THE SHARE OF INTENSIVE AND EXTENSIVE FACTORS ON THE GDP DEVELOPMENT OF SELECTED EU COUNTRIES[12]

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Abstract

The paper introduces new methodology how to count the share of intensive factors (total factors productivity) and extensive factors (total input factors, TIF) on the GDP development. The methodology is applicable for all possible developments and not only for growth of GDP as in case of growing accounting equation. The methodology is used for investigation of intensive and extensive development of selected EU countries with history of socialistic regime. The development of TIF is further divided on the development of labor and capital. The results are compared with results achieved for EU-15.

Keywords: GDP development, intensive and extensive factors, total factor productivity, total input factors, labor, capital

Introduction:

The comparison of the GDP development of different states enabling the identification of the ways resulting growth, decline or stagnation belongs to the permanent solved issue of economic analysis. Generally speaking, GDP development can be achieved by intensive or extensive ways or by their combination. Intensive development is based on the innovation and is seen as qualitative ones. The extensive development, based on the increasing units of inputs, must, at certain point, meet with the limit of scare resources. It is not also able to increase production without further increasing of inputs what can endanger environment, nature and even life on the Earth. The knowledge society should therefore rely on intensive factors of development, especially on innovations. The representatives of any economic system should know whether the development of the system is based on the intensive or extensive factors including the share of both factors. The growth accounting equation is usually used for measuring the shares. The equation, however has certain limitations and only allows to express the impact shares for the production growth, on condition of positive impact of both intensive and extensive factors. That is why we suggest alternative methodology how to measure the share of the intensive and extensive factors on the GDP development. Our proposed solution can express the effect of intensive factors for both growing and declining product, including the stagnation thereof, whereas it also addresses potential compensation of extensive and intensive factors, as well as corresponding effect of both factors on the production growth or decline.

The paper is organized as follows[13]. First our methodology of the measurement of

[12] The article is one of the outputs of the specific research „Identifikace pusobeni znalostní spolecnosti a inovacního vyvoje ve firmách (Identification of the effects of knowledge society and firms innovation development()", which I realized by University of Finance and Administration and financed by Ministry of Education, Youth and Sport of Czech Republic

intensive and extensive factors is introduced and the parameters of intensity and extensity are derived. The methodology is than applied for quantification of GDP development of selected EU countries (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania Poland, Romania, Slovenia and Slovakia) for the period 1990-2010. Conclusion summarizes our results.

Methodology: derivation of dynamic intensive and extensive parameters

The basic shape of the national economy aggregate production function (Cyhelský, Mihola, Wawrosz, 2012, p. 38, statement (27) or Hájek and Mihola 2009, p. 741, statement (2)) is given by the plain multiplicative (geometrical) relation that expresses the product Y as the product of the total factors productivity TFP[14] and the total input factor (TIF):

$$Y = TFP * TIF \quad (1)$$

The national economy aggregate production function is characteristic by the fact that the value of TFP and TIF is given by the specific mix of the production types, applied technology, production efficiency and distribution of such production. Therefore, the specific value of TFP at this level is affected by the TIF structure. The determination of the level and development of TFP/TIF is the subject matter of the static or dynamic analysis.

The summary input factor TIF (Cyhelský, Mihola, Wawrosz 2012, p. 38, statement (26)) is obtained as the weighted geometrical aggregation of the two basic factors of production, i.e. labor L[15] and capital K. The function has characteristic of Cobb-Douglas production function and can be written as[16].

$$TIF = L^{\alpha} . K^{(1-\alpha)} \quad (2)$$

This function has constant returns to scale (Soukup 2010, p. 460), because, as the sum of the weights, i.e. function exponents, equals to 1, by increasing each of the production factors t-times, the TIF will also increase t-times.

$$t.TIF = (t.L)^{\alpha} . (t.K)^{(1-\alpha)} \quad (3)$$

If we substitute TIF in (1) by its expression in (2), we will get

$$Y = TFP . L^{\alpha} . K^{(1-\alpha)} \quad (4)$$

The expression (4) corresponds to the special form of production function in the neoclassical model of economic growth

$$Q = \kappa . f(K, L) \quad (5)$$

Coefficient κ from expression (5) is represent by TFP in expression (4) and function f(K, L) is aggregate function of total input factor. The fact that Solow understood the level of the used technology κ much more widely that just as a level of technology can be corroborated by his statement (Solow, 1957, p. 312): "The term technical change is used as a short-hand expression of any kind of shift in the production function. Thus slowdowns, speed-ups, improvements in the education of the labor force, will appear as technical change." In case the TFP does not change and L and K increase t-times, it will be a purely extensive development (growth) corresponding to constant returns to scale. In case the growth of product Y is achieved solely as a result of changes in the TFP, it will be a purely extensive growth.

