Hájek Jan,
PhD Student of the Faculty of Social Sciences,
Charles University in Prague (Prague, Czech Republic);
Hoeschle Felix,
PhD Student of the Department of Economics,
Ludwig-Maximilians-University Munich (Munich, Germany);
Bilan Yuriy,
PhD, Associate Professor of the Microeconomics Department,
University of Szczecin (Szczecin, Poland);
Strielkowski Wadim,
PhD, Research Associate of Cairnes School of Business and Economics,
National University of Ireland, Galway (Galway, Republic of Ireland)

ECONOMIC PERFORMANCE AND CONVERGENCE IN THE EUROZONE

This paper deals with determining the factors that impact the convergence of the Czech economy to the economy of Eurozone. Moreover, it attempts to determine the level of economic convergence in the EU using the β-convergence and σ-convergence techniques. The existence of this convergence is one of the necessary conditions for the creation of Monetary Union as stems from the Optimal Currency Area (OCA) theory. The paper employs the OCA theory as the key theoretical basis for empirical analysis and evaluates the cyclical and structural synchronization by the means of correlation coefficients of the GDP development, industrial production, inflation and interest rates. The results point out at the considerable level of convergence of the Czech economy (except the shock analysis), even though the values seem to be overvalued due to the recent economic and financial crisis.
Keywords: economic convergence, transformation, β-convergence, σ-convergence transition, Optimal Currency Area, financial crisis, European Union, Czech Republic.

Introduction. The Accession Treaty with the European Union (EU) made the Czech Republic to accept the single European currency and thus to enter the European Monetary Union (EMU) in some foreseeable time frame [55]. However, in order to enter the EMU the Czech economy needs to fulfil formal criteria (commonly known as Maastricht criteria). The formal criteria were just one of the conditions that had to be taken into consideration mainly because the EMU accession presupposed that that applicant country would give away its autonomous position in terms of monetary policy-making. This is of course a considerable loss for policymakers and therefore it might be desirable to keep the costs of entering the EMU at the lowest possible level, see e.g. [3; 4; 14; 16-18; 32; 37; 41-43].

The EMU entrance criteria are closely connected with achieving the certain level of economic convergence between the entrant and the incumbents (in this case the EMU current members) and therefore are based on the principles of the Optimum Currency Area (OCA) theory, see e.g. [1; 16; 29; 44; 45].

In the past, there were several attempts to analyze the convergence in the EU (for various countries and groups of countries) with varying degree of success, see e.g. [2; 34-36; 51-53]. Convergence intuitively means that the difference between two or more variables over time decreases and becomes negligible – i.e. converges to zero. One can examine the process of convergence between several variables over time based on the development of a standard deviation, or variance [21; 23; 30]. For two variables, this would mean to monitor the

difference of these two variables. The next step would be to show that this measure does not converge or converges to zero. For two countries this would show that this inequality is valid:

$$|y1,t - y2,t| > |y1,t+s - y2,t+s|, \qquad (1)$$

where $y1,t$ and $y2,t$ yield relevant economic values of countries 1 and 2 in time t and the convergence in question is measured as the difference between times t and $t+s$.

Absolute convergence stemming from the neoclassical growth model implies that countries with lower levels of real GDP per capita exhibit higher growth rates, without this being subject to other characteristics of the economies [10-12; 15; 22; 26; 46; 57]. This conclusion comes from the higher rates of convergence to the same steady state for economies that are further away. In the very simple model, where technology represents a constant (e.g. Cobb – Douglas production function $Y(t) = K(t)α(A(t)L(t))1-α)$, the income per capita growth in the constant state equals to zero and the level of income under this constant state is either positive or negative for lower (or higher) income levels than the corresponding steady state. For more complex models (e.g. Solow or Ramsey models) with the technology increasing in time, the rate of growth of income per capita equal to the growth of technology and under constant condition is higher or lower over him. In any case, the rate of approaching a steady state is an increasing function of output and output gap in a constant state [6].

In the concept of conditional convergence the unrealistic assumption of constant and identical steady states for different states of the economy is lifted. This is due to the fact that the economies grow faster, the greater the difference between the output in steady state output and pursued output. In addition, it is possible to find cases where countries with higher per capita income grow faster than countries with lower levels of income per capita. Therefore, convergence is preconditioned by "controlling" of variables that lead to various steady states (rate of savings, parameters of production function, governmental policies affecting the location of production functions, etc.).

According to the concept of β-convergence, poorer countries (i.e. countries with lower income per capita) grow faster than richer countries, see e.g. [13; 56]. The concept of β-convergence can be defined by the following formula:

$$yi,T - yi,0 = α1 - β1·βi,0 + εi, \qquad (2)$$

where i is the number of observation (a country), 0 and T are time periods. β-convergence assumes the positive value of β1. If all countries had the same steady state $α1$ and the time frame was long enough so all the countries could converge to it, $β1$ would be equal to 1. The coefficient $β1$ yields how big is the difference that the countries would be able to eliminate respective to the steady state on average. Surely, we suppose that that in the steady state the growth per capita equals to 0.

Moreover, the concept of σ-convergence means reducing the level of "dispersion" of the income per capita (i. e. variance or standard deviation) between economies in a given period of time. To avoid the effect of random fluctuations which have only a transient effect between the time periods t and $t + 1$, $σ$ - convergence defines the following relationship:

$$\delta_t^2 \rangle E\left[\delta_{t+1}^2\right], \qquad (3)$$

or, ex post, this can be written as follows:

$$\delta_{t-1}^2 \rangle \delta_t^2, \tag{4}$$

The OCA theory focuses on provisions of currency areas and, therefore, it is the key theoretical basis of the proposed analysis.

The aims of the article is to evaluate one of the conditions of the OCA theory – the convergence criterion. This paper is organized as follows: the first part briefly outlines the OCA theory. The second part focuses on the methodology used in our analysis, while the results of the analysis itself are presented in the third section. The final part of the paper provides conclusions and discussions of the main results.

Analysis of recent research and publications. The term "Optimum Currency Area" (OCA) was coined by Robert Mundell (1961) when the author attempted to create a definition based to the idea of mobile factors. He claimed that if the mobility of factors in the region was sufficiently high while it was low outside the area, it could have replaced the variability of exchange rate [50]. Therefore, the floating exchange rate regime would no longer be the desirable system, see e.g. [8; 27; 28; 38; 40; 48].

Ronald McKinnon extended the Mundell's idea in McKinnon by raising the question what country would be an ideal candidate for entering the optimum currency area. In accordance with this, he focused on the openness of the economy and he concluded that countries with more open economy are much better candidates for forming an optimum currency area mainly because it is beneficial for open economies to lower the variability of exchange rate as much as possible and, secondly, because of the fact that higher fraction of international trade on country's GDP implies higher fraction of foreign goods on the domestic market.

Peter Kennen, an American economist, substituted Mundell's original (but not very realistic in the case of Europe) ideas of perfect factor mobility by an idea of diversification of products. Kennen claimed that highly diversified economies are good candidates for forming an optimum currency area because the potential good-specified shocks will be either symmetric or their impacts will be substantially low. That is due to the diversification and the similarity of goods [5].

The three abovementioned authors are considered to be the founding fathers of the OCA theory. However, the OCA theory built in the 1960s had to face future critique of incorrect assumption of Phillips curve in Mundell's model. Another critique aimed at losses caused by migration of the labour force or at information barrier that economic subjects have to face in terms of the length of the shock and, eventually, the OCA theory did not get away of the famous Lucas critique [19].

