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Economic growth and total factor productivity in the Czech Republic from 1992 to 2004

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Abstract:
The study examines the resources of economic growth in the Czech Republic in the course of years from 1992 until 2004. Using the growth accounting method, it analyses the contribution of individual factors to economic growth. Special attention is given to total factor productivity, which, apart from labour, also includes a fixed capital stock at constant prices. Compared to the previous period, the acceleration of the growth of total factor productivity decisively contributed to the speeding up of economic growth in the years 1999-2004. Furthermore, the study examines growth resources in six national economy sectors and analyses the contribution of individual sectors to the growth of macroeconomic total factor productivity. The analysis has shown that namely industry, transport, communications, and other services were involved in the speeding up of the growth of macroeconomic total factor productivity. A comparison of the dynamics of total factor productivity of the CR and EU-15 at the macroeconomic level has shown that while in 1992-1998, the growth of total factor productivity was slower in the CR, after 1998, it was faster (in 1999-2004, the average annual growth rate in the CR was 2.2% and 0.6% in EU-15). In the years 1996-2004, for which revised data are available for the CR, the average annual growth rate of total factor productivity in the CR was 1.5%, compared to 0.7% in EU-15. The analysis indicated that since 1999, total factor productivity in the CR has been converging to the EU-15 level, accelerating in 2003 and 2004, thereby achieving 63% of the EU-15 level in 2004.

Key Words: economic growth, sources of economic growth, growth accounting, sectoral growth, total factor productivity.

JEL Classification: D24, O47

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The main area of professional interest of Ing. Mojmír Hájek, CSc. is economic growth and aggregate productivity. He has been engaging in macroeconomic analyses of the development of Czech economy, with special emphasis on economic performance in an international comparison. He has been examining the economic growth resources of Czech economy, paying particular attention to the growth of total factor productivity. He has been focusing on the performance and the structure of the supply side of Czech economy. His research also embraces estimates of the potential product and the product gap in Czech economy, as well as problems relating to the convergence of the Czech Republic towards the European Union.

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1. Introduction

The objective of the study is to analyse long-term development trends of Czech economy from the growth theory perspective. In a broad sense, the resources of economic growth in the long-term are labour, capital, and technical progress. They determine the aggregate supply.

Linking up with the previous contribution of the author dealing with the performance of the supply side in the CR,[1] this study expands and deepens the analysis of economic growth resources in the CR in the course of years 1992-2004. It is based on the revised data of the Czech Statistical Office (CSO), which are available from 1995. As to the period before 1995, it starts from currently available data. The study newly brings a comparison of the CR with EU-15.

The theoretical framework of the analysis consists of the production function and the growth accounting method. The behaviour of the supply side is analysed from both the macroeconomic and the sectoral viewpoint. Thereby, the traditional macroeconomic approach is extended by another dimension. The sectoral analysis is based on six national economy sectors: (1) agriculture and fishing, (2) industry, (3) building industry, (4) trade, repairs, catering and accommodation, (5) transport and communications, and (6) other services. Thus, we follow up with and broaden previous research.[2]

Technical progress plays an important role among economic growth resources. Empirical calculations measure it as a difference between product growth and the weighted sum of the labour and capital growth rates and it is designated as total factor productivity. Apart from other indicators, the macroeconomic performance of economy, including an international comparison, is appraised according to its dynamics.

Moreover, apart from scientists, also renowned international institutions and organizations engage in total factor productivity measurements and empirical analyses (European Committee, OECD[3], IMF, World Bank). In the US, these calculations and analyses are regularly performed by the U.S. Bureau of Labor Statistics (BLS), which is the main agency securing data and facts in the area of labour economics and statistics for the Federal Government, as well as other US institutions. In the Czech Republic, these calculations are made by the Ministry of Finance of the CR (see Macroeconomic Predictions of the CR and convergence programmes[4]). With respect to individual studies, this area has been recently covered by Jaroš (2002), Hurník, Navrátil (2003), and Hurník (2005).

[1] Hájek (2004).
[2] Hájek et al.(1997), Hájek and Bezděk (2001), Flek et al.(2001).
[3] For example, two comprehensive studies OECD (2003, 2004) focus on economic growth and total factor productivity analysis.
[4] Ministry of Finance of the CR (2005), Convergence Programme (2004) and its evaluation by the European Commission, see EC (2004).

2. Sources of Economic Growth

The primary determinants of product economic growth are the growth of labour, capital, and technical progress. The initial theoretical concept is the original contribution of R. Solow (1957), who combined the aggregate Cobb-Douglas production function with productivity. R. Solow started from a special production function form,

$$Y = A\ F(N, K) \tag{1}$$

of product

where Y is the product, N labour, K capital and A represents the state of technology, or the production function shift parameter[5] determined as the residual within empirical application and designated as total factor productivity (TFP). Differentiate (1) totally with respect to time and divide by Y we obtain

$$g(Y) = \frac{\partial Y}{\partial N}\frac{N}{Y}g(N) + \frac{\partial Y}{\partial K}\frac{K}{Y}g(K) + g(A) \tag{2}$$

where g(.) is the growth rate of the applicable variable. Thus, the product growth rate equals the weighted sum of labour and capital growth rates plus the technical progress growth rate (total factor productivity), the weight being the labour elasticity and the capital elasticity of a product. Presuming constant returns to scale, the sum of both the capital and the labour elasticity is equal to one. If now the factors are paid their marginal products[6], then the labour elasticity equals to labour income share v_L (i.e. share of labour in income) and capital elasticity equals capital income share v_K (i.e. share of capital in income). And as the following applies

$$v_L + v_K = 1 \tag{3}$$

the growth rate of product equals to

$$g(Y) = v_L g(N) + (1 - v_L) g(K) + g(A) \tag{4}$$

The indicated formula, designated as "growth accounting", divides product growth rate to the contribution of the growth of labour and capital on one side and the contribution of the growth of technical progress (total factor productivity) on the other side. Whereas, we may designated the weighted sum of the growth rate of labour and capital as the growth rate of total factor input.

[5] The indicated production function figure presumes Hicks' neutral technical progress. Hicks' parameter A measures the shift of production function at a particular labour and capital level. To define technical progress types conf. Barro R.J, Sala-i-Martin (1995), pp. 32-34.

[6] It is $\partial Y / \partial N$ equals the price of labour and $\partial Y / \partial K$ equals the price of capital.

The purpose of empirical analysis is to determine the growth rate of technical progress $g(A)$. As we are able to ascertain the product, labour and capital growth rates as well as the share of labour empirically, the growth rate of technical progress is determined as the residual and designated as the TFP growth rate

$$g(A) = g(Y) - v_L g(N) - (1 - v_L) g(K) \tag{5}$$

All the variables in the above specified equation are in continuous time. As stated by Jorgenson and Griliches (1967, 1972), it is a Divisia index growth rate. For empirical calculations, an approximation of the Divisia continuous time index to discrete data is necessary. We will follow Jorgenson and Griliches (1967, 1972), who had used Tornqvist's (1936) procedure for discrete approximation. Thus, for discrete time labour weight is defined as follows

$$\overline{v}_{L,t} = (v_{L,t} + v_{L,t-1}) / 2 \tag{6}$$

whereas $\overline{v}_{L,t}$ is the arithmetic average of weights from two periods. The product growth rate $g(Y)$ is $\ln Y_t - \ln Y_{t-1}$, or $(Y_t - Y_{t-1}) / Y_{t-1}$ for minor changes, and analogically for other growth rates.[7]

However, the practical calculation of the effect of technical progress on growth, designated as TFP, does not only include the influence of technical progress in a narrow sense, i.e. the implementation of new technical innovations in production. Determining the TFP growth rate at the macroeconomic level as a difference between the product growth rate and the weighted sum of the growth of employment (the number of persons employed) and physical capital means that it comprises the contribution of technical progress (e.g. ICT). the effect of research and development, the contribution of the growth of labour quality, institutional and organizational changes, the effect of factor reallocation among sectors, increasing returns to scale, the changes in utilisation of factors (for measurements over shorter periods), as well as measurement errors (e.g. conversion of macroeconomic variables to constant prices).

