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Implementation of KLEMS Economic Productivity Accounts in Poland

Abstract: The aim of the article is to demonstrate how the KLEMS economic productivity accounts for Poland have been performed. The main research problem was to find solutions to certain country-specific data insufficiencies. On this basis, a hypothesis was put forward that by using some innovative but acceptable missing data assessment techniques, it is possible to supply sufficient data for Poland for the mentioned accounts. After an overview of KLEMS economic productivity accounts and the relevant fundamental methodology, the article presents further how specific data problems that have arisen have been solved.

Keywords: productivity accounting, KLEMS, production factor, primary factors, labour factor, capital factor, productivity growth, decompositions, labour composition, hours worked, employees, hours per employee.

JEL: O47, E22, E23, E24

1. Introduction

The acronym KLEMS originates from traditional symbols used in formal equations for economic values (K for capital and L for labour) and from capital letters in English (E for energy, M for materials and S for services). Therefore, it indicates the factors of production included in KLEMS productivity accounting. The first two, i.e. capital and labour, are the so-called primary factors. The other three are components of intermediate consumption otherwise called intermediate input.

The aim of this paper is to present KLEMS economic productivity accounts now being implemented in Poland and discuss them. In the second section, the origins of the methodology framework derived from the neoclassical production function are outlined. In the third section, this methodology is explained in more detail in terms of individual production factors. Theory and statistical technicalities are combined in this section. In the fourth section, data processing techniques are presented and discussed to demonstrate that carrying out KLEMS economic productivity accounting for Poland is now feasible. The conclusion section summarises the outcomes.

2. Basic overview

Measuring economic productivity growth has a quite long tradition. Initially, the growth of the economy was assumed to depend on only one production factor, i.e. the capital factor or the labour factor. Then the Cobb-Douglas function was tested in the 1920s. This function relates the economic growth to two factors of production – capital K and labour L:

$$Y = AK^{\alpha}L^{\beta}, \tag{1}$$

where α is the income share of capital and β is the income share of labour in total income. This means that the *gross domestic product* (GDP) from the left hand side of the equation (1) is being equated to *gross domestic income* (GDI) divided into factor shares from the right hand side of the equation (1). The assumption of constant returns to scale and perfect market competition is necessary to treat the elasticities α and β as factor income shares that sum up to unity. From this production function, Robert Solow (1956; 1957) derived his well-known decomposition:

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \alpha\frac{\Delta K}{K} + (1-\alpha)\frac{\Delta L}{L}. \tag{2}$$

In this formula, residual value $\Delta A/A$, called the *Solow residual*, appears. It represents an “unknown factor” contributing also to economic growth. Robert Solow thought that this residual value represents technological progress considered as exogenous. Actually, it is usually understood as technological or organisational progress which is not embodied in the factors. However, because $\Delta A/A$ is calculated residually (through subtraction between the other values of the equation), it also contains all sorts of known and unknown possible factors of production other than capital and labour, and equation (2) is always met. The Cobb-Douglas production function and the Solow decomposition have become the foundations from which the KLEMS economic productivity accounts were developed.

In the following developments, the idea of global output decomposition was put forward. This required the inclusion of intermediate input (intermediate consumption) as a production factor in the decomposition and replacing gross domestic product (GDP) by gross value added (GVA). Those changes were accompanied by the introduction of the System of National Accounts (SNA), which allowed to integrate the production theory accounts with statistical methods, therefore a decomposition by industry aggregations has become possible. A new term was introduced for the Solow residual (and its other name *total factor productivity* – TFP), i.e. *multifactor productivity* (MFP).

According to theoretical developments, KLEMS productivity accounting should be based on the global output decomposition, but there is an inconvenience that may be not negligible. The more vertical integration of firms' economic activities is present in a given economy, the more intermediate consumption is hidden as intrafirm supplies not statistically reported. This hinders international comparisons because there are huge differences in vertical integration of economic activities in firms between different countries. In order to mitigate this problem to some degree, an appropriate subdivision of the economy into statistical industries is chosen (the ideal subdivision would mean that vertical integration should happen only within the statistical industries, not between them).

A similar methodology to KLEMS productivity accounting is used in the OECD productivity accounts, as shown in Figure 1. However, in order to encompass as many countries as possible, only a decomposition of GDP is applied, instead of global output and GVA decomposition (see: OECD, 2001; 2009, and particularly: OECD, 2013: 66–70). There is no mention of intermediate input. Some assumptions in the OECD methodology are relaxed in comparison with the KLEMS methodology, such as constant returns to scale, which are considered as being only approximately met. Conversely to the OECD methodology, the KLEMS methodology goes further in its details. It contains also the labour factor decomposition into the contributions of hours worked and labour quality, as well as the capital factor decomposition into the contributions of ICT and non-ICT capital. If the global output decomposition is also performed, then the intermediate input is decomposed into the above-mentioned contributions of energy, materials and services.