The reaction on the growing criticism came in the late 1990s in a paper written by the two American economists Jeffrey Frankel and Andrew Rose [31]. They created the idea of endogeneity framework which says that maintaining of the currency area formed by countries not fulfilling the criteria of OCA ex-ante will lead the area into OCA ex-post due to many integration processes and substantially higher level of trade among them [31].

The early theories on OCA by Mundell, Kennen, and McKinnon based their predictions on Keynesian macroeconomic theory and were fairly pessimistic. They predicted very high costs caused by rising unemployment due to the shocks. This view was, however, moderated by the monetarists in the 1970s, who claimed that workers focus on real (rather than nominal) wages and the adverse effects are not so strong [47].

One of the setbacks of the OCA theory is that it only provides the axes, along which we can assess whether countries should form a currency union. It does not specify any threshold they need to surpass in order to become successful. Even though some authors tried to develop

indices [31] and several countries used the OCA criteria (either implicitly or explicitly) to decide whether they should join the Eurozone [5; 25], none of the measures was widely accepted and the concept of OCA still refrains from providing any definitive answers.

One of the findings that changed the way we look at the OCA criteria was the endogeneity theory of Frankel and Rose. In this theory, using a sample of 20 OECD countries, they developed an empirical link between the intensity of trade between countries and their business cycle synchronization. The following logic was that by joining a currency union the costs of international trade decreased, the volume increased, and the business cycle synchronization followed.

This, along with the actual launch of the Eurozone project in 1999 and 2002, provided a new impulse to the economists who concerned themselves with currency unions. Several of them analyzed this issue, refining the theory and using different sources of data. Fidrmuc used a dataset from the 1990s and focused on the intra-industry trade. While his model did not detect any link between general trade volume and the business cycles, he found significant evidence that intra-industry trade induces business cycle convergence. Schiavo confirms the endogeneity specifically on the European financial markets and shows that capital markets integration increases the output correlation between countries.

On the other hand, Matthes claims that the endogeneity force has been offset by divergence inducing effects, especially the real interest rate decrease in the outset of the European monetary union. Others contrast the OCA endogeneity theory with the specialization theory which claims that integration pushes countries towards a more specialized production [49]. Such shift would make the currency union members less diversified and more vulnerable to supply shocks.

Some authors adopt a more conservative stance and point out that one should try and carefully distinguish the effects of different EU-wide developments (be it initiatives or policy choices) and the effect of Euro itself [54; 58]. They claim that only further research can show the real endogeneity effects, aligning with some of the original claims of Frankel and Rose (1998) who admitted that the effects could take decades to truly manifest.

One of the most important contributions on OCA theory in the Central and Eastern Europe was done by the prominent Hungarian economist Julius Horváth in his "Optimum currency area theory: a selective review" [39].

Basic material. Mundell's original condition for the Optimal Currency Area to work had been replaced under the weight of criticism by the request of synchronization of business cycles and economic shocks that come into economies [20]. Therefore, our paper focuses on cyclical and structural aspects of the synchronization among the Czech economy and the economy of the Eurozone.

The synchronization of business cycles is estimated on 3 data sets, in detail it is GDP per capita in Purchasing Power Parity (PPP), GDP growth rate and Industry Production Index (IP). Seasonally adjusted data was obtained at Eurostat database and by using Hodrick-Prescott (HP) filter for the cyclical data. In terms of the time specification of data sets, GDP per capita in PPP data has a year periodicity starting in 2000 and ending in 2011, while the other two data sets are measured quarterly starting in 2000:Q1 and ending in 2012:Q2.

As for the structural similarities that affect the convergence of economies, we based our analysis on the 3 data sets: i) inflation measured as HICP, ii) 3-month money market interest rates (short-term rates), and iii) EMU convergence criterion bond yields (long-term rates). These three data sets were obtained from the Eurostat database and have a month periodicity starting at January 2000 and ending in September 2012.

The sample for all data sets includes all 27 members of EU. In order to determine the level of convergence among the tested countries, a simple correlation analysis was employed. The analysis uses the standard correlation coefficient measured as:

$$corr_{xy} = s_{xy}/\sqrt{\sigma_x^2 \sigma_y^2}, \tag{5}$$

where s_{xy} is an estimate of covariance, while σ_x and σ_y are estimates of standard errors of time series x and y [6; 7].

When testing the economic convergence in the EU, the data covering the time period of 18 years, from 1995 to 2012, is used. The sample is composed of all current EU members ("EU28"). We think that it is quite reasonable to assume that all the EU states are similar enough so that we can theoretically expect that there should be economic convergence among them, an assumption that would allow us to estimate σ-convergence as well as β-convergence.

Empirical model. *Correlation of economic activity.* The value of CZ-EA17 synchronization is almost -0.3 indicating negative convergence [33]. The same figure for CZ-DE synchronization is -0.42 which is even worse (Figure 1).
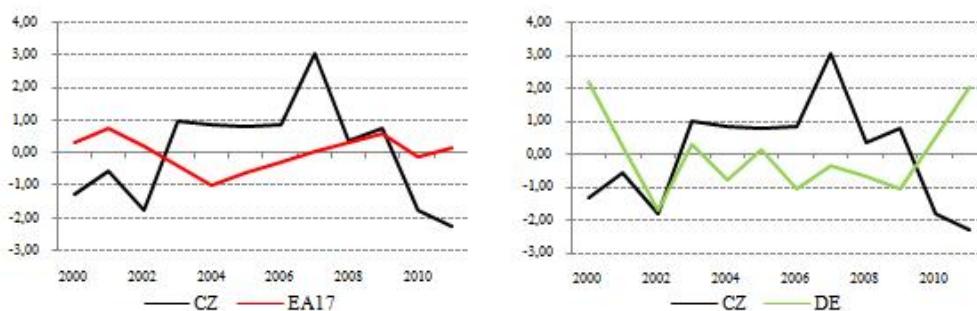
Note: CZ – Czech Republic, EA17 – members of Euro area

*Figure 1 –* **GDP per capita in PPP cycle** (authors' results)

As mentioned previously, GDP per capita in PPP is a tool for actual relevant comparison rather than for a cyclical synchronization analysis. On the other hand, from the figures in Table 1 can be extracted at least some trend notion – the situation for the Czech economy seem to improve gradually. GDP per capita in PPP convergence is long-term process and it is not likely to change substantially in the closest years. Moreover, financial crisis in 2008 seemed to put the convergence on hold, hopefully, it is just a temporary pattern [53].

Even though the GDP PPP values for Czech Republic are the highest among the other Central and Eastern European countries (CEECs), the Czech economy can be compared only with the least developed EA countries such as Portugal, Slovenia, or Slovakia [9; 55] (moreover, the Slovak economy experienced a fabulous growth over the last decade in terms of GDP per capita in PPP and, therefore, it is quite likely that the Slovakian GDP per capita in PPP figures will be the highest among CEEs in upcoming years).

In the field of GDP growth rate convergence, the situation is considerably different. CZ-EA17 correlation value accounts roughly for 0,81 indicating high level of synchronization. The situation of other countries is practically the same (Figure 2).

