Analysis of Long-Run GDP Development in the USA, the EU15, China and the USSR/Russia

Jiří Mihola[1] | *University of Finance and Administration, Prague, Czech Republic*
Petr Wawrosz[2] | *University of Finance and Administration, Prague, Czech Republic*

Abstract

The paper analyses how changes in GDP in China, the USA, the EU15 and the USSR/Russia over a period of 50 years (1961–2011) were affected by change of intensive factors and change of extensive factors. Intensive factors consist primarily of technological progress. Extensive factors are the amounts of labour and capital. The analysis does not use growth accounting, but instead works with the 'dynamic parameters' of intensity and extensity. Contrary to the values of growth accounting, these parameters can be calculated not only for situations of GDP growth, but also for situations of GDP contraction and stagnation. They thus provide a complete picture of GDP development. The paper briefly explains the methodology for deriving the parameters. Their values for each territory are then analysed. The results show that the parameters are able to describe the real development of GDP and their information value is very high.

Keywords

Intensive and extensive economic growth, dynamic parameter of intensity, dynamic parameter of extensity, measurement of intensity

JEL code

C22, C43, O33, O47

INTRODUCTION

Economic theory solves from its beginning many questions. Which factors affect the development of production at various levels of the social system, belongs to the most important ones, especially the whole-economy level and the company level (Barro and Sala-I-Martin, 1999). Before the start of the Industrial Revolution, society had been developing with only slow application of technical progress, so the key factors of development appeared to be soil, labour and capital. Such development was largely of an extensive nature, characterized mainly by change in inputs, while technology remained basically the same. Starting in the 19th century, the expansion of innovations, which resulted from qualitative (intensive) changes in the production process (Varadzin et al., 2004), gave rise to a need to compare the effects of quantity and

[1] Estonská 500, 101 00 Prague 10, Czech Republic. E-mail: jiri.mihola@quick.cz.
[2] Estonská 500, 101 00 Prague 10, Czech Republic. E-mail: petr.wawrosz@centrum.cz.

quality, i.e. extensive and intensive factors. This issue was formulated more precisely by Solow (1957, p. 312) who introduced a special form of the production function considering both extensive and intensive factors.[3] Solow's function reads: $Q = F(K,L;t)$, where Q represents output and K and L represent capital and labour inputs in 'physical' units. As for symbol t, Solow adds: 'The variable t for time appears in F to allow for technical change. It will be seen that I am using the phrase "technical change" as a short-hand expression for *any kind of shift* in the production function. Thus slowdowns, speed-ups, improvements in the education of the labor force, and all sorts of things will appear as "technical change".'

Growth accounting was developed at the end of the first half of the 20th century to measure the impact of qualitative changes (technological progress) and quantitative changes (changes in the volume of labour and capital – generally inputs) on the change in output. However, growth accounting is based on many special conditions. It turned out that the influence of technical progress could be assessed only for growth of production induced by current growth of labour, capital and technical progress, and only roughly for slow rates of growth.[4] To overcome this problem with growth accounting it was proposed (Mihola, 2007a; Mihola, 2007b; Hájek, 2006; Hájek and Mihola, 2009) to use an alternative solution in the form of dynamic parameters of intensity and extensity that quantify the influence of intensive factors (innovations) and extensive factors (input changes) on the change in output. The advantage of these dynamic parameters lies mainly in the fact that they can be used for any rate of growth or decline in GDP. Another advantage consists in their ability to quantify the influence of intensive and extensive factors for any development of these factors. The indicators can thus be used for present growth in intensive and extensive factors, for a present decline in intensive and extensive factors and for the situation of total or partial compensation, i.e. where one factor is increasing and the other one is decreasing. Applications (e.g. Cyhelský, Mihola and Wawrosz, 2012; Mihola and Wawrosz, 2013) of these dynamic parameters at the whole-economy and company level have so far indicated that the results are very easy to interpret.

The aim of this paper is to apply this methodology to compare the quality of the dynamics of development of big countries (China, the USA and the USSR/Russia) and the 15-country European Union[5] (EU15). Fifty-year-old time series of initial data (1960–2011) were collected for each territory under scrutiny to enable us to carry out an annual quality analysis of their development. The paper initially deals with the question of how to set the weights of labour and capital in the total input. Growth accounting sets the weights for labour and capital in each evaluated year based on real values under the condition that the sum of the scales equals 1. Based on an analysis of real isoquants, the present paper suggests a simplified option, setting both the weight on labour and the weight on capital equal to 0.5. The paper demonstrates that this relatively simple application methodology[6] provides us with information that is consistent with the results obtained by using growth accounting or other methods based on more complex tools. The article is organized as follows. First, we explain how to quantify the impact of a change in extensive or intensive factors on the change in GDP. The outputs of the explanation are the 'dynamic parameters' of intensity and extensity. Section 2 presents the methodology for comparing the territories under analysis, and especially the way of acquiring input data. Sections 3 and 4 represent the core of

[3] The same applies if one wants to find out how time and velocity change, i.e. how acceleration affects the distance travelled. If the acceleration is zero, the velocity is constant and the distance travelled depends only on the time for which you are in motion.

[4] Details about growth accounting and the aforementioned problem with it can be found, for example, in Barro (1999) and Čadil (2007).

[5] The EU15 consists of the following countries: Belgium, Denmark, Finland, France, Italy, Ireland, Luxembourg, the Netherlands, Germany, Portugal, Austria, Greece, Spain, Sweden and the UK. The European Union made up of these 15 countries existed from 1 January 1995 to 30 April 2004.

[6] The issue of the weight levels for labour and capital is analysed, for example, by Mihola and Wawrosz (2013). The main condition is that no input factor (neither labour nor capital) can equal 0, and so the isoquants cannot cross any axis. Our function satisfies this condition.

the article. Section 3 presents the input data for China, the USA, the EU15 and the USSR/Russia, i.e. $G(Y)$, $G(L)$ and $G(K)$, the values calculated from these data, i.e. $G(K/L)$, $G(TIF)$ and $G(TFP)$, and the dynamic parameters of intensity and extensity for each territory. Section 4 analyses the evolution of the dynamic parameters of intensity and extensity in each year for each territory analysed, focusing primarily on years in which the dynamic parameter of intensity is negative, and links these negative values with relevant real events. The conclusion summarizes the main findings.