By adjusting equation (5), we arrive at

$$g(A) = v_L \left[g(Y) - g(N) \right] + (1 - v_L) \left[g(Y) - g(K) \right] \tag{7}$$

where the figures in square brackets represent labour productivity growth rate and capital productivity growth rate. If we substitute the growth rate of labour productivity by g(Y/N) and of capital productivity by g(Y/K), we can simplify the equation

$$g(A) = v_L g(Y / N) + (1 - v_L) g(Y / K) \tag{8}$$

[7]To measure TFP growth, Denison (1962) used the chained Laspeyres index (i.e. an index with repeatedly changing weights). It is a chain-index procedure compared to the standard fixed-weighted index. It partially reduces the substitution deflection of the Laspeyres index (fixed-weighted).

Thus, the TFP growth rate is the weighted sum of the growth rate of labour productivity and capital productivity. Moreover, the single-factor approach is extended, which is based only on an analysis of the development of labour and labour productivity.

3. Data

3.1 Product, Labour and the Share of Labour in a Product

The data on real GDP (and its components) since 1995 are data revised by the CSO from late 2004. The data before 1995 are data currently available, which will be revised later.

From a sectoral point of view, we have divided the national economy into the six sectors indicated below (the Classification of Economic Activities in European Community – NACE, is indicated in brackets):

1. Agriculture, forestry, fishing (A to B)
2. Industry (C to E)
3. Building industry (F)
4. Trade, repairs, catering and accommodation (G to H)
5. Transport and communications (I)
6. Other services (J to P)

The sixth national economy sector, i.e. "Other services", comprises the following sectors: banking and insurance (J), real-estate, corporate services, research and development (K), public administration, defence, social security (L), education (M), health care, veterinary and social services (N), other public, social, and personal services (O), and households employing personnel (P).

Employment represents the number of persons employed according to the Labour Force Survey – ILO definition (LFS).[8] As these data are available only from 1993, the growth rates of employed persons in the civil sector of national economy were applied for the previous periods.[9] These growth rates were utilised for the calculation of the absolute number of employed persons, based on the absolute number of employed personsin 1993 (according to the LFS).

The labour income share in a product for the sector as well as for the whole economy, applied in growth accounting for the weighing of the labour growth rates in equation (4) and (5), and in the subsequent equations, was calculated as a ratio of the total labour costs (i.e. including social expenditures) per employee and the gross value added in current prices per employed person. Thereby, we have imputed the average total labour costs per entrepreneur in the same amount as the average labour costs per employee. This procedure

[8] CSO (2005c).
[9] CSO (2004c).

is implemented by the European Committee and the indicated average is denoted as the adjusted wage share.[10]

The total labour costs include (1) direct costs (wages and compensation), (2) social expenditures (statutory and other), (3) social benefits and (4) personnel costs. These employee costs are indicated for the total economy as well as for individual sectors.[11] With three sectors: (i) agriculture and fishing, (ii) trade, repairs, catering, and accommodation, and (iii) other services, we were forced to aggregate costs per employee in individual sub-sectors for each year by applying the share in the number of employees. As for the remaining three sectors, i.e. industry, building industry and transportation, incl. communications, these costs per employee are available directly. Data are available for the period from 1994 to 2003. The labour income share for the years from 1991 until 1993 have been chosen congruent with the year 1994, and for the year 2004 congruent with the year 2003. The labour income share for 2002 is shown in Table 1.

Table 1: Labour income share in 2002 (in %)

National economy	62.0
Agriculture and forestry	51.8
Industry	59.5
Building industry	70.1
Trade, repairs, catering and accommodation	69.8
Transportation and communications	56.9
Other services	60.3

Source: CSO and own calculations.

Whereas the complement of labour income share to one represent the capital income share applied for weighing the capital growth rate in equation (4) and in the subsequent equations.

3.2 Capital Stock

For the period from 1991 to 2004, we have made our own estimate of capital stock at constant prices based on the CSO data. In late 2004 and early 2005, the CSO revised the national account data, which comprise the period from 1995. With regard to the period from 1991 to 1995 we have used the data published in the Statistical Yearbooks of the CR.[12]

The ascertainment of statistical data on capital stock at constant prices, either assumed or reconstructed, was subject to the acquisition of sectoral data and depended on their consistence with the data for the overall national economy. The own reconstruction of sectoral capital series at constant prices before the year 1995 proved as impassable, therefore, we have started from the data published in the Statistical Yearbooks of the CR.

[10] ECFIN (2005), p. 14.
[11] CSO (2005).
[12] These data will be revised in the following period.

For the following period, these sequences were calculated by applying the perpetual inventory method, for both individual sectors and the total economy, starting from the sectoral gross fixed capital formation at constant prices.

Period until 1995

The data on capital stock in constant prices until 1995 are time series taken over from the Statistical Yearbooks of the CR (SY CR), where we have aggregated data from 60 items (sub-sectors) in the double-digit classification according to NACE into the six national economy sectors.

The data for 1991 and 1992 are in the double-digit classification according to NACE in constant prices of 1984, entitled "Gross Tangible Fixed Capital Stock".[13]

From 1993 until 1995, the "Gross Tangible Fixed Capital Stock" (or the "Gross Stock of Buildings and Structures, Machinery and Equipment") was available in constant prices of 1994 (including the overlapping year 1992) and it is also indicated in the double-digit classification according to NACE.[14] With view to capital stock corrections, we have always used absolute and the closest data from the SY CR to calculate the growth rate at constant prices (i.e. data from the SY CR 2000 for the 1995 growth rate, data from the SY CR 1998 for the 1994 growth rate, and data from the SY CR 1997 for the year 1993).

The aggregation of the capital into six national economy sectors for the period 1991-1995 was effected by summarising the following sub-sectors from the double-digit NACE classification:

1. Agriculture and fishing (A,B): items 01 to 05
2. Industry (C, D, E): items 10 to 41
3. Building industry (F): item 45
4. Trade and catering (G, H): items 50 to 55
5. Transport and communications (I): items 60 to 64
6. Other services (L to Q): items 65 to 93

Period from 1995 to 2004

For the period from 1995 to 2004, we have made our own estimate of capital stock in constant prices of 1995 based on the CSO data. Concurrently, this stock in constant prices of 1995 is available, published by the CSO for the period 1995-2002.[15]

When determining the (real) capital stock at constant prices (for sectors and for the total economy) we started from the relevant data in constant prices of 1995, revised in late 2004

[13] SY CR ´96, pp. 308-311; congruent data with the SY CR ´95, pp. 272-275, designate it as "Gross Stock of Tangible Fixed Assets".
[14] SY CR ´97, pp. 308-311, SY CR ´98, pp. 334-337, SY CR 2000, pp. 340-343.
[15] CSO (2005b).

and early 2005 by the CSO, and by applying the perpetual inventory method (see below), we have estimated the stock at constant prices in the successive years.