Table 1 – **GDP per capita in PPP (EA17 = 100)** (authors' results)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CZ	63,4	65,2	65,8	70,0	71,6	72,5	73,4	76,1	74,3	75,2	74,1	74,1
AT	117,9	112,5	114,4	116,4	117,4	114,7	115,6	113,8	113,8	114,7	116,7	119,4
DE	105,4	103,6	102,7	105,5	105,5	106,4	105,5	106,4	106,4	106,4	109,3	111,1
EE	40,2	41,1	45,0	50,0	52,3	56,9	60,6	64,2	63,3	58,7	59,3	62,0
PT	72,3	71,4	72,1	71,8	70,6	73,4	72,5	72,5	71,6	73,4	74,1	71,3
PL	42,9	42,0	43,2	44,5	46,8	46,8	47,7	49,5	51,4	56,0	58,3	60,2
HU	48,2	51,8	55,0	57,3	57,8	57,8	57,8	56,9	58,7	59,6	60,2	61,1
SK	44,6	46,4	48,6	50,0	52,3	55,0	57,8	62,4	67,0	67,0	67,6	67,6
SL	71,4	71,4	73,9	76,4	79,8	79,8	80,7	80,7	83,5	79,8	78,7	77,8
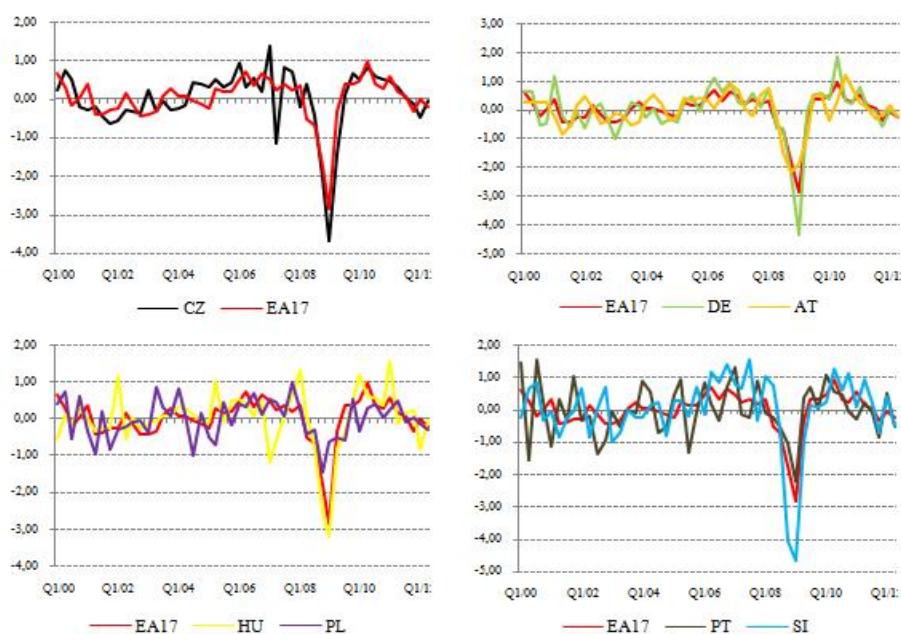
Note: CZ – Czech Republic, EA17 – members of Euro area; AT – Austria; DE – Germany, SI – Sweden, HU – Hungary, PT – Portugal, PL – Poland

Figure 2 – **GDP growth rate cycle** (authors'results)

Intuitively, from Figure 2 one can detect that the impact of crisis cannot be negligible. Thence, it appears to be interesting to see how much the correlation coefficients changed between the period without crisis (2000:Q1 – 2008:Q2) and the whole studied period.

Table 2 shows the effect of crisis on the level of convergence. In the case of CZ-EA17 and CZ-DE relation, the level of convergence more than doubled. Similar pattern applies for other countries included in the sample. The correlation coefficients for the whole period might be a bit overvalued due to crisis. Here, the industrial production index is included in the analysis because it is (as well as GDP growth rate) significant indicator of economic activity. Obtained results on the convergence level should not differ much from the previous case (Figure 3).

The level of synchronization seems to be even higher than in the case of GDP growth rate.

Table 2 – **Impact of financial crisis on the level of GDP growth rate cycle convergence**
(authors'results)

Country	EA17				CZ			
	Crisis not included	Crisis included	Diffe-rence	Percentage change	Crisis not included	Crisis included	Diffe-rence	Percentage change
EA17	1	**1**	0	100	0,3693	**0,8078**	0,4385	218,75
CZ	0,3693	**0,8078**	0,4385	218,75	1	**1**	0	100
DE	0,8653	**0,9558**	0,0906	110,47	0,2224	**0,7365**	0,5142	331,23
DK	0,246	**0,4944**	0,2484	200,97	0,3463	**0,5334**	0,187	154,01
EE	0,4338	**0,6792**	0,2454	156,58	0,4549	**0,689**	0,2341	151,46
LT	0,3926	**0,7517**	0,3591	191,45	0,1728	**0,6971**	0,5244	403,53
LV	0,3317	**0,6314**	0,2996	190,32	0,1913	**0,5883**	0,397	307,51
AT	0,5316	**0,7615**	0,2298	143,23	0,34	**0,6949**	0,3549	204,40
HU	0,1365	**0,7334**	0,5969	537,37	0,007	**0,6788**	0,6717	9668,86
PL	0,4223	**0,5072**	0,085	120,12	0,142	**0,4116**	0,2697	289,97
PT	0,2199	**0,5135**	0,2936	233,47	0,2407	**0,4618**	0,2211	191,84
Sl	0,3860	**0,8172**	0,4312	211,71	0,2541	**0,7537**	0,4995	296,56
SK	0,1751	**0,5978**	0,4227	341,37	0,2985	**0,6212**	0,3227	208,09
FI	0,5013	**0,7984**	0,2971	159,26	0,3279	**0,7106**	0,3828	216,75
SE	0,2721	**0,7086**	0,4365	260,45	0,4366	**0,7024**	0,2658	160,88