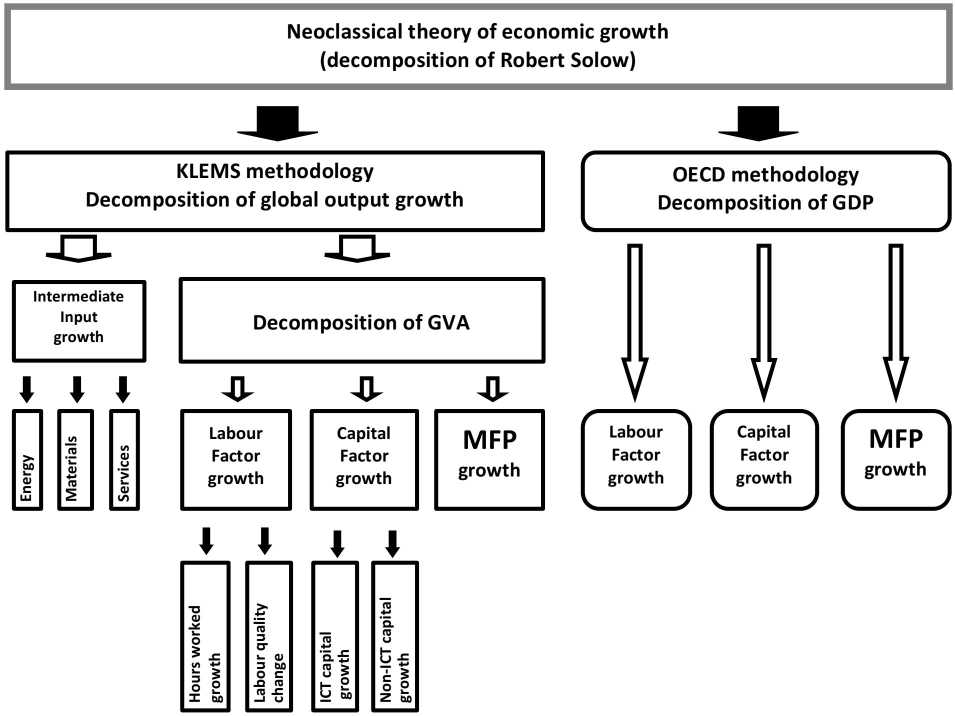

Figure 1. Two major methodologies of productivity accounting

Source: own contribution

3. Formal methodology presentation

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, Fraumeni (1987), Jorgenson (1989) and Jorgenson, Ho, Stiroh (2005)[1]. This methodology has been summarised by Timmer et al. (2007a; 2007b), and O'Mahony, Timmer (2009) for the EU KLEMS[2]. It is based on the standard growth accounting decomposition of output into the contribution of input factors and MFP:

$$\Delta \ln Y_{jt} = \bar{v}_{jt}^{X} \Delta \ln X_{jt} + \bar{v}_{jt}^{K} \Delta \ln K_{jt} + \bar{v}_{jt}^{L} \Delta \ln L_{jt} + \Delta \ln A_{jt}^{Y}, \qquad (3)$$

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

[2] See also a large overview of the subject: Jorgenson (2009). The EU KLEMS methodology differs in some few details from Poland KLEMS and this matter will be referred to latter on.

where Y is the output, X – intermediate consumption, K – capital stock, L – the labour factor and where A^Y stands for residual multifactor productivity (MFP). These values are subscripted by j for industries and t for years. $\bar{v}$ with appropriate superscripts and subscripts are average value shares of the individual factors in the 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 $\bar{v} = (v_{t1} + v_t)/2$ (subscripts omitted here for simplicity). Since the growth of A^Y is residually calculated, equation (3) is always met.