The European System of National Accounts (ESA 95) mentions two options for estimating fixed capital stock at constant prices. The former is based on the cumulation of gross fixed capital formation (fixed investments) at constant prices and on deducting fixed capital consumption at constant prices. This method is designated as the Perpetual Inventory Method – PIM). The latter is based on data on the value of fixed assets acquired from manufacturers and by applying price indexes for gross fixed capital formation it is converted to constant prices.[16]

We have applied the first method and thus, we have followed the calculation method specified by the European Commission in the Statistical Annex to European Economy, according to which real capital stocks and their growth rates are established and subsequently the total factor productivity growth rate for the EU-15 countries. We then use these data for the purposes of comparison with the CR. The Statistical Annex states:
"Net capital stock is the sum of the residual value of all fixed assets used so far at the end of the accounting period. Net capital stock at constant prices of year t is calculated as follows:

Net capital stock at constant prices in year t-1
plus Gross fixed capital formation at constant prices in year t
minus Capital consumption at constant prices in year t."[17]

Therefore, formally we may write

$$K_t = K_{t-1} + I_t - D_t \tag{9}$$

where K_t and K_{t-1} is the capital stock in year t and $t-1$, I_t is gross fixed capital formation at constant prices (GFCF). If the ratio of fixed capital consumption to its stock is constant, i.e. the depreciation rate δ is constant, we may write

$$K_t = K_{t-1} + I_t - \delta K_{t-1} \tag{10}$$

and after adjustment

$$K_t = (1-\delta)K_{t-1} + I_t \tag{11}$$

[16] The ESA 95, Chapter 10, Paragraph 10.56 stipulates: "Constant-price data are needed both for stocks of produced fixed assets and for inventories. For the former, such data as are necessary for the calculation of capital output ratios are available if use is made of the perpetual inventory method. In other cases information on the values of stocks of assets may be collected from producers and deflation made by the price indices used for fixed capital formation, taking into account the age structure of stocks." EUROSTAT (2005a).
[17] ECFIN (2005), p. 28.

We have determined the depreciation rate δ as an average of the depreciation rates in the period 1996-2002 at current prices, whereas in individual years, this rate represents a ratio of fixed capital consumption to the stock of fixed assets from the previous year at current prices. The ascertained depreciation rate (as an average in the period 1996-2002) for national economy and the six national economy sectors are indicated in Table 2.[18]

Table 2: Average depreciation rate in the period 1996-2002 (in %, current prices)

National economy	4.6
Agriculture and forestry	5.9
Industry	6.7
Building industry	8.8
Trade, repairs, catering and accommodation	7.4
Transport and communications	4.4
Other services	3.5

Source: CSO and own calculations.

The depreciation rate is the highest in the building industry and the lowest in other services. As there are substantially higher depreciation rates for machinery and equipment than for buildings and structures, the indicated difference basically corresponds to the fact that there is a significantly higher share of machinery and equipment in the building industry in the structure of capital stock than in other services.

The depreciation rate average in 1996-2002 at current prices is not significantly different from the average at constant prices of 1995. For example, the average depreciation rate for national economy at current prices in the specified years amounted to 4.6% and to 4.8% at constant prices.[19]

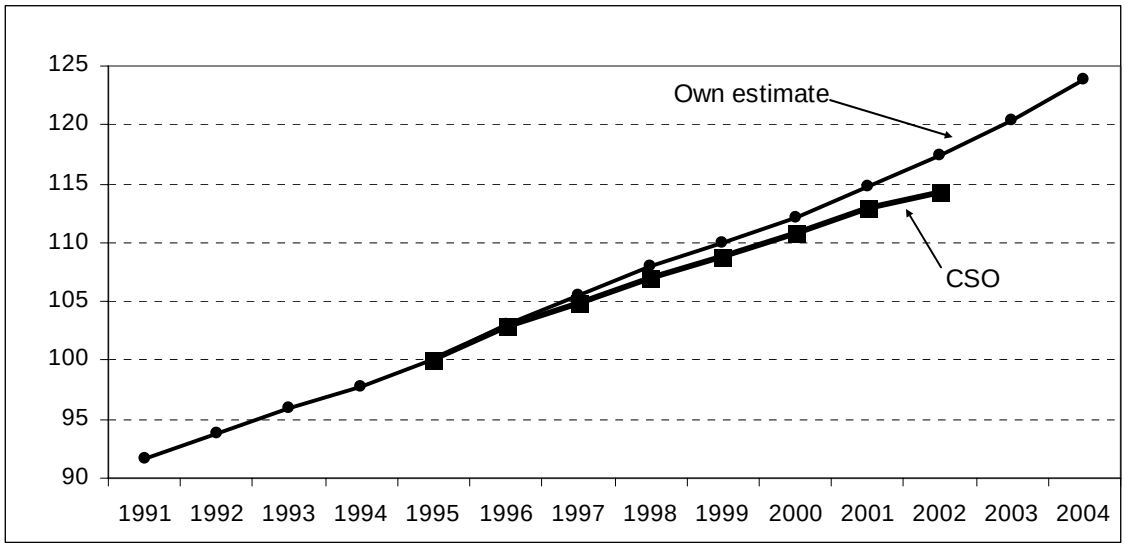
Now, knowing the GFCF[20] at constant prices of 1995 and classified according to sectors and total economy, we have calculated the time series of capital stock at constant prices based on the above indicated equation (11). Figure 1 illustrates the estimated basic index of capital stock in national economy at constant prices, whereas since 1995 it is grounded on revised CSO data. Concurrently, the figure indicates the capital stock index at constant prices published by the CSO based on revised data (as of March 4, 2005), which relates to the period from 1995 to 2002. Our calculations deflect from this index only fractionally. A relatively larger deflection occurs in 2001 and 2002.

Thus, according to our estimate, the average annual capital growth rate at constant prices in the years 1996-2002 amounted to 2.3% and 1.9% according to the CSO estimate. There is a rather large difference between the capital growth rate at current and constant prices according to the CSO data. This results in the fact that the implicit price deflator of capital is two times higher than the deflator gross fixed capital formation (see Table 3).

[18] Calculated based on data indicated by the CSO (2005b).
[19] CSO (2005b).
[20] The GFCF at constant prices is taken from CSO (2004b) (for the period 1995-2003) and "Quarterly National Accounts of the CR in Q4 2004", CSO, March 10, 2005 (for the year 2004).

Hurník and Navrátil (2003) and Hurník (2005) also indicate capital stock growth at constant prices. In the course of years 1996-2002, the average annual growth rate of this stock was 7.7 %.[21] The growth rate is unusually high, as it is almost five times higher than the real GDP growth rate (which amounted to 1.6 %). The main reason probably is the utilisation of the original fixed capital stock (balance of fixed assets), which was almost one half lower than the revised stock in 1995. Thus, under similar conditions, gross fixed capital formation at constant prices is attributed to a significantly lower base and thereby, the capital growth rate is higher.[22]

Figure 1: Capital at Constant Prices of 1995 (basic indexes, 1995=100)



Source: CSO and own calculations.

Table 3: Capital and Price Deflator of Capital and Gross Fixed Capital Formation (GFCF), 1996-2002 (average annual growth rates in %)

Current price capital	CSO	7.6
Constant price capital	CSO	1.9
Capital deflator	CSO	5.6
GFCF deflator	CSO	2.9
Constant price capital	own estimate	2.3

Source: CSO and own calculations.