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[13] The article is one of the outputs of specific research "Identification of effects of knowledge society and innovation development in firms" which is realized by University of Finance and Administration and financed by Ministry of Education, Youth and Sport of Czech Republic.

[14] Robert M. Solow (see Solow 1957) examines the steady state growth, under which the growth rate of capital and labor equalize. The production growth per capita is then subject to technical progress, which is seen as an exogenous factor here. Further elaboration of the idea has revealed that it is not just technical progress, but rather the summary effect of all intensive growth factors.

[15] In this paper, we will not examine the measuring methods of L or K in detail. The range of definition for all used values results from the range of definition for labor and capital $L > 0$ and $K > 0$.

[16] The comprehensive multiplication production study with the factors of labor, capital, and technical progress is mentioned in Barro and Sala-I-Martin (1995, p. 29); this is the Cobb-Douglas production function $Y=AK^{\alpha}L^{(1-\alpha)}$.

The functions (1) and (4) represent the static task that concentrates on the GDP of specific years and counts the share of TFP and TIF (TIF divided on the share of labor and capital) for that year. The static task fully determines the aggregation method in a dynamic task which investigates the growth rate or the change coefficient of GDP and how the growth rate or change coefficient were caused by change of TPF, TIF, respective of labor (L) and capital (C). The statement (1) may easily be converted to the dynamic version of an aggregate production function expressed with the use of change coeficient

$$I(Y) = I(TFP) \,.\, I(TIF) \,, \tag{6}$$

Or with the use of growth rates[17]

$$G(Y) = \{[G(TFP) + 1].\,[G(TIF) + 1]\} - 1 \tag{7}$$

In case I(TFP) = 1 and I(Y) = I(TIF) > 1, it is a purely extensive growth. The same may be achieved using the growth rates. In case G(TFP) = 0 and G(Y) = G(TIF) > 0, it is a purely extensive growth. If both indices have same value greater than 1, i.e. I(TFP) = I(TIF) > 1, then $I(Y) = I^2(TFP) = I^2(TIF)$, which represents the so-called intensively-extensive growth. Detailed classification of all basic types of development and proposal of values of the corresponding dynamic parameters are addressed in paper (Mihola, 2007, p. 123).

Similarly, it is also possible to convert statement (2) into a dynamic version

$$I(TIF) = I^{\alpha}(L) \,.\, I^{(1-\alpha)}(K) \,, \tag{8}$$

Whereas the following applies for the growth rates

$$G(TIF) = \{[G(L) +1]^{\alpha} \,.\, [G(K) +1]^{(1-\alpha)}\} - 1 \tag{9}$$

Furthermore, we could provide an analogous typology of the TIF development for these two relations, based on the impact of labor/capital development on such development.

If we substitute I(TIF) in (6) by its expression in (8), we will get a dynamic aggregate production function

$$I(Y) = I(TFP) \,.\, I^{\alpha}(L) \,.\, I^{(1-\alpha)}(K), \tag{10}$$

After using logarithmic calculation, it is possible to get from (10) the following statement after introducing the growth rates

$$\ln[G(Y) +1] = \ln[G(TFP) +1] + \alpha.\ln[G(L) +1] +(1-\alpha).\ln[G(K) +1] \tag{11}$$

For small growth rates of up to ±5%, the following statement applies sufficiently accurately[18]

$$\ln[G(A) +1] \approx G(A) \tag{12}$$

By utilizing this approximate relation (12), it is possible to modify statement (10) as follows:

$$G(Y) = G(TFP) + \alpha.G(L) +(1-\alpha).G(K) \tag{13}$$

The expression (12) is the basic equation of growth accounting[19]. It is apparent from the construction that when using the initial dynamic multiplicative aggregate production function (10) for higher change rates, it is necessary to use the precise statement (11).

