, (2007) Measuring multifactor productivity growth, STI Working Paper 2007/5, OECD.