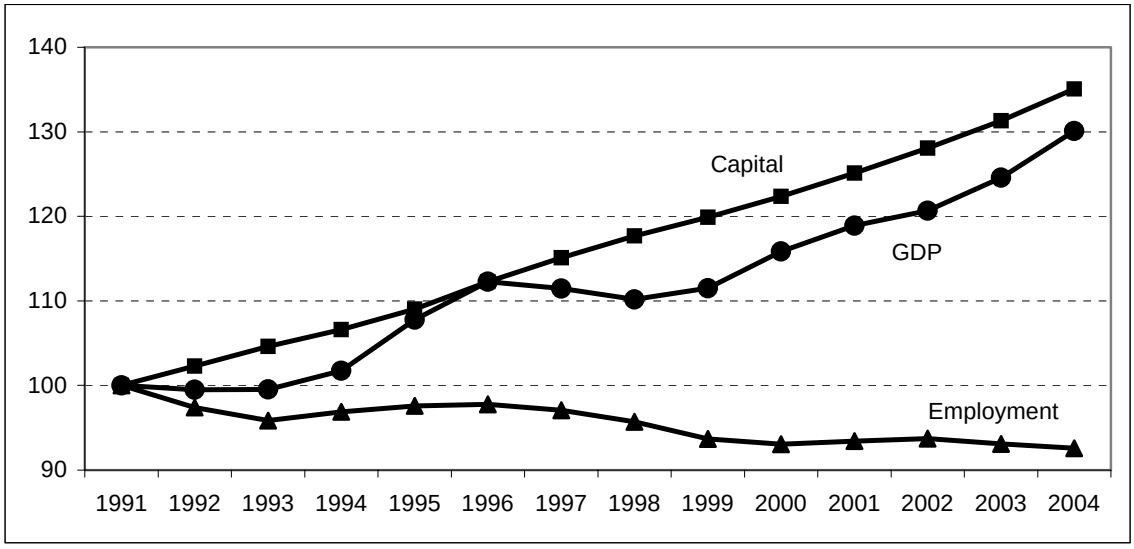
[21] Hurník (2005), p. 5. The annual growth rates specified in the essay also comprise 2003. For the purposes of comparison, we have determined the average for the period 1996-2002 from annual data.
[22] The original capital stock (fixed assets) for 1995 was CZK 3,713 billion (Statistical Yearbook of the CR, p. 160) and the revised stock is CZK 6,589 billion (CSO, 2005b, Table TB 15).

4. Decomposition of Economic Growth in the CR

4.1 Sources of Economic Growth in the Years 1992-2004

After a transformation recession in the early 1990s, economic growth (real GDP) gradually accelerated in Czech economy in the first half of the 1990s. However, the increasing imbalance finally resulted in a decline of real GDP in 1997 and 1998. After restoring economic growth, the growth (of real GDP) again accelerated. Figure 2 shows the development of real GDP in the period from 1991 to 2004. In the examined period, employment witnessed a long-term decrease. Contrary to that, capital stock at constant prices grew somewhat faster than real GDP.

Figure 2: Growth of Real GDP, Employment and Capital, 1991-2004 (basic indexes, 1991=100)

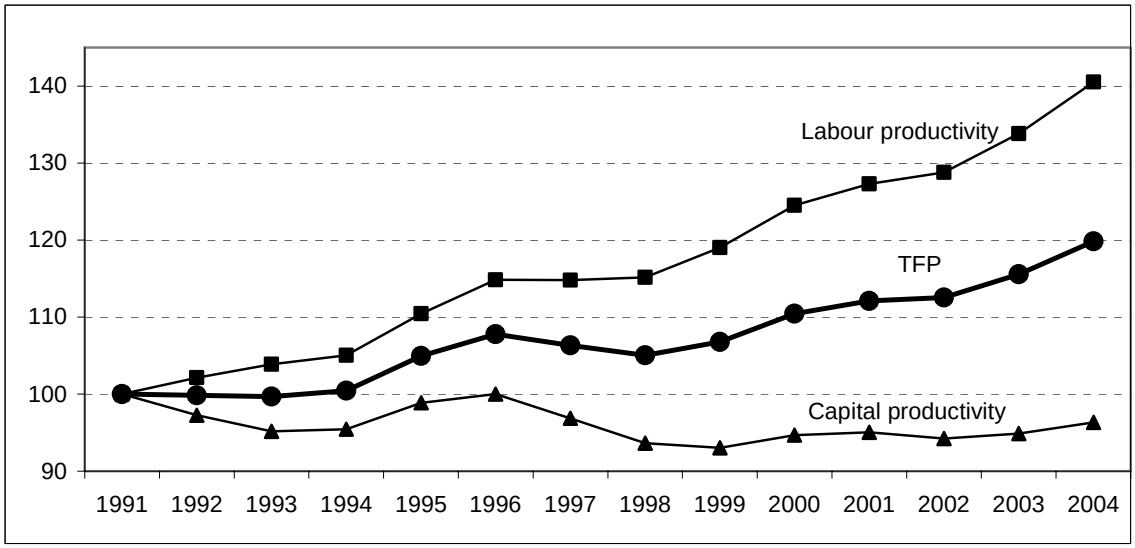


Note: Capital and GDP are at 1995 constant prices.
Source: CSO and own calculations.

In the analysed period 1992-2004, real GDP grew at a relatively low rate at an annual average of 2%. Employment dropped by 0.6% and capital stock increased by 2.3% at an annual average (see Table 4).

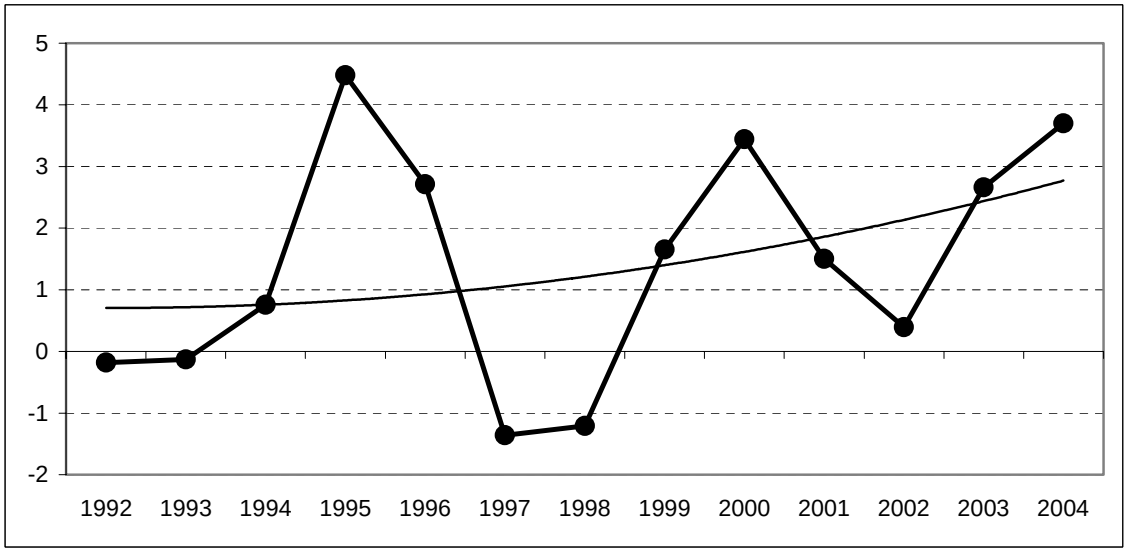
The development of labour productivity, capital and total factor productivity (TFP) is indicated in Figure 3. Labour productivity increased by 2.7%, while capital productivity decreased by 0.3%. Thus, total factor productivity (TFP) grew at an annual average of 1.4% (see Table 4).

Figure 3: Total Factor Productivity, Labour and Capital Productivity (basic indexes, 1991=100)



Note: TFP means total factor productivity.
Source: CSO and own calculations.

