EFFICIENCY OF PRODUCTION FACTORS IN THE EU

Martina NOVOTNÁ[a], Tomáš VOLEK[a]

[a] Faculty of Economics, University of South Bohemia, Studentská 13, České Budějovice 370 05, Czech Republic, E-mail: novotna@ef.jcu.cz, volek@ef.jcu.cz

Cite this article: Novotná, M., Volek, T. (2018). Efficiency of Production Factors in the EU. *Deturope*, 10(2), 147-168

Abstract

The aim of the article is to consider, on the basis of indicators of effectiveness of production factors, the development of particular member states of the EU in the period 1996-2015 and relations between them in connection with the real business cycle in the EU and different starting positions (groups according to GVA per worker). The hypothesis that the development of labour productivity in the established groups of countries and at the intervals of the real economic cycle differs statistically significantly was verified based on the ANOVA test. The analysis illustrated different development and reaction of indicators of productivity in the monitored groups of the EU countries to the cyclic development of economies. It has been confirmed that the states with worse starting conditions have greater growth intensity in productivity and the business cycle does not interfere with the efficiency of production factors to any real extent.

Keywords: factor of production, productivity, European Union, business cycle

INTRODUCTION

The main trend in contemporary economies in Europe is to focus on dynamic growth, and the cornerstone of dynamic growth is the increasing effectiveness of using the factors of production, i.e. productivity growth. The development of the economies of individual EU countries is not identical and, therefore, it can be assumed that the productivity dynamics in particular states will develop differently as well. Cyclic development of an economy is an important factor influencing the productivity dynamics in particular EU states. Among other factors, the initial condition (initial level of output) of an economy can influence the actual productivity of the unit of input. Consequently, the question is how the development of productivities in particular economies is influenced by the business cycle and whether these cyclic differences in the economies influence the linkages between particular productivity indicators.

The basis for measuring country-level productivity and performance is Solow's production model. If Q represents output and K and L represent capital and labour inputs in "physical" units, then the aggregate production function can be written as: Q = F (K, L; t). The variable

"t" for time appears in F to allow for technical change (Solow 1957). Other authors as Barro and Sala-i-Martin (2004), Fried, Lovell, Schmidt, and Yaisawarng (2002), Färe, Grosskopf, Norris, and Zhang (1994) or Chen and Inklaar (2016) have continued Solow's fundamental work. Into the basic equation of production function Chen and Inklaar (2016) today, add the variable "R" which represents R & D capital (research and development). Modern growth theory builds on this neoclassical model of exogenous growth, which views the accumulation of physical capital, associated with a permanent flow of technical progress (Bhattacharjee, de Castro, & Jensen-Butler, 2009) as the driver of economic growth and productivity. Economic performance (Q) of countries to measure productivity can be expressed in economic reality in different ways. Most often, we use measures of total economic output, income or expenditure, such as Gross Value Added (GVA) at the regional level (Cuadrado-Roura, Mancha-Navarro, & Garrido-Yserte, 2000) or Gross Domestic Product (GDP) at the national level (Harper, Moulton, Rosenthal, & Wasshausen, 2009). These measures are good indicators of overall economic activity and productivity. Productivity is generally the ratio of output to input (Coelli, 2005). There are many different productivity measures, and the choice between them depends on the purpose of productivity measurement, and, in many instances, on the availability of data. The simplest and the most frequently applied measure is labour productivity. Labour productivity is defined as gross value added (or gross output) per worker and per worker-hour (O´Mahony, Rincon-Aznar, & Robinson, 2010). The size and dynamics of labour productivity in the regions is one of the indicators of regional competitiveness. The capital productivity index shows the time profile of how productively capital is used to generate value added. The importance of all factors of production is summarised in the indicator of total factor productivity (TFP). TFP is the empirical indicator of the effect of technical change on productivity (Praag & Versloot, 2008). We can find common relationships among productivity indicators. The total factor productivity determines labour productivity, not only directly, but also indirectly, by determining capital per worker (Prescott, 1998).

Differences in productivity can be identified between countries (Färe et al. 1994), regions (Le Gallo & Dall'erba, 2008, Lengyel & Szakálné Kanó, 2014), sectors (Gobel & Zwick, 2012) or firms (Korcsmáros & Mura, 2017). Productivity is influenced by many factors. One of these factors is the economic cycle. Productivity is influenced by the business cycle and productivity affects the business cycle. First, consider how business cycles affect productivity. Mayer, Ruth, and Scharler (2016) show that productivity increases in response to adverse supply, demand, and wage mark-up shocks. Productivity fluctuates endogenously over the

business cycle. Saintpaul (1993) shows that demand shocks tend to have a negative impact on productivity, both in the short and long run. An alternative approach between productivity and business cycle shows that productivity shocks play a central role in real business cycles as an exogenous impulse to macroeconomic activity. (Evans 1992). In the standard model of real business cycles (Kydland & Prescott, 1982), productivity is taken as an endogenous component (Rebelo, 2005) and productivity shocks play a central role as an exogenous impulse to macroeconomic activity (Evans 1992). We have two types of structural shocks: (1) technological shocks, that is, changes in the technological progress which affects productivity in the long-run, and (2) non-technological shocks, that is, all the other shocks that affect productivity temporarily through their effects on capital accumulation and aggregate demand (Travaglini, 2012), such as an economic crisis. Positive productivity shocks have a significant short-run negative impact on employment (Smets & Wouters, 2007) and the reaction of countries through economic performance and productivity are not the same (Suchy, Kolosta, & Koziak, 2015). Correlations between employment and productivity are negative for technology shocks, positive for non-technology shocks (Gali, 1999).

The effect on productivity growth in the diversity across countries shows that national systems of innovation have a strong influence on the way technology push and demand pull effects increase productivity. Within European countries, in the same way as in sectors, either the technological competitiveness, or the cost competitiveness model prevails as a key mechanism for productivity growth. This result points out the importance of the patterns of national specialization in innovation, alongside those in export, production and technology, and opens up an additional direction for research addressing the specificity of technological strategies and their links with specialization and performance (Crespi & Pianta, 2008). Country variability may well be the outcome of differences in terms of the institutional setting in which firms operate (Sala & Silva 2013).

The link between business cycle and productivity growth is different across countries. Costello (1993) found that aggregate output growth and productivity growth are positively correlated in the US, Germany and Japan. On the other hand, the analysis by O´Mahony & Van Ark (2003) showed no significant effect on the productivity growth measures due to the business cycle in the US and the EU. The key factor affecting productivity is the starting position (initial level) of productivity. Sustainable economic growth and development in the European Union is influenced by the starting position of old or new EU member states (Ciegis, Jurgaityte, Rakickas, & Kareivaite, 2008; Konig, 2015) and by the heterogeneity of the entrepreneurial processes across countries (Pušnik & Tajnikar 2010). As already

mentioned before, the development of economic efficiency indicators is influenced by the business cycle. In the case of human labour, the efficiency indicators are labour productivity and labour cost. Rising labour costs do not necessarily lead to higher labour productivity, but to weaker competitiveness and lower economic growth. We can find a significant relationship between the business cycle and labour cost or minimum wage (Sabia, 2014). The reaction of countries is not identical. Mesina, Strozzi, and Turunen (2009) define three types of countries: countries with mainly pro-cyclical real wages, countries with mainly counter-cyclical real wages and the rest of the world with very different patterns of cyclicality. This paper will show relationships between particular productivity indicators in the context of the business cycle. The main contribution of this paper is that we establish the value of economic normalcy of productivity indicators, by describing the pattern of indicator values during the business cycle.

OBJECTIVES AND METHODS

The main aim of the article is to consider, on the basis of selected indicators of efficiency of production factors, the development processes of particular member states of the EU in the period 1996-2015, and differences and similarities between them in connection with the real business cycle of the EU and to their different initial positions. The analysis of relations between relevant indicators can be labelled as a trend analysis.

