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MEASURING THE BUSINESS CYCLES SIMILARITY AND CONVERGENCE TRENDS IN THE CENTRAL AND EASTERN EUROPEAN COUNTRIES TOWARDS THE EUROZONE WITH RESPECT TO SOME UNCLEAR METHODOLOGICAL ASPECTS

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Abstract

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The adoption of Euro in Slovakia since January 2009 and current world economic crises revived a debate on timing of the Euro adoption in the Czech Republic and other Central and Eastern European countries. The purpose of the article is to contribute to a discussion on the process of joining the Eurozone by the Czech Republic and other candidate countries. The paper provides an analysis of few business cycle similarity and convergence measures using different indicators and detrending techniques. Measures of business cycles similarity are ordinarily used to evaluate preparedness of candidate countries to join the Eurozone. The results indicate continuing convergence of the business cycles similarity between the candidate and Eurozone member countries. The paper also sheds some light on possible influence of selected detrending techniques upon the resultant correlations. It gives a recommendation to interpret the results of business cycles correlation measuring in the close context with used methodology. A short note on a regional approach to analyse the GDP cycles is also included in a text.

business cycles, convergence, correlation, eurozone, optimum currency areas

Most of the Central and Eastern European countries as well as the Baltic countries that acceded to the European Union in 2004 solve the decision problem of an appropriate timing to join the Eurozone. The current discussion is based on the evaluation of the traditional Maastricht criteria as well as the alternative similarity and convergence criteria mostly defined in the context with the theory of optimum currency areas (OCA). This theory proposed by the Nobel Price Laureate Robert Mundell in his classic article from 1961 defines the characteristics of optimum currency areas determining an effective formation of a common currency area. Besides Mundell, the list of original OCA characteristics is enhanced by the other authors and pioneers of this theory such as McKinnon (1963), Kenen (1969) or Ingram (1962). A later approach to OCA theory called the "New Optimum Currency Areas Theory" (Mongelli, 2002) brings other characteristics including business cycles similarity, a/symmetry of shocks. High long-term similarity of business cycles reduces the risk of potential idiosyncratic shocks and also decreases the significance of an autonomous monetary policy in an acceding economy.

Measures of business cycles similarity and convergence are currently used by the central banks, government institutions and academic researchers to give some evidence of the continuing economic and monetary integration process. The studies on business cycles similarity also provide arguments for the policy makers to discuss the timing of the Euro adoption in the candidate countries. A majority of the studies use some form of correlation of stylised economic activity time series to measure the cycles similarity[1]. Fidrmuc and Korhonen (2006) provide an overall literature analysis of the business cycle correlation literature. Apart from correlation methods there are also studies using the alternative approaches to the business cycle synchronicity measuring. Harding-Pagan (2006), Artis *et al.* (2004) measure the concordance index of selected European countries. The index defined by Harding–Pagan (2002a) measures the fraction of time the cycles are in the same phase (Harding–Pagan, 2002). The concordance technique requires applying of some business cycles dating rules to identify the turning points and phases of cycles[2].

A variety of studies measuring the business cycle similarity in the past decade provide many results of actual synchronicity or convergence trends in the European economies. However, many of them bring different and rather spurious results. Firstly, it is obvious that the selected indicator, time frequency of input data, detrending techniques or similarity measure can influence the results. Secondly, the final economic interpretation of the numeric results usually suffers from missing mention of the context with the used methodology as well as the subjective interpretation by the author. The OCA theory does not specify what exact techniques to use to measure the defined characteristics. Therefore, one might ask: Do the Central and Eastern European (CEE) economies really converge to the Eurozone and how similar they actually are? How reliable are the interpreted results? Canova (1998, 1999) and Baxter-King (1999) examine a potential impact of data stylizing methods on business cycles identification. An interesting point of a bias of the central bankers, who are more conservative than the academic researchers, is mentioned by Fidrmuc–Korhonen (2006).

