Development Intensity of four Prominent Economies[1]

Jiří Mihola[2] | *University of Finance and Administration, Prague, Czech Republic*
Petr Wawrosz[3] | *University of Finance and Administration, Prague, Czech Republic*

Abstract

The paper offers answers to one of the typical problems of economic theory – how it is practically possible to measure and interpret the quality of economic time series at all economic levels. At the macroeconomic level, the task is solved by weighted geometric aggregation of input factors (labor and capital) into a summary input factor (SIF) – the method is similar to the Cobb-Douglas production function. The paper shows differences between our approach and the approach of growth accounting – our approach is based on more general conditions and covers not only situations of growth of economic indicators but also situations of their decline or stagnation. The approach also allows for distinguishing the compensation of input factors. Therefore, the methodology presented in the paper can be used in many practical applications; for instance, it enables us to clearly calculate intensive and extensive parameters of economic growth.

Keywords	***JEL code***
Aggregate production function, summary input factor, dynamic indicators, economic growth, intensive and extensive factors of change of indicators	*C22, C43*

INTRODUCTION

The way a production growth is achieved at all levels of economy has been one of the key economic questions. Generally speaking (e.g. Wawrosz, 2012, p. 54), growth may result from either intensive or extensive factors, or the combination thereof, as appropriate. The development trajectory, which relies more on intensive development factors – as expected within the knowledge society, is considered to be superior. The extensive trajectory is a less preferred one, which expands the scope of production, while preserving the same production method. If both extensive and intensive factors contribute to the output development, it is worth quantifying their respective shares. The quantification is normally performed with the use of a growth accounting formula (Mihola, 2007a, Mihola, 2007b, Hájek, 2009, Cyhelský, 2012), which; however, has certain deficiencies and only allows to express the impact shares for the production growth, on condition of positive impact of both intensive and extensive factors. Our calculation method has thus been modified to ensure that it is sufficiently accurate for any growth rates of all algorithm values. The proposed solution can express the effect of intensive factors for both growing and declining

[1] Output of the IGA Project Ref. No. 7743.
[2] University of Finance and Administration, Estonská 500, 101 00 Prague 10, Czech Republic. Corresponding author: e-mail: jiri.mihola@quick.cz.
[3] University of Finance and Administration, Estonská 500, 101 00 Prague 10, Czech Republic. Corresponding author: e-mail: petr.wawrosz@centrum.cz.

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.

Following up on (Hájek, 2009) and (Cyhelský, 2012), the objective of this paper is to elaborate the methodology and illustrate its application to the international comparison of the development quality for the EU-15, in the United States, China and Russia for the period of ten and fifty years. While growth accounting assumes the determination of the labor/capital growth rate weights for each subject under review within each assessed year, we propose a simplification regarding the selection of these weights in this paper in terms of the sensitivity analysis and interpretation analysis of real isoquants of selected values.

1 THEORETICAL BACKGROUND

The basic shape of the national economy aggregate production function (Cyhelský, 2012, p. 38, statement (27)) or (Hájek, 2009, p. 741, statement (2)) is given by the plain multiplicative (geometrical) relation that expresses the product Y as the product of the summary productivity of factors SPF[4] and the summary input factor SIF:

$$Y = SPF \times SIF. \quad (1)$$

The national economy aggregate production function is characteristic by the fact that the value of SPF and SIF is given by the specific mix of the production types, applied technology, production efficiency and distribution of such production. Therefore, the specific value of SPF at this level is affected by the SIF structure. The determination of the level and development of SPF/SIF is the subject matter of the static or dynamic analysis. On a micro level, the production function of a specific product is given by the specific technology, which assigns specific efficiency to certain consumption of the given production factor. This is one of the reasons why it is convenient to use the polynomial function for the modeling of this product production function, as it generally has both degressive and progressive part.

The summary input factor SIF (Cyhelský, 2012, p. 38, statement (26)) is obtained as the weighted geometrical aggregation of the two[5] basic factors of production, i.e. labor L[6] and capital K. Therefore, we actually derive from the production function with technical progress.[7]

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

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 SIF will also increase t-times.

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

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

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

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4 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.

5 In the Czech Republic, the issue of multi-factor production function KLEM is examined by, for example Klacek (2008).

6 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.

7 The comprehensive multiplication production study with the factors of labor, capital, and technical progress is mentioned in (Barro, 1995, p. 29); this is the Cobb-Douglas production function $Y = A \times K^{\alpha} \times L^{(1-\alpha)}$. The study also comprises the comparison with the proposals of Leontief Y = F(K,L) = min(AK,BL) of 1941; Harod of 1939; Domar of 1946; Solow of 1969; and many others. With regard to the Czech Republic, it is possible to refer to, for example, article by Hájková (2007).

Special form of the production function of neoclassical model of economic growth according to (Solow, 1957, p. 39) $Y = \kappa \times f(K, L)$, where κ stands for the SPF and the function f(K, L) is an aggregate Cobb-Douglas production function. 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."

Since the SPF is a qualitative indicator, its change will determine whether the function (4) would have constant returns to scale or not. In case the SPF 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 SPF, it will be a purely extensive growth. For the purpose of this classification, it is more useful to dynamize the equations of the given production functions.