The term on the left-hand side and the three factor terms on the right-hand side should be calculated by aggregations with the use of Törnqvist quantity indices as follows:

$$\Delta \ln Y_{jt} = \sum_y \bar{w}^Y_{yjt} \Delta \ln Y_{yjt}, \tag{4}$$

$$\Delta \ln L_{jt} = \sum_l \bar{w}^L_{ljt} \Delta \ln L_{ljt}, \tag{5}$$

$$\Delta \ln K_{jt} = \sum_k \bar{w}^K_{kjt} \Delta \ln K_{kjt}, \tag{6}$$

$$\Delta \ln X_{jt} = \sum_x \bar{w}^X_{xjt} \Delta \ln X_{xjt}, \tag{7}$$

where y stands for individual enterprises or given groups of enterprises within a given industry j (whose aggregation is usually done on a regular basis by the NSI[3] departments responsible for the National Accounts), l stands for adopted labour types in a given methodology (18 in the EU KLEMS), k stands for asset types (8 in the EU KLEMS) and x stands for different kinds of intermediate inputs. The shares (with appropriate superscripts and subscripts) are calculated in a similar way to $\bar{v}$ shares.

For many analyses, it is useful to subdivide the intermediate inputs into three groups:

$$\Delta \ln X_{jt} = \bar{w}^E_{jt} \Delta \ln X^E_{jt} + \bar{w}^M_{jt} \Delta \ln X^M_{jt} + \bar{w}^S_{jt} \Delta \ln X^S_{jt} \tag{8}$$

and to use the Törnqvist quantity indices independently for the three components of the intermediate input[4].

As for the EU KLEMS countries performing this accounting, the methodology has been reduced to a GVA decomposition following the standard equation:

[3] National Statistical Institutes.

[4] The formulae for the three Törnqvist quantity indices are very similar to formulae (4), (5), (6) and (7), with appropriate superscripts and subscripts.

$$\Delta \ln V_{jt} = \bar{w}_{jt}^{K} \Delta \ln K_{jt} + \bar{w}_{jt}^{L} \Delta \ln L_{jt} + \Delta \ln A_{jt}^{V}, \tag{9}$$

where V is GVA and where A^{V} stands for residual MFP. $\bar{w}$ with appropriate subscripts are average value shares of the individual factors in GVA (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 above-mentioned formula (3). The other symbols have the same meanings as in equation (3).

Both in (3) and (9), the capital factor is decomposed into two sub-factors as follows:

$$\bar{w}_{jt}^{K} \Delta \ln K_{jt} = \bar{w}_{jt}^{KIT} \Delta \ln KIT_{jt} + \bar{w}_{jt}^{KNIT} \Delta \ln KNIT_{jt}, \tag{10}$$

where KIT stands for ICT capital and KNIT for non-ICT capital, treated as separate factors, which is expressed also by their different shares $_{jt}$ (appropriately superscripted). These shares are also calculated in the same way as other shares through linear interpolation. The Törnqvist quantity indices should be used here also independently for the two sub-factors.

The labour factor is decomposed somehow differently as follows:

$$\bar{w}_{jt}^{L} \Delta \ln L_{jt} = \bar{w}_{jt}^{L} \Delta \ln H_{jt} + \bar{w}_{jt}^{L} \Delta \ln Q_{jt}, \tag{11}$$

where H stands for hours worked and Q for labour quality, treated however as a single factor, which is expressed by the same share as for L (calculated also in a similar way as the other shares through linear interpolation). Here the growths of the so-called sub-factors sum up directly to the growth of the entire labour factor as follows:

$$\Delta \ln L_{jt} = \Delta \ln H_{jt} + \Delta \ln Q_{jt}. \tag{12}$$

The labour quality sub-factor growth is therefore residually calculated through subtraction. This small difference in comparison with the capital factor decomposition (3) is, however, of no importance as far as the additivity of the sub-factor contributions to the GVA growth is considered[5]. We assume here that the total labour factor (L) growth is the sum of the physical growth of the working labour force accounted as hours worked (H) and of the labour quality (Q) growth. If labour quality is understood as labour composition (LC), as in the EU KLEMS framework, then it should be calculated according to the formula:

$$\Delta \ln LC_{jt} = \sum_{l=1}^{18} \bar{v}_{ljt} \Delta \ln H_{ljt} - \Delta \ln H_{jt}. \tag{13}$$

[5] Equation (15) in O'Mahony, Timmer (2009: F378) also expresses this difference but instead of "labour quality", we have "labour composition", which is more narrowly defined.

The first term on the right-hand side is the Törnqvist quantity index applied over 18 kinds of labour l in individual industries j. $\bar{v}_{ljt}$ are average value shares of the individual labour kinds l in industries j calculated in a similar way as for formula (3) through linear interpolation. However, labour quality contribution can be understood also differently, as hourly wage growth contribution (arising from wage changes within the above-mentioned 18 kinds of labour), and it may therefore give different results to some extent. In such a case, the formula for labour quality should be:

$$\Delta \ln LC_{jt} = \sum_{l=1}^{18} \bar{v}_{ljt} \Delta \ln W_{ljt} - \sum_{l=1}^{18} \bar{v}_{ljt} \Delta \ln H_{ljt}, \tag{14}$$

where W with appropriate subscripts stands for the total labour compensation in the given aggregation. For Poland, the final data are now ready in both methodologies of labour quality calculation.