The relationship between indexes of selected indicators is useful to express through the inequalities. The changes in economic activity can be measured by the variations in the growth rates of the firm's performance. The research question was if it is possible to establish the economic normal of economic activity on the aggregate level of the national economy. The authors define the term "Economic normal[1]" as a system of inequations that determines the positive development of the national economy. The research question was if it is possible to create the economic normal at the national economy level. The authors took into account the business cycle and the initial level of output as the main factors that can significantly affect the normal course of the national economy. Verification of economic standards monitors the trends of indicators in the various phases of the real business cycle, depending

[1] Hoffman (1992) defined "Economic normal" as a system of inequations which assess if the development of economic indicators is positive for enterprises (in the context of indicators´ relationships). Application of economic normal is based on the knowledge of index analysis. A respective index represents evolution of the respective item in time (negative or positive change) and so economic normals give a recommendation of what values of particular economic indicators are expected to enable a company or an economy to reach their goals.

on the initial position of individual countries that can influence both the intensity of the trend and its direction.

The period 1996-2015 has been chosen for analysis, i.e. 20 years, in the knowledge that several states had not been members of the EU at the beginning of this period. First, it is necessary to classify the current EU-member countries according to their economic position in the first year of monitoring (1996). . As a tool, the following ratio of labour productivity has been used:

$$\frac{\frac{GVA_{i,1996}}{L_{i,1996}}}{\frac{GVA_{1996}}{L_{1996}}}, \quad (1)$$

where: $GVA_{i,1996}$ is gross value added in PPS for EU country "i" in 1996, (purchasing power standard - PPS), i = 1, …, 28.

$L_{i,1996}$ is total employment, - domestic concept, of EU country "i" in 1996, i = 1, …, 28.

GVA_{1996} is total aggregate gross value added for the whole EU (all the 28 countries) in 1996,

L_{1996} is total employment - domestic concept for the whole EU (all the 28 countries) in 1996.

The next step of the analysis was the consideration of the dynamics of the GVA index for the whole of the EU (i.e. all the 28 countries) in the period 1996-2015 to enable the construction of intervals corresponding to particular stages of the real business cycle.

The purpose of the above-mentioned steps was to create groups of countries according to their initial position, and also to monitor the dynamics of selected indicators characterizing the effectiveness of factors of production in the various intervals of the real business cycle defined for the whole of the EU. Analysis of variance (ANOVA) is a collection of statistical models used to analyse the differences among group means and to identify associated measures of variation (such as variation among and between groups), and ANOVA methods can be used to assess the importance of one or more factors, by comparing the response variable means at different factor levels. The null hypothesis states that all population means (factor level means) are equal while, the alternative hypothesis states, that at least one of these means is different from the others.

In the current analysis the ANOVA test was used to explore the influence of two factors on the variance in labour productivity growth rates, by a model without interaction. The ANOVA model for two factors without interaction may be represented by the linear statistical model, as:

$$y_{ki} = \mu + \alpha_k + \beta_i + \varepsilon_{ki}, \quad (2)$$
$$k = 1, 2, ...,K; \; i = 1, 2, ..,r,$$

where y_{ki} is level of labour productivity group of countries *k*th according to initial position and *i*th the stage of the real business cycle,

k = 1… 4 are groups of countries according to initial level of Gross value added per worker in basic year,

i = 1… 6 are the stages of the real business cycle.

For a detailed description of ANOVA see for example (Hebák, 2007), (Montgomery & Runger, 2007).

The following indicators have been chosen: labour productivity, LP (i.e. gross value added (GVA)/ total employment-domestic concept(L)), capital productivity, CP (gross value added (GVA) / gross fixed capital formation (C)), capital-labour ratio, CLR (gross fixed capital formation (C) / total employment domestic concept (L)), real unit labour costs, RULC (compensation of employees (CE) /gross value added (Y)), aggregate productivity of factors of production. Considering two factors of production: labour (L), capital (C), we can compute the aggregate productivity of factors of production TFP = $\boldsymbol{A}_1/\boldsymbol{A}_0$:

$$\frac{A_1}{A_0} = \frac{Y_1}{Y_0}.\left(\frac{C_1}{C_0}\right)^{-\alpha_{Ct}}.\left(\frac{L_1}{L_0}\right)^{-\alpha_{Lt}} \quad (3)$$

where Y_1/Y_0 is the index of real product (of GVA in prices PPS),

C_1/C_0 is the index of real gross stock of long-term property (index of creation of gross fixed capital formation),

L_1/L_0 is the index of either the number of hours worked, or average number of employees,

α_{Lt} is the arithmetical mean of the ratio of the compensation of employees in GVA, in the base and current periods,

α_{Ct} is the arithmetical mean of the gross operating surplus in GVA, in the base and current periods, thus it applies that $\alpha_{Lt} + \alpha_{Ct} = 1$.

The index of productivity of the factors of production (TFP = Total Factor Productivity A_1/A_0) illustrates technological benefits for economic development.

All mentioned indicators were determined as real values measured in PPS, i.e. through the purchasing power parity of currency, as is recommended for international comparisons.

This evaluation deals only with the price relations of goods in various states, irrespective of the impact of supply and demand for the actual currencies (Jílek, 2005).

The calculation of average annual indices, i.e. average growth rates of monitored productivities at partial time intervals, was carried out by the geometric mean:

$$\overline{k} = \sqrt[n]{k_1 . k_2 . \dots . k_n} = \sqrt[n]{\frac{u_1}{u_0} . \frac{u_2}{u_1} . \dots . \frac{u_n}{u_{n-1}}} = \sqrt[n]{\frac{u_n}{u_0}}, \quad (4)$$

Where: $\overline{k}$ is average growth rate, or, as the case may be, average growth coefficient

$k_1 \dots k_n$ are chain indices of indicators,

$u_0 \dots u_n$ are values of particular indicators.

Another aim is to consider the proportional growth rates of gross fixed capital formation (C), the number of employed people (L) and the volume of output (Y), i.e., GVA. Desirable relationships between these indicators can be derived logically: $I_Y \rangle I_C \rangle I_{CE}$ where I_Y is the growth rate of Y (GVA), I_C is the growth rate of C (gross fixed capital formation) and I_{CE} is the growth rate of CE (compensation of employees).

The relation between output Y and gross fixed capital formation C can be marked by the capital productivity (CP) and expressed by the ratio:

$$CP = \frac{Y}{C} \quad \Rightarrow \quad I_{CP} = \frac{\frac{Y_1}{C_1}}{\frac{Y_0}{C_0}} = \frac{\frac{Y_1}{Y_0}}{\frac{C_1}{C_0}} = \frac{I_Y}{I_C} \quad (5)$$

If you divide Y and C on the right side of the equation by the average number of workers, (L) (total employment-domestic concept), capital productivity can be expressed as:

$$\frac{Y}{C} = \frac{\frac{Y}{L}}{\frac{C}{L}} \quad (6)$$

where

$\frac{Y}{C}$ is the capital productivity, CP,

$\frac{Y}{L}$ is the labour productivity, LP and

$\frac{C}{L}$ is the capital stock per worker, the level of technical equipment that labour can work with (capital-labour ratio, CLR).

Formula (5) clearly shows that capital productivity can be expressed as a ratio of labour productivity and capital-labour ratio. The same relations apply to the indices, i.e. growth rates as well (multiplicative model)

$$I_{\frac{Y}{C}} = \frac{I_{\frac{Y}{L}}}{I_{\frac{C}{L}}} \tag{7}$$

When the capital productivity index equals 1 , then it is apparent from relation (5) that the GVA index rises as quickly as the index of gross fixed capital formation; the capital productivity remains the same and it can be called extensive development.

If the capital productivity index is higher than 1, then gross fixed capital formation compared to GVA rises less than proportionally, which results in a relative saving in material fixed capital and further related savings (Střeleček & Lososová, 2003). Thus capital productivity will increase if the growth rate of economic output (Y) is higher than the growth rate of capital (C), i.e. increasing the capital-labour ratio will result in higher labour productivity (from relation 7).

If the capital productivity index is lower than 1, then GVA rises more slowly than gross fixed capital formation, i.e. relative excess of gross fixed capital occurs.