1 HOW TO MEASURE THE IMPACT OF A CHANGE IN EXTENSIVE OR INTENSIVE FACTORS ON THE CHANGE IN GDP

Let's start with an aggregate economic production function expressing GDP as a product of total factor productivity[7] *TFP* and the total input factor *TIF*:

$$GDP = TFP \cdot TIF. \tag{1}$$

Qualitative development is reflected in changes in total factor productivity *TFP*, whereas quantitative development is reflected in changes in the total input factor *TIF*. Their development is based on the specific structure of production and the technologies applied. The total input factor *TIF* (Mihola and Wawrosz, 2013, p. 32) is obtained as the geometric mean of two basic production factors[8] – labour *L* and capital *K*. We thus apply the production function with technical progress[9] for $\alpha = 0.5$

$$TIF = \sqrt{L \cdot K}. \tag{2}$$

This function by definition has constant returns to scale, because, as a result of the scale sum 1, if each production factor is scaled up by a factor of *t*, *TIF* will also be scaled up by a factor of *t* (Soukup, 2010)

$$t \cdot TIF = \sqrt{(t \cdot L) \cdot (t \cdot K)}. \tag{3}$$

If we insert expression (2) into expression (1) we get:

$$GDP = TFP \cdot \sqrt{L} \cdot \sqrt{K}. \tag{4}$$

Whether this function has constant returns to scale is determined by the size of *TFP*, which reflects the qualitative element of development. If *TFP* does not change and *L* and *K* increase by a factor of *t*, the growth is 'strictly extensive', corresponding to constant returns to scale. Growth of *Y* resulting solely from changes in *TFP* represents 'strictly intensive' growth. In order to be able to better quantify the influence of *TFP* and *TIF*, it is better to dynamize the production functions. The dynamic version of the aggregate production function (1) can be written either as follows (in terms of indexes of change):

$$I(GDP) = I(TFP) \cdot (TIF), \tag{5}$$

---

[7] Robert M. Solow (see Solow, 1957) examines steady state growth as characterized by stabilization of the rate of growth of capital and labour. Growth in output per capita is conditional on technological progress, which is regarded as an exogenous factor. Further elaboration of this idea revealed that such growth is due not to technological progress alone, but to the overall effect of all intensive factors.

[8] We do not intend to carry out a detailed analysis of the measurement of *L* and *K*. The domains of definition of all the quantities used result from the domains of definition of labour and capital $L > 0$ and $K > 0$.

[9] A comprehensive study of the multiplicative Cobb-Douglas production function, with labour, capital and technological progress as factors ($Y = AK^{\alpha}L^{(1-\alpha)}$), is presented in Barro and Sala-I-Martin (1999, p. 29). The authors also describe the production functions proposed by Leontief in 1941 ($Y = F(K, L) = \min(AK, BL)$), Harrod in 1939, Domar in 1946 and Solow in 1969, among many others. For a production function relevant to the Czech Republic, see, for example, Hájková and Hurník (2007).

or as follows (in terms of rates of growth):

$$G(GDP) = (G(TFP) + 1) \cdot (G(TIF) + 1) - 1. \tag{6}$$

Similarly, expression (2) can be expressed dynamically:

$$I(TIF) = I(\sqrt{L}) \cdot I(\sqrt{K}), \tag{7}$$

where the rates of growth follow:

$$G(TIF) = G(\sqrt{L}) + 1) \cdot (G(\sqrt{K}) + 1) - 1. \tag{8}$$

If we insert expression (7) into expression (5), we get the dynamic aggregate production function:

$$I(GDP) = I(TFP) \cdot I(\sqrt{L}) \cdot I(\sqrt{K}). \tag{9}$$

After calculating the logarithm of expression (5), we get the following formula:

$$\ln I(GDP) = \ln I(TFP) + \ln I(TIF). \tag{10}$$

Expression (10) is the basis for the dynamic parameters of intensity and extensity. Their detailed derivation is described in Mihola (2007a, pp. 123–124). The dynamic parameter of intensity is determined by the relation:

$$i = \frac{\ln I(TFP)}{|\ln I(TFP)| + |\ln I(TIF)|}. \tag{11}$$

The dynamic parameter of extensity is then determined by the relation:

$$e = \frac{\ln I(TIF)}{|\ln I(TFP)| + |\ln I(TIF)|}. \tag{12}$$

The analysis of countries (or economic unions such as the EU15) in sections 3 and 4 uses an algorithm which (based on familiar data such as the rate of GDP growth $G(Y)$, the rate of labour growth $G(L)$ and the rate of capital growth $G(K)$) first computes $G(TIF)$ by means of expression (8) and subsequently calculates $G(TFP)$ with the aid of expression (13) based on expression (6).

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

The following relation is applied to calculate the index of change of labour over capital $I(K/L)$

$$I = \left(\frac{K}{L}\right) = \frac{I(K)}{I(L)}. \tag{14}$$

The rate of growth of the change in labour over capital G(K/L) follows:

$$G = \left(\frac{K}{L}\right) = \frac{G(K) + 1}{G(L) + 1} - 1. \tag{15}$$

2 INTERNATIONAL COMPARISON METHODOLOGY

The quality of the development dynamics of China, the USA, the EU15 and Russia (until 1992 the USSR) over the last fifty years (1961–2011) will be assessed on the basis of data on annual rates of growth of

output, labour and capital, i.e. $G(GDP)$, $G(L)$ and $G(K)$. How were the data obtained? For the USA and the EU15, the main source for $G(GDP)$, $G(L)$ and $G(K)$ was the Statistical Annex of European Economy, which is released by the European Commission every year. $G(GDP)$ is available for the USA and the EU15 for each year of the whole period since 1961. As for determining the rate of capital growth, the data were obtained using the perpetual inventory method (for details see Sixta, 2007). The method is based on adding gross investment to the capital reserve and subtracting depreciated capital, with the value of the depreciation coming from the estimated rate of depreciation.

As for China, the rates of GDP growth were taken from Chinese Statistical Yearbooks and from the website of the National Bureau of Statistics of China. The data on the rate of labour growth for China were obtained from the International Labour Organization (ILO). The rate of capital growth of China for the first half of the period is mentioned in the literature only as the contribution of capital to GDP growth, calculated as the capital income share multiplied by the rate of capital growth. By reverse division by the capital income share, we get the growth rate of the capital stock. The rate of capital growth $G(K)$ in the second period was taken from the literature (e.g. Chong-En et al., 2006), which also uses the perpetual inventory method.