The aggregation method for the factors of production in a static task fully determines the aggregation method in a dynamic task. The statement (1) may easily be converted to the dynamic version of an aggregate production function expressed with the use of indices:

$$I(Y) = I(SPF) \times I(SIF), \tag{5}$$

or with the use of growth rates:[8]

$$G(Y) = \{[G(SPF) + 1] \times [G(SIF) + 1]\} - 1. \tag{6}$$

In case I(SPF) = 1 and I(Y) = I(SIF) > 1, it is a purely extensive growth. The same may be achieved using the growth rates. In case G(SPF) = 0 and G(Y) = G(SIF) > 0, it is a purely extensive growth. If both indices were greater than or equal to 1, i.e. I(SPF) = I(SIF) > 1, then $I(Y) = I^2(SPF) = I^2(SIF)$, 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:

$$I(SIF) = I^{\alpha}(L) \times I^{(1-\alpha)}(K), \tag{7}$$

whereas the following applies for the growth rates:

$$G(SIF) = \{[G(L) + 1]^{\alpha} \times [G(K) + 1]^{(1-\alpha)}\} - 1. \tag{8}$$

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

The isoquants of permanent production Y that correspond to statement (1) and isoquants of permanent change of production I(Y) that correspond to statement (3) are equilateral hyperbolas with c. e. of substitution 1, i.e. with variable marginal rate of substitution.

The isoquants of permanent SIF that correspond to statement (2) and isoquants of the permanent change of the summary input factor I(SIF) that correspond to statement (7) are also equilateral hyperbolas with c. e. of substitution 1; however, only if $\alpha = 0.5$. The marginal rate of substitution would only be constant on linear isoquants, which does not reflect reality in case of substitution of labor and capital. For example, in case of a high level of substitution of labor by technology, it will be necessary to use increasing amounts of capital to maintain the same SIF if the substitution intensifies.

In both cases, the hyperbolic isoquants that do not intersect the axes correspond to real economy, because neither of the values L, K, SIF, or SPF may equal to zero.

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

If we substitute I(SIF) in (5) by its expression in (7), we will get a dynamic aggregate production function:

$$I(Y) = I(SPF) \times I^{\alpha}(L) \times I^{(1-\alpha)}(K). \tag{9}$$

After using logarithmic calculation, it is possible to get from (9) the following statement after introducing the growth rates:

$$\ln[G(Y) + 1] = \ln[G(SPF) + 1] + \alpha \times \ln[G(L) + 1] + (1 - \alpha) \times \ln[G(K) + 1]. \tag{10}$$

For small growth rates of up to ±5%, the following statement applies sufficiently accurately:[9]

$$\ln[G(A) + 1] \approx G(A). \tag{11}$$

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

$$G(Y) = G(SPF) + \alpha \times G(L) + (1 - \alpha) \times G(K). \tag{12}$$

This is the basic equation of growth accounting.[10] It is apparent from the construction that when using the initial multiplicative aggregate production function (9) for higher change rates, it is necessary to use the precise statement (10).

2 DYNAMIC PARAMETERS OF INTENSITY AND EXTENSITY

The basic equation of growth accounting (12) is usually used to calculate a residual value, i.e. growth rate G(SPF). We will certainly get an accurate result for higher growth rates as well, if we first determine G(SIF) from statement (8) and calculate G(SPF) using statement (13) that is based on statement (6).

$$G(SPF) = \frac{G(Y) + 1}{G(SIF) + 1} - 1. \tag{13}$$

Statement (12) is also used to calculate the effect of the SPF development, G(L) development, and G(K) development, always linked to the development of G(Y). This is usually performed by dividing statement (12) 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 is a production growth caused by positive effects of all three factors under review.

The effects of the SPF development, i.e. intensive factors, were derived for all types of development in Mihola (2007a, pp. 123 and 124).

The dynamic intensity parameter is given by the relation:

$$i = \frac{\ln I(SPF)}{|\ln I(SPF)| + |\ln I(SIF)|}. \tag{14}$$

And the dynamic extensity parameter is given by the following relation:

$$e = \frac{\ln I(SIF)}{|\ln I(SPF)| + |\ln I(SIF)|}. \tag{15}$$

To show the entire dynamic space of the development quality and ensure transparent displaying of development trajectories, it is convenient to use Figure 1, which has I(SIF) or G(SIF) on the *x*-axis and I(SPF) or G(SPF) on the *y*-axis. In order to ensure comprehensive display of this space,[11] it is possible to

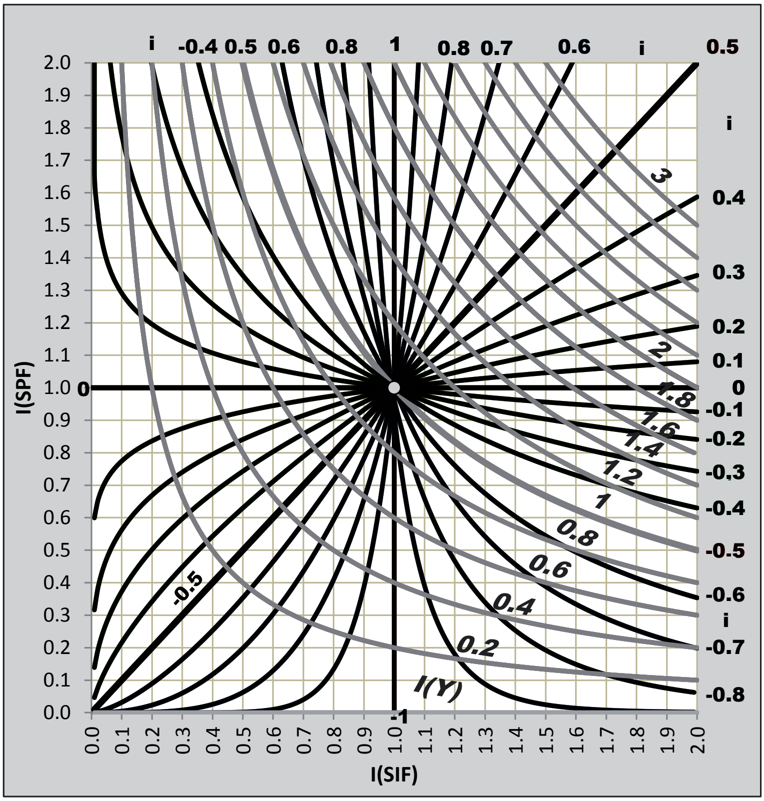
9 When G(A) ±5% , the error equals to 0.12 p. b. – i.e. 2.5% of the value.