For instance, if the capital-labour ratio increases, i. e. fixed assets per labour unit increases and labour productivity remains stable (capital rises more quickly than economic output Y), a decrease in capital productivity will occur. This may happen in the case when capital having limited productive ability rises, so that economic output, e.g. investments into infrastructure etc. could rise at the same speed or more quickly. The dynamics of capital productivity can be further assessed using different dynamics of labour productivity, resulting in various qualitative trends of development with different consequences, which will be dependent on the real business cycle.

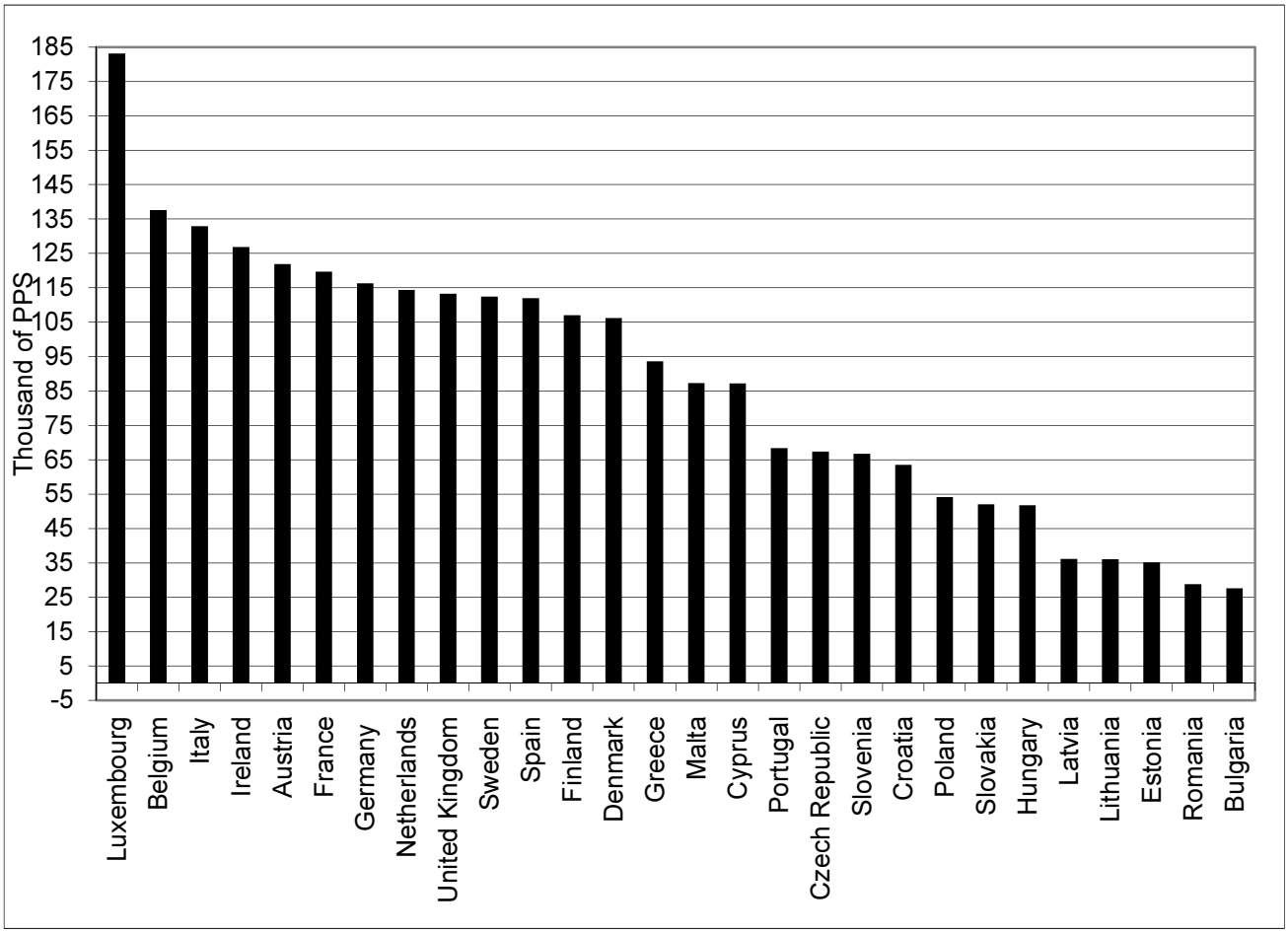
RESULTS

The individual steps of the analysis are based on the primary distribution of the 28 EU-countries to groups (see the methodology). Figure 1 shows GVA per worker (domestic

concept) in the individual countries compared to the average GVA per worker in the EU of 28 countries, in the starting year of monitoring (1996) in descending order, expressed as percentages of the EU-average. Based on these collected data, the EU-countries were divided into three groups.

The first group includes the countries in which GVA per worker is higher than the average value of the 28 EU-member countries, i.e. the index value is higher than 100%. The second group consists of countries in which GVA per worker is ranging from 50% to 100% of the average value in the EU. The third group represents the countries in which the value is not higher than 50%.

Figure 1 Gross value added (GVA) per worker in basic year 1996 (EU 28 - 100%)



Source: authors' calculation based on data of Eurostat

Since Luxembourg's GVA per worker is significantly higher than that of the other countries and, therefore, it would fundamentally distort the total results, this country was monitored separately.

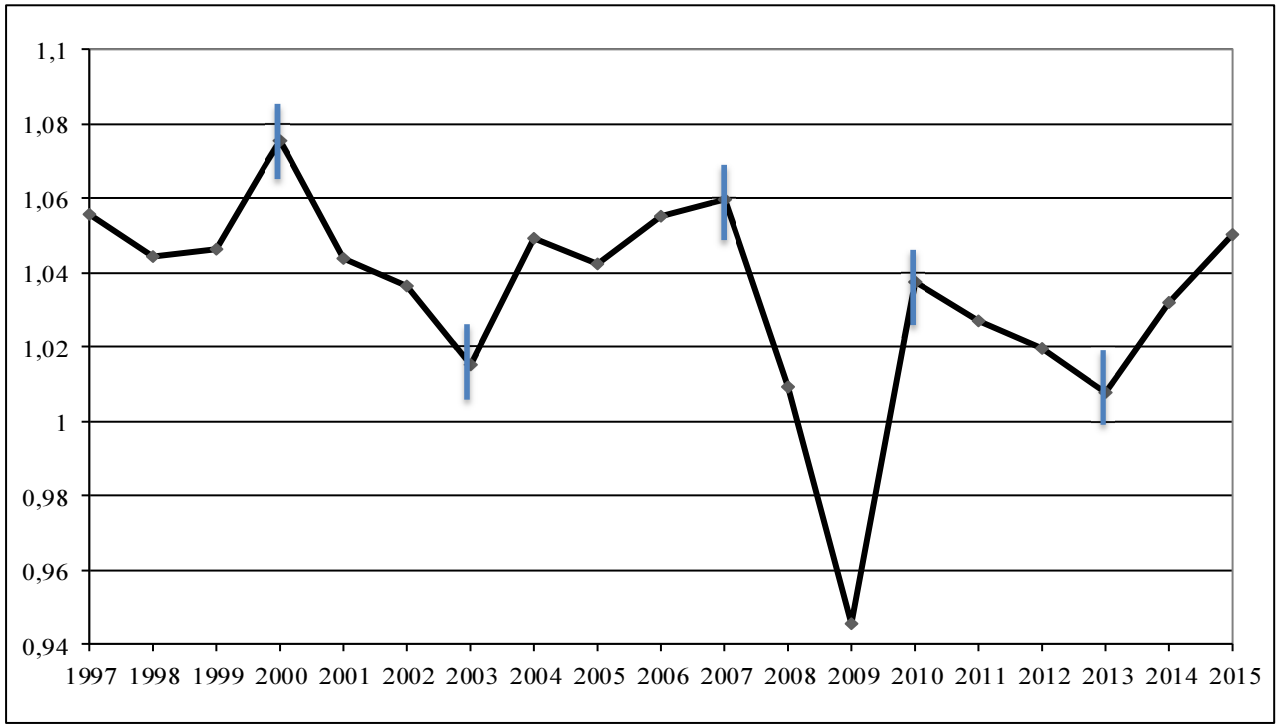
Group 1: Belgium, Italy, Austria, Ireland, France, Germany, Spain, Netherlands, Sweden, United Kingdom, Finland, Denmark

Group 2: Malta, Greece, Cyprus, Portugal, Slovenia, Czech Republic, Slovakia, Hungary, Croatia, Poland

Group 3: Latvia, Estonia, Lithuania, Bulgaria, Romania.