Difficulties emerge in the case of Russia, specifically for the period of 1961–1991, as Russia was part of the Soviet Union and the available data refer to the USSR, not to Russia. We therefore decided to make the USSR identical to Russia, because Russia as the biggest part of the USSR had great significance in terms of all three input indicators – GDP growth, labour growth and capital growth. The rates of GDP growth since 1992 are taken from the web page of the International Monetary Fund.[10] For the Soviet Union (1961–1991), the rates of output growth refer to real gross national product GNP, the dynamics of which do not significantly differ from those of GDP. The rates of GNP growth for the Soviet Union were obtained from the literature (e.g. Christian Science Monitor, 1982; Shanker, 1986; Bergson 1997, BBC 1998, Kontorovich, 1999) and they represent estimates, because the former Soviet Union did not publish these data. Where annual data were missing but five-year averages were available, the missing annual data were supplemented in order to maintain the average five-year rate of growth. The rates of labour growth for Russia since 1992 are taken from the ILO. For the former Soviet Union, the data for 1961–1991 were obtained from journal articles (see above) and the missing annual rates of growth were supplemented in order to correspond to the average rates of growth for the five-year periods. As for the rate of capital growth, the data for 1992–2011 were obtained from a UN study and the IMF's World Economic Outlook. The rates of capital growth were derived from the contribution of capital to GDP growth. The rates of capital growth for the Soviet Union for the period of 1961–1991 were obtained from the literature (see above) and the missing annual data were supplemented in order to correspond to the five-year average rate of growth described in the literature.

With the aid of expression (8), the rate of growth of the total input factor $G(TIF)$ was calculated for each territory under analysis. Expression (13) was used to calculate the rate of growth of the total productivity factor $G(TFP)$. The rates of growth determined in this way allow us to calculate both dynamic parameters i and e with the aid of expressions (11) and (12). Expression (15) was used to calculate the rate of growth of labour over capital $G(K/L)$.

3 ANALYSIS OF THE DEVELOPMENT DYNAMICS OF THE USA, CHINA, THE EU15 AND THE USSR/RUSSIA

The initial average data obtained by the means described in the previous section, together with all the calculated average rates for the whole period, are presented in Table 1 and depicted in Figure 1 and 2.

[10] From World Economic Outlook.

[11] The calculation of the average annual rates of growth is based on the geometric mean of the indexes.

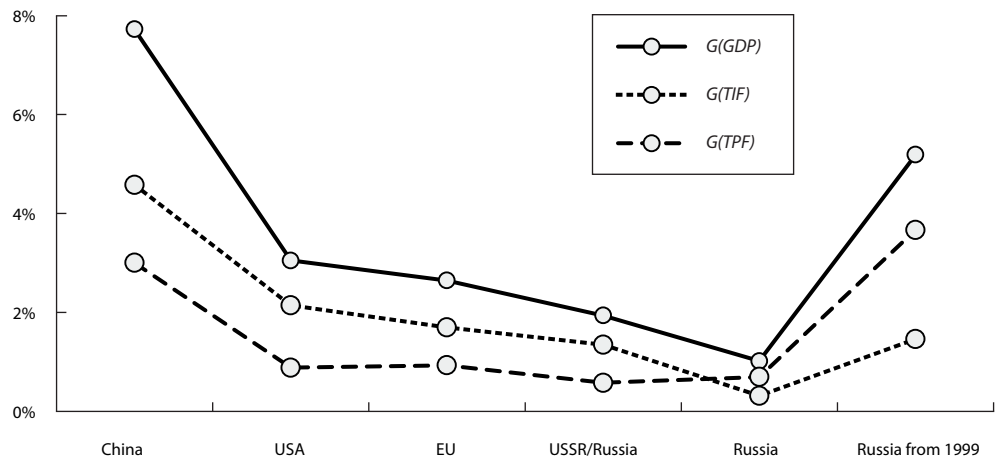
The highest average annual rate of GDP growth, 7.7%, is shown by China. It is followed by the USA with an average rate of growth of 3.1%. The EU15 shows an average rate of GDP growth of 2.6%. The lowest rate – 1.9% – is recorded by the USSR/Russia.[12] Russia alone (1992–2011) has an even lower rate of output growth of 1%. However, since consolidating and overcoming the negative effects of the transformation period after the break-up of the USSR, i.e. since 1999, Russia has been showing an annual average rate of output growth of 5.2%.

Table 1 Rates of growth of inputs and output parameters *i* and *e*, 1960–2011

	G(GDP)	*G(L)*	*G(K)*	*G(K/L)*	*G(TIF)*	*G(TFP)*	*i*	*e*
China	7.7%	2.2%	7.1%	4.8%	4.6%	3.0%	40%	60%
USA	3.1%	1.5%	2.8%	1.3%	2.1%	0.9%	29%	71%
EU	2.6%	0.4%	3.0%	2.5%	1.7%	0.9%	35%	65%
USSR/Russia	1.9%	0.5%	2.2%	1.6%	1.3%	0.6%	30%	70%
Russia since 1992	1.0%	–0.3%	0.9%	1.3%	0.3%	0.7%	69%	31%
Russia since 1999	5.2%	0.7%	2.3%	1.6%	1.5%	3.7%	71%	29%

Source: Authors' calculations based on year-on-year rates of growth of starting data, i.e. *G*(*Y*), *G*(*L*) and *G*(*K*)

Figure 1 Average rates of growth *G*(*GDP*)



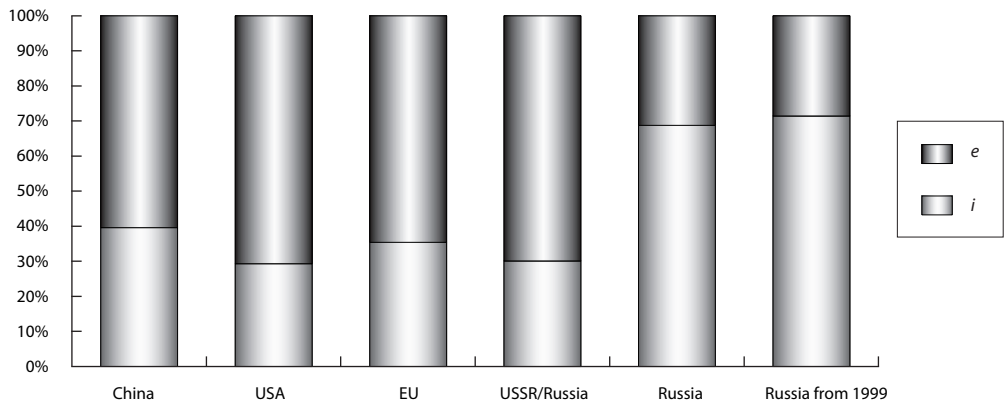
Source: Authors' calculations based on year-on-year rates of growth of starting data, i.e. *G*(*Y*), *G*(*L*) and *G*(*K*)