Figure 4: Total Factor Productivity Growth in National Economy (growth rate in %)



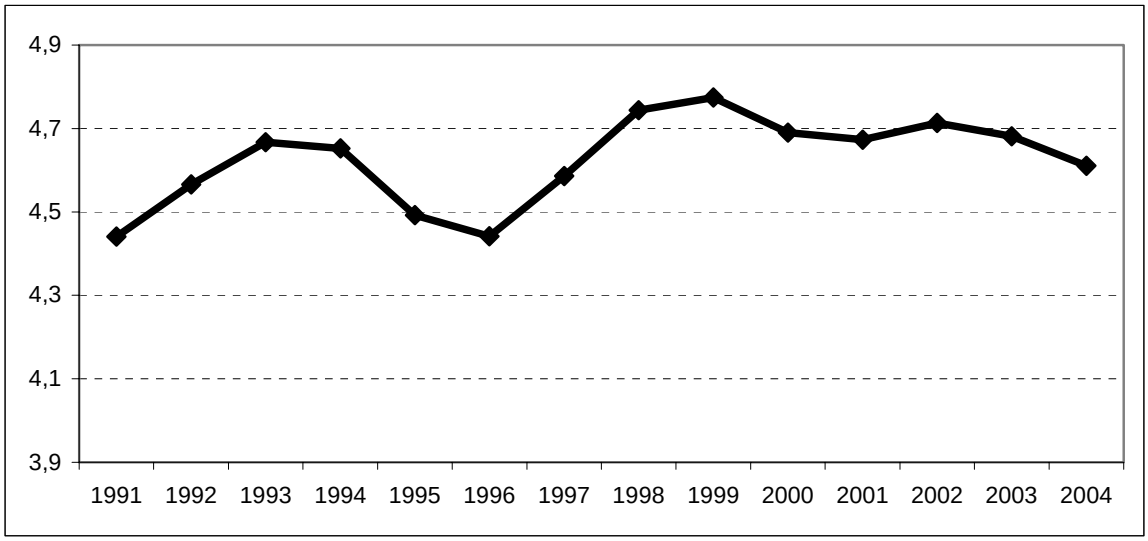
Source: CSO and own calculations.

The annual TFP growth rates are indicated in Figure 4, which implies the speeding up of TFP growth after 1998. In its Macroeconomic Prediction of the CR of July 2005, the Ministry of Finance of the CR indicated TFP growth rates since 1995.[23] In this prediction, the annual TFP growth rate is practically congruent with our calculations.

[23] MF of the CR (2005), p. 6, Figure B.1.4.

The capital productivity decline means that the capital coefficient (K/Y)[24], which represents the inverse value of capital productivity, has been increasing at average by 0.3 % p.a. It absolute value is shown in Figure 5.

Figure 5: Capital Coefficient in National Economy (constant prices of 1995)



Note: The capital coefficient is the capital stock to GDP ratio at constant prices (K/Y).
Source: CSO and own calculations.

4.2 Acceleration of Economic Growth and Total Factor Productivity in the Years 1999-2004

We have divided the analysed period from 1991 to 2004 into two sub-periods according to the progress of the economic cycle. The first period until 1998 begins and end with the year, when real GDP achieved the saddle in the particular cycle phase.[25] The second period continues from 1998.

As illustrated by Table 4, compared to the first period (1992-1998), real GDP growth accelerated in the second period (1999-2004) at an annual average from 1.4% to 2.8%. At average, employment declined in both the periods at a similar rate. The capital stock growth rate did not practically change and amounted to an annual average of 2.4%, or 2.3%.

Growth of labour productivity increased from 2% to 3.4% at an annual average and declining capital productivity changed into growth at an annual average of 0.5%. The TFP growth rate increased from 0.7 % to 2.2%, i.e. it practically tripled.

[24] Also designated as capital/output ratio.
[25] In 1991, gross value added at constant prices reached the saddle for the total economy (as a sum of sectoral gross values added at constant prices), with the aid of which we analyse structural development in Chapter 5. GDP at constant purchase prices reached the saddle a year later.

Table 5 shows the contribution of factors to real GDP growth. An analysis indicated that the speeding up of real GDP growth from 1.4% to 2.8%, i.e. by 1.4 percentage point, was largely attributed to the acceleration of TFP growth from 0.7% to 2.2%, i.e. by 1.5 percentage point (see last column of Table 6). By contrast, the contribution of capital growth slightly declined (by – 0.1 percentage point). Thus the acceleration of real GDP growth may be practically credited to the increased TFP growth rate.

Table 4: Sources of Growth of Real GDP in National Economy (average annual growth rates in %)

	1992-2004	1992-1998	1999-2004	1999-2004 minus 1992-1998
Real GDP	2.0	1.4	2.8	1.4
Employment	-0.6	-0.6	-0.6	0.1
Capital	2.3	2.4	2.3	0.0
Capital-labour ratio	2.9	3.0	2.9	-0.1
Labour productivity	2.7	2.0	3.4	1.3
Capital productivity	-0.3	-0.9	0.5	1.4
Total factor productivity	1.4	0.7	2.2	1.5

Note: GDP is in 1995 constant prices; capital-labour ratio = K/N; the data were rounded.
Source: CSO and own calculations.

Table 5: Contribution of Factors to Real GDP Growth in National Economy (average annual growth rates in %)

	1992-2004	1992-1998	1999-2004	1999-2004 minus 1992-1998
Real GDP	2.04	1.40	2.81	1.41
Contribution:				
Employment	-0.34	-0.35	-0.33	0.02
Capital	0.99	1.05	0.91	-0.14
Total factor productivity	1.40	0.71	2.22	1.51

Note: GDP is in 1995 constant prices.
Source: CSO and own calculations.

5. Sectoral Growth in the CR

In this chapter, we examine the performance of the supply side at an intermediary level. Attention is given to the sources of growth in individual sectors, particularly to the sectoral development of total factor productivity and the influence of structural changes on its growth for the total economy. The sectoral analysis embraces six sectors specified in Chapter 3.

5.1 Sources of Growth in Individual Sectors in the Years 1992-2004

In the period from 1992 to 2004, the real gross value added (GVA) increased more rapidly in trade and catering, in particular at an average growth rate of 4.1%, i.e. approximately two times faster than the total economy.[26] It is followed by industry with 3.2% p.a. The real

[26] Due to consistency with sectoral data, we are working with GVA for total economy at 1995 constant prices, representing the sum of sectoral gross values added at 1995 constant prices.

GVA also grew in a slightly above-average rate in transport and communications. In other services and in agriculture it increase below the average and it declined in the building industry (see Table 6).

With the long-term decline of employment in the overall economy, employment grew in three sectors, namely in trade and catering (by 3.4% p.a.), in the building industry (by 1.1% p.a.) and in other services (by 0.8% p.a.), while in other sectors, it declined, most rapidly in agriculture.

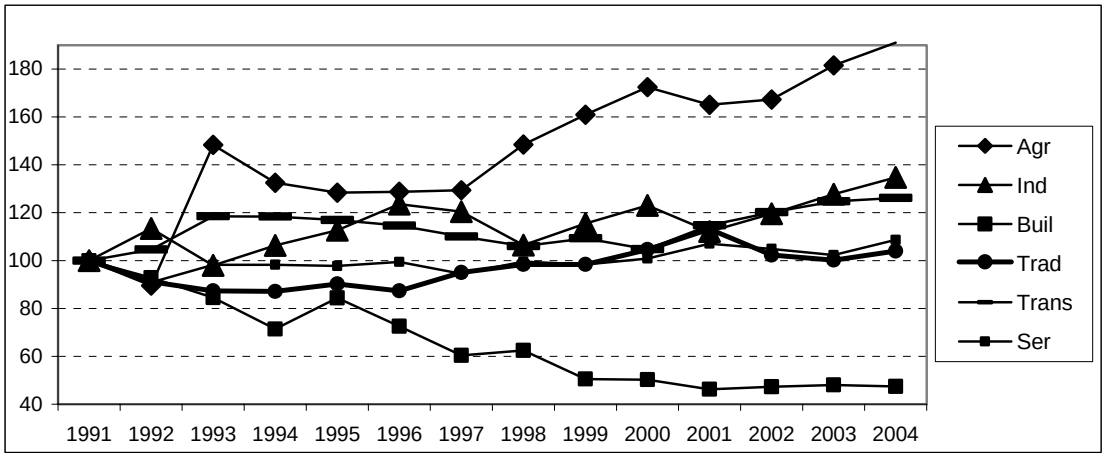
Capital stock at constant prices increased more rapidly in industry, building industry and in trade and catering. Its growth was slower in transport and communications and capital increase was below the average in other services and in agriculture.