10 The calculation of the aggregate productivity of factors using this relation is addressed by a number of studies, e.g. OECD (2003), OECD (2004). In terms of Czech authors, see, for example, Hurník (2005), Dybczak (2006), Hájek (2006), Ministry of Finance (2009); in Slovakia, see Zimková (2007).

11 For spatial display, see Mihola (2007a , pp. 126 and 127).

select a wide range of definition for index (I(SIF), I(SPF)) from 0 to 2, which corresponds to the range of definition from −1 to 1 for the growth rates.[12] Thanks to the relation (5) or (6), it is also possible to plot the hyperbolic isoquants I(Y) or G (Y), as appropriate, in the chart. The zero-growth isoquant, where I(Y) = 1 or G(Y) = 0, goes through the center of the coordinate system – i.e. point [1,1]. This hyperbolic isoquant is characterized by absolute compensation of intensive and extensive development factors, where either i = 0.5 and e = −0.5 or i = −0.5 and e = 0.5. The shapes of the isoquants for development dynamics in Figure 1 depend on the weight α.

Figure 1 Range of the development dynamics quality



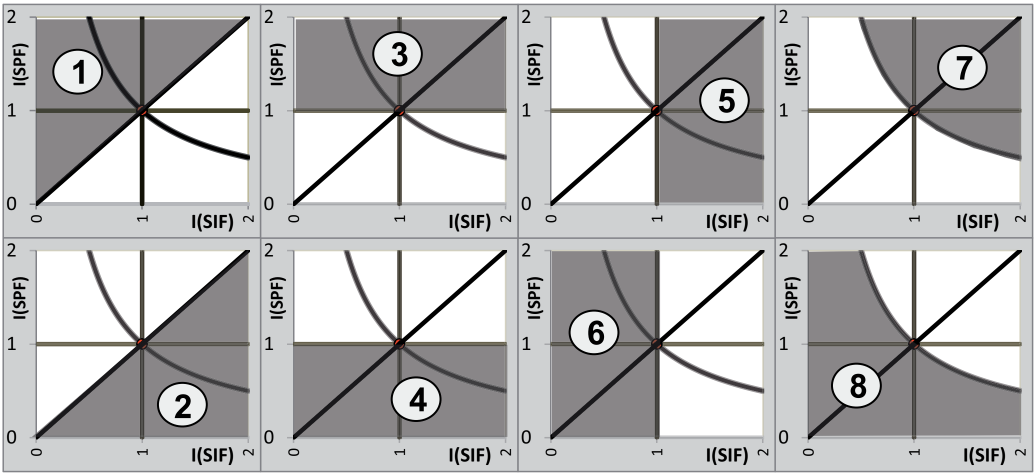
Source: Own calculations

In order to illustrate the matter, only such range is selected in practical application, in which the analyzed data fluctuate. Most isoquants will then appear to be in the form of abscissae and not curves.

Based on the location of the point within the respective combination of zones, it is possible to unambiguously characterize the development of the analyzed unit. The main qualitatively different zones are shown on the chart below, consisting of 8 ranges of the development dynamics quality (Figure 2). The described zone is always shown in grey color and identified with a number. Each two graphs located on the top of each other show zones that complete each other.

[12] Such range of definition makes it possible to model the decline of inputs or outputs to zero as well as their increase by up to 100%.

Figure 2 Qualitative zones within the development dynamics range



Characteristics of the zones:
Zone 1: i ≥ e; intensive factors exceed or equal to (within the diagonal zone border) extensive factors;
Zone 2: i ≤ e; extensive factors exceed or equal to (within the diagonal zone border) intensive factors;
Zone 3: i ≥ 0; intensive factors are positive or equal to zero (on the horizontal zone border);
Zone 4: i ≤ 0; intensive factors are negative or equal to zero (on the horizontal zone border);
Zone 5: e ≥ 0; extensive factors are positive or equal to zero (on the vertical zone border);
Zone 6: e ≤ 0; extensive factors are negative or equal to zero (on the vertical zone border);
Zone 7: I(Y) ≥ 1 i.e. G(Y) ≥ 0; product increases or stagnates (on the hyperbolic zone border);
Zone 8: I(Y) ≤ 1 i.e. G(Y) ≤ 0; product decreases or stagnates (on the hyperbolic zone border).

Source: Own calculations

Each specific point is always located within several zones concurrently. For example, if a point is located within the intersection of zones no. 1, 6, and 7, it means the product growth results from the predominant effect of intensive factors, which are partly compensated by extensive factors.