Let's look at Figure 1. China shows the highest values of all six rates of growth analysed. It has the highest rates of GDP growth (7.7%), labour growth (2.2%) and especially capital growth (7.1%). This is reflected in a high rate of growth of TIF (4.6%). China uses its factors of production with the highest rate of growth of TFP (3.0%), as reflected in the highest rate of growth of labour over capital (4.8%). The second highest rates of growth of GDP, labour and TIF are shown by the USA. However, its rate of TFP growth is the same as that in the EU15, i.e. 0.9%. The EU15 shows a significantly higher rate of growth of labour over capital (2.5%) than the USSR and Russia (1.6%), Russia since 1992 (1.3%), Russia

[12] The Russian data are a follow-up to the USSR data.

since 1999 (1.6%) and the USA (1.3%.) However, we cannot simply assume that the USA is at a lower technical level, as it may be that the USA already achieved this higher level before 1960. The lowest rate of GDP growth for the whole period of 1961–1991 is shown by the USSR/Russia. This is, however, substantially influenced by the break-up of the USSR. Russia alone (i.e. since 1992) shows the lowest rates of growth of both GDP (only 1%) and capital 0.9%, along with a negative rate of labour growth –0.3%. This is reflected in the lowest rate of growth of *G*(*TIF*) and a modest rate of growth of *G*(*TFP*) (0.7%). At the same time, it shows an extremely high intensity of 69%. If we study the consolidated Russia since 1999, we find that Russia shows the second highest (behind China) annual average rate of GDP growth (5.2%) and the highest rate of TFP growth (3.7%).

Figure 2 Intensity and extensity of development 1961–2011



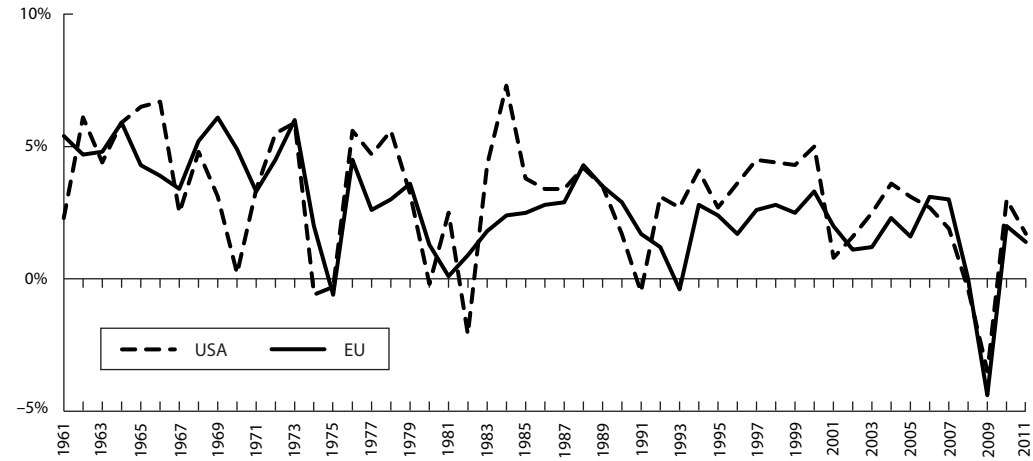
Source: Authors' calculations based on year-on-year rates of growth of starting data, i.e. *G*(*Y*), *G*(*L*) and *G*(*K*)

Figure 2 compares the quality of development of the territories analysed. It contains the average values of the dynamic parameter of intensity and the dynamic parameter of extensity for the whole period of 1961–2011. In the case of Russia (i.e. Russia excluding the USSR) the values of the parameters are calculated separately for 1992–2011 and 1999–2011. Extensive development prevails in all the economies studied (except for Russia since 1992 and Russia since 1999). China achieves the highest intensity (40%), followed by the EU15 (35%), the USSR/Russia and the USA (the USA – 29 %, %), the USSR/Russia – 30%). Russia has been showing a high share of intensive factors – 69% since 1992 and 71% since 1999.

4 ANALYSIS OF THE ANNUAL DYNAMICS OF THE QUALITY OF DEVELOPMENT OF THE USA, CHINA, THE EU15 AND THE USSR/RUSSIA

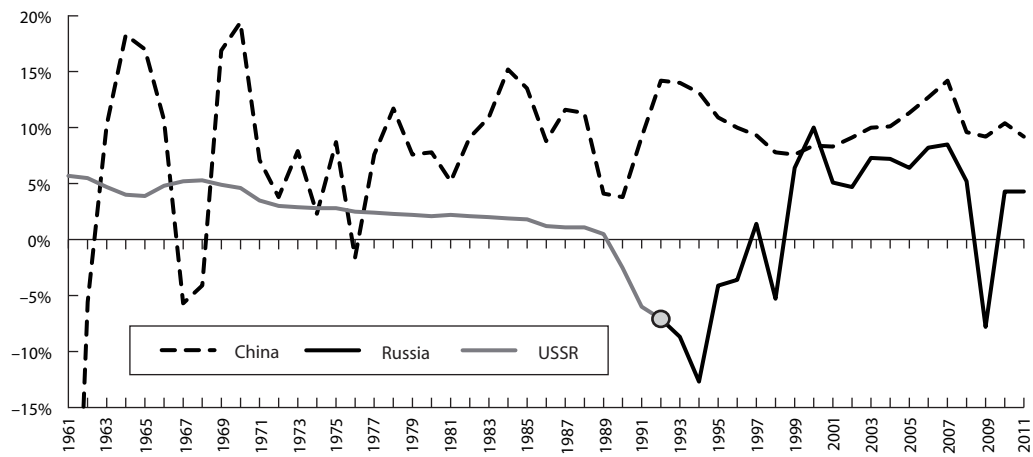
Figure 3 and 4 allow us to compare the annual *G*(*GDP*) rates of the territories analysed. The rates of growth of the USA and the EU show lower volatility than the sustained high rates of growth of China. The lowest volatility is shown by the USSR with its continuously slowly decreasing rates of GDP growth. The development of Russia after the break-up of the USSR is very interesting. The period of 1992–1999 was one of chaos following the dissolution of the USSR, with unsuccessful reforms and privatization. Boris Yeltsin was president at that time. After this period, Russia shows stably high rates of growth interrupted only by the world crisis in 2009. This global economic crisis was hardly reflected at all in the rate of development of China, which shows a significant home market and turnover despite its growing openness.