The main goal of the article is to measure and evaluate actual similarity of business cycles and to identify the convergence trends in the CEE countries (and Baltic countries in case of GDP cycles) towards the Eurozone. Secondly, the partial goal is to give some evidence of an impact of selected methodology on the empirical results. Thus two indicators, three detrending techniques and three measures of similarity and convergence were used in the study to increase a robustness of found results and to shed some light on the technical problems with used methods.

The paper is structured as follows. The next part explains the used methodology and data. Third chapter includes the descriptive statistics of analysed time series and results of business cycles correlations. In particular, cross correlation and rolling window correlation were used in that chapter. Different characteristics of the stylised time series possibly indicating the influence of chosen detrending techniques are discussed in the forth part. Next part includes a short note on approach to regional GDP measuring in the Czech Republic. Sixth section concludes the analysis.

DATA AND METHODOLOGY

Input data contains seasonally adjusted time series of quarterly gross domestic product (GDP) and the monthly index of industrial production (IP). The Eurostat and International Financial Statistics (IFS) of the International Monetary Fund (IMF) were the key data sources[3]. The selection of Central and Eastern European countries (CEEC) countries covering Hungary, Poland, Slovakia, Czech Republic and Slovenia was made in relation to former intensive economic and political relations as well as to a similar position at the beginning of the transformation period in 90's. Although Slovenia and Slovakia have joined the Eurozone since 2007 and 2009 respectively, they were the candidate countries during most of the analysed time period and it is useful to compare the similarity and convergence trends with the other CEECs. The selection of the Eurozone member countries includes dominant Germany, France and periphery economies with relatively lower GDP per capita such as Spain, Portugal and Greece. The sample of EMU member countries finally includes Austria, which is structurally similar to the majority of selected CEECs, and formerly dynamically growing Ireland. The Baltic countries Estonia, Latvia and Lithuania were also included in the GDP cycles analysis. Germany and Eurozone average were the reference benchmark in the analysis.

From a technical point of view on the business cycles identification process the economic literature distinguishes between the classical and growth (deviation) business cycles. The classical approach defines business cycles as a cyclical fluctuation covering the decline and growth in an absolute level of aggregate economic activity of a nation (Burns–Mitchell, 1946). The growth cycles are considered as an alternative to the classical cycles. The growth (deviation) cycle specifies business cycles as cyclical fluctuation in the cyclical component of an economic variable around its trend (Lucas, 1977). The

1 See e.g. Artis-Zhang (1997, 1995), Boone-Maurel (1998), Inclaar–DeHaan (2001), Boreiko (2003), Backé (2004), Darvas–Szapáry (2004).

2 For explorations of dating business cycles dating rules see Canova (1999) or Harding –Pagan (2002a).

3 The GDP time series covered the quarterly data of 1996–2008 (Greece 2000–2008, Ireland 1997–2008) and IP the monthly data of 1993–2008 (Greece 1995–2008, Eurozone 1998–2008). Accordingly Germany was used as the reference country for the IP correlation analysis instead of Eurozone average.

later approach therefore needs the application of selected time series detrending techniques.

Accordingly, the natural logarithms of indicators were stylised with the first order differences procedure (FOD). This is partially in line with the presumptions of the classical approach to business cycle identification. The time series were also detrended by Hodrick–Prescott Filter (HP) applying parameters $\lambda = 1\,600$ for quarterly data and $\lambda = 14\,400$ for monthly data[4]. Finally the Baxter-King bandpass filter (BK–BP) was applied. This frequency domain detrending technique passes through components of the time series with periodic fluctuations between 6 and 32 quarters, while removing components at higher and lower frequencies[5]. The two later mentioned filtering techniques produce the stylised time series in accordance with the growth business cycles definition.

The technique of cross correlation was used to measure the actual similarity and the convergence trends when applying correlation in two consecutive time periods. The short term dynamics of convergence was measured with the five-year and three year-rolling window correlation.

The reason for using more detrending techniques and indicators with different frequencies is to increase the robustness of results for measuring the actual business cycles similarity. The other reason is to give some evidence of a potential influence of selected data stylizing methods and on the resultant similarity and convergence indicators. Therefore some statistic characteristics of the time series stylised with FOD, HP and BK–BP filters are compared in the discussion part of the paper.