Table 6: Sources of Grovth of Gross Value Added (GVA) in Sectors, 1992-2004 (average annual growth rates in %)

	GVA	Employment	Capital	TFP
Total	2.2	-0.6	2.3	1.5
Agriculture	1.0	-7.7	0.7	5.1
Industry	3.2	-2.3	4.6	2.3
Building industry	-3.4	1.1	4.3	-5.6
Trade and catering	4.1	3.4	4.2	0.3
Transport and communications	2.9	-0.1	2.5	1.8
Other services	1.6	0.8	1.1	0.6

Note: GVA is gross value added in 1995 constant prices; TFP is total factor productivity based on GVA; the data were rounded. Source: CSO and own calculations.

Figure 6: Growth of Total Factor Productivity in Sectors, 1991-2004 (basic indexes, 1991=100)



Source: CSO and own calculations.

In the monitored period, total factor productivity grew above-average in agriculture (by 5.1% at an annual average), in industry (by 2.3%), and in transport and communication (by 1.8%). In other sectors it grew below the average, whereas in the building industry it declined (see Table 6 and Figure 6).

5.2 Structure of Growth Acceleration after 1998

What changes occurred between the first (1992-1998) and the second (1999-2003) period with respect to economic growth? The growth of real GVA in national economy accelerated (see Table 7). In terms of structure, this development resulted from the accelerated real GVA in industry, transport and communications, other services, and in agriculture. On the other hand, growth slowed down in trade and the building industry faced accelerating decline.

On the side of employment experiencing an overall stable decline, the trend changed in transportation and communications, when after a slight rise in the first period, employment declined in the second. The situation was similar in trade, as well as in the building industry. In other sectors, trends from the first period continued, whereas the decline of employment either abated (in agriculture and industry) or its growth slightly accelerated (in other services).

The capital stock growth rate remained practically the same in the overall economy. Structurally, capital growth significantly accelerated in trade and catering. In other sectors it faced a slow down, while in transport and communication the growth rate remained unchanged.

Table 7: Growth Resources of Gross Added Value (GAV) in Sectors (average annual growth rates in %)

	GVA		Employment		Capital		TFP	
	1992-98	1999-04	1992-98	1999-04	1992-98	1999-04	1992-98	1999-04
Total	1.5	3.0	-0.6	-0.6	2.4	2.3	0.8	2.4
Agriculture	0.2	2.0	-10.4	-4.5	1.4	-0.1	5.8	4.3
Industry	1.6	5.2	-3.1	-1.3	4.8	4.4	0.9	4.0
Building industry	-2.7	-4.3	3.2	-1.3	4.6	4.1	-6.5	-4.5
Trade	5.4	2.6	6.6	-0.2	3.4	5.2	-0.2	0.9
Transport and communications	2.2	3.7	0.3	-0.6	2.5	2.5	0.8	2.9
Other services	1.0	2.3	0.8	0.9	1.3	0.8	-0.1	1.5

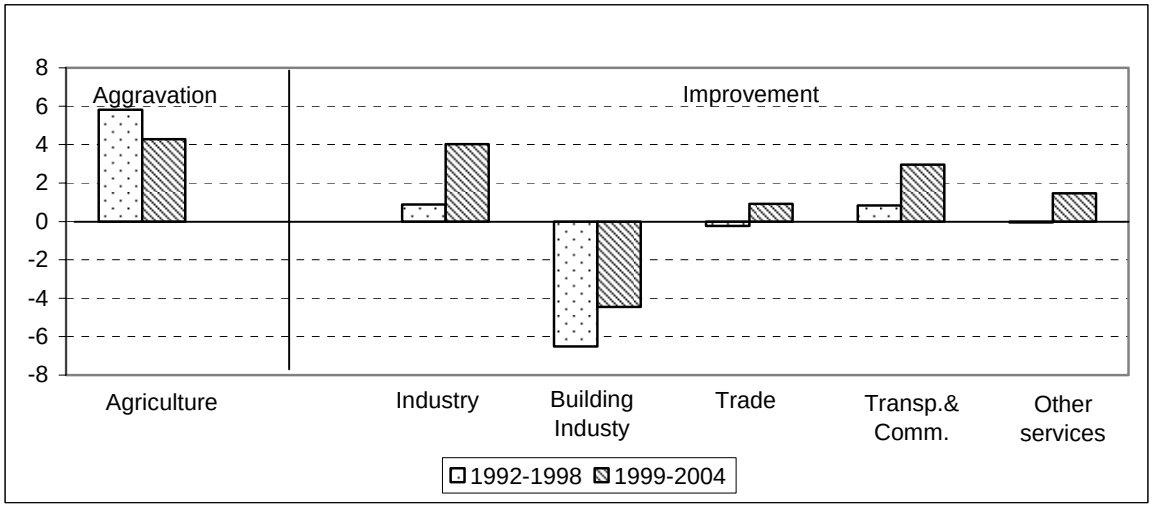
Note: GVA is gross value added in 1995 constant prices; TFP is total factor productivity based on GVA.
Source: CSO and own calculations.

Compared to the first period (1992-1998), the growth of total factor productivity (TFP) in the overall national economy in the second period (1999-2004) accelerated. With the exception of agriculture, TFP growth accelerated in all sectors, whereas in the building industry, its decline alleviated (see Figure 7).

What was the contribution of resources to the speeding up or slowing down of the growth of real GVA in sectors? In sectors, in which the growth of real GVA accelerated (industry, agriculture, transport and communications a other services), the acceleration of TFP growth participated in the acceleration in industry, transport, and communications to a large extent. By contrast, in agriculture it was the positive contribution of employment, or the slowing down of the decline of employment, whereas TFP growth decelerated. For example, in industry the growth rate of real GVA increased by 3.6 percentage points, of which 3.1

percentage points are attributed to the increased TFP growth rate (see Table 8). In other services, the increased TFP growth rate overcompensated the increase of the growth rate of real GVA. In the remaining two sectors (building industry and trade), the growth rate of real GVA declined, however, the TFP growth rate increased. Therefore, namely the decline of employment contributed to the deceleration of the growth of real GVA (see Table 8).

Figure 7: Total Factor Productivity in Sectors, 1992-1998, 1999-2004 (average annual growth rates in %)



Source: CSO and own calculations.

Table 8: Contribution of Growth Factors to the Dynamics of Real GVA in Sectors (average annual growth rates in %)

	AGRICULTURE			INDUSTRY			BUILDING INDUSTRY		
	1992-98	1999-04	Difference	1992-98	1999-04	Difference	1992-98	1999-04	Difference
Real GVA	0.2	2.0	1.8	1.6	5.2	3.6	-2.7	-4.3	-1.6
Contribution of									
Employment	-6.4	-2.3	4.1	-1.6	-0.7	0.9	2.2	-0.9	-3.1
Capital	0.5	0.0	-0.6	2.3	1.8	-0.5	1.5	1.2	-0.2
TFP	5.8	4.3	-1.5	0.9	4.0	3.1	-6.5	-4.5	2.1

	TRADE			TRANSPORT AND COMMUNICATIONS			OTHER SERVICES		
	1992-98	1999-04	Difference	1992-98	1999-04	Difference	1992-98	1999-04	Difference
Real GVA	5.4	2.6	-2.6	2.2	3.7	1.5	1.0	2.3	1.3
Contribution of									
Employment	4.4	-0.1	-4.5	0.1	-0.4	-0.5	0.4	0.5	0.1
Capital	1.1	1.7	0.6	1.3	1.1	-0.2	0.7	0.3	-0.3
TFP	-0.2	0.9	1.2	0.8	2.9	2.1	-0.1	1.5	1.5

Note: GVA is gross value added in 1995 constant prices; TFP is total factor productivity based on GVA.
Source: CSO and own calculations.