Figure 3 Average annual rates of growth *G*(*GDP*) – the USA and the EU15



Source: Authors' calculations based on year-on-year rates of growth of starting data, i.e. *G*(*Y*), *G*(*L*) and *G*(*K*)

Figure 4 Average annual rates of growth *G*(*GDP*) – China and the USSR/Russia

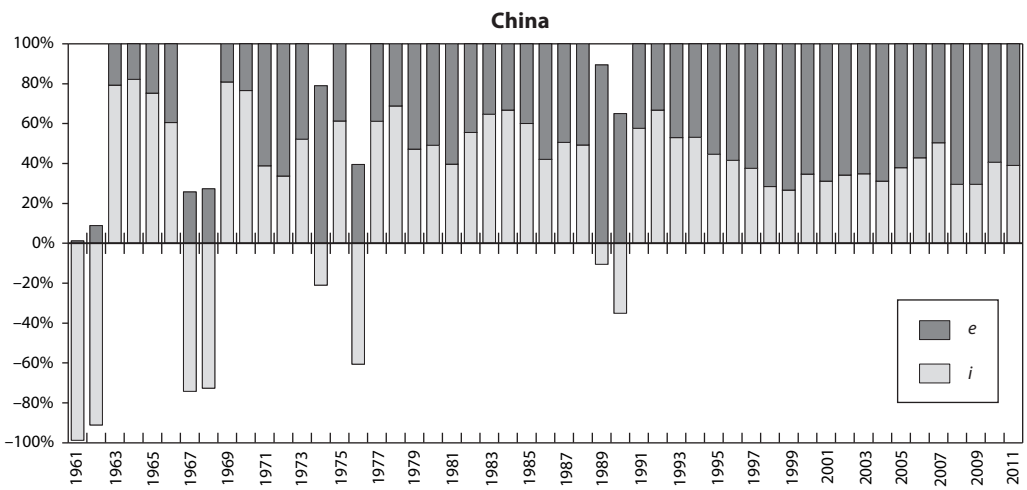


Source: Authors' calculations based on year-on-year rates of growth of starting data, i.e. *G*(*Y*), *G*(*L*) and *G*(*K*)

Information on the intensity of GDP growth, as described in Figure 3 and 4, in the territories analysed over the whole period is presented in the following four figures (Figures 5–8). The figures clearly demonstrate that the GDP growth of all the territories analysed was mostly due to both extensive and intensive factors. Figure 5 presents information on the influence of intensive and extensive factors on GDP development in China. The years in which China achieves high *G*(*GDP*) rates simultaneously show high intensity. Each recession or sharp decrease in the rate of GDP growth shows dis-intensive development with decreasing efficiency and thus negative intensity. Such development occurred in 1961, 1962, 1967, 1968, 1974, 1976, 1989 and 1990. In all these years, the fluctuation is a result of some significant event. Briefly, 1961 and 1962 fall within the period of the 'Great Leap Forward' (usually dated as lasting from 1958 to 1962), a set of measures introduced by the Chinese Communist leader Mao Zedong, who

aimed to rapidly transform the country. Mao's collectivization measures divided China into communes, which were supposed to be self-sufficient and responsible for their achievements. However, the measures had the opposite result to what Mao intended – GDP decreased and tens of millions of people died.[13] After this policy was abandoned, the country recovered and its rates of GDP growth rose to 18%, though the base for this growth was evidently low. The growth recorded in the 1960s, however, was stopped in 1966 by the 'Cultural Revolution', which caused further chaos as Red Guard groups[14] went on the rampage and campaigns were launched against intellectuals and others. This resulted again in shrinking GDP (especially in 1967 and 1968), the deaths of many inhabitants[15] and other negative consequences. The negative aspects of the Cultural Revolution began to be gradually eliminated in 1969. Slow progress continued to be made in the early 1970s – diplomatic relations with the USA were restored (including President Nixon's official visit to China in 1972) and China joined the United Nations and became more involved in international trade. All this was positively reflected in the country's economic development, although many of the negative aspects and consequences of the Cultural Revolution persisted. Zhou Enlai, the Chinese premier, and Mao Zedong, the Communist leader, both died in 1976 (in January and September respectively). A struggle for power ensued. 1989 saw the suppression of student movements. The high intensity of development achieved between 1977 and 1988 reflects China's policy of opening up to the outside world and partial economic and political liberalization. The 1990s saw high rates of GDP growth and intensity, although with a falling tendency. Nonetheless, other reforms implemented at that time and in the early 21st century (during the presidencies of Jiang Zemin and Hu Jintao) resulted in increased rates of GDP growth and growth of the dynamic parameter of intensity, especially after 2005. The slight deceleration in GDP growth and the decrease in the dynamic parameter of intensity after 2008 are both manifestations of the global economic crisis, which inevitably hit China because of its increased involvement in international trade. The main reason for the lower GDP growth rate and lower dynamic parameter of intensity is lower foreign demand for Chinese goods.