The next step was the construction of the intervals that define the stages of the real business cycle (Figure 2). The stages were inferred from the annual development (growth) of GVA in the whole of the EU in PPS. Adamowiczh & Walcyk, (2011) show in their paper, that one can observe progressive synchronization of cyclical fluctuations in the 'new' and 'old' EU member states, particularly evident in the timing of turning points and duration of the recent recession. Dissimilarities were noted in the values of the turning points that resulted in disparity in the amplitude and intensity of cyclical changes. These were higher in the 'new' EU countries, especially in the Baltic, states than in the EU15. Since the EU enlargement, the 'new' EU economies boomed with rates of cyclical growth of the gross value added and manufacturing production (the latter to a lesser degree), much above the EU15 averages.

Figure 2 Growth rate of GVA in the European Union (28 countries)



Source: Own calculations based on the data of Eurostat

Looking at the development of GVA for the whole of the EU (28 countries), it is possible to identify the intervals by which we can cut up the 20-year period (1996 – 2015) into six periods:

- Period 1: 1996 – 2000 is characterized by stable or slightly rising annual GVA increases,

- Period 2: 2000 – 2003 is characterized by decreasing GVA growth rates (,
- Period 3: 2003 – 2007 indicates the trend of repeatedly increasing GVA growth rates,
- Period 4: 2007 – 2009 can be described as a period of sharply decreasing GVA growth rates, with, in 2009, the GVA growth rate reaching a negative value, i.e. the growth rate in this year was lower than 1,
- Period 5: 2009 – 2013. The annual growth rates did not fall below 1 but still growth rates were decreasing in this period.
- Period 6: 2013 – 2015 increasing increments of GVA.

To illustrate different performance levels of the three country groups not only the level of labour productivity, but also the annual labour productivity growth rates are presented in Table 1 and Figure 3. As is shown in Table 1 the level of labour productivity differs in the three country groups.

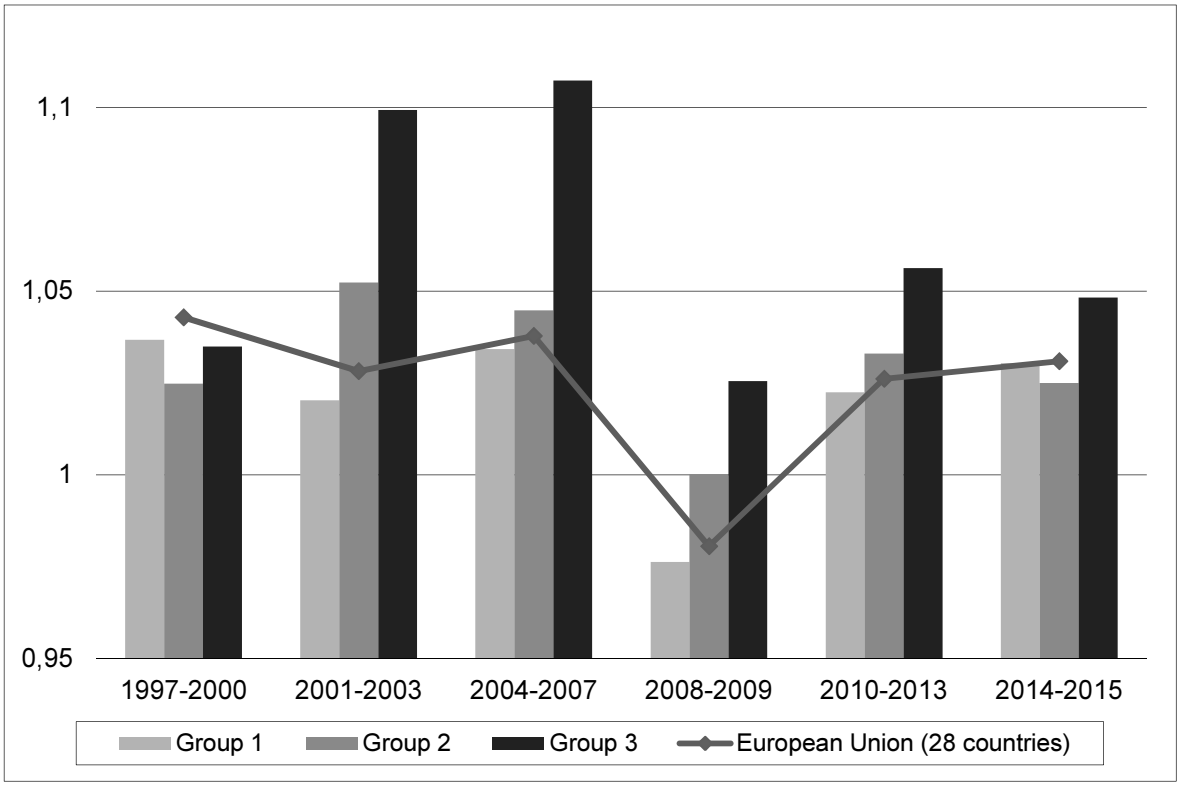
Table 1 Average annual labour productivity per each period in thousands of PPS per employment

GEO/TIME	1996-2000	2000-2003	2003-2007	2007-2009	2009-2013	2013-2015
EU (28 countries)	36.91	42.90	48.05	49.75	52.71	56.41
Group 1	43.28	48.88	53.83	55.15	57.75	61.47
Group 2	25.52	29.01	34.00	36.30	39.62	42.53
Group 3	10.35	13.95	19.60	24.37	27.93	31.73
Luxembourg		69.92	81.61	82.53	86.32	96.33

Source: Own calculations based on the data of Eurostat

According to the expectations, the first group is above the average of the EU (of 28 countries). This group includes mainly the "old" member states, which have the most influence on the level of the EU-average. The second group of states reaches approximately 68%-75% of the labour productivity level of the EU-average in each period, and the third group varies between 28% and 53% of the EU-average. Luxembourg, which was assessed separately, significantly exceeds the average labour productivity of the EU (of 28 countries): the index varies in the periods around 165% the EU-average. The dynamics (Figure 3) differs from the indicator levels. The average growth rate of labour productivity in the third group of countries exceeds significantly both the average of the EU and of the first group of countries. The dynamics of labour productivity in the second group of countries is slightly above the average growth rate of labour productivity in the EU.

Figure 3 Average growth rate of labour productivity



Source: Own calculations based on the data of Eurostat

Regarding capital productivity in its absolute terms (Table 2), there are no such apparent differences as for labour productivity (Figure 3). The values of this indicator, in the first group of countries, are, again, as expected, approximately the same as of the EU average (of 28 states). The major differences between the second and third group are not obvious, and during the first two periods of the cycle, the third group of countries even exceeds the second one. This can be the result of the ongoing restructuring of the economy, occurring mainly in the second group, where higher investments into fixed capital result in a lower level of the capital productivity. The third group of countries are lagging according to the level of capital productivity in the last observed periods. During the period of growth, this is reflected in lower levels of capital productivity.