The basic equation of growth accounting (13) is usually used to calculate a residual value, i.e. growth rate G(TFP). We will certainly get an accurate result for higher growth rates as well, if we first determine G(TIF) from statement (9) and calculate G(TFP) using following statement (14) that is based on statement (7).

$$G(TFP) = \frac{G(Y)+1}{G(TIF)+1} - 1 \tag{14}$$

Statement (14) is also used to calculate the effect of the TFP development, G(L) development, and G(K) development, always linked to the development of G(Y). This is usually performed by dividing statement (14) by the value G(Y), whereas each of the three terms indicates the relevant effect share. However, this method may only be applied in case it

[17] The TFP growth rate, i.e. G(TFP), was used by (Denison, 1967, p. 15), for example, for the purpose of an international comparison of 9 developed countries.

[18] When G(A) ±5% , the error equals to 0.12 p. b. – i.e. 2.5% of the value.

[19] The calculation of the aggregate productivity of factors using this relation is addressed by a number of studies, e.g. OECD (2003), OECD (2004).

is a production growth caused by positive effects of all three factors under review. Therefore we suggest different indicators for measuring the share of intensive and extensive factors on GDP development. The indicators can be easily derived from the statement (6) by using logarithmic calculation (see Mihola 2007, pp. 123 and 124 for details.)

$$\ln I(Y) = \ln I(TFP) + \ln I(TFI) \quad (15)$$

The dynamic intensity parameter is then given by the relation

$$i = \frac{\ln I(TFP)}{|\ln I(TPF)|+|\ln I(TIF)|} \quad (16)$$

And the dynamic extensity parameter is given by the following relation

$$e = \frac{\ln I(TIF)}{|\ln I(TPF)|+|\ln I(TIF)|} \quad (17)$$

Absolute values in both denominators guarantee that the share of intensity and extensity development can be measured for all possible development of the share of extensive and intensive factors (Mihola 2007, p. 125):

- Change in the extensive factors only, without any change in the intensive factors;
- Change in the intensive factors only, without any change in the extensive factors;
- Simultaneous growth of both extensive and intensive factors;
- Simultaneous decline of both extensive and intensive factors;
- Compensation of extensive factors for intensive factors;
- Compensation of intensive factors for extensive factors;
- Stagnation of both extensive and intensive factors.

Using analogy to the expression (16) and (17), we can also define formulas for the dynamic parameter the share of the development of labor L and capital K on the TIF development. The share of the labor development on the TIF development can be expressed as

$$l = \frac{\alpha * \ln I(L)}{\alpha * |\ln I(L)| + (1-\alpha) * |\ln I(K)|} \quad (18)$$

The share of the capital development on the TIF development can be expressed as

$$k = \frac{(1-\alpha) * \ln I(L)}{\alpha * |\ln I(L)| + (1-\alpha) * |\ln I(K)|} \quad (19)$$

Comparative analysis of the intensive and extensive development of selective EU countries for the period 1990-2010

The methodology derived in the previous section will be used for the purpose of comparing the quality of development dynamics for Poland, Slovakia, Slovenia, Czech Republic, Estonia, Hungary, Romania, Bulgaria, Lithuania, and Latvia for the period of the past twenty years (1990 – 2010). The data for the EU-15 will also be shown for the sake of comparison[20]. The following comparative analysis also assigns the corresponding values for the 4 dynamic parameters under review – ***i***; ***e***; ***l*** and ***k*** – to the average annual development G(GDP) in stable prices of year 2000 for each analyzed country.

The data were taken from the Statistical Annex of European Economy[21], included in the EU prognoses, as well as research studies and articles in scientific journals. To ensure credibility of the generated data, we have confronted their development with the evaluation of the respective stages by various authors and organizations. Moreover, year-to-year weights α were identified for each country using standard method. Furthermore, the time series of the growth rates G(GDP), G(L), and G(K) for the period of 1990 through 2010 were also used as input data for the analysis. Using statement (9) for the given alpha, a growth rate of the

[20] EU-15 consists of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal, Spain, Sweden, and United Kingdom.