Figure 5 Intensity and extensity of development of China, 1961–2011

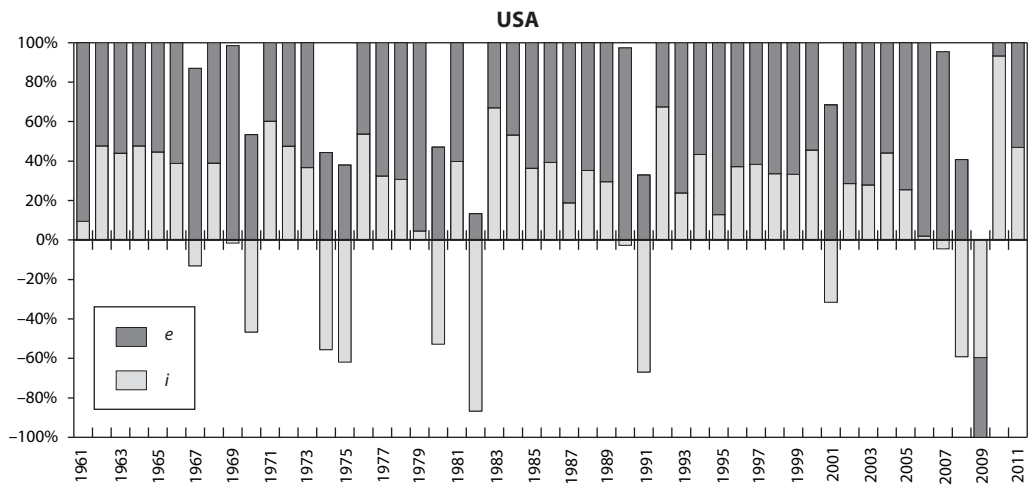


Source: Authors' calculations based on year-on-year rates of growth of starting data, i.e. *G*(*Y*), *G*(*L*) and *G*(*K*)

[13] It is estimated that 20–40 million died during the Great Leap Forward. See Fairbank (2010).
[14] Red Guard groups were formed mainly of young people. For more details see e.g. Walder (2009).
[15] The number of victims of the Cultural Revolution is estimated at around 8 million. See Fairbank (2010).

Figure 6 shows the influence of intensive and extensive factors on GDP growth in the USA. When the USA achieved *G*(*GDP*) rates exceeding 2.3%, both factors affected the growth. High rates of output growth are always attended by high intensity. Recessions or sharp decreases in GDP growth were in all cases accompanied by dis-intensive development, with intensive factors affecting the decrease in the rate of GDP growth or the decrease in GDP itself. Such development occurred in 1967, 1970, 1974, 1975, 1980, 1982, 1991, 2001, 2007, 2008 and 2009. All these fluctuations correspond to significant events that occurred in the U.S. economy. Briefly, the Caribbean crisis in 1961 is followed by the golden growth of the 1960s, which ended with the first collapse of the Bretton Woods system of fixed exchange rates in 1971. In 1972 and 1973, intensive and extensive quantities are both positive. In 1974 and 1975, however, the rate of GDP growth decreases and there is negative intensity. The slump was caused by the definitive collapse of the Bretton Woods system[16] in 1973, the increase in oil prices following the defeat of the Arab countries by Israel in the Yom Kippur War in the same year, growth in inflation resulting from this oil price increase, high government spending on the war in Vietnam and the de facto defeat of the USA in that war, and even by the Watergate scandal. The GDP slump accompanied by negative intensity in 1980 was caused by the victory of the Islamic Revolution in Iran in 1979, which resulted in another oil price increase. In 1981, Ronald Reagan became president. Reagan's presidency is associated with tax cuts and a decrease in other public budget revenues, which, however, were not matched by a commensurate reduction in public spending. The good entrepreneurial environment created by Reagan's policies was threatened by high inflation in the early part of his presidency. In 1982, restrictive monetary policy succeeded in bringing down inflation. For a short time, however, it induced a recession and negative intensity. Reaganomics continued for a short time after 1989 with George Bush as president. A slump in GDP and intensity occurred in 1991 when war erupted in Iraq. The decrease in intensity in 2001 is connected with the 9/11 attacks in New York and the stagnation around 2001 caused by the bursting of the technological bubble. The period of 2007–2009 was marked by a mortgage-related financial crisis. Years immediately following a crisis are always characterized by high intensity.

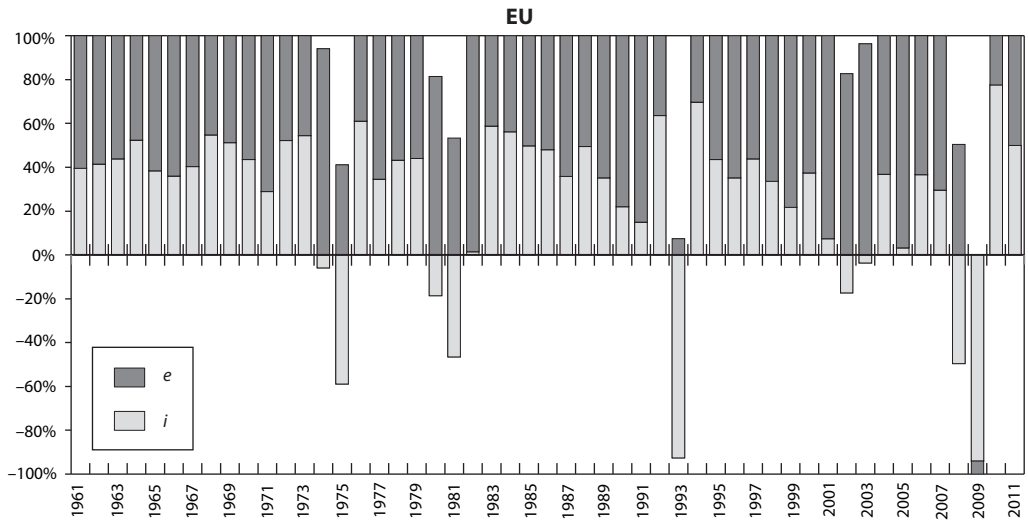
Figure 6 Intensity and extensity of development of the USA, 1961–2011



Source: Authors' calculations based on year-on-year rates of growth of starting data, i.e. *G*(*Y*), *G*(*L*) and *G*(*K*)

[16] Some attempts were made to restore the Bretton Woods system between 1971 and 1973, but they failed. For details see e.g. Scammel (1975).