RESULTS

Descriptive statistics

The input data of descriptive statistics comprises the first log difference of seasonally adjusted quarterly GDP (Table I) and monthly IP (Table II). Descriptive statistics allow measuring the average quarterly growth rate (in percentage), standard deviation indicating volatility of the cycles, minimum and maximum rate. The normalised deviation denotes the relative volatility comparing to the Eurozone average.

Comparing to the 0.5% average quarterly growth rate of the Eurozone average (0.35 in Germany), the CEE as well as Baltic countries could be considered as converging economies. Also dynamically growing Ireland and Greece show significant real convergence to the average. Normalised standard deviation depicts Hungary as the less volatile CEE economy closely to the Eurozone cycle volatility. Also growing Ireland reveals high GDP growth volatility.

The industrial production is used as an appropriate complementary aggregate economic activity indicator reflecting actual use of production fac-

I: *Descriptive statistics of GDP growth in Eurozone members, CEE and Baltic countries*
Source: Eurostat, author's calculations
Note: First log differences of seasonally adjusted quarterly GDP in 1996–2008. Two members of CEE-5 (SLO, SVK) already adopted the Euro.

	Mean	Median	St.deviation	Norm.st.dev.	Min	Max
AT	0.0059	0.0066	0.0033	0.5823	–0.0019	0.0114
GER	0.0035	0.0035	0.0067	1.1752	–0.0213	0.0159
EUR	0.0054	0.0051	0.0057	1.0000	–0.0161	0.0284
FRA	0.0050	0.0053	0.0044	0.7796	–0.0112	0.0126
ESP	0.0084	0.0090	0.0041	0.7150	–0.0098	0.0153
POR	0.0048	0.0042	0.0076	1.3260	–0.0159	0.0210
IRL	0.0133	0.0127	0.0233	4.0910	–0.0741	0.0722
GRE	0.0096	0.0093	0.0041	0.7177	0.0006	0.0183
CR	0.0075	0.0095	0.0074	1.2904	–0.0109	0.0214
HU	0.0087	0.0102	0.0053	0.9372	–0.0118	0.0158
POL	0.0108	0.0121	0.0115	2.0105	–0.0324	0.0598
SLO	0.0098	0.0097	0.0105	1.8457	–0.0419	0.0390
SVK	0.0125	0.0129	0.0162	2.8428	–0.0341	0.0674
EE	0.0147	0.0184	0.0166	2.9196	–0.0442	0.0505
LT	0.0147	0.0173	0.0125	2.1979	–0.0229	0.0390
LV	0.0140	0.0191	0.0217	3.8058	–0.0524	0.0617

4 See Hodrick–Prescott (1980)

5 See Baxter–King (1999); BK filter application is influenced by the truncation period, which is 3 years. Accordingly, application of the filter is limited by the reduction of the initial time series for 3 years at its end and beginning. Thus this technique was used only for actual cross correlation measuring.

II: *Descriptive statistics of IP gowth in the Eurozone members and CEECs*
Source: IFS IMF, author's calculations
Note: First log differences of seasonally adjusted monthly IP in 1993–2008.

	Mean	Median	St.deviation	Norm.st.dev.	Min	Max
AT	0.0034	0.0020	0.0197	2.1809	–0.0485	0.0653
GER	0.0012	0.0022	0.0133	1.4711	–0.0458	0.0420
EUR	0.0007	0.0021	0.0090	1.0000	–0.0368	0.0199
FRA	0.0005	0.0010	0.0111	1.2363	–0.0357	0.0381
IT	0.0002	0.0000	0.0113	1.2567	–0.0398	0.0302
ESP	0.0009	0.0009	0.0174	1.9278	–0.0801	0.0693
POR	0.0010	0.0008	0.0304	3.3776	–0.0969	0.1051
GRE	0.0008	0.0014	0.0244	2.7031	–0.0788	0.0773
IRL	0.0067	0.0039	0.0515	5.7134	–0.2069	0.1364
CR	0.0022	0.0045	0.0264	2.9332	–0.0799	0.0677
HU	0.0051	0.0065	0.0257	2.8512	–0.1504	0.0681
POL	0.0057	0.0072	0.0387	4.2938	–0.1309	0.1168
SVK	0.0028	0.0083	0.0370	4.1039	–0.1571	0.1116
SLO	0.0009	0.0026	0.0252	2.7999	–0.1583	0.0574