3 DYNAMIC SPACE OF THE SIF STRUCTURE DEVELOPMENT

The SIF structure development range relies on similar principles as the development dynamics quality range. In this case, I(L) or G(L) is shown on the *x*-axis, while I(K) or G(K) is shown on the *y*-axis. Since the formula (7) or (8) applies, we may also plot the isoquants I(SIF) and G(SIF) in this space. Using analogy, we can also define formulas for the dynamic parameter effect of the development of labor L on the SIF development for the formulas of dynamic intensity/extensity parameters:

$$l = \frac{\alpha \times \ln \mathrm{I(L)}}{\alpha \times |\ln \mathrm{I(L)}| + (1-\alpha) \times |\ln \mathrm{I(K)}|} . \quad (16)$$

And the effect of the development of capital K on the SIF development:

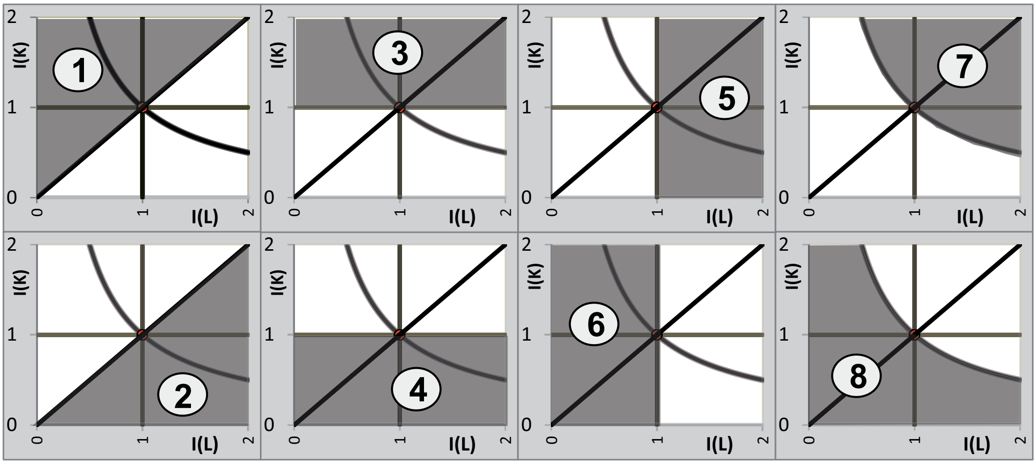
$$k = \frac{(1-\alpha) \times \ln \mathrm{I(K)}}{\alpha \times |\ln \mathrm{I(L)}| + (1-\alpha) \times |\ln \mathrm{I(K)}|} . \quad (17)$$

In this space, it is also possible to plot the isoquants of constant change in the capital/labor ratio I(K/L) or G(K/L), since the following formula applies:

$$\mathrm{I(K/L)} = \mathrm{I(K)} / \mathrm{I(L)}. \quad (18)$$

This space depends on the selection of the weight α. It is symmetrical to the quadrant I axis for α = 0.5 only. Furthermore, it is also possible to define qualitative zones in this space, as shown in Figure 3.

Figure 3 Qualitative zones within the SIF structure range



Characteristics of the zones:
Zone 1: $k \geq l$; capital increases faster than or at the same rate (at the zone border) as labor; the capital/labor ratio increases; the substation of labor by capital takes place or remains constant (at the zone border);
Zone 2: $k \leq l$; labor increases faster than or at the same rate (at the zone border) as capital; the capital/labor ratio decreases or remains constant (at the diagonal zone border);
Zone 3: $k \geq 0$; capital increases or stagnates (at the horizontal zone border);
Zone 4: $k \leq 0$; capital decreases or stagnates (at the horizontal zone border);
Zone 5: $l \geq 0$; labor increases or stagnates (at the vertical zone border);
Zone 6: $l \leq 0$; labor decreases or stagnates (at the vertical zone border);
Zone 7: I(SIF) ≥ 1 i.e. G(SIF) ≥ 0; the summary input factor increases or stagnates (at the hyperbolic zone border);
Zone 8: I(SIF) ≤ 1 i.e. G(SIF) ≤ 0; the summary input factor decreases or stagnates (at the hyperbolic zone border).

Source: Own calculations

In case K and L increase at the same rate, the capital/labor ratio will not change either.

$$I(L) = I(K) = I(SIF). \tag{19}$$

In this case, if we substitute in statement (16):

$$l = \alpha. \tag{20}$$

And at the same time in statement (17):

$$k = (1 - \alpha). \tag{21}$$

Then the same effect of the development of both factors, i.e. L and K on the development of the SIF should correspond to the same share I(L) and I(K), i.e. 50%. Due to (20) and (21), the equality t $l = k$ only applies for α = 0.5.

In case of compensation of both factors, where I(SIF) = 1, i.e. G(SIF) = 0, also the statements (20) and (21) apply for I(L) > 1. In case I(L) < 1, it is necessary to change the sign in statements (20) and (21). Therefore, in the given case for α = 0.5, $l = 0.5$ and $k = -0.5$ or $l = -0.5$ and $k = 0.5$, which has very good interpretation corresponding to the compensation interpretation of intensive and extensive factors within the range of the development dynamics quality (see Figure 1).

Using all 4 parameters – i.e. *i, e, l,* and *k*, it is possible to expand the typology of developments. For example, the following applies for a purely extensive development: $i = 0$, $e = 1$, $l = 0.5$ and $k = 0.5$.