[21] There is currently no uniform source of such data, whereas it is also necessary to respect revisions that correct the data *post facto*, in time intervals of various duration.

summary input factor G(TIF) was calculated. Statement (14) was used to calculate the growth rate of the summary productivity of factors. The growth rates determined in the aforementioned manner enable the calculation of all four dynamic parameters under review - ***i***; ***e***; ***l*** and ***k*** – by means of statements (16) through (19). The algorithm was applied to average indexes[22] of the initial annual data for the examined period of 1990 – 2010 as a whole.

Since the twenty-year time series of several input indicators form an extensive set, Table no. 1 only show average year-to-year indicators G(GDP); G(TIF), G(TFP), G(L), and G(K) – supplemented with dynamic parameters. The countries are sorted based on the recorded average year-to-year GDP growth rate, in a descending order. The last column shows data for the EU-15.

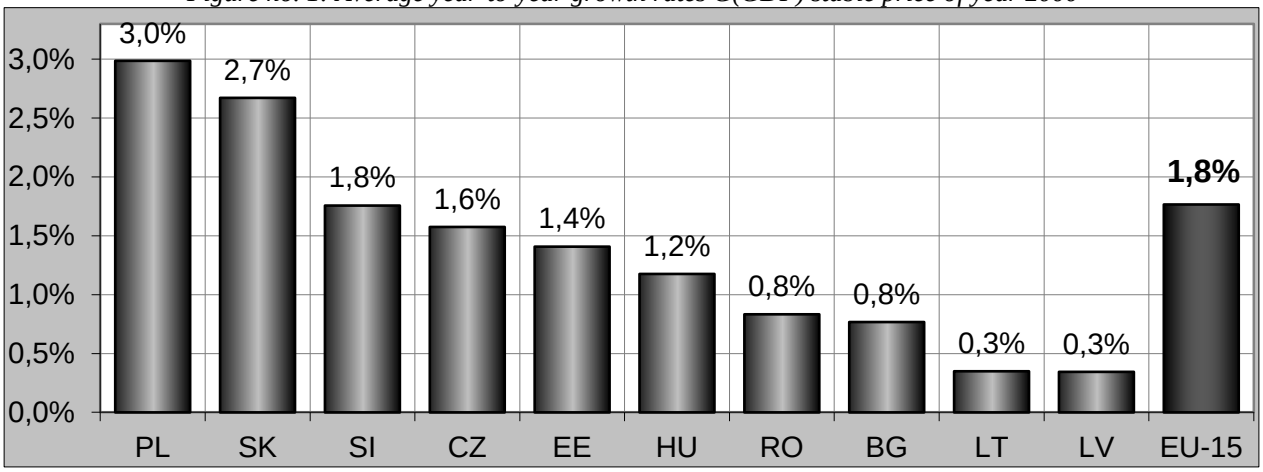
Table no. 1: Average year-to-year dynamic characteristics (all indicators are expressed in %)

	PL	**SK**	**SI**	**CZ**	**EE**	**HU**	**RO**	**BG**	**LT**	**LV**	**EU-15**
G(GDP)	3.0	2.7	1.8	1.6	1.4	1.2	0.8	0.8	0.3	0.3	1.8
G(TIF)	0.2	1.5	0.0	0.6	0.2	-0.1	-0.9	-0.1	0.2	-0.2	0.7
G(TFP)	2.8	1.1	1.8	0.9	1.2	1.3	1.8	0.9	0.2	0.6	1.1
G(L)	-1.3	-0.4	-0.5	-0.9	-1.9	-1.1	-2.1	-0.9	-2.1	-0.4	0.7
G(K)	2.0	1.4	3.4	3.0	3.3	1.7	2.3	1.0	2.%	1.9	2.1
i	94	42	100	60	87	90	65	87	47	71	61
e	6	58	0	40	13	-10	-35	-13	53	-29	39
l	-35	-12	-48	-21	-46	-53	-74	-55	-42	-53	39
k	65	88	52	79	54	47	26	45	58	47	61

Source: Own calculations

The growth rates for individual countries are shown in Figure no. 1. Only Poland and the Slovak Republic recorded higher average growth rate than the EU-15. Slovenia shows the same growth rate as the EU-15. The mentioned countries are followed by the Czech Republic and other countries under review.