All data have been calculated after being converted initially into 2005 prices and presently into 2010 prices, following the same change in Eurostat transmission tables that happened during the work on KLEMS in Poland. The chain index number theory as presented, for example, by Schreyer (2004) and Milana (2009) was applied. Information on data processing by other countries was studied for comparison and reference in Gouma, Timmer (2013a; 2013b). During the work, the ESA'95 Eurostat system changed into the ESA2010 system.

4. Polish data processing issues

For the labour factor, data are available as a representative survey with a code name Z–12 for the even years: 2004, 2006, 2008, 2010, 2010 and 2014. They are therefore sufficient to perform KLEMS accounting with the final results from 2005 onward. The pre–2004 data are unsystematically and inconsistently collected, therefore of very low quality. For the uneven years, linear interpolation has been applied. For the year 2004, the data deliver information on the number of full-time workers, average hourly gross wages per hour worked in the nominal time and in the overtime during the entire years by full-time workers in Polish zlotys and the number of hours worked by full-time workers. From 2006 onward these data concern also part-time workers.

The data are in the NACE 1 classification system (European equivalent of ISIC 3) for the years 2004–2007. From 2008 onward, they are in the NACE 2 classification system (European equivalent of ISIC 4). However, the Demographic Surveys and Labour Market Department of the Central Statistical Office of Poland delivered the data for 2008 also in the NACE 1 classification system[6].

[6] A great many thanks to our colleagues from the CSO Demographic Surveys and Labour Market Department for having performed this conversion, and also for compiling data from the above-mentioned Z12 survey.

The growths for 2008 could then be calculated by subtraction of the 2007 levels from the 2008 levels in the NACE 1 system, whereas the growths for 2009 could be calculated by subtraction of the 2008 levels from the 2009 levels in the NACE 2 system. The other ways of doing these calculations delivered results with unusual breaks. When necessary, a simplified subdivision into 14 wide industries combining the two NACE systems provided by the EU KLEMS was also used. According to the KLEMS requirements, the data of the Z–12 survey are available by 18 above-mentioned labour kinds, which arise from subdivisions by 2 sexes, 3 age groups and 3 education attainments. This way, data matrices 18X14 were available for further data processing.

The data from the above-mentioned Z–12 representative survey concern 7–8 million employees (the number slowly increasing over the above-mentioned period of 2004–2014), which is not the entire labour market of about 14–16 million of employees together with the self-employed. However, the said data were used only as a structure to distribute the entire labour market data acquired from some other source. The best option for this other source was to use Eurostat transmission tables, which are templates provided by Eurostat to individual countries' National Statistical Institutes (NSIs) to be filled with data. This is because they are filled according to evened regimes for all the countries and in accordance with the SNA and its European equivalent ESA national account systems.

As far as the capital factor is considered, it is to be divided into nine categories, according to the KLEMS framework[7]:

1) residential structures,
2) non-residential structures,
3) transport equipment,
4) other machinery and equipment,
5) computing equipment,
6) communications equipment,
7) agricultural biological assets,
8) intangibles,
9) software.

In the practical implementation, agricultural biological assets and the intangibles are usually combined into the "other assets" category, therefore the EU KLEMS data sets have only 8 categories of assets. The category of residential structures is specific because there is the problem of ownership vs. use here, and as Timmer et al. (2007a: 42) mention, it is unclear how individual countries deal with this problem. If residential capital is excluded from total capital stock, then only 7 asset categories are left in the accounts, just as it is done in the OECD meth-

[7] There is some discrepancy in the names of the assets between the Eurostat transmission tables and the EU KLEMS manuals, and also with other references. Therefore, we are using here our own nomenclature, but quite similar and concerning the same items.

odology (see Figure 1). It must be noted here that in the case of Poland the inclusion of dwellings in KLEMS growth accounting remains a controversial issue because of the opaque Polish dwelling market that not always reflects real values. However, for international comparisons with the EU KLEMS countries, it should be included. For Poland, the final data are now ready in both methodologies of capital stock calculation.