4 METHODOLOGY OF INTERNATIONAL COMPARISON

The methodology derived within the previous chapters will be applied to the comparison of the development dynamics quality of the EU-15, United States, China, and Russia (Soviet Union until 1992) for the period of last fifty (1961–2011) and last ten year. At the same time, relevant total data for these four economic units will be calculated. The result will be shown within a suitable segment of the development dynamics quality and within the SIF structure development range.

The data were collected in the Statistical Annexes of European Economy, which are included in the EU prognoses, as well as in research studies and articles published in scientific journals. For the sake of credibility of the collected data, we confronted their development with the evaluation of relevant stages by different authors and organizations.

The GDP growth rate for the EU-15 region is available since 1961, similarly as for the United States – for individual years of the period. Such data are collected from the Statistical Annexes of European Economy published by the EU. With regard to China, the annual data for the period under review are available from the Chinese Statistical Annual Reports and from the National Statistical Bureau. In terms of Russia, the data starting from 1992 have been adopted from the prognoses of the International Monetary Fund (World Economic Outlook, IMF), which always specify the relevant data for the past years. The period of 1961 to 1991 relates to the former Soviet Union; however, due to its size, Russia had a predominant importance for the dynamics of the entire Soviet Union. In this sense, it is possible to use the data – with minor objections – for the assessment of the entire period under review. With regard to the Soviet Union, the product growth rates concern the real gross national product GNP; however, the dynamics in principle do not differ from the GDP dynamics. The GNP growth rates for the former Soviet Union were taken over from scientific literature and it concerns estimates, because the former Soviet Union did not publish such data. In case the annual data were missing; however, there were five-year averages available, we completed the annual data to preserve the average growth rate for the respective five-year period.

The annual employment growth rates for the EU-15 and the United States were taken from the Statistical Annexes of European Economy (EU) for the entire period under review. With regard to China, such annual data were collected in scientific articles and from the International Labor Organization ILO; the ILO also provided the data for Russia for the period of 1992–2011. With regard to the former Soviet Union, the data for the period of 1961–1991 were taken take over from scientific articles and, once again, some missing growth rates were completed to correspond to the published average annual growth rate for the respective five-year period.

The annual growth of the capital reserve for the EU-15 and the United States were taken from the Statistical Annexes of European Economy of the E for the entire period under review. With regards to methodology, the collection of the data consists in the application of the perpetual inventory method. The method subsists in adding gross investments to the capital reserve and in subtracting any capital written off, based on the estimated level of depreciation. With regard to China, the literature only mentions contribution of capital to the GDP growth – calculated as the product of the income share of capital multiplied by the capital growth rate for approximately first half of the given period. Therefore, by retroactively dividing it by the income share of capital, we get the capital reserve growth rate. With regard

[13] There is currently no integrated source of the information, whereas it is necessary to respect revisions, which modify data, on post facto basis, from time intervals of different duration.

to the second period, the capital growth rate is adopted from scientific literature, where it had been calculated using the perpetual inventory method. With regard to Russia (1992–2011), the data have been taken over from the UN study as well as the World Economic Outlook of the IMF. The capital growth rates have been, once again, derived from the contribution of capital to GDP growth. In terms of the former Soviet Union, the capital growth rates for the period of 1961–1991 were collected from scientific literature and the missing annual data were completed so that the average of the annual data corresponds to the growth rate for the respective five-year period specified in the literature. With regard to the United States, the year-to-year weights α were determined using a standard method.

The initial data for the analysis are the time series of the growth rates G(GDP), G(L) and G(K) for the period of 1961–2011. Using the formula (8) for[14] $\alpha = 0.5$, the summary input factor growth rate G(SIF) has been calculated. The statement (13) was used for the purpose of calculating the growth rate of the summary productivity of factors G(SPF).

Such growth rates make it possible to calculate all four reviewed dynamic parameters of ***i***; ***e***; ***l***, and ***k***. Using statement (18), modified for the growth rates, the growth rate of the capital/labor ratio G(K/L) was calculated. The selection of the weight α only affects the range of the SIF structure. We believe that it is not necessary to prefer any of the factors of production L and K[15] when aggregating them into the SIF.[16] There is also no reason for the asymmetry of the SIF structure range, because the isoquants I(K/L) do not depend on the selection of α.

5 COMPARING THE DEVELOPMENT DYNAMICS OF INDIVIDUAL SUPERPOWERS

The initial average data, similarly as all the calculated characteristics for the entire period, are shown in Table 1 and Table 2 (for the last 10 years).

Table 1 Growth rates for output, input parameters *i*, *e*, *l*, *k* for the period of 1960–2011

1961–2011	G(Y)	G(L)	G(K)	G(SIF)	G(SPF)	G(K/L)	*i*	*e*	*l*	*k*
USA	3.1%	1.5%	2.8%	2.2%	0.9%	1.3%	30%	70%	35%	65%
EU-15	2.7%	0.4%	3.0%	1.7%	0.9%	2.6%	35%	65%	13%	87%
China	8.1%	2.2%	7.1%	4.7%	3.2%	5.0%	41%	59%	24%	76%
Russia	2.1%	0.6%	2.2%	1.4%	0.7%	1.6%	33%	67%	20%	80%

Source: Own calculations based on year-to-year growth rates of the initial data, i.e. G(Y); G(L) and G(K)

The performance of the economies under review characterizes the GDP growth rate at constant prices. China recorded the highest average year-to-year growth rate of 8.1%, followed by the United States with the growth rate of 3.1%, and the EU-15 with 2.7%. Russia[17] recorded the lowest growth rate of 2.1%. China

[14] As part of the calculations, the sensitivity analysis relating to the value of the selected weight α had also been performed. The selection within the interval of 0.5 to 0.7 for all economies did not have any significant impact on the generated results, namely on mutual proportions and ranking. If we were to reduce α below 0.4, the differences between the economies under review will start to fade.