Figure 7 Intensity and extensity of development of the EU15, 1961–2011



Source: Authors' calculations based on year-on-year rates of growth of starting data, i.e. *G*(*Y*), *G*(*L*) and *G*(*K*)

Figure 7 illustrates the development of the EU15. A comparison with Figure 6 clearly demonstrates that the development of the EU15 largely copies that of the USA. With the exception of the global crisis in 2009, there is no negative value of the dynamic parameter of extensity. The dynamic parameter of intensity was negative in only nine cases. The average annual *G*(*GDP*) rate of 5% in the 1960s was accompanied by high values of the dynamic parameter of intensity (25%–55%). This period ended with stagflation caused by the oil crisis in 1974 and 1975. As a consequence of the Arab-Israeli War in October 1973, Middle Eastern oil-producing countries increased their prices and restricted oil supplies to some European countries. This caused economic problems throughout the EU. The GDP decrease of 0.6% in 1975 was accompanied by a labour decrease of nearly 1%. The intensity parameter dropped to nearly –60%. The development that year was mainly intensive – intensity achieved 61% while extensity stood at 39%. The crisis in 1980 and 1981 reflects inefficient economic policy in some countries, for example the UK, which resulted in high rates of inflation and unemployment. (In the UK inflation reached 15% and unemployment 8%. These problems contributed to the victory of Margaret Thatcher in the 1979 general election.) A further cause of problems was the victory of the Islamic Revolution in Iran and the subsequent increase in oil prices. The post-crisis years of 1983 and 1984 are marked mainly by intensive growth of 59% and 57% respectively. The recession in 1993 was characterized by a GDP decrease of 0.4% amid almost purely dis-intensive[17] development with an intensity of –93%. This recession was a result of transformation processes in the EU. In 1992, the Maastricht Treaty establishing the European Union was signed. This represents the most important turning point in EU history. It stipulated rules for the future single currency, for foreign and security policy and for closer cooperation in the areas of justice and domestic affairs. Under the Treaty, the name 'European Community' was officially replaced by 'European Union'. In 1993, the single market was created and its four freedoms – free movement of goods, services, persons and capital – became reality. Since 1986, more than 200 legal rules have been issued, aiming to eliminate obstacles especially in the area of tax policy, business activity and profes-

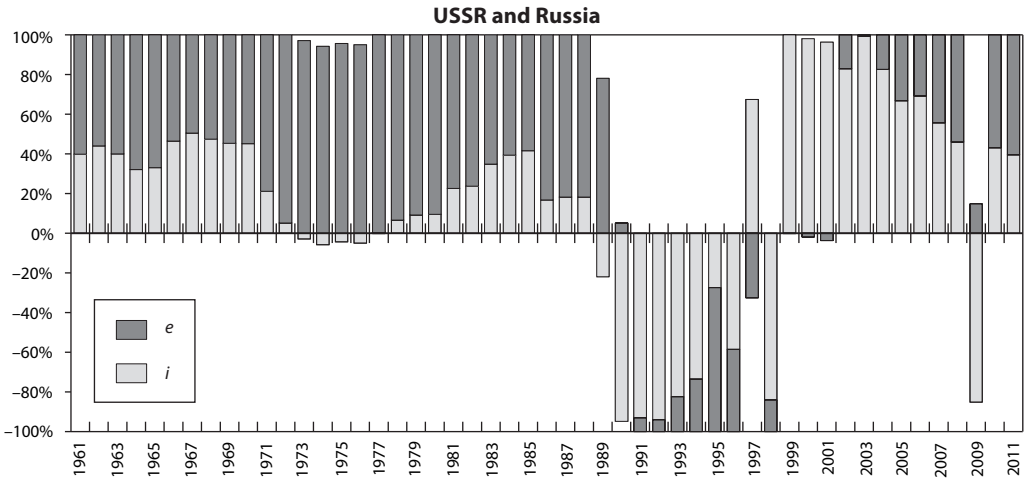
[17] Term "dis-intensive" means that the value of the dynamic parameter of intensity is negative.

sional qualifications. The implementation of free movement of some services, however, was delayed. In 2009, GDP decreased by 4.4%, with negative intensity of –94% and negative extensity of –6%. The world economy was affected by the global financial crisis. Problems started to arise because of bad mortgage loans in the USA. Several European banks also ran into difficulties. The crisis brought about closer economic cooperation between EU countries. It turns out that in the case of the EU15, our analytical tools respond well to the real course of events.

Generally, we observe that the dynamic parameters of intensity and extensity can, in the case of China, the USA and the EU15, describe real development well. What was the situation in the Soviet Union and in Russia after the dissolution? It is illustrated in Figure 8. The 1960s were characterized by steady GDP growth of about 5%, with intensity between 30% and 50%. The 1970s saw a continuous slight decrease in the rate of GDP growth from 4.6% to 2.2%. During the oil crisis starting in 1973, these decreasing rates of GDP growth were accompanied by negative intensity ranging between –2.9% and –5.8%. The period of 1977–1985 is characterized by steady GDP growth of about 2%, although with a continuous rise in intensity from 0.2% to 42%. From 1985 to 1991, Mikhail Gorbachev was the leader of the Soviet Union. This was a period of significant democratic reforms, which restricted consistent supervision of companies and improved business and other relations with the West. The dynamic parameter of intensity was positive until 1988, but lower than in the previous period. The unstable political environment was not conducive to technological progress. This fact is clearly visible in 1989 and 1990, when the dynamic parameter of intensity took negative values. This marked the start of the real dissolution of the USSR, which was accompanied by local armed conflicts. 1991 saw a plot aimed at toppling President Gorbachev. The USSR ceased to exist on 31 December 1991. The first period of Russian development during Boris Yeltsin's presidency (1992–1999) is characterized by an unconsolidated economy and a continuous recession from 1992 to 1996, with rates of growth of between –3.65% and –12.7% in 1994. GDP growth of 1.4% in 1997 was followed by another recession of –5.3% in 1998, caused by a financial crisis during which inflation soared to 84% and the rouble lost three quarters of its value.[18] The privatization and transformation from a central economy to a market society between 1992 and 1998 were related to the fact that the state only poorly fulfilled its basic functions such as law enforcement. The fact that state property was transferred without proper supervision and various groups of oligarchs and organized criminals emerged clearly had a negative impact on the parameter of intensity. The first presidency of Vladimir Putin (1999–2007), who succeeded in solving the aforementioned problems at least partially, was characterized by steady GDP growth of between 4.7% and 10% in 2000 (GDP increased eightfold in this period). 1999 is interesting in that purely intensive growth was recorded, with intensity of 100%. The whole of Putin's presidency saw mainly intensive growth, with intensity not dropping below 70%. Exports rose by 74% between 2000 and 2006. The country's accumulated debt fell from 60% of GDP in 2000 to only 7.9% of GDP in 2008. Steady GDP growth of between 4.3% and 8.5% was also recorded during Dmitry Medvedev's presidency (2007–2012), amid intensive-extensive development (intensity and extensity both at about 50%). The only exception was 2009, when GDP decreased by about –7.8%, with intensity of –85% and extensity of 15%. The results show that the dynamic parameters of intensity and extensity also proved their informative quality in the case of the USSR and Russia, even though the quality of the input data is debatable. Probably the most discussed period is 1978–1985, the relatively high intensity for which is out of step with the idea of a stagnant Brezhnev and post-Brezhnev USSR. The explanation might lie in the fact that in the case of the USSR, the rates of growth of the input indicators ($G(Y)$, $G(K)$ and $G(L)$) are estimated or calculated subsequently and might be overvalued.