Figure no. 1: Average year-to-year growth rates G(GDP) stable price of year 2000



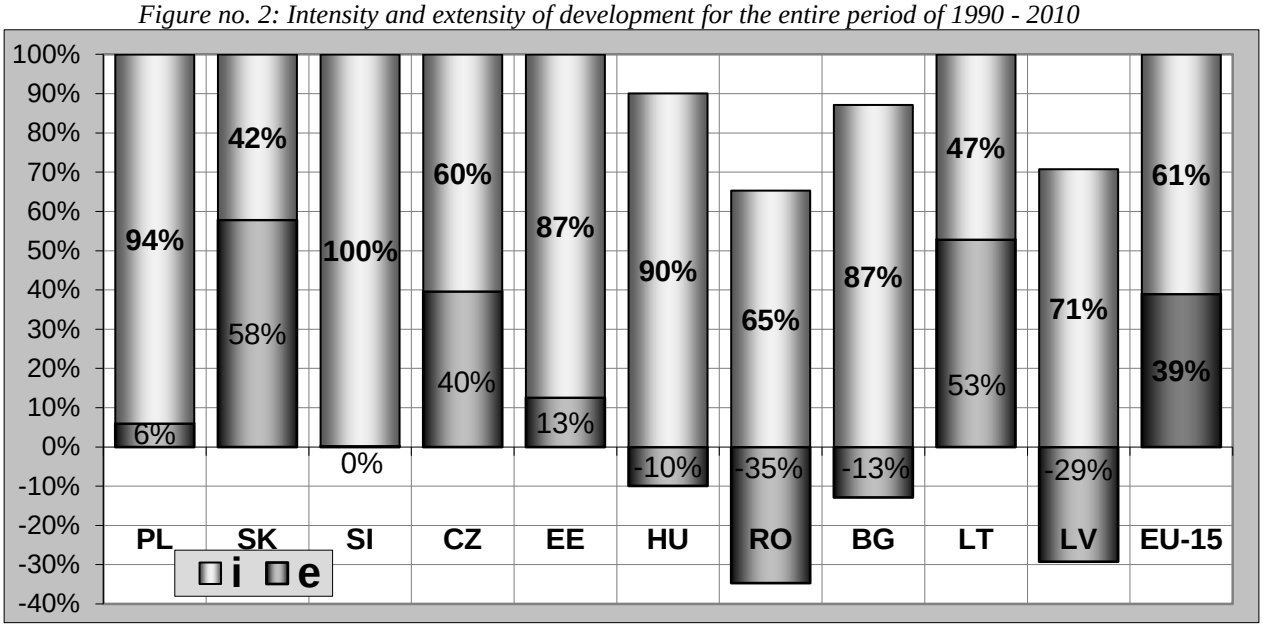
Source: Table no. 1; own calculations

The degree of intensity or extensity, as appropriate, of such development is shown in Figure no. 2 that lists the examined countries in the same order as Figure no. 1. Most countries appear to be predominantly intensive in the period under review. The development of Estonia seems to be purely intensive. The development of Slovakia, Lithuania as well as the Czech Republic is extensively-intensive. Four countries with a lower growth rate – i.e. Hungary, Romania, Bulgaria, and Latvia – experience intensive compensation. Slovakia and

[22] Geometric mean of annual indices and the corresponding annual growth rates were used to calculate the average indices. The use of arithmetic mean for the annual growth rates does not lead to correct results.

Lithuania show the least intensive development. Development in the Czech Republic shows very similar parameters to the EU-15.