[15] This is not even subject to the fact that namely substitution of labor by technology has been historically winning recognition; the labor/capital ratio has thus been permanently rising. This process takes place through investments, which is associated with increasing SPF in case of rational behavior. This will be expressed as a transition to isoquants with higher production.

[16] One of the reasons why it does make sense to prefer one of the considered factors of production is the fact that all countries, in principle, gradually apply basically the same technical and other progress.

[17] The data for Russia – as the successor country of the Soviet Union – comprise a time series of data for the Soviet Union, transformation period after 1992, as well as for Russia; such data are also affected by the aforementioned transformation period.

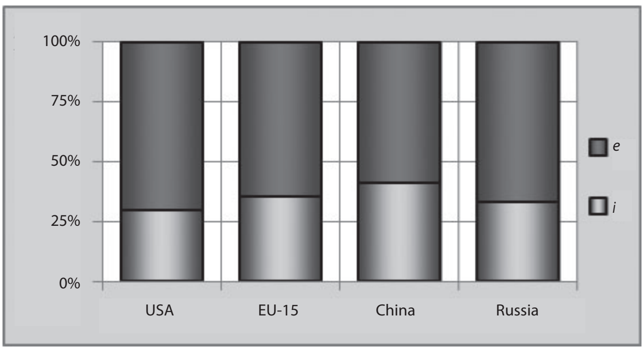
has the highest growth rates for all six categories under review. In China, the highest growth rate of both labor (2.2%) and capital (7.1%) is reflected in high growth rate of the SIF (4.7%). These newly deployed factors of production are used with the highest growth rate of SPF = 3.2%, which is also reflected in the highest growth rate of the capital/labor ratio of 5.0%. The second highest growth rates of the product, labor, capital, and thereby the SIF have been recorded by the United States; however, the effectiveness growth rate measured by the SPF is the same as in the EU-15, specifically 0.9%. The EU-15 shows a significantly higher capital/labor ratio (2.6%) compared to Russia (1.6%) and the United States (1.3%). However, we should not simply assume that the United States may be on a lower technical level, as this can result from the fact that the United States had already reached the higher level prior to 1960. With the exception of the capital/labor ratio growth rate, the lowest growth rates of all the remaining categories under review were recorded in Russia. However, this was significantly affected by the collapse of the Soviet Union; therefore, we will also separately monitor the period of the past ten years within this example.

In order to compare the development dynamics quality of individual units, we will use Figure 4. It is apparent that both factors – i.e. extensive and intensive – affect the product growth. The extensive development prevails in all the economies under review. The highest intensity is recorded in China (41%), followed by the EU-15 (35%), Russia (33%), and the United States (30%). In order to compare the SIF development, we will use Figure 5. The growth of both factors under review affects the SIF growth in all the analyzed economies, whereas the impact of the capital development on the SIF development is higher in all the analyzed economies. The lowest impact of the labor development on the SIF development was recorded in the EU-15 – specifically 13%. Higher effects were recorded for Russia (20%), followed by China (24%), and the United States (35%).

For the purpose of the comprehensive assessment of the development quality of the analyzed units, the development quality range (Figures 6 and 8) and the SIF structure development range (Figures 7 and 9) will be used. These ranges makes it possible to compare simultaneously all the above mentioned economic units in terms of all the characteristics under review.

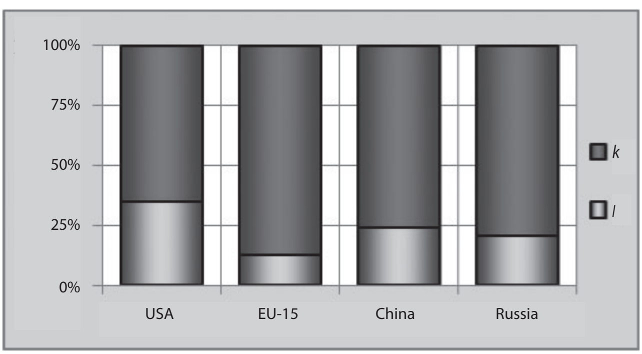
The point corresponding to the sum (total) of all four economies under review corresponds to the SIF growth rate or nearly 2.5% and the SPF growth rate of 1.4%. The average production growth rate amounts to nearly 4%. The dominance of exten-

Figure 4 Development intensity and extensity 1961–2011



Source: Own calculations based on year-to-year growth rates of the initial data, i.e. G(Y); G(L) and G(K)