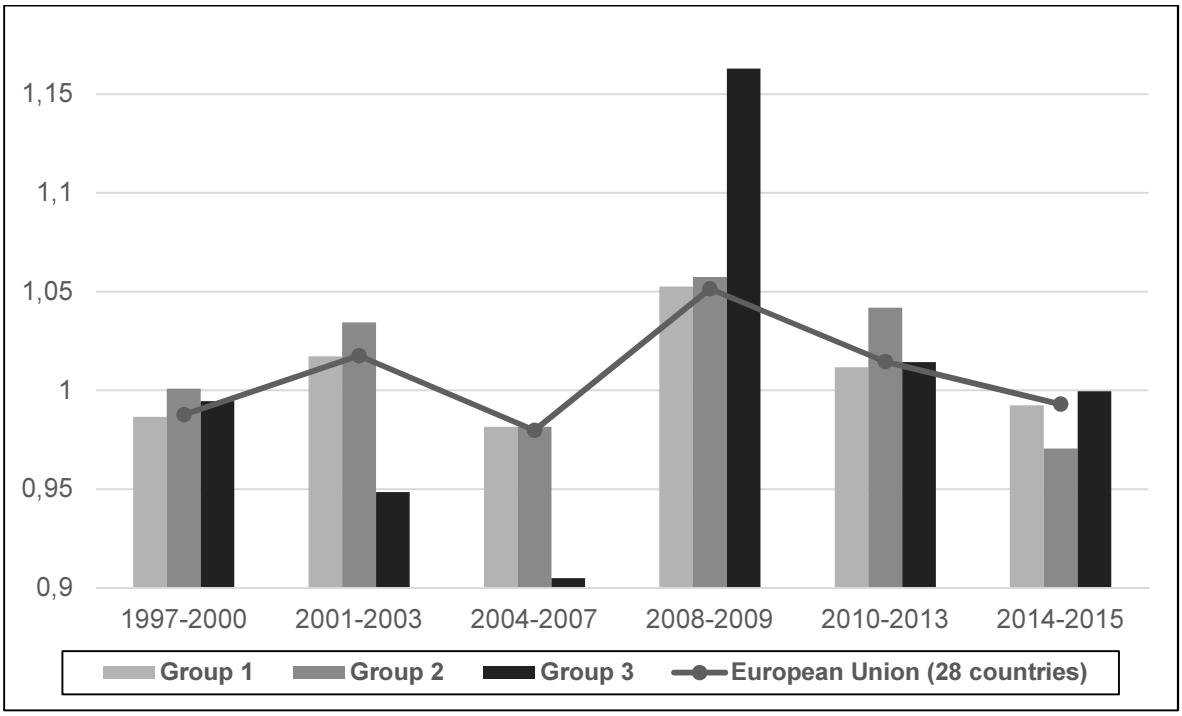
Table 2 Average annual capital productivity per each interval

GEO/TIME	1996-2000	2000-2003	2003-2007	2007-2009	2009-2013	2013-2015
EU (28 countries)	4.22	4.26	4.14	4.19	4.52	4.60
Group 1	4.27	4.28	4.16	4.26	4.54	4.62
Group 2	3.44	3.80	3.84	3.85	4.47	4.56
Group 3	4.69	4.11	3.31	3.07	3.70	3.82
Luxembourg		4.07	4.50	4.51	4.75	4.94

Source: Own calculations based on the data of Eurostat

The average growth rates of capital productivity are recorded in Figure 4. Figure 4 shows significant fluctuations in the growth rate of capital productivity (especially for the third group of countries). There is an obvious impact of the real business cycle. The pace of growth in capital productivity is converging between the country groups in the period 2013-2015 (due to an overall growth of all the countries). Comparing Figures 3 and 4, an opposite (mirror) development can be inferred, which follows from the described relations between the respective indicators, as shown in the methodology.

Figure 4 Average growth rate of capital productivity

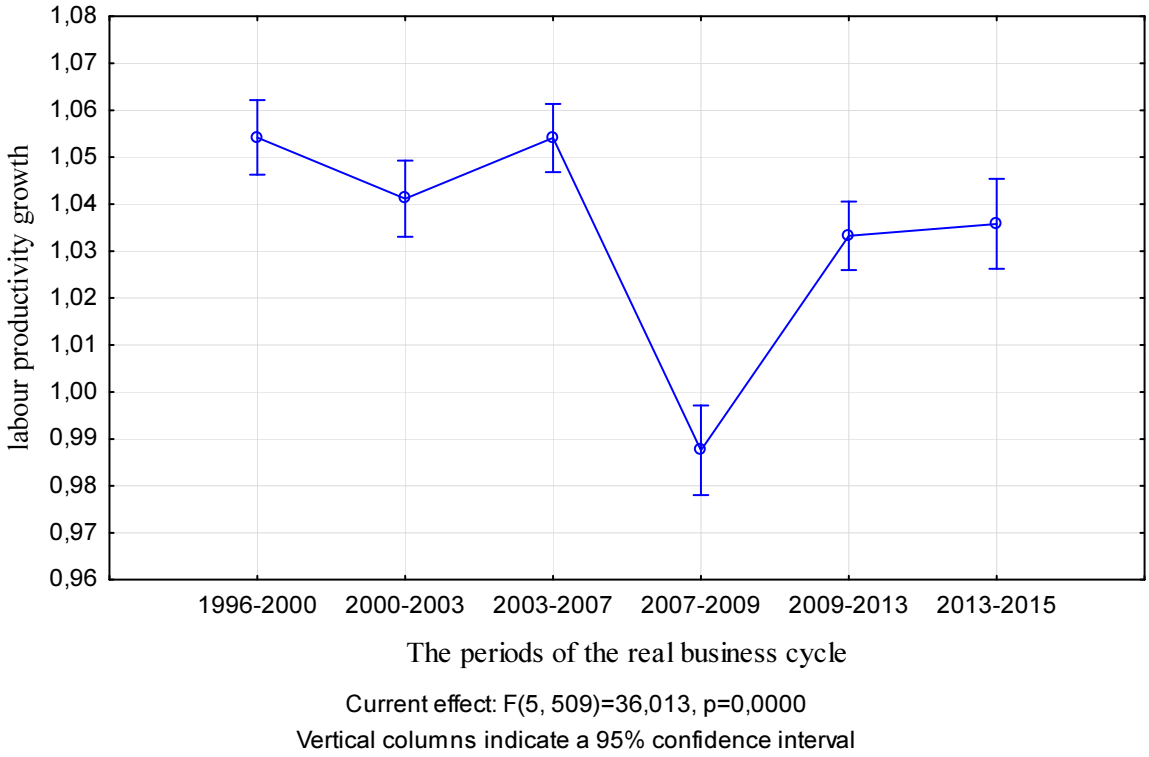


Source: Own calculations based on the data of Eurostat

The statistical method ANOVA was used to verify the above grouping of the countries, according to the initial level of the labour productivity and to the defined time periods of the real business cycle.

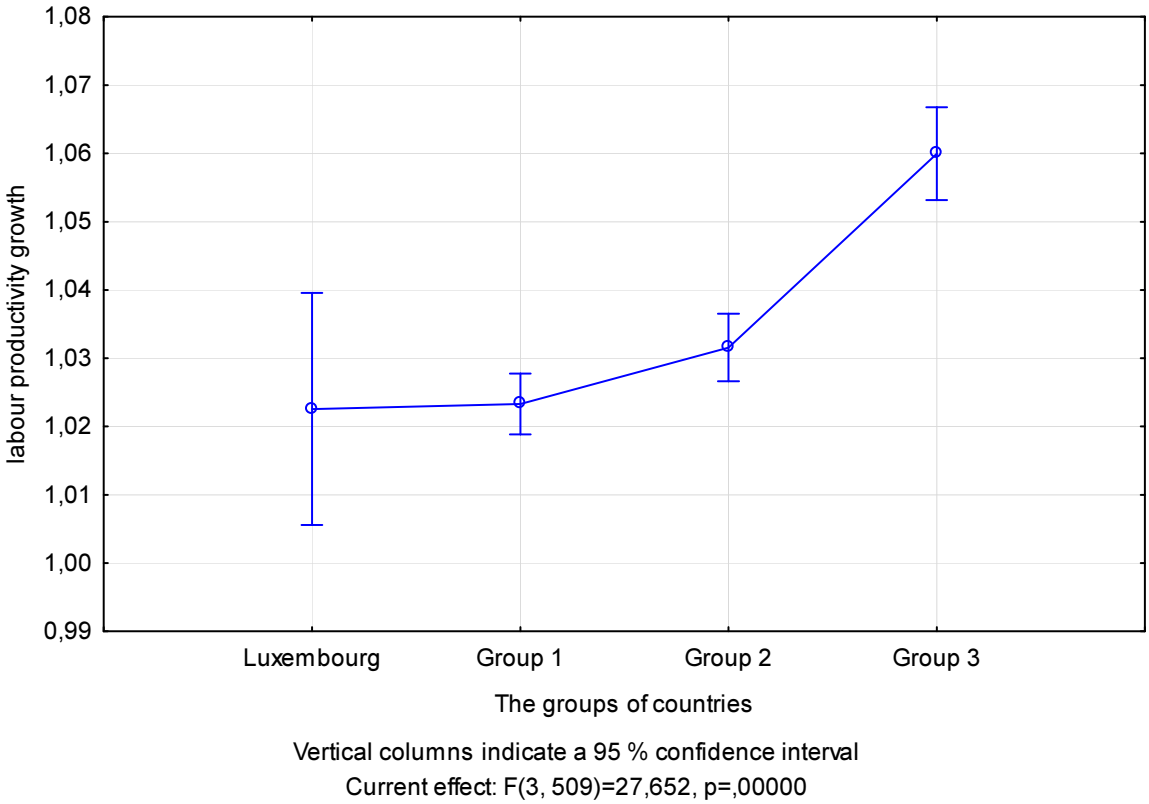
The ANOVA test showed statistically significant difference in labour productivity dynamics in the individual phases of the real business cycle (Figure 5). Proven was also a statistically significant difference in the dynamics of labour productivity among the three different groups of countries, according to the initial level of the indicator (Figure 6).