5.3 Contribution of Sectors to the Acceleration of Total Factor Productivity Growth

The growth of total factor productivity (TFP) based on GVA accelerated in the national economy. In the course of years 1992-1998, TFP grew by 0.8% and in the period 1999-2004 it grew by 2.4% at an annual average (based on GVA). Thus, its average growth rate increased by 1.6 percentage point (after rounding). How did the individual sectors contribute to this increase? The determination of the contribution of individual sectors is based on the share of individual sectors in the total factor input in national economy. These shares serve as weights for the sum of growth rates of sectoral TFPs and their changes. An analysis has shown that three sectors participated in the increase of the growth rate of macroeconomic TFP, namely other services, industry, transport and communications (see Table 9).

Table 9: Contribution of Sectors to the Growth of Total Factor Productivity (average annual growth rates in %)

	1992-1998	1999-2004	1999-2004 minus 1992-1998
Total TFP	0.83	2.38	1.54
Sector contribution:			
Agriculture	0.22	0.03	-0.19
Industry	0.39	0.91	0.53
Building industry	-0.09	-0.03	0.05
Trade	0.00	0.01	0.02
Transport and communications	0.36	0.83	0.46
Other services	-0.05	0.62	0.67

Note: TFP is total factor productivity based on gross value added; the data were rounded.
Source: CSO and own calculations.

5.4 Structural Effect and Total Factor Productivity Growth

What were the contributions from intra-sectoral factor reallocation between individual sectors for the growth of macroeconomic TFP? Calculations indicate (see Table 10) that the structural effect was positive in the first period and slightly lower than the intra-sectoral effect. In the second period, structural effect was almost zero and the intra-sectoral effect was decisive. In other words, the reallocation od production factors between the sectors contributed to the growth of macroeconomic TFP only in the first period.

Table 10: Total Factor Productivity and Structural Effect (average annual growth rates in %)

	1992-1998	1999-2004
Total factor productivity	0.83	2.38
Of which:		
Intra-sectoral effect	0.47	2.47
Structural effect	0.36	-0.09

Note: Total factor productivity based on gross value added in national economy.
Source: CSO and own calculations.

6. Economic Growth and Total Factor Productivity in the CR and EU-15 at the Macroeconomic Level

6.1 Concise Comparison of Performance of EU-15 and the USA

Until the mid 1970s, the EU-15 catching-up process with the USA was underway, both in terms of GDP per capita and labour productivity. The first turn occurred in the mid 1970s, when in the successive period, the catching-up process continued only in labour productivity and ceased with respect to GDP per capita.
The second turn took place in the mid 1990s, when the catching-up process in labour productivity not only stopped, but the gap to the disfavour of EU-15 began to increase.[27] The second turn also concerns the development of total factor productivity (TFP). In the course of years 1995-2003, the TFP average growth rate in EU-12 was 0.8% and 1.4% in the USA.[28] Denis et al.(2005) states that since 1966, EU-15 achieved a higher TFP growth rate than the USA, yet this tempo gradually decelerated quite significantly. Approximately from the mid 1990s, the average TFP growth rate in EU-15 was lower than in the USA and has been further decreasing, while in the USA it grew.[29]

6.2 Dynamics of Growth and Total Factor Productivity in the CR and EU-15

To compare the growth of real GDP and total factor productivity (TFP) in the CR and EU-15, we have utilised our calculations grounded on the method specified in the already mentioned Statistical Annex of European Economy (see sub-chapter 3.2) and for the EU-15 countries, we have applied data from the indicated annex to European Economy. The surveyed periods are congruent with those that are the subject of the analysis of the development of the economy in the CR in the previous chapters, i.e. 1992-1998 and 1999-2004. Apart from that, we also present the period 1996-2004, for which revised data are available for the CR. The results are summarised in Tables 11 and 12.

In the first period (1992-1998), Czech economy achieved a lower growth rate of real GDP than EU-15. In the second period (1999-2004), the 2.8% growth rate of real GDP was higher than in EU-15 (2.1%), yet relatively small. Apart from Luxembourg, a higher growth rate was achieved by Ireland, Greece, Spain and Finland. In the period 1996-2004 the average annual growth rate of real GDP in the CR was basically congruent with the EU-15 growth rate (see Table 11).

[27] Ark (2005), p. 4 (Figure 1).
[28] Estevavo (2004), p. 9 (Table 2).
[29] Denis et al. (2005), p. 11 (Figure 3), p. 12 (Table 1).

Table 11: Real GDP in the CR and EU-15 (average growth rates in %)

	1992-1998	1999-2004	1996-2004
Belgium	1.8	2.1	2.1
Denmark	2.4	1.7	2.0
Germany	1.3	1.2	1.3
Greece	1.8	4.1	3.8
Spain	2.2	3.1	3.3
France	1.5	2.2	2.2
Ireland	7.0	7.0	7.7
Italy	1.4	1.4	1.5
Luxembourg	4.2	4.6	5.1
The Netherlands	2.7	1.6	2.3
Austria	2.2	1.9	2.2
Portugal	2.3	1.5	2.4
Finland	2.4	3.0	3.7
Sweden	1.7	2.8	2.7
United Kingdom	2.7	2.7	2.8
EU-15	**1.8**	**2.1**	**2.2**
Czech Republic	1.4	2.8	2.1

Source: CSO, ECFIN (2000-2005), own calculations.

In the first period (1992-1998), the growth of total factor productivity (TFP) was slower than in EU-15,however,in the second period (1999-2004), while TFP growth in EU-15 decelerated to 0.6%, in the CR its growth rate increased substantially to an annual average of 2.2% and was approximately 3.5 times higher than in EU-15 (Table 12). In this period, a higher TFP growth rate was only achieved by Ireland (2.8%) and Greece (2.3%). In the course of years 1996-2004, when the CR experienced a decline in 1997 and 1998, the average annual TFP growth rate in the CR reached 1.5% and 0.7% in EU-15. Thus, it was approximately two times higher. In this period, a higher TFP growth rate than in the CR was achieved only by Ireland (3.1%), Finland (2.3%), Greece (1.9%), and Sweden (1.8%)(see Table 12).

Table 12: Total factor productivity in the CR a EU-15 (average annual growth rates in %)

	1992-1998	1999-2004	1996-2004
Belgium	0.7	0.9	0.8
Denmark	1.7	0.9	1.0
Germany	0.6	0.4	0.4
Greece	0.1	2.3	1.9
Spain	0.6	0.1	0.3
France	1.0	0.7	0.9
Ireland	3.3	2.8	3.1
Italy	1.1	0.0	0.2
Luxembourg	1.0	0.0	0.7
The Netherlands	1.1	0.6	0.8
Austria	0.8	0.5	0.7
Portugal	1.4	-0.3	0.2
Finland	3.3	1.8	2.3
Sweden	2.2	1.6	1.8
United Kingdom	1.8	1.2	1.2
EU-15	**1.0**	**0.6**	**0.7**
Czech Republic	0.7	2.2	1.5

Source: CSO, ECFIN (2000-2005), own calculations.