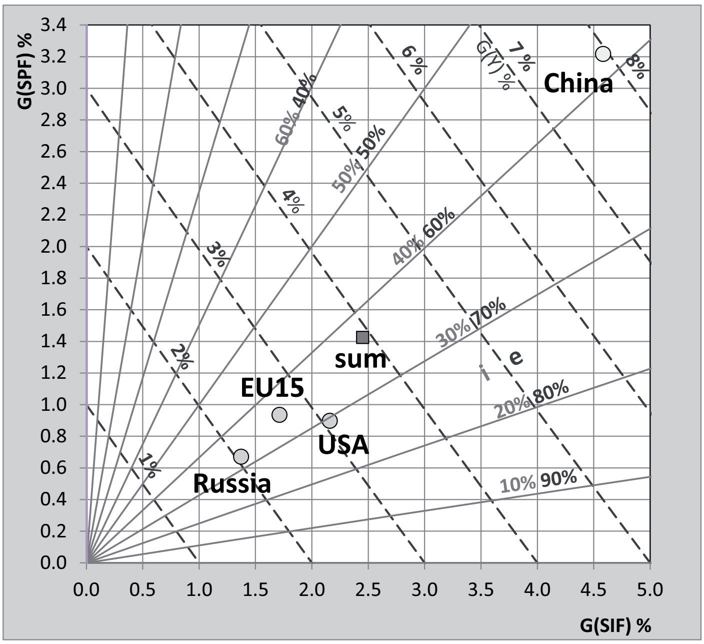
Figure 5 SIF structure development 1961–2011



Source: Own calculations based on year-to-year growth rates of the initial data, i.e. G(Y); G(L) and G(K) sive factors is also corroborated by the fact the intensity exceeds 35%, i.e. this corresponds to extensity of slightly below 65%.

The location of the sum point to the right of and above the cluster of three points representing the economies of the United States, Russia, and the EU-15 indicates significant impact of China, which experienced significantly different development than the remaining three economies. The development China appears to be the most rapid and intensive: China's point is located above the 40%-intensity level, while the remaining economies under review are within the 30% to 40%-intensity level. The development of the remaining three economies over the entire fifty-year period does not differ much. The production growth rate of the United States is slightly higher than 3%, with the EU-15 recording a modestly lower growth rate, while Russia recorded the product growth rate of slightly over 2%. Of the three economic units, the EU-15 is slightly more intensive than Russia and the United States (intensity of almost 30%).

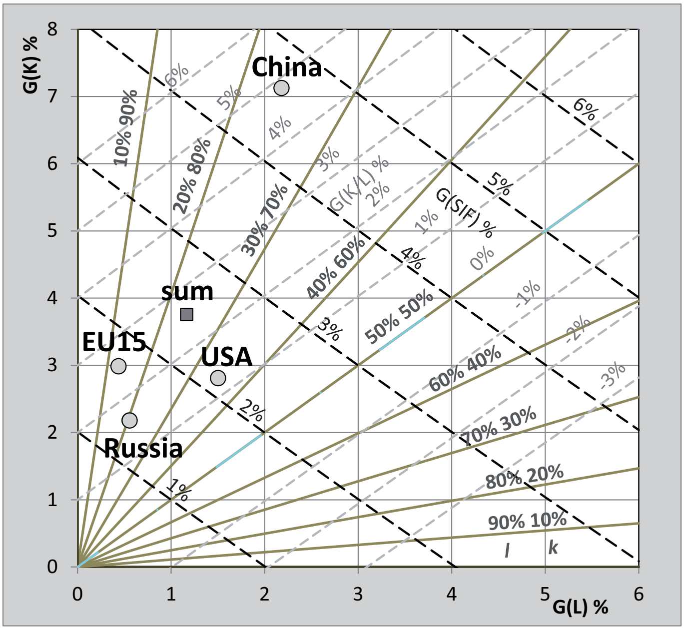
Figure 6 Comparison of the development dynamics quality (indicators G(SIF) and G(SPF)) for the period of 1961–2011



Source: Own calculations

The SIF structure development for the individual economies under review is shown in Figure 7. All the economies experience the growth of the capital/labor ratio (technology), whereas the SIF growth is affected by the labor increases as well as capital increases. The points representing the economies of the United States, Russia and the EU-15 are close together again, while the point representing China deviates to higher SIF growth rates. The effect of capital is higher in Russia (approximately 80%), with the highest level recorded in the EU-15 (nearly 90%). It is significantly lower in the United States, around 65%. The results will be different if we compare the technical substitution growth rate. China has a significantly higher rate (almost 5%), the EU-15 has the same growth rate as the total (little over 2.5%), while Russia and the United States show the value around 1.5%.

Figure 7 Comparison of the development dynamics quality (indicators G(L) and G(K)) for the period of 1961–2011



Source: Own calculations

We can similarly analyze the development in the last ten years as well. The initial and calculated data are consolidated in Table 2, once again. The table is arranged analogically to Table 1.

Table 2 Growth rates for output, input parameters *i, e, l, k* for the period of 2000–2011

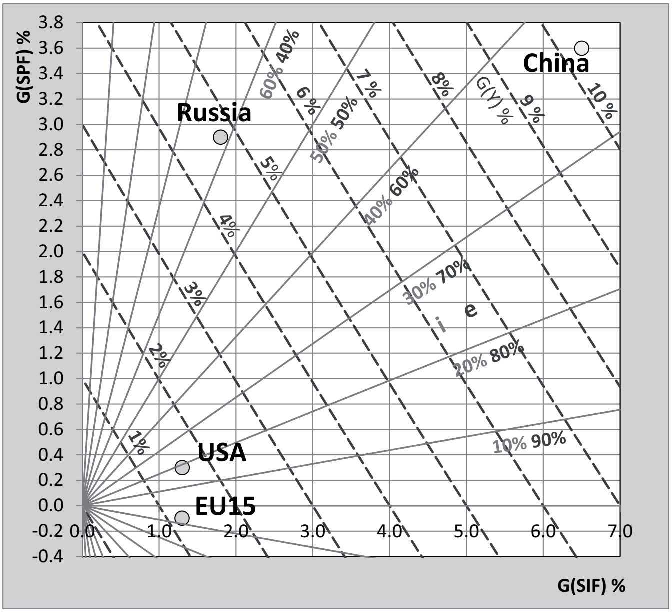
2001–2011	G(Y)	G(L)	G(K)	G(SIF)	G(SPF)	G(K/L)	*i*	*e*	*l*	*k*
USA	1.5%	0.2%	2.3%	1.3%	0.3%	2.1%	17%	83%	8%	92%
EU-15	1.2%	0.6%	2.0%	1.3%	–0.1%	1.4%	–6%	94%	23%	77%
China	10.4%	0.7%	12.3%	6.5%	3.6%	12.0%	36%	64%	6%	94%
Russia	4.7%	0.7%	2.8%	1.8%	2.9%	2.1%	62%	38%	20%	80%