[18] More detailed information about developments in Russia can be found in Hafner (2014, pp. 20–21).

Figure 8 Intensity and extensity of the development of the USSR and Russia, 1961–2011



Source: Authors' calculations based on year-on-year rates of growth of starting data, i.e. $G(Y)$, $G(L)$ and $G(K)$

CONCLUSION

This article presented a practical example of the analysis of the quality of GDP growth based on the application of intensive factors of development describing the knowledge society over a 50-year period (1961–2011). It turned out that the analysis of development quality can be successfully elaborated by applying a multiplicative aggregate production function where the total input factor is calculated as a weighted geometric mean of labour and capital. The international comparison presented in the article contains only the dynamic role.[19] To extend the analysis to include the static role, it would be necessary to obtain absolute data on the values of K and L or the national wealth of the relevant countries. The static role can answer the question of whether the current extensive development in the USA is a result of it having reached a high technical level in the past (i.e. before 1960).

Our example comparing the quality of annual development in the USA, China, Russia and the EU15 over the last 50 years demonstrates how much useful information can be obtained from time series of only three economic indicators ($G(Y)$, $G(L)$, $G(K)$). The analysis showed that China appears to be the most dynamically and intensively developing great power. In the last decade, Russia's development seems to have been very intensive as well. Given the above-mentioned facts, we believe that the method of measuring the effect of intensive and extensive factors on the development of output (GDP in our case) presented in the article can serve as an alternative to growth accounting. As for output growth versus input growth, the results of our method are going to be very similar. Moreover, our method allows the effect of intensive and extensive factors to be quantified even in cases of decreasing GDP and decreasing inputs.

ACKNOWLEDGMENT

The article is the output of the project SV 7427 "Analýza kvalitativního vývoje firem ve znalostní společnosti", which is carried out by the University of Finance and Administration and financed by the Ministry of Education, Youth, and Sports of the Czech Republic.

[19] The meanings of dynamic role and static role are explained in Mihola (2007b, p. 448).

References

BARRO, R. Notes on Growth Accounting. *Journal of Economic Growth*, 1999, Vol. 4, No. 2, pp. 119–137.

BARRO, R., SALA-I-MARTIN, X. *Economic Growth*. McGraw-Hill, 1999.

BERGSON, A. How big was the Soviet GDP? *Comparative Economic Studies*, 1997, Vol. 39, No. 1, pp. 1–14.

BBC. *Russian GDP down 40 per cent since collapse of USSR.* BBC Monitoring Former Soviet Union, 30 November 1998.

CHONG-EN B., et al. The Return to Capital in China. *Brookings Papers on Economic Activity,* 2006, No. 2, pp. 61–101.

CHRISTIAN SCIENCE MONITOR. *How fare the US, USSR? USSR – quick growth for 30 years but still behind Japan and Europe.* Boston: The Christian Science Monitor, 27 Dec. 1982.

CYHELSKÝ, L., MIHOLA, J., WAWROSZ, P.. Quality Indikators of Developments Dynamics at All levels of the Economy. *Statistika: Statistic and Economy Journal*, 2012, Vol. 49, No. 2, pp. 29–43.

ČADIL, J. Growth accounting, total factor productivity and approximation problem. *Prague Ecnomic Papers,* 2007, Vol. 16, No. 4, pp. 347–357.

FAIRBANK, J. K. *Dějiny Číny*. Prague: Nakladatelství Lidové noviny, 2010.

HAFNER, P. Prebudzanie Ruska. *ZEM &VEK*, 2014, Vol. 2, No, 6, pp. 53–62.

HÁJEK, M. Zdroje růstu, souhrnná produktivita faktorů a struktura v České republice. *Politická ekonomie*, 2006, Vol. 54, No. 2, pp 170–189.

HÁJEK, M., MIHOLA, J. Analýza vlivu souhrnné produktivity faktorů na ekonomický růst České republiky. *Politická ekonomie*, 2009, Vol. 57, No. 6, pp. 740–753.

HÁJKOVÁ, D., HURNÍK, J. Cobb-Douglas Production Function: The Case of a converging Economy. *Finance a úvěr*, 2007, Vol. 57, No. 9–10, pp. 465–476.

KONTOROVICH, V. Economists, Soviet Growth Slowdown, and the Collapse. *SSRN Working Paper Series*, Nov. 1999.

MIHOLA, J. Agregátní produkční funkce a podíl vlivu intenzivních faktorů. *Statistika*, 2007a, Vol. 44, No. 2, pp. 108–132.

MIHOLA, J. Souhrnná produktivita faktorů – přímý výpočet. *Statistika*, 2007b, Vol. 44, No. 6, pp. 446–463.

MIHOLA, J., WAWROSZ, P. Development Intensity of four Prominent Economies. *Statistika: Statistic and Economy Journal*, 2013, Vol. 93, No. 3, pp. 26–40.

SCAMMELL, W. *International monetary policy: Bretton Woods and After.* London: Macmillan, 1975.

SHANKER, T. Soviet Economic. *Chicago Tribune*, 18 Nov. 1986, p. 5.

SIXTA, J. Odhad spotřeby fixního kapitálu. *Statistika*, 2007, Vol. 44, No. 2, pp. 156–163.

SOLOW, R. M. Technical Change and the Aggregate Production Function. *Review of Economics and Statistics*, 1957, Vol. 39, August 1957, pp. 312–320.

SOUKUP, J. *Makroekonomie*. 2nd ed. Prague: Management Press, 2010.

VARADZIN, F., et al. *Ekonomický růst*. Prague: Professional Publishing, 2004.

WALDER, A. G. F*ractured Rebellion: The Beijing Red Guard Movement*. Cambridge (MA): Harvard University Press, 2009.