6.3 Relative Level of Total Factor Productivity in the CR and the Catching-Up Process with EU-15

The calculation of the relative level of TFP is based on the Cobb-Douglas production function with technical progress

$$Y = AN^{\alpha}K^{1-\alpha} \tag{12}$$

where Y is real GDP, A represents total factor factor productivity (TFP) within empirical analyses, N is labour, K capital and α is constant labour elasticity of a product measured by the labour income share in a product. By an adjustment for A, we arrive at

$$A = \frac{Y}{N^{\alpha}K^{1-\alpha}} \tag{13}$$

and from here after an adjustment, we get

$$A = \left(\frac{Y}{N}\right)^{\alpha}\left(\frac{Y}{K}\right)^{1-\alpha} \tag{14}$$

where Y/N is labour productivity and Y/K is capital productivity. By a logarithmic calculation, we acquire

$$\ln A = \alpha \ln(Y/N) + (1-\alpha)\ln(Y/K) \tag{15}$$

If we mark the difference of the variables with the Δ symbol, we arrive at

$$\Delta \ln A = \alpha \Delta \ln(Y/N) + (1-\alpha)\Delta \ln(Y/K) \tag{16}$$

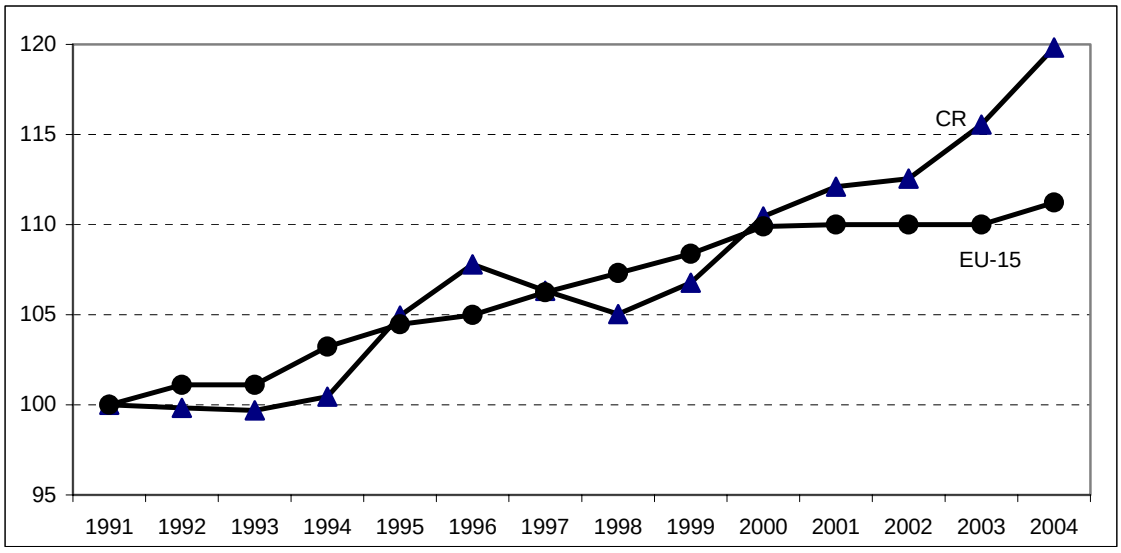
If now, $\Delta \ln(Y/N)$ represents the difference in labour productivity between two countries, contrary to a change in productivity between two years in a single country (and analogically in terms of capital productivity), then $\Delta \ln A$ measures the difference in total factor productivity between two countries.

The calculation of the relative level of total factor productivity (TFP) of the CR compared with EU-15 in 1995 is based on the following data. Labour productivity was lower in the CR by 48%.[30] The capital coefficient in the CR was equal to 4.5 and to 3.2 in EU-15.[31] The capital coefficient inverse value, i.e. capital productivity, was equal to 0.22 in the CR and to 0.31 in EU-15. Thus, in the CR capital productivity was lower by 29% than in EU-15. If we now choose the constant labour share α = 0.65, this means that $(1-\alpha)$ = 0.35, as usual

[30] Calculation is based on Eurostat data, see EUROSTAT (2005b). GDP per person employed in PPS.
[31] For the CR the capital coefficient was calculated based on data from the CSO (2005b) and CSO (2004b), and for EU-15 it is based on ECFIN (2002).

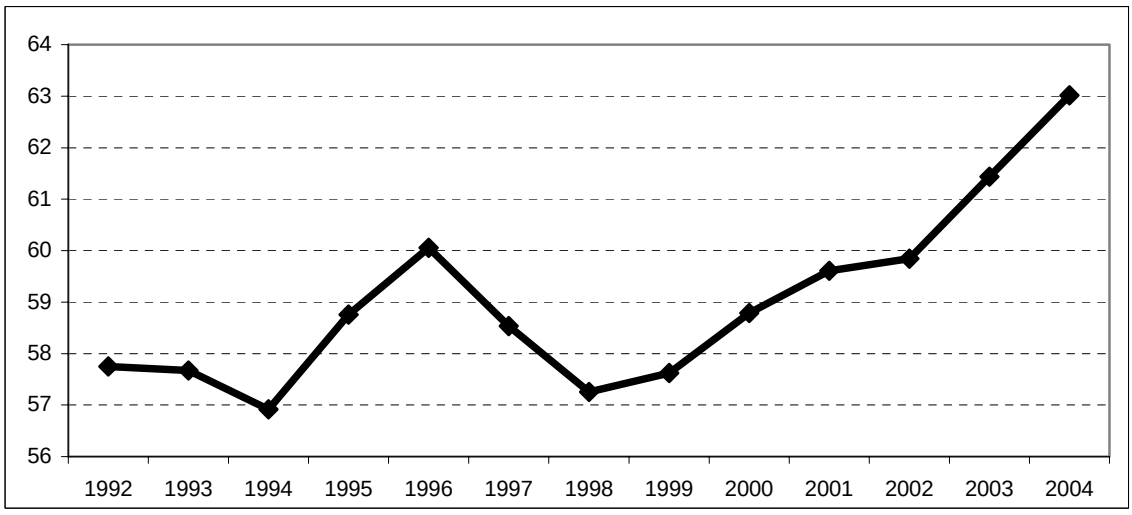
within international comparisons, and if we use these weights to determine the TFP difference, we arrive at 0.65(48%)+0.35(29%) = 41.2 %. TFP was thus lower in the CR by 41.2% than in EU-15, or in other words the CR TFP reached 58.8% of the level of EU-15. This initial relative TFP level in the CR (EU-15=100) in 1995, i.e. 58.8, was extended forwards as well as backwards by applying the TFP growth rate indexes in the CR and EU-15 (the basic indexes are indicated in Figure 8). Thereby, we have acquired the relative TFP level for the CR for individual years (see Figure 9). Calculations have shown that after 1998, the relative TFP level in the CR towards EU-15 is constantly increasing, with acceleration in the years 2003 and 2004.

Figure 8: Total Factor Productivity in the CR and EU-15 (basic indexes, 1991=100)



Source: CSO, ECFIN (2000-2005), own calculations.

Figure 9: Relative Level of Total Factor Productivity in the CR towards EU-15 (EU-15=100)



Source: CSO, ECFIN (2000-2005), own calculations.

7. Conclusion

In the course of years from 1999 to 2004, as compared with the period from 1992 to 1998, the CR experienced an acceleration of the growth of real GDP. The contribution of employment and physical capital stock was negligible according to "growth accounting". Thus, the speeding up of real GDP growth, may be fully attributed to the acceleration of total factor productivity growth.

The analysis of the six national economy sectors revealed that primarily the sectors of industry, transport and communications, other services, and an abatement of the decline in the building industry participated in the acceleration of the growth of macroeconomic total factor productivity.

In comparison with EU-15, the average annual growth of total factor productivity in the CR in the period 1992-1998 was slower (0.7% versus 1%), while in the period 1999-2004, it was faster (2.2% versus 0.6%).

In addition, in the course of years from 1996 to 2004, for which revised data are available for the CR, the average annual growth rate of total factor productivity in the CR was twice the speed than in EU-15 (1.5% versus 0.7%).

Since 1999, total factor productivity in the CR has been converging towards the EU-15 level, with acceleration in the years 2003 and 2004. In 2004, its level achieved 63% in the CR of the EU-15 level, compared to 59% in 1995, or 57% in 1998.

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