In Poland, the asset categories 5) computing equipment and 6) communications equipment are not extracted from the category 4) other machinery and equipment. Also, the category 9) software is not extracted from the category 8) intangibles. As we know, in the EU KLEMS framework, these three categories of assets are aggregated into the so-called ICT capital, and the other remaining categories of assets are aggregated into the so-called non-ICT capital. Therefore, for the capital factor, the basic operation was to extract these three categories of ICT capital. This was done thanks to Supply and Use Tables (SUT) from which the structure of software services was used to distribute the values of the aggregated investment figures present in these tables for the above-mentioned three categories of ICT capital, based on the assumption that software services are quite proportional to these three categories of investment (they can be seen as "collateral"). Then the resulting structure was turned into 34 EU KLEMS aggregations. Non-ICT capital values were calculated by subtraction of ICT capital values from total capital values. Since SUTs are available only in NACE 1 and NACE 2 not converted between each other (and they shall not be converted!), the same 14 wide industry correspondences were used as for the labour factor[8]. Asset stocks were used to distribute aggregate capital income shares into capital income shares by industries. This method was chosen because the relatively high quality and very detailed data on asset stocks (a specific and outstanding feature of Polish statistics) made it superior to other methods[9].

One expected problem in KLEMS productivity accounting in Poland was the transition from the ESA'95 to ESA2010 systems, as not all data were converted from one system to the other (and some data shall never be converted as it is the case with SUTs from before 2010). Therefore, although only occasionally, there was a need to use mixed data from both systems. To test whether it is acceptable, subtractions between asset growths in the ESA2010 system and asset growths in the ESA'95 system were performed and it was found that the differences between the two systems in this case were always negligible.

The data prepared in this way were further processed conformably to the methodology presented in the previous section. However, for the sake of com-

[8] Otherwise, the two factors could well be not balancing each other in gross value added from place to place.

[9] A great many thanks to our colleagues from the CSO National Accounts Department for compiling data on asset structures for us.

parison, four techniques of calculation, which arise from two dichotomies, were used. One is the possibility to calculate everything at all aggregation levels or, alternatively, only at the lowest aggregations and aggregate partial results using the above-mentioned Törnqvist quantity index, which theoretically is the best procedure. The other is the possibility of using two mathematical formulae for relative growth, i.e. $\Delta x/x$ and $\Delta \ln x$, and here when the Törnqvist quantity index is used, logarithms are theoretically necessary. The four techniques delivered similar results, but the most appropriate technique based on the Törnqvist quantity index is the one to be referred to.

5. Conclusions

The draft results of KLEMS productivity accounting for Poland are now ready for the years 2005–2014 and they are to be posted on the CSO website[10]. In the 2018 release, the years 2015–2016 should be covered (if no unforeseen setback occurs), and the accounts shall be developed[11]. Meanwhile, on the EU KLEMS platform, a September 2017 release has been posted, just before the final publication of this paper, with 2014 or 2015 (depends on the country) as the last covered year. The results for Poland can therefore be compared with those of the EU KLEMS countries. They are quite similar to those of Gradzewicz et al. (2014) but based on a methodology more in line with KLEMS, thanks to the data operations presented in this paper. The final data for Poland are both for labour quality understood as labour composition and as labour hourly remuneration change. They are also both for capital stocks including and not including residential capital. This gives four combinations available. Thus, it was proven that the KLEMS economic productivity accounts for Poland can be carried out and possibly extended.

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[10] However, Polish KLEMS data sets are not yet complete on the EU KLEMS website.

[11] It is finally intended to carry out a further, in-depth decomposition of the labour factor, to include gross output decomposition into GVA and intermediate consumption, and to perform KLEMS at the regional level, i.e. for the 16 Polish voivodships.

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Implementacja rachunku produktywności gospodarki KLEMS w Polsce

Streszczenie: Celem artykułu jest pokazanie, w jaki sposób zrealizowano rachunek produktywności gospodarki KLEMS dla Polski. Głównym problemem badawczym było znalezienie sposobu uporania się ze specyficznym dla kraju niedostatkiem danych. W związku z tym postawiono hipotezę, że dzięki pewnym innowacyjnym, ale akceptowalnym technikom oszacowania brakujących danych możliwe jest dostarczenie odpowiednich danych do tego rachunku dla Polski. Po zaprezentowaniu podstawowych informacji o rachunku produktywności gospodarki KLEMS oraz metodologii w artykule pokazano, jak zostały rozwiązane specyficzne problemy, które ujawniły się z danymi.

Słowa kluczowe: rachunek produktywności, KLEMS, czynniki produkcji, czynniki pierwotne, czynnik praca, czynnik kapitał, przyrost produktywności, dekompozycja, kompozycja pracy, godziny przepracowane, pracownicy, godziny na pracownika

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