For both relations CZ-EA17 as well as CZ-DE the coefficient exceeds 0,9 which confirms the results of GDP growth rate correlations. The impact of crisis considerably affected coefficients. The amplitude of the change will be probably lower from the previous case.
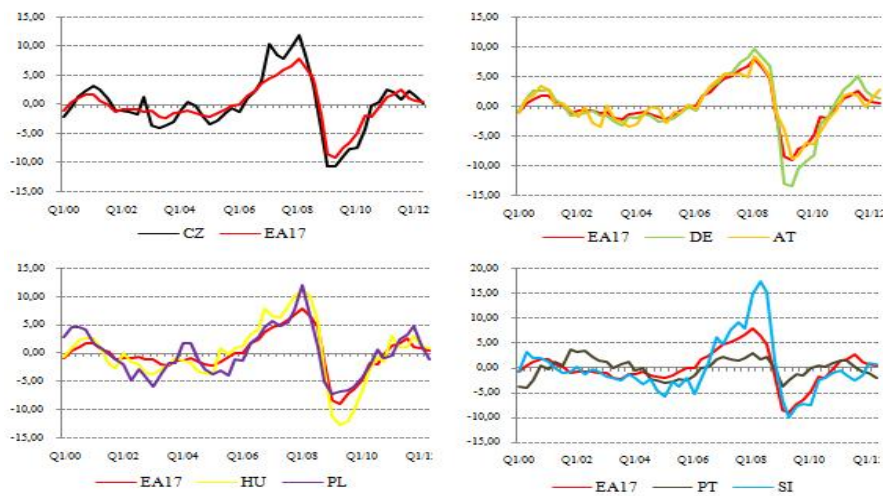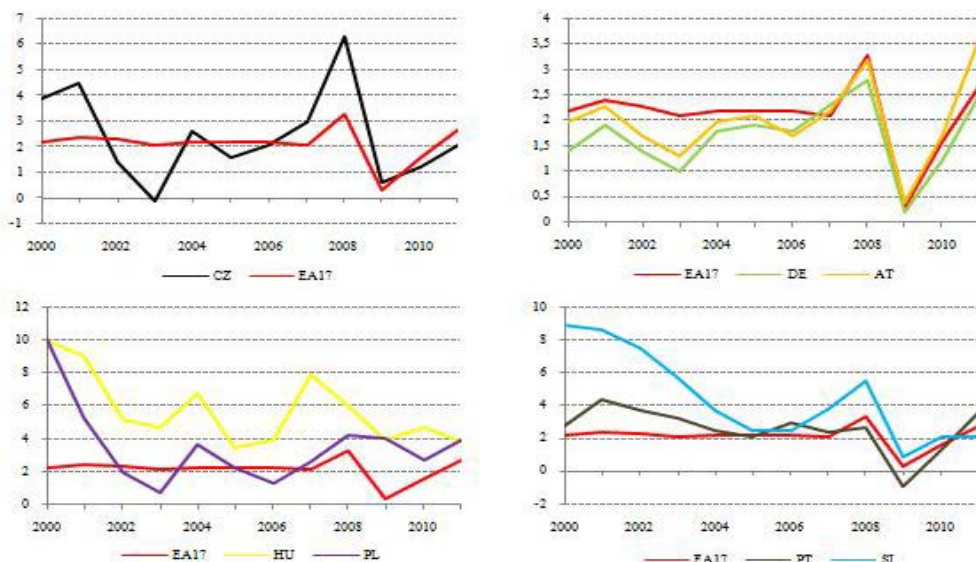

Note: CZ – Czech Republic, EA17 – members of Euro area; AT – Austria; DE – Germany, SI – Sweden, HU – Hungary, PL – Poland

Figure 3 – **Industrial production cycle,** (authors'results)

Correlation of the inflation rates. As mentioned above, in terms of structural similarities that affect the convergence level the core is the inflation (and interest rates) analysis. Correlation value for CZ-EA17 or CZ-DE is higher than 0,6 indicating considerable convergence. From the view on Figure 4, it becomes obvious that financial crisis (again) overvalued correlation coefficients. The same pattern applies for other European countries both for non-members of the EA.

Note: CZ – Czech Republic, EA17 – members of Euro area; AT – Austria; DE – Germany, SI – Sweden, HU – Hungary, PL – Poland

Figure 4 – **Inflation development (HICP y-o-y change)** (authors'results)

Correlation of interest rates. In the field of short-term interest rates, the situation is quite similar as in the case of inflation. Correlation is substantially high either for CZ-EA relation or relation of any other two EU member states. We think that it is not even much surprising – before the bubble burst central banks tried to take advantage of the situation by rising the interest rates up while after the bubble burst all of them tried to counterattack the drop off in commercial loans by lowering the interest rates. Figure 5 shows the 3-month money market interest rates for EA and Czech Republic and their Repo rates.
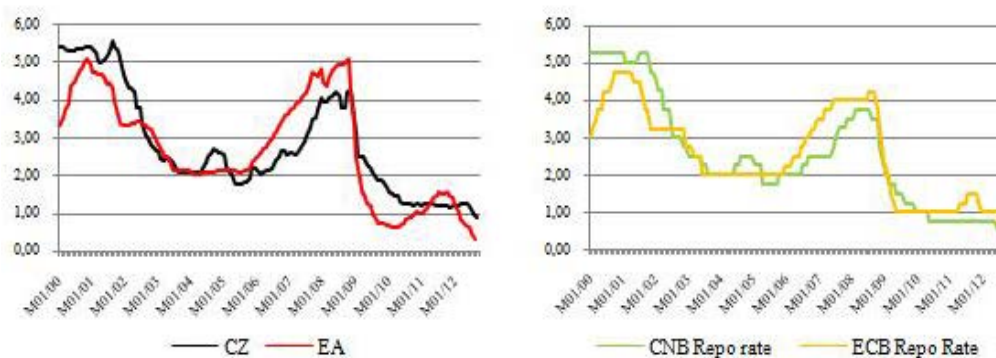

Note: CZ – Czech Republic, EA – economic area, CNB Repo rate – Repo currency rate of the Czech National Bank, ECB Repo rate – Repo currency rate of the European Central Bank

Figure 5 – **3-month money market rates and Repo rates development** (authors'results)

In 2008, Czech National Bank (CNB) lowered Repo rate from 3,75 to 3,5 percentage points, which was on the eve of the crisis quite unique act in Europe. Although, it remains unclear, whether this movement was intended to adjust the framework of the economy for upcoming crisis (as claimed by CNB) or to counterattack the strengthening of Czech Crown against Euro, the main message is that the weakening of Koruna helped the Czech economy making the export goods more competitive.

Taking a brief look on Figure 6, it is certain that the convergence level of long-term interest rates across the EU worsened considerably as an outcome of the crisis (after mid-2008, interest rate differentials among most of the EU countries started to be significantly positive because of the risk evaluation change making it more detailed and 'individually' based than before crisis. In other words, it was no longer possible for peripheral countries such as Greece or Portugal to borrow money for German long-term interest rates just because they are part of Eurozone. This phenomenon is referred to as decoupling).
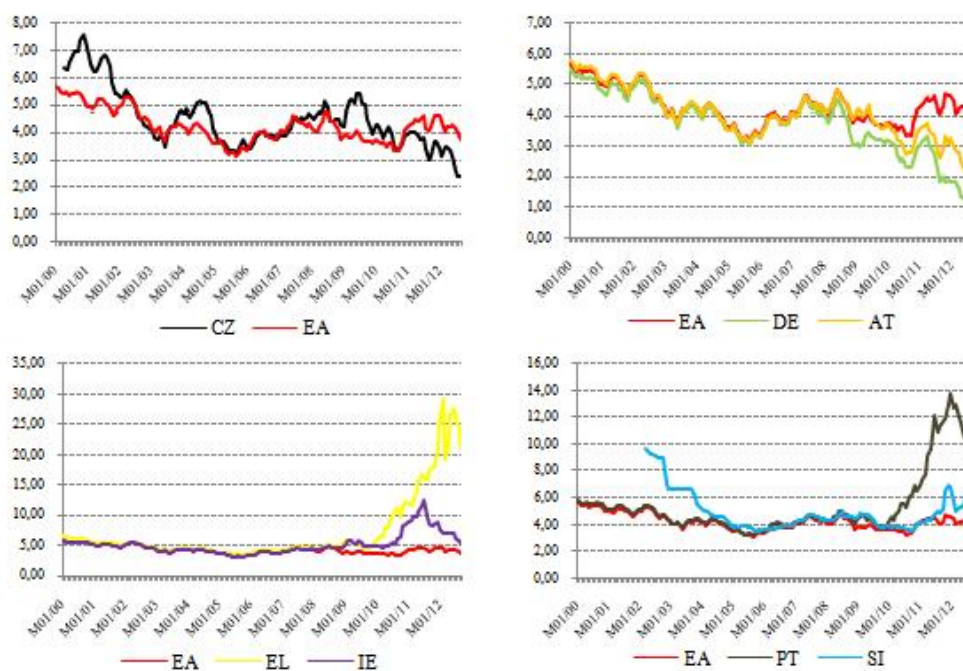
Note: CZ – Czech Republic, EA – members of Euro area; AT – Austria; DE – Germany, E – Greece, IE – Ireland, PT – Portugal, SI – Sweden

Figure 6 – **10-year bond yield development**

Correlation coefficients for CZ-EA17 and CZ-DE relations are 0,25 and 0,64 respectively. However, in this case, comparing blindly the Czech long-term interest rates and the ones of EA could be a bit misleading with EA being so heterogeneous after 2008. Therefore, it could be useful to subtract the influence of peripheral countries (we used the term 'peripheral' countries by which I mean countries that economically do not belong to the core of the

Euro area ether from institutional or structural aspect. Spain is also included in the table, but because of the size of Spanish economy it is intuitive that Spain cannot be considered as peripheral economy as other countries in the table might (e.g. Greece, Portugal)) (Table 3). From this example, it is obvious that, after subtracting the influence of certain countries, both average and minimum correlation increases while the variance decreases.