Figure 5 Labour productivity growth rate in the periods of the real business cycle decomposed using ANOVA



Source: Own calculations based on the data of Eurostat

Figure 6 Labour productivity growth rates in the groups of countries decomposed using ANOVA



Source: Own calculations based on the data of Eurostat

In the next step, the following indicators were included: total factor productivity (see the methodology), capital-labour ratio and real unit labour costs, or their growth rates. The relations between these indicators were investigated within each group separately.

Analysing these links within the first group of countries, tables 3 and 4, show that during stable or increasing GVA growth rate periods (periods 1, 3, and 6), the first group of countries has some common features:

1) The relations between indicators are almost identical, i.e. capital-labour ratio grows dynamically (6-7%), which results in an average decrease of annual capital productivity (-1 to -2%) and, so, there is an annual decrease in the real unit labour costs growth rate as well; to put it more simply, the labour costs are decreasing. It can be noted that all the three periods are characterised by the highest growth rates of labour productivity (above 3%) and by small growth rates of total productivity (around 1%).
2) There is a relative excess of gross fixed capital formation (because $I_{CP} \langle 1 \Rightarrow I_Y \langle I_C$ see formula 5, GVA grows slower than C), i.e. the capital in these periods does not have sufficient production potential. Many cost-intensive investments are carried out which are likely to have an effect in the long term.

Table 3 Average annual growth rates of indicators - Group 1

Indicator	1997-2000	2001-2003	2004-2007	2008-2009	2010-2013	2014-2015
Labour productivity, LP	1.0368	1.0203	1.0343	0.9763	1.0224	1.0304
Capital productivity, CP	0.9836	1.0168	0.9810	1.0533	1.0114	0.9899
Total factor productivity, TFP	1.0143	1.0161	1.0113	1.0121	1.0218	1.0097
capital-labour ratio, CLR	1.0620	1.0062	1.0578	0.9271	1.0101	1.0612
real unit labour costs, RULC	0.9992	1.0011	0.9973	1.0243	0.9948	0.9868

Source: Own calculations based on the data of Eurostat

Table 4 Relationships between indicators – Group 1

Number	Periods	
1	1996-2000	$I_{LP} \rangle I_{TFP} \rangle 1 \rangle I_{RULC} \rangle I_{CP}$
2	2000-2003	$I_{LP} \rangle I_{CP} \rangle I_{TFP} \rangle I_{RULC} \rangle 1$
3	2003-2007	$I_{LP} \rangle I_{TFP} \rangle 1 \rangle I_{RULC} \rangle I_{CP}$
4	2007-2009	$I_{CP} \rangle I_{RULC} \rangle I_{TFP} \rangle 1 \rangle I_{LP}$
5	2009-2013	$I_{LP} \rangle I_{TFP} \rangle I_{CP} \rangle 1 \rangle I_{RULC}$
6	2013-2015	$I_{LP} \rangle I_{TFP} \rangle 1 \rangle I_{CP} \rangle I_{RULC}$

Source: Own calculations based on the data of Eurostat

The period of decreasing GVA growth rates for the first group of countries (periods 2 and 4 and 5) can be described by these facts:

In these periods, the two highest annual growth rates of capital productivity can be noted, which is obviously induced by considerable investments in the previous periods (especially in period 4 GVA decreases slower than investment (GVA – decline to 2.8%; C – decline to 7.7%). Probably for this reason, total productivity is still slightly growing. However, labour productivity lags behind and, in period 4 on average, the labour productivity growth rate is declining annually, due to the crisis in 2009.

In Tables 5 and 6, the same indicators are monitored for the second group of countries, including the Czech Republic, and the relations between them.

Table 5 Average annual growth rates of indicators - Group 2

Indicator	1997-2000	2001-2003	2004-2007	2008-2009	2010-2013	2014-2015
Labour productivity, LP	1.0248	1.0523	1.0448	1.0002	1.0330	1.0250
Capital productivity, CP	0.8958	1.0403	0.9759	1.0413	1.0222	0.9667
Total factor productivity, TFP	1.0268	1.0295	1.0126	1.0269	1.0403	0.9950
capital-labour ratio, CLR	1.0620	1.0321	1.0689	0.9366	0.9746	1.0599
real unit labour costs, RULC	0.9968	1.0027	0.9969	1.0161	0.9939	0.9937

Source: Own calculations based on the data of Eurostat

Table 6 Relationships between indicators – Group 2

Number	Periods	
1	1996-2000	$I_{TFP} \rangle I_{LP} \rangle 1 \rangle I_{RULC} \rangle I_{CP}$
2	2000-2003	$I_{LP} \rangle I_{CP} \rangle I_{TFP} \rangle I_{RULC} \rangle 1$
3	2003-2007	$I_{LP} \rangle I_{TFP} \rangle 1 \rangle I_{RULC} \rangle I_{CP}$
4	2007-2009	$I_{CP} \rangle I_{TFP} \rangle I_{RULC} \rangle I_{LP} \rangle 1$
5	2009-2013	$I_{TFP} \rangle I_{LP} \rangle I_{CP} \rangle 1 \rangle I_{RULC}$
6	2013-2015	$I_{LP} \rangle 1 \rangle I_{TFP} \rangle I_{RULC} \rangle I_{CP}$

Source: Own calculations based on the data of Eurostat

Some differences appear in the second group of countries, i.e. countries for which lower labour productivity was reported in 1996, which can be due to the fact, that most of these national economies are linked up with the economies of the first group of countries. Therefore, they undergo the same stages of the real business cycle with some delay and often with lower intensity. It is obvious that:

1) The average rate of labour productivity grows in all periods (in period 4, when a worldwide decline was reported, the annual rate shows no change). The growth rate of labour productivity in the 2nd and 3rd periods exceeds the growth rate of total productivity and capital productivity, even with the constant growth of capital-labour ratio.

2) A slightly negative development of relations between indicators appears in period 4. In this period, the relations between indicators develop similarly to the first group of countries. A slightly positive development is obvious in periods 5 and 6.
3) RULC in this group of countries tend to develop similarly to the first group, i.e. it tends to decrease slightly in all periods except for period 4, known as a worldwide crisis period. In this period RULC grows annually by 1.61% on average, meaning that the compensations of employees do not respond to the decline of gross value added promptly which leads to cost remanence.