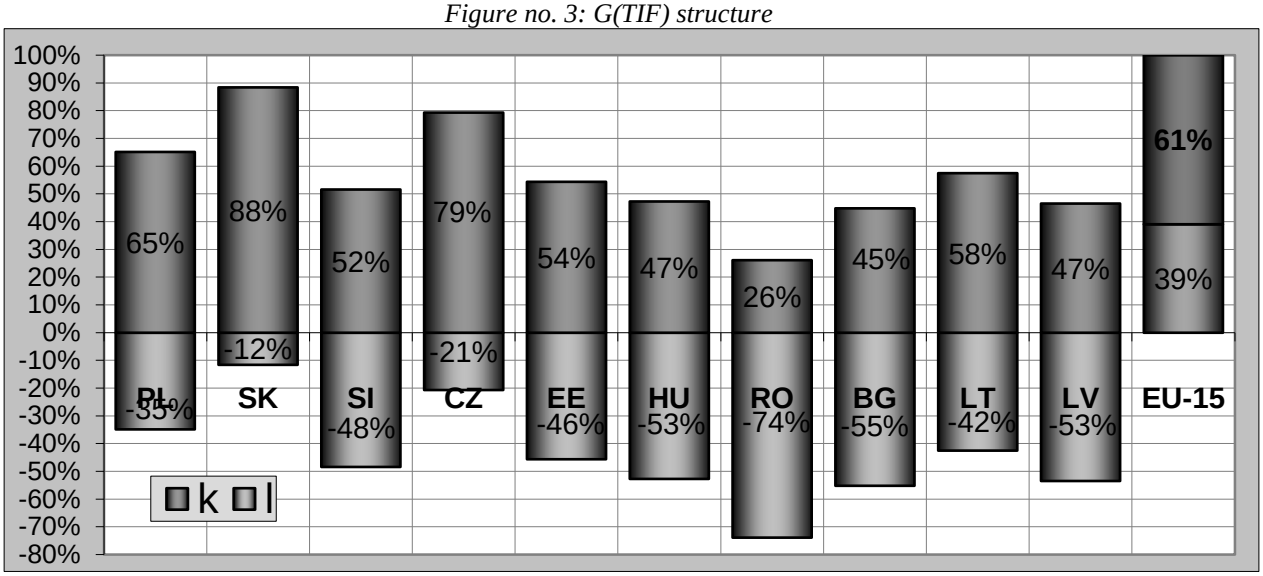
Figure no. 2: Intensity and extensity of development for the entire period of 1990 - 2010



Source: Table no. 1; own calculations

Figure no. 3 gives an overview of the growth rate structure of the summary input factor G(TIF). All the examined countries experienced the decrease of labor during the period under review, which is – in most cases – more than compensated by the increase of capital. In case of Slovenia, the decrease of labor by 48% was directly eliminated by the increase of capital by 52%, which led to stagnating TIF and zero extensity. In case of Romania, Latvia, Bulgaria, and Hungary, the decrease of labor was so significant that the increase of capital could not compensate in full, thereby resulting in the decrease of TIF and negative extensity.

Figure no. 3: G(TIF) structure



Source: Table no. 1, own calculations

Conclusion:

The article shows how time series of the basic macroeconomic indicators (GDP, total factor productivity TFP, total factor inputs TIF, value labor and capital) expressed in money terms may be used to analyze, whether the change in such indicators in time is caused by mainly extensive factors, reflecting the change of inputs, or by mainly intensive factors, with

changes in the efficiency indicator. We introduced new method how to measure the share of intensive and extensive factors on the GDP development which is applicable for all possible development and not only for growth of GDP as in the case of equation of grow accounting. So the methodology could be considered as more accurate and exact. Further the article explains how the developments of labor and capital contribute on the development total input factors (TIP).

Our methodology was applied for the investigation of the GDP development of Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania Poland, Romania, Slovenia and Slovakia for the period 1990-2010. The results reveal that most of the countries achieved in the observed period more intensive development than traditional EU countries (EU-15). The only exception were Lithuania and Slovakia where the value of intensity parameters was lower than in the EU-15 and the Czech Republic with same value as EU-15. The intensive development in Rumania and Latvia and partly in Bulgaria and Hungary even eliminated the decline of total input factors. All countries under our review faced the fall of labor force which was, however usually compensated by increasing of capital inputs. Our analysis confirms that the investigated countries with socialist experience before observed period tried to draw level of EU-15 in the observed period. To be able to achieve the concentration of the intensive factors was necessary. Further it was confirmed that all countries suffered from over-employment during socialistic period that resulted in the decline of the share of labor force on the development of TIF after year 1989. The method brings exact result of the development of main macroeconomic indicators connected with GDP and create base for further investigation.

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