Table 3 – **Influence of peripheral countries on the level of long-term interest rates convergence** (authors'results)

Group	Quantity	Average	Min	Max	Variance
EA	120	0,2591	-0,8035	0,9971	0,2864
EA/EL	105	0,3040	-0,6912	0,9971	0,2528
EA/EL&PT	91	0,3542	-0,5248	0,9971	0,2234
EA/EL&PT&ES	78	0,3890	-0,5248	0,9971	0,2237
EA/EL&PT&IE	78	0,4178	-0,5248	0,9971	0,2071
EA/EL&PT&CY	78	0,4230	-0,5072	0,9971	0,2000
CZ-EA	16	0,3074	-0,5359	0,8243	0,2300
CZ-EA/EL	15	0,3636	-0,4264	0,8243	0,1947
CZ-EA/EL&PT	14	0,4200	-0,2785	0,8243	0,1609
CZ-EA/EL&PT&ES	13	0,4640	-0,2785	0,8243	0,1462
CZ-EA/EL&PT&IE	13	0,4666	-0,2785	0,8243	0,1429
CZ-EA/EL&PT&CY	13	0,4738	-0,1857	0,8243	0,1328

Overall, it becomes apparent that these adjusted numbers appear to be more relevant for correlation analysis than the standard ones. And so, the same could be actually said about the whole correlation analysis that we attempt to perform here in general, despite the fact that it makes the calculations more difficult.

Synchronization of shocks. When it comes to the shocks (see Table 4), the CZ-EA convergence level of supply shocks is 0,3 pointing at certain level of convergence. On the other hand, zero convergence level in the case of demand shocks may indicate potential problems for Czech economy's acceptance of hypothetical monetary policy created by ECB, in a sense that if there is a demand shock, there is also no certainty that the reaction of ECB monetary policy would be optimal for Czech economy because economies of Eurozone and the Czech economy react in totally different way.

Table 4 – **Correlation of economic shocks with EA** (CNB (2011))

Country	Demand shocks		Supply shocks	
CZ	0,04		0,30	**
AT	-0,17		0,33	*
DE	0,61	***	0,83	**
PT	-0,11		-0,32	**
HU	0,14		-0,46	**
PL	-0,14		0,33	
Sl	-0,10		-0,51	**
SK	-0,07		-0,23	*

Note: significance levels: * $0.05 < p < 0.10$; ** $0.01 < p < 0.05$; *** $p < 0.01$

Testing for the economic convergence in the EU. It is usually estimated using the coefficient of variation which is a ratio of standard deviation and mean of data series, i.e. it is in the following form:

$$CV_t = standard\ deviation_t\ /\ mean_t\ ,\ t = 1,2,3,...,18. \tag{6}$$

The data used are for GDP per capita based on purchasing-power-parity, obtained from statistical database of the IMF and the World Bank. Then, the coefficient of variation is regressed on time. The regression is as follows:

$$CV_t = \alpha_0 + \alpha_1\ t + \varepsilon_t. \tag{7}$$

The result of estimation of this regression equation is shown in Figure 7. The coefficient on time is significantly negative (with p-value very close to zero), implying that the coefficient of variation is decreasing in time. In other words, the σ-convergence for EU27 in 1995-2012 is confirmed. However, it is useful to mention that there were also short periods of divergence, namely the second half of the 1990s and the crisis years 2009 and 2010.

y = -0,005x + 0,5236
R² = 0,8258

coefficient of variation
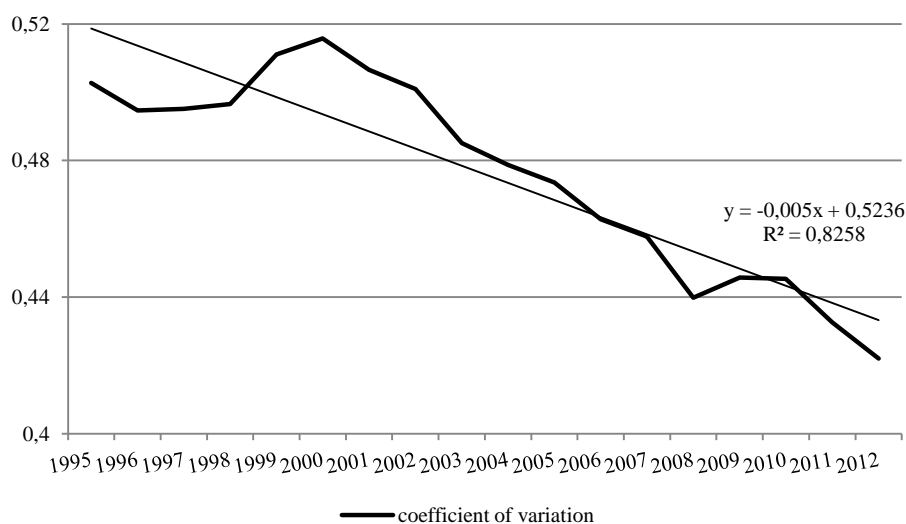
Note: y – dependent variable, R^2 – regression coefficient (squared)

Figure 7 – **Estimation of σ-convergence**

As far as the β-convergence is concerned, we estimate the simplest form of cross-sectional regression which appears in literature quite a lot. We regress average growth rate of GDP per capita at PPP over the period 1995-2012 on the initial level of GDP per capita. The regression equation is in the following form:

$$\frac{1}{T}ln\left(\frac{y_i}{y_i^0}\right) = \alpha + \beta\ ln(\ y_i^0\ ) + u_i, \tag{8}$$

where y_i is GDP per capita at PPP for member country i. If the coefficient on the initial level (the 1) will be significantly negative, the convergence will be confirmed. The results of estimation are presented in Table 5.

Table 5 – **Estimation of β-convergence** (authors'results)

Period	Coefficient	p-value	R^2	Convergence
1995-2012	-0,0194	0,000	59,74%	yes
1995-2003	-0,0147	0,005	26,86%	yes
2004-2012	-0,0223	0,000	48,79%	yes
1995-2007	-0,0220	0,000	49,77%	yes
2008-2012	-0,0091	0,149	7,85%	no
1995-1999	-0,0013	0,844	0,15%	no
2000-2007	-0,0321	0,000	63,84%	yes
2008-2012	-0,0091	0,149	7,85%	no

The estimation has revealed that the *I* coefficient is significantly negative (p-value is very close to zero) of value -0,0194 approximately. The R^2 of the regression is quite high, almost 60%, indicating a favourable goodness of fit. As a result, the analysis proved the convergence among EU27 states during time period of 1995-2012. The GDP per capita has grown at the fastest pace in the states with the lowest 1995 income p. c. (for example the Baltic countries). On the contrary, the opposite is true for the richer group of states. It means that the poor have been catching up with the rich.