The third group of countries (countries with the worst starting position at the beginning of the survey) show patterns corresponding to the second group of countries in some features (Tables 7 and 8):

1) Labour productivity in the first three periods reaches the highest annual growth in all groups of studied countries (3.49% to 10.73%). In this period, these countries invest, i.e. the capital-labour ratio grows by more than 13% (in period 3 by 18.9%). Therefore, capital productivity declines and total productivity levels off. The average annual growth of labour productivity is always higher than the growth rate of real unit labour costs, except in period 4. In period 4 of the worldwide crisis, labour productivity still increases by 2.55%. The capital productivity grows significantly (by 16%).
2) The average annual growth of labour productivity is always (except for period 4) higher than the growth rate of real unit labour costs (RULC).

Table 7 Average annual growth rates of indicators - Group 3

Indicator	1997-2000	2001-2003	2004-2007	2008-2009	2010-2013	2014-2015
Labour productivity, LP	1.0349	1.0993	1.1073	1.0255	1.0563	1.0483
Capital productivity, CP	0.9945	0.9485	0.9049	1.1629	1.0143	0.9995
Total factor productivity, TFP	0.9946	1.0123	0.9941	1.0934	1.0279	1.0219
capital-labour ratio, CLR	1.1546	1.1366	1.1890	0.8426	1.0578	1.0225
real unit labour costs, RULC	1.0000	0.9887	1.0117	1.0295	0.9808	1.0283

Source: Own calculations based on the data of Eurostat

Table 8 Relationships between indicators – Group 3

Number	Periods	
1	1996-2000	$I_{LP} \rangle 1 = I_{RULC} \rangle I_{TFP} \rangle I_{CP}$
2	2000-2003	$I_{LP} \rangle I_{TFP} \rangle 1 \rangle I_{RULC} \rangle I_{CP}$
3	2003-2007	$I_{LP} \rangle I_{RULC} \rangle 1 \rangle I_{TFP} \rangle I_{CP}$
4	2007-2009	$I_{CP} \rangle I_{TFP} \rangle I_{RULC} \rangle I_{LP} \rangle 1$
5	2009-2013	$I_{LP} \rangle I_{TFP} \rangle I_{CP} \rangle 1 \rangle I_{RULC}$
6	2013-2015	$I_{LP} \rangle I_{RULC} \rangle I_{TFP} \rangle 1 \rangle I_{CP}$

Source: Own calculations based on the data of Eurostat

The tables 9 and 10 illustrate the average growth rates of the monitored indicators and the relationships between them in the EU (EU 28). The inequality in the period 4 (global economics crisis) shows a high level of consensus with the inequalities of all three groups of countries. The differences can only be seen in the dynamics of the indicators (The group 1 is characterized by the highest decrease of indicators). In the post-crisis period (Period 5) is obvious the increase of efficiency of production factors (both partial I_{LP}, I_{CP} and total I_{TFP}), i.e. all productivity indices were greater than 1. The differences between groups of countries are in the position productivity indices in relevant inequality.

The periods of higher growth (the period 3 and 6) are characterized by a system of inequalities $I_{LP} \rangle I_{TFP} \rangle 1 \rangle I_{RULC} \rangle I_{CP}$ (Table 10). This inequality exists for each group of countries with minor differences, based on the level and dynamics of the indicators.

Table 9 Average annual growth rates of indicators – EU (28 countries)

Indicator	1997-2000	2001-2003	2004-2007	2008-2009	2010-2013	2014-2015
Labour productivity, LP	1,0429	1,0282	1,0378	0,9806	1,0262	1,0309
Capital productivity, CP	0,9876	1,0175	0,9798	1,0513	1,0145	0,9929
Total factor productivity, TFP	1,0165	1,0232	1,0098	1,0131	1,0207	1,0129
capital-labour ratio, CLR	1,0559	1,0105	1,0593	0,9327	1,0115	1,0383
real unit labour costs, RULC	1,0020	0,9983	0,9948	1,0177	0,9975	0,9964

Source: Own calculations based on the data of Eurostat

Table 10 Relationships between indicators – EU (28 countries)

Number	Periods	
1	1996-2000	$I_{LP} \rangle I_{TFP} \rangle 1 \rangle I_{RULC} \rangle 1 \rangle I_{CP}$
2	2000-2003	$I_{LP} \rangle I_{TFP} \rangle I_{CP} \rangle 1 \rangle I_{RULC}$
3	2003-2007	$I_{LP} \rangle I_{TFP} \rangle 1 \rangle I_{RULC} \rangle I_{CP}$
4	2007-2009	$I_{CP} \rangle I_{RULC} \rangle I_{TFP} \rangle 1 \rangle I_{LP}$
5	2009-2013	$I_{TFP} \rangle I_{LP} \rangle I_{CP} \rangle 1 \rangle I_{RULC}$
6	2013-2015	$I_{LP} \rangle I_{TFP} \rangle 1 \rangle I_{RULC} \rangle I_{CP}$

Source: Own calculations based on the data of Eurostat

DISCUSSION AND CONCLUSION

The analysis demonstrates diverse development and response patterns of the productivity indicators in the observed groups of the EU countries, to the real business cycle during the years 1996-2015. In general, the starting positions of the states, as a standpoint for their division into groups, will obviously determine the dynamics of the indicators. The hypothesis that the development of labour productivity in the 3 established groups of countries, and at the periods of the real business cycle differs statistically significantly, was verified based on a two-factor ANOVA test.

The analysis of one-factor productivities shows that the rate of labour productivity grows in the same periods when GVA grows, i.e., economic output measured by gross value added grows faster than the amount of labour as a factor of production, measured by the number of employees. It holds true in all the 3 groups of countries. A rather different situation is seen regarding capital productivity. The dynamics of capital productivity decreases in the periods when the growth of GVA is increasing in the EU on average. In some groups of countries, the intensity of growth rate differs but the trends are the same. Hence, the growth rate of gross fixed capital formation is higher than the growth rate of the output (gross value added). This may be due to investments into capital with lower production capacity, and to time delay. In the periods of decreasing growth rates of gross value added, the tendency and intensity of one-factor productivity indicators (labour productivity, capital productivity) are inverse. This situation is explained, among other things, by the relationship between individual indices, as described in the methodology.

Focused on the various groups of countries, the first group (countries with the highest initial GVA per worker, i.e. higher than 100% of the EU average) most exactly corresponds to the annual average dynamics of the l EU as a whole. A strong relationship to the business cycle is obvious in the dynamics of the indicators of capital-labour ratio, capital productivity and labour productivity. The annual average growth of labour productivity exceeds the dynamics of real unit labour costs except for the crisis years 2007-2009, and so it has an anti-inflationary effect. On the contrary, the total factor productivity (TFP) keeps growing constantly, regardless of the business cycle.

Some differences are obvious in the second group of countries, including the Czech Republic and other states that accessed EU in 2007. In these countries, GVA per worker ranged between 50 – 100% of the EU average in 1996. Many national economies in this group are connected to the economies of the first group of countries, which can lead to some delay or lower intensity while undergoing the business cycle. Regardless of the business cycle, labour productivity and gross value added grow faster than capital productivity and the stable capital stock per worker in the first three monitored periods, until most of these states joined the EU. The output growth rate was higher than the input growth rate when capital, as a factor of production, grew faster than labour. The last three studied periods (2007-2009, 2010-2013, 2013-2015) are characterised by a lower growth rate of gross fixed capital, which could lead to growing capital productivity and total factor productivity (except for the period 2013-2015). The growth was initiated by labour productivity in the first three periods, and, by the following growth of capital productivity.

The third group of countries (having less than 50% of GVA per worker of the EU average) tend to develop similarly to the second group, with high labour productivity growth rates in the first three periods (in period 2003-2007 the annual growth rate was 10.73% which was the highest average annual growth rate) and steep growth of capital-labour ratio, which caused a decline in the growth rate of capital productivity, while TFP remained stable. Changes of the business cycle are not so obvious in these economies, as labour and capital productivity still continue to grow in periods of the worldwide economic decrease.

The analysis of the patterns of selected indicators for the groups of countries over the 20 years has shown that economic growth should remain in state of "economic normal" with slight modifications: This relation of the indicator trend can be confirmed by the development of the first group of countries ("old" Member States). In the other two groups there are various modifications resulting from the different initial positions of the economies of the countries regarding the level of GVA per worker, often showing higher intensity of trends and higher fluctuations). This conclusion is confirmed by Kutan & Yigit (2007), stating that in the new EU Member States productivity growth and convergence rates increase with the integration into the EU.