Source: Own calculations based on year-to-year growth rates of the initial data, i.e. G(Y); G(L) and G(K)

The development quality of the economies under review will be compared in the same projection; however, with a slightly different section that will allow to display moderately negative SPF growth rates, which were recorded in the EU-15.

At first sight, it is clear that China still has a high product growth rate – over 10% with intensity of 36%. Russia has assumed an absolutely new role, with the product growth rate of nearly 5 % and the group-leading intensity of 60%. The SPF growth rates for China (more than 3.6%) and Russia (nearly 3%) are comparable; however, Russia has a SIF growth rate of almost 2%, opposed to China's SIF growth rate of 6.5%. The United States and the EU-15 have the same SIF growth rate of 1.3%. However, the United States recorded the SPF growth rate of 0.3%, while the EU-15 even experienced slight negative SPF growth rate of –0.1%. Consequently, the United States failed to reach intensity of 20%, while the EU-15 experienced negative intensity of –6%.

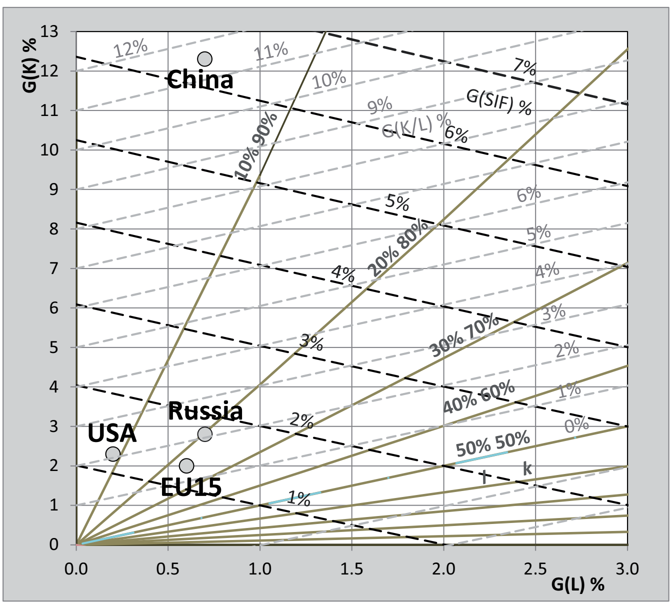
Figure 8 Comparison of the development dynamics quality (indicators G(SIF) and G(SPF))



For the period of 2001–2011.

Source: Own calculations

Figure 9 Comparison of the SIF structure development (indicators G(L) and G(K))



For the period of 2001–2011.

Source: Own calculations

As apparent from Figure 9, the SIF structure developments were less significant. The distribution of the points representing individual economies continues to be very similar, even though Russia has a somewhat different role. China continues to be far from the other economies, whereas the SIF growth rate is 2% higher, as it reached 6.5%. The impact of the capital development on the SIF development increased, amounting to nearly 95%, i.e. 2% up compared to the United States. China still has the highest capital/labor ratio growth rate of 11.5%. Furthermore, the impact of the capital increase on the SIF development prevails over the impact of the labor development.

CONCLUSION

The paper has provided a practical example of international comparison with regard to the application of intensive development factors, characteristic for the knowledge society, in the time series of fifty years. It has been demonstrated that it is possible to successfully elaborate the analysis of the development trajectory quality using the multiplicative aggregate production function, where the summary input factor can be calculated as a weighted geometrical average. The sensitivity analysis of the results has revealed that a single selection of the weights at $\alpha = 0.5$, which represents the symmetric range (space) of the SIF structure development, has not significantly modified the collected results to the extent of sensitivity of α 0.5–0.7. A single selection of α is based on the idea of a globally delayed, yet still uniform, technological and knowledge progress. The international comparison presented in the paper is only covered by a dynamic task.[18] For the desired expansion of the matter by a static task, it would be necessary to obtain absolute data about the actual values of K and L or national wealth, as appropriate, for individual countries. A static task could provide an answer to whether or not the current extensive development in the United States represents the effect of achieving high technical level in the past (prior to 1960).

The example concerning the development quality comparison for the superpowers – i.e. for the United States, China, Russia, and the EU-15 – for the period of last 50 and 10 years shows the abundance of data that can be extracted from the time series of mere 3 national economy characteristics. The analysis has revealed that China appears to be the most dynamically and intensively developing superpower. Furthermore, the development of Russia also appears to be very intensive in the past decade.

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[18] The terms "dynamic task" and "static task" are explained in Mihola (2007b, p. 448).

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