With regard to the period in (a), one can see that the β-convergence occurred both before and after the Eastern enlargement in 2004 when 10 new countries (especially from Eastern Europe) entered the EU. However, the pace of converging trend was bigger from 2004 onwards. Moreover, the significance of the coefficient and also the goodness of fit are higher, indicating more robust convergence. Based on this, we probably can claim that the entry to the EU contributed to faster catching up. This statement was concluded also in Wunsch (2013).

The second period division, the division (b), is also very interesting, but not so surprising. A robust convergence is evidenced for the pre-crisis time span. The significance and R^2 are high and the absolute value of the coefficient is higher than for the whole period covered. The latter is explained by the result for 2008-2012. During the crisis, the analysis doesn't prove any convergence since the *I* coefficient is insignificant. Wunsch (2013) said about the situation in the EU that since the crisis the new member states have still been catching up as a group, but the South has diverged from the North. This could clarify my findings of no convergence. The last period division is added to check interconnection between the findings from the estimation of the σ-convergence and the β-convergence. In the sub-period 1995-1999, the coefficient on the initial level of income per capita is very insignificant, implying no convergence among the EU27 states during these years. This corresponds with the path of coefficient of variation which shows the existence of σ-divergence in the second half of the 1990s. By contrast, the time span 2000-2007 was a period of the fastest and most robust convergence among the current EU members. The bigger pace was driven mainly by faster growth in the new member states entering the EU in 2004, probably mostly thanks to preparations for the entry and the entry itself.

Testing beta convergence with panel data models. In order to deepen the analysis with regard to the β-convergence we further employ a panel data model that can be described in the following form:

$$Yit = \alpha + \beta yit + uit, \tag{9}$$

where *Yit* is the GDP per capita in country i at time t, and yit the corresponding GDP per capita growth.

We estimate the model with real GDP per capita and with GDP per capita data in terms of PPS to stay consistent with the previous analysis. Also, we estimate the model including data up until 2013 and also with data until 2007 to exclude possible effects of the crisis.

To take full advantage of the panel data set we use a random effects and a fixed effects estimator for every specification. Following that we conduct a Hausman-Test to indicate which estimators should be used. The Hausman-Test evaluates if a random effects estimator could be used or if a fixed effects estimator is required to avoid inconsistent. Our Hausman-Test rejects the null hypothesis which suggests that a random effects model would be biased and it is needed to use fixed effects estimators.

Table 6 shows significant negative coefficients for the relationship between GDP per capita levels in terms of PPS with random effects estimators. This is the case regardless whether the crisis is taken into account or not. Yet, the fixed effects estimators suggest the opposite. For both time spans the fixed effects estimators are significant and positive. Therefore, the random effects estimators suggest the existence of beta convergence. The random effect estimators suggest the opposite. Since we can conclude from the Hausman-Test that a random effects estimator should be biased Table 5 provides evidence against beta convergence.

Table 6 – **Results of a panel data model (GDP per capita in terms of PPS)** (authors'results)

2002-2013	β-coefficient	p-value	R2	Hausman-Test	convergence
Random Effects	-.0001822**	0.015	0.0744	Prob>chi2 = 0.0112	Hausman Test suggests fixed effect model
Fixed Effects	.0006517*	0.054	0.0744		
2002-2008	β coefficient	p-value	R2	Hausman-Test	convergence
Random Effects	-.0002625***	0.006	0.1683	Prob>chi2 = 0.0002	Hausman Test suggests fixed effect model
Fixed Effects	.0015511***	0.002	0.1683		
Dependent Variable: GDP per capita in Terms of PPS, Dependent Variable Real GDP per Capita.					

Note: significance levels: * $0.05 < p < 0.10$; ** $0.01 < p < 0.05$; *** $p < 0.01$

Table 7 shows the same coefficients based on real GDP per capita data. As in Table 6 we find significant negative random effects estimators that suggest the existence of β-convergence. The fixed effects estimators are also significant yet differ in terms of their sign, depending on whether we include the crisis or not. Here the fixed effects models suggest that there was β-convergence before the crisis, but not if the years past 2007 are included. Just as in the regressions underlying Table 5 we conclude from the Hausman-Test that a fixed effects estimator has to be used since the random effects estimator is likely biased.

The Hausman-Test concludes in both estimations that lead to Table 6 and 7 that the random effects estimator is biased and the fixed effects estimator has to be used. In result the panel data analysis suggests that there is no beta convergence or was removed by the crisis as shown in Table 7 were we perform the regression with only pre-crisis data.

Overall the existence of β-convergence remains doubtful after a careful application of panel data methods.

Table 7 – **Results of a panel data model (GDP per capita)** (authors'results)

2002-2013	β coefficient	p-value	R2	Hausman-Test	Convergence
Random Effects	-5.80e-07***	0.003	0.0354	Prob>chi2 =	Hausman Test suggests
Fixed Effects	.0000107***	0.000	0.1683	0.0001	fixed effect model
2002-2008	β coefficient	p-value	R2	Hausman-Test	convergence
Random Effects	-1.02e-06***	0.000	0.2208	Prob>chi2 =	Hausman Test suggests
Fixed Effects	-2.76e-06***	0.002	0.1683	0.5986	random effect model
Dependent Variable: GDP per capita in Terms of PPS, Dependent Variable Real GDP per Capita.					

Note: Significance levels: * $0.05 < p < 0.10$; ** $0.01 < p < 0.05$; *** $p < 0.01$

Conclusion and directions for further research. Our OLS analysis that was employed in order to determine the level of convergence between Czech economy and the economy of Eurozone as one of the necessary conditions for forming a Monetary Union as stated in the provisions of OCA theory, indicated certain level of convergence in all relevant studies variables. On the other hand, by the use of comparative statics it was shown that financial crisis considerably overvalued the convergence levels (except the long-term interest rates case).

Therefore, one has to keep in mind that the use of correlation analysis has certain limitations. Furthermore, the Czech economy is constantly not synchronized with the Eurozone in terms of demand shocks which might be seen as a potential problem.

As far as the international comparison goes, the Czech Republic is convergent with the core of Eurozone countries, possibly even more than some EA member states. This fact demonstrates the undisputable level of heterogeneity in the Monetary Union. In our opinion, this is the main problem that Eurozone experiences, since its beginnings and financial crisis proved that this issue cannot be neglected anymore.

When it comes to the existence of economic convergence among the current EU member states during the time period of 1995-2012, the main findings can be summarized as follows: There was σ-convergence during the whole period concerned among the EU27, with some shorter sub-periods of divergence (as in the late 1990s and in 2009-2010). Moreover, there is quite a robust evidence of the existence of β-convergence in 1995-2012 since the relatively poor states grew on average faster than the rich ones. The pace of catching up increased after the EU Eastern Enlargement in 2004. In addition, in the 1990s we detected no convergence, while in the pre-crisis 2000s we found evidence for the convergence being the fastest and the most robust. Since the start of the world economic and financial crisis (from 2008 onwards), the convergence was not detected.