An example is the third group of countries, in which real unit labour costs are growing, but at the same time, labour productivity growth rate is higher than the growth rate of unit labour costs. The analysis demonstrates that cyclic economic fluctuations influence the effectiveness of utilisation of the production factors, and this confirms previous results (Aghion & Saint-Paul 1998); however, other factors such as the initial levels of monitored indicators also play an important role. States with inferior initial positions grow more intensively in productivity and the business cycle does not affect their productivity so much. Gradual convergence to the EU average seems to be reasonably expected from this analysis.

Acknowledgement

This paper was supported by the Grant Agency of Faculty of Economics, the University of South Bohemia IGS13C1.

REFERENCES

Adamowicz, E., & Walcyk, K. (2011): Cyclical Fluctuations of Business Activity in the New EU Countries. *Transformation in Business & Economics,* 10(2A), 440-451.

Aghion, P., & Saint-Paul, G. (1998). Uncovering some causal relationships between productivity growth and the structure of economic fluctuations: a tentative survey. *Labour*, 12(2), 279-303.

Barro, J. R., & Sala-i-Martin, X. (2004). *Economic growth*. London: The MIT Press.

Bhattacharjee, A., de Castro, E., & Jensen-Butler, C. (2009). Regional variation in productivity: a study of the Danish economy. *Journal of productivity analysis*, 31(3), 195–212.

Ciegis, R., Jurgaityte, R., Rakickas, A., & Kareivaite, R. (2008). The Analysis of Socio-Economic Progress and Future Perspectives in the New EU Members. *Transformations in Business & Economics*, 7(2), 34-54.

Costello, D. M. (1993). A cross-country, cross-industry comparison of productivity growth. *Journal of Political Economy*, 101(2), 207-222

Crespi, F., & Pianta, M. (2008). Diversity in innovation and productivity in Europe. *Journal of Evolutionary Economics*, 18(3), 529-545.

Chen, W., & Inklaar, R. (2016). Productivity spillovers of organization capital. *Journal of Productivity Analysis,* 45(3), 229-245.

Coelli, T. (2005). *An Introduction to Efficiency and Productivity Analysis*. New York: Springer.

Evans, C. L. (1992). Productivity shocks and real business cycles. *Journal of Monetary Economics,* 29(2), 191-208.

Cuadrado-Roura, J. R., Mancha-Navarro, T., & Garrido-Yserte, R. (2000). Regional productivity patterns in Europe: An alternative approach. *Annals of Regional Science, 34*(3), 365-384. doi: 10.1007/s001680000019

Färe, R., Grosskopf, S., Norris, M., & Zhang, Z. (1994). Productivity growth, technical progress, and efficiency change in industrialized countries. *American Economic Review*, 84(1), 66-83.

Fried, H. O., Lovell, C., Schmidt, S., & Yaisawarng, S. (2002). Accounting for environmental effects and statistical noise in data envelopment analysis. *Journal of productivity Analysis*, *17*(1), 157-174.

Gali, J. (1999). Technology, employment, and the business cycle: do technology shocks explain aggregate fluctuations? *American economic review*, *89*(1), 249-271.

Gobel, C., & Zwick, T. (2012). Age and Productivity: Sector Differences. *Economist-Netherlands, 160*(1), 35-57. doi: 10.1007/s10645-011-9173-6

Harper, M. J., Moulton, B. R., Rosenthal, S., & Wasshausen, D. B. (2009). Integrated GDP-Productivity Accounts. *American Economic Review,* 99**,** 74-79.

Hebák, P. (2007). *Vícerozměrné statistické metody*. Prague: Informatorium.

Hoffmann, V. (1992). Úvod do podnikové ekonomiky: ředitelská analýza 2. Praha: Český komitét pro vědecké řízení, 89 s.

Jílek, J. (2005). *Nástin sociálněhospodářské statistiky*. Prague: Oeconomica.

Konig, J. (2015). European Integration and the Effects of Country Size on Growth. *Journal of Economic Integration*, 30(3), 501-531.

Korcsmáros, E., Mura, L., & Šimonová, M. (2017). Identification of small and medium-sized enterprises development in Slovakia. *Journal of Applied Economic Sciences*, 12(6), 1702-1712.

Kydland, F. E., & Prescott, E. C. (1982). Time to build and aggregate fluctuations. *Econometrica*, 50(6), 1345-1370.

Kutan, A.M., & Yigit, T. M. (2007). European integration, productivity growth and real convergence. *European Economic Review*, 51(6). 1370-1395.

Le Gallo, J., & Dall'erba, S. (2008). Spatial and sectoral productivity convergence between European regions, 1975-2000. *Papers in Regional Science, 87*(4), 505-526. doi: 10.1111/j.1435-5957.2007.00159.x

Lengyel, B., & Szakálné Kanó, I. (2014). Regional economic growth in Hungary 1998–2005: What does really matter in clusters? *Acta Oeconomica*, 64(3), 257-285.

Mayer, E., Ruth, S., & Scharler, J. (2016). Total factor productivity and the propagation of shocks: Empirical evidence and implications for the business cycle. *Journal of Macroeconomics,* 50**,** 335-346.

Mesina, J., Strozzi, C., & Turunen, J. (2009). Real wages over the business cycle: OECD evidence from the time and frequency domains. *Journal of Economic Dynamics and Control,* 33, 1183-1200.

Montgomery, D., & Runger, G. (2007). *Applied Statistics and Probability for Engineers***.** Hoboken, N.J.: Wiley.

O'Mahony, M., Rincon-Aznar, A., & Robinson, R. (2010). Productivity growth in the US and the EU: A sectoral analysis. Review of Economics and Institutions 1(1). Retrieved from http://www.rei.unipg.it/rei/article/view/5 (accessed March 5, 2017).

O'Mahony, M., & Van Ark, B. (2003). *EU productivity and competitiveness: an industry perspective: can Europe resume the catching-up process?* Luxembourg: Office for Official Publications of the European Communities.

Praag, M., & Versloot, P. (2008). The Economic Benefits and Costs of Entrepreneurship: *A Review of the Research. Foundations and Trends in Entrepreneurship*, 4(2), 65-154.

Prescott, E. C. (1998). Lawrence R. Klein Lecture 1997: Needed: A Theory of Total Factor Productivity. *International Economic Review*, 39(3), 525-551.

Pušnik, K., &Tajnikar, M. (2010). Heterogeneity and Competitiveness of Entrepreneurial Processes in the European Union with Special Attention on Croatia as Candidate Country. *South East European Journal of Economics and Business*, 5(1), 7-18.

Rebelo, S. (2005). Real Business Cycle Models: Past, Present and Future*. Scandinavian Journal of Economics*, 107(2), 217-238.

Sabia, J. J. (2014). The Effects of Minimum Wages over the Business Cycle. *Journal of Labor Research,* 35, 227-245.

Saintpaul, G. (1993). Productivity growth and the structure of the business-cycle. *European Economic Review,* 37**,** 861-883.

Sala, H., & Silva, J. (2013). Labor productivity and vocational training: evidence from Europe. *Journal of Productivity Analysis*, 40(1), 31-41.

Smets, F., & Wouters, R. (2007). Shocks and frictions in US business cycles: A Bayesian DSGE approach. *American Economic Review,* 97**,** 586-606.

Solow, R. M. (1957). Technical change and the aggregate production function. *The review of Economics and Statistics*, 312-320.

Střeleček, F., & Lososová, J. (2003). An evaluation of the types of technical development in agriculture in the years 1995-2000. Agricultural Economics, 49(4), 151 - 165.

Suchy, M., Kolosta, S., & Koziak, R. (2015). Regional disparities in European Union in the pre-crisis and crisis periods. *18th International Colloquium on Regional Sciences*, 19-24. doi: 10.5817/cz.muni.p210-7861-2015-1

Travaglini, G. (2012). Trade-off between labor productivity and capital accumulation in Italian energy sector. *Journal of Policy Modeling*, 34(1), 35-48.