As we deepen the analysis and employ a panel data approach with fixed effects estimators the case against convergence becomes more evident. We find that there is no evidence for beta convergence. This result holds strong both in terms of GDP per Capita with or without PPS no matter if the time window is including or excluding the crisis.

After both our OLS and fixed effects approach, it appears that it is optimal to keep the Czech crown as the national currency for some time yet although the level of convergence probably improves over time. One must not forget that the convergence analysis is not the only condition that should be taken into consideration for such a big step.

1. Ádám, Z., Bandasz, K., & Stavytskyi, V. (2011). The changing perspectives on systemic change and privatization in post-communist transition. *ActaOeconomica*, *61(2)*, 233-250 [in English].

2. Armstrong, H. (1995). Convergence among Regions of the European Union 1950-1990. *Papers in Regional Science, 74*, 143-152 [in English].

3. Artis, M., Marcellino, M., & Proietti, T. (2005). Business Cycles in the New EU Member Countries and their Conformity with the Euro Area. *Journal of Business Cycle Measurement and Analysis, 2(1)*, 7-41 [in English].

4. Babetskii, I., Boone, L., & Maurel, M. (2004). Exchange Rate Regimes and Shocks Asymmetry: The Case of the Accession Countries. *Journal of Comparative Economics, 32 (2)*, 212-229 [in English].

5. Baldwin, R., & Wyplosz, C. (2006): *European Economic Integration.* 2nd edition, McGraw-Hill Education [in English].

6. Barro R. (1991). Economic Growth in a Cross-section Countries. *Quarterly Journal of Economics, 106(2)*, 407-443 [in English].

7. Barro, R., & Sala-i-Martin, X. (1992). Convergence. *Journal of Political Economy, 100*, 223-251 [in English].

8. Bayoumi, T., & Eichengreen, B. (1997). Ever Closer to Heaven? An Optimum-Currency-Area Index for European Countries. *European Economic Review, 41*, 761-770 [in English].

9. Belas, J. (1998). Basic determinants and factors of the generation of savings in the national economy related to individual economic subjects, *EkonomickyCasopis*, *46(2)*, 264-279 [in English].

10. Belás, J., Bilan, Y., Demjan, V., & Sipko, J. (2015). Entrepreneurship in sme segment: Case study from the Czech Republic and Slovakia, *Amfiteatru Economic*, *17(38)*, 308-326 [in English].

11. Bernard, A.B., & Durlauf, S.N. (1995): Convergence in International Output. *Journal of Applied Econometrics*, *10(1)*, 97-108 [in English].

12. Cheung, Y., & Pascual, A.G. (2004). Testing for Output Convergence: a Re-examination. *Oxford Economic Papers, 56*, 45-63 [in English].

13. Clowes, D., & Bilan, Y. (2014). Tracking income per head in central-southern europe Country responses to the global downturn (2008-2012). *Economic Computation and Economic Cybernetics Studies and Research, 48(2)*, 257-270 [in English].

14. Galloppo, G., Paimanova, V., & Aliano, M. (2015). Volatility and Liquidity in Eastern Europe Financial Markets under Efficiency and Transparency Conditions. *Economics & Sociology*, *8(2)*, 70-92. [in English].

15. Cole, M.A., & Neumayer, E. (2003). The Pitfalls of Convergence Analysis: Is the Income Gap Really Widening? *Applied Economic Letters, 10*, 355-357 [in English].

16. Cuaresma J.C., Ritzberger-Grünwald, D., & Silgoner M.A. (2008). Growth, convergence and EU membership. *Applied Economics*, *40(5)*, 643-656 [in English].

17. Czasonis, M., Quinn, M. (2012). Income convergence in Europe: Catching up or falling behind? *ActaOeconomica*, *62(2)*, 183-204 [in English].

18. Darvas, Zs., & Szapáry, Gy. (2004). Business Cycle Synchronization in the Enlarged EU: Co-movements in the (Soon-to-Be) New and Old Members. *Magyar Nemzeti Bank (National Bank of Hungary)*, *Working Paper, 1* [in English].

19. De Grauwe, P. (1997). *The Economics of Monetary Union*, 3rd edition, Oxford University Press [in English].

20. Delgado-Rodriguez, M.J., & Alvarez-Ayuso, I. (2008). Economic Growth and Convergence of EU Member States: An Empirical Investigation. *Review of Development Economics, 12*, 486-497 [in English].

21. Dobrinsky R. (2006): Catch-up inflation and nominal convergence. The balancing act for new EU entrants. *Economic systems, 30(4)*, 424-442 [in English].

22. Dogan, N., & Saracoglu, B. (2007). Income Convergence of European Union and Candidate Countries: Are they All the Same? *International Research Journal of Finance and Economics, 12:* 160-164 [in English].

23. Doyle, P., Juany, G., & Kuijs, L. (2001). *Real convergence to EU income levels: Central Europe from 1990 to the long term*, *1* [in English].

24. Čábelková, I., Mitsche, N., & Strielkowski, W. (2015). Attitudes Towards EU Integration and Euro Adoption in the Czech Republic. *Economics & Sociology*, *8(2)*, 93-101 [in English].

25. Gotz, M. (2012). Prospects for the eurozone: evaluation of economic components. *Transformations in Business & Economics*, *11(3)*, 20-35 [in English].

26. Estrin, S., Urga, G., & Lazarova, S. (2001). Testing for Ongoing Convergence in Transition Economies, 1970 to 1998. *Journal of Comparative Economics, 29(4),* 677-691 [in English].

27. Fidrmuc, J., & Korhonen, I. (2003). Similarity of Supply and Demand Shocks between the Euro Area and the CEECs. *Economic Systems, 27(3)*, 313-334 [in English].

28. Fidrmuc, J., & Korhonen, I. (2004). The Euro Goes East: Implications of the 2000-2002 Economic Slowdown for Synchronisation of Business Cycles between the Euro Area and CEECs. *Comparative Economic Studies, 46(1)*, 45-62 [in English].

29. Fidrmuc, J. (2004). The Endogeneity of the Optimum Currency Area Criteria, Intra-industry Trade and EMU Enlargement. *Contemporary Economic Policy*, *22(1)*, 1-12 [in English].

30. Fleissig, A., & Strauss, J. (2001). Unit-Root Tests of OECD Stochastic Convergence. *Review of International Economics, 9*, 153-162 [in English].

31. Frankel, J., & Rose, A. (1998). Endogeneity of the Optimum Currency Area Criteria. *The Economic Journal*, *108(449)*, 1009-1025 [in English].

32. Gouveia, S., & Correia,L. (2008). Business Cycle Synchronisation in the Euro Area: the Case of Small Countries. *International Economics and Economic Policy, 5*, 103-121 [in English].

33. Hajek, J. (2011). *Ekonomic kásladěnost Českérepubliky s Eurozóno uvesvětle finanční krize* (Economic convergence of the Czech Republic and Eurozone in the times of financial crisis). Bachelor thesis, Institute of economic studies, Faculty of social sciences, Charles University in Prague, May 2011 [in Polish].

34. Hall, S., Robertson, D., & Wickens, M. (1997). Measuring Economic Convergence. *International Journal of Finance and Economics, 2*, 131-143 [in English].

35. Hallett, A.H., Richter, C. (2008). Have the Eurozone Economies Converged on a Common European Cycle? *International Economics and Economics Policy, 5*, 71-101 [in English].

36. Heichel, S., Pape, J., & Sommerer, T. (2005). Is there Convergence in Convergence Research? An Overview of Empirical Studies on Policy Convergence. *Journal of European Public Policy, 12(5)*, 817-840 [in English].

37. Horvath, J. (2004). *Optimum currency area theory: A selective review*. EconWPA, OSI Budapest [in English].

38. Horvath, J., & Rátfai, A. (2004). Supply and Demand Shocks in Accession Countries to the Economic and Monetary Union. *Journal of Comparative Economics, 32(2)*, 202-211 [in English].

39. Horváth, R. (2005). Exchange rate variability, pressures and optimum currency area criteria: some empirical evidence from the 1990s. *Applied Economics Letters*, *12(15)*, 919-922 [in English].

40. Jiroudková, A., Rovná, L.A., Strielkowski, W., & Šlosarčík, I. (2015). EU Accession, Transition and Further Integration for the Countries of Central and Eastern Europe. *Economics & Sociology*, *8(2)*, 11-25 [in English].

41. Kocenda, E. (2001). Macroeconomic Convergence in Transition Countries. *Journal of Comparative Economics, 29*, 1-23 [in English].

42. Kolodko, G. (2010). Two decades of great postsocialist transformation—and what next? *ActaOeconomica*, *60(4)*, 361-373 [in English].

43. Krugman, P. (1993). *Lessons of Massachusetts for EMU*, In: Torres, F. and Giavazzi, F.: *Adjustment and Growth in the European Monetary Union*, Cambridge University Press, 241-261 [in English].

44. Kutan, A.M., & Yigit, T.M. (2004). Nominal and Real Stochastic Convergence of Transition Economies. *Journal of Comparative Economics, 32(1)*, 23-36 [in English].

45. Kutan, A.M., & Yigit, T.M. (2005). Real and Nominal Stochastic Convergence: Are the New EU Members Ready to Join the Euro Zone? *Journal of Comparative Economics, 33*, 387-400 [in English].

46. Matkowski, Z., & Prochniak, M. (2007). Economic Convergence between the CEE-8 and the European Union. *Eastern European Economics, 45*, 59-76 [in English].

47. Matthes, J. (2009). Ten years EMU – Reality test for the OCA endogeneity hypothesis, economic divergences and future challenges. *Intereconomics*, *44(2)*, 114-128 [in English].

48. McKinnon, R. (1963). Optimum Currency Areas. The American Economic Review, *53(4):* 717-725 [in English].

49. Mongelli, F.P. (2005). What is European Economic and Monetary Union Telling us About the Properties of Optimum Currency Areas? *Journal of Common Market Studies*, *43(3)*, 607-635 [in English].

50. Mundell, R. (1961). A Theory of Optimum Currency Areas. The American Economic Review, *51(4),* 657-665 [in English].

51. Puziak, M (2009). Real convergence of new EU members. An experience for Ukraine. *Journal of International Studies*, *2(1)*, 40-49 [in English].

52. Simionescu, M. (2014). Testing Sigma Convergence Across EU-28, *Economics & Sociology*, *7(1)*, 48-60 [in English].

53. Stanišić, N. (2012). The effects of the economic crisis on income convergence in the European Union. *ActaOeconomica*, *62(2)*, 161-182 [in English].

54. Tiganasu, R., Pascariu, G., & Baciu, L. (2014). Conditionalities in the recovery process of economic growth and convergence in Central and Eastern European countries. *Transformations in Business and Economics, 13(3)*, 389-409 [in English].

55. Vintrová, R. (2004). The CEE Countries on the Way into the EU – Adjustment Problems. *Europe–Asia Studies, 4*, 521-542 [in English].

56. Vintrová, R. (2005). What GDP Indicators Do Not Tell You: Alternative Indicators of Economic Growth and Real Convergence. *Czech Journal of Economics and Finance*, *11-12*, 579-595 [in English].

57. Vojinovic, B., & Oplotnik, Z.J. (2008). Real Convergence of GDP per Capita in the New EU Member States. *Transformations in Business and Economics, 7*, 89-103 [in English].

58. Willett, T.D., Permpoon, O., & Wihlborg, C. (2010). Endogenous OCA Analysis and the Early Euro Experience. *The World Economy*, *33(7)*, 851872 [in English].

Я. Хаєк, аспірант факультету соціальних наук, Карлів університет у Празі (м. Прага, Чеська Республіка);

Ф. Хьошле, аспірант кафедри економіки, Мюнхенський університет ім. Людвіга-Максиміліана (м. Мюнхен, Німеччина);

Ю. Білан, PhD, доцент, кафедра мікроекономіки, Університет Щеціна (м. Щецін, Польща);

В. Стрелковский, PhD, науковий співробітник, Школа Бізнесу та Економіки Кайрнес, Ірландський національний університет у Голуеї (м. Голуеї, Ірландія)

Економічні показники та конвергенція в Єврозоні

Стаття присвячена визначенню факторів, що впливають на зближення/конвергенцію чеської економіки з економікою Єврозони. Крім того, у статті зроблено спробу визначити рівень економічної конвергенції з Європейським Союзом з використанням методів β-конвергенції і σ-конвергенції. Існування цієї конвергенції є однією з необхідних умов для створення валютного союзу, відповідно до теорії оптимального валютного простору. Теорію оптимального валютного простору використано як ключову теоретичну основу для емпіричного аналізу, для оцінювання циклічної та структурної синхронізації за допомогою коефіцієнтів кореляції розвитку ВВП, промислового виробництва, інфляції та відсоткових ставок. Результати дослідження вказують на значний рівень конвергенції чеської економіки (за винятком шокового аналізу), хоча значення видається завищеним через нещодавню економічну та фінансову кризу.

Ключові слова: економічна конвергенція, трансформація, β-конвергація, σ-конвергенція перехідної економіки, оптимальна валютна зона, фінансова криза, Європейський Союз, Чеська Республіка.

Я. Хаек, аспирант факультета социальных наук, Карлов университет в Праге (г. Прага, Чешская Республика);

Ф. Хёшле, аспирант кафедры экономики, Мюнхенский университет им. Людвига-Максимилиана (г. Мюнхен, Германия);

Ю. Билан, PhD, доцент, кафедра микроэкономики, Университет Щецина (г. Щецин, Польша);

В. Стрелкоский, PhD, научный сотрудник, доцент, Школа Бизнеса и Экономики Кайрнес, Ирландский национальный университет в Голуэе (г. Голуэй, Ирландия)

Экономические показатели и конвергенция в Еврозоне

Статья посвящена определению факторов, которые влияют на конвергенцию чешской экономики в экономику Еврозоны. Кроме того, сделана попытка определить уровень экономической конвергенции в Европейского Союза с использованием методов β-конвергенции и σ-конвергенции. Существование этой конвергенции является одним из необходимых условий для создания валютного союза, исходя из теории оптимального валютного пространства. В статье теория оптимального валютного пространства используется в качестве ключевой теоретической основы для эмпирического анализа и оценивает циклическую и структурную синхронизацию с помощью коэффициентов корреляции развития ВВП, промышленного производства, инфляции и процентных ставок. Результаты исследования указывают на значительный уровень конвергенции чешской экономики (за исключением анализа шока), хотя значения кажутся переоцененными из-за недавнего экономического и финансового кризиса.

Ключевые слова: экономическая конвергенция, трансформация, β-конвергенция, σ-конвергенция переходной экономики, оптимальная валютная зона, финансовый кризис, Европейский Союз, Чешская Республика.