tors highly correlated with GDP series. In addition, the IP index is available in monthly frequencies revealing higher relative volatility. The IP statistics offer a similar picture to GDP. All CEE countries apart from Slovenia reveal faster monthly growth in IP comparing to 0.07% in case of Eurozone average and 0.12% monthly growth rate in Germany. Poland, Slovakia and Ireland again reveal high cycles' volatility.

Business cycles correlations

a) Cross correlations

The left-lower part of the table show the correlation coefficients of GDP time series detrended with the Hodrick–Prescott filter and right-upper part depicts results when first order differencing (FOD) applied[6]. The results of cross correlation show that the Eurozone member countries are more correlated to

III: *a) Cross correlations of GDP in the Eurozone members, CEEC and Baltic countries in 1996–2008*
Source: Eurostat, author's calculations
Note: The upper triangle denotes the correlation coefficients (with p-values in table IIIb) of the input data – logs of seasonally adjusted quarterly GDP stylized with the first order differencing technique (FOD) and the lower part data is stylized with the Hodrick–Prescott filter (λ = 1 600).

	AT	GER	EUR	FRA	ESP	POR	IRL	GRE	CR	HU	POL	SLO	SVK	EE	LT	LV
AT		0.49	0.42	0.63	0.63	0.41	0.35	–0.09	0.21	0.40	0.26	0.39	–0.08	0.29	0.00	0.17
GER	0.65		0.80	0.52	0.56	0.31	0.51	0.33	0.23	0.38	0.14	0.48	–0.19	0.47	0.10	0.10
EUR	0.54	0.89		0.66	0.67	0.30	0.53	0.40	0.12	0.44	0.17	0.46	–0.24	0.52	0.23	0.30
FRA	0.86	0.72	0.74		0.71	0.39	0.47	0.18	0.07	0.58	0.28	0.47	–0.21	0.45	0.27	0.39
ESP	0.80	0.75	0.77	0.88		0.48	0.50	0.42	0.22	0.67	0.23	0.49	–0.23	0.67	0.32	0.37
POR	0.73	0.66	0.61	0.68	0.63		0.27	–0.03	–0.11	0.29	0.20	0.28	–0.02	0.26	0.17	0.12
IRL	0.62	0.63	0.63	0.71	0.80	0.48		0.12	0.12	0.48	0.33	0.30	–0.26	0.47	–0.02	0.39
GRE	–0.04	0.07	0.04	0.14	0.30	–0.13	0.21		0.11	0.34	0.21	0.19	–0.07	0.39	0.53	0.20
CR	0.45	0.58	0.60	0.51	0.68	0.27	0.63	0.18		0.04	0.06	0.25	0.18	0.24	0.15	0.20
HU	0.35	0.17	0.23	0.43	0.57	0.10	0.57	0.44	0.45		0.02	0.34	–0.25	0.61	0.21	0.40
POL	0.56	0.43	0.26	0.52	0.41	0.44	0.35	0.38	0.04	0.11		0.08	–0.19	0.14	0.11	–0.04
SLO	0.62	0.77	0.66	0.62	0.73	0.58	0.64	0.15	0.51	0.24	0.42		–0.16	0.32	0.30	0.26
SVK	–0.08	–0.02	–0.12	–0.23	–0.15	0.10	–0.15	–0.06	–0.08	–0.18	0.01	0.07		0.04	0.25	0.16
EE	0.15	0.33	0.36	0.21	0.45	0.11	0.51	0.39	0.43	0.68	0.13	0.36	0.29		0.61	0.55
LT	–0.24	–0.12	–0.09	–0.20	–0.02	–0.16	0.04	0.54	–0.05	0.35	0.08	0.06	0.53	0.75		0.47
LV	0.33	0.30	0.42	0.41	0.60	0.23	0.61	0.33	0.46	0.67	0.16	0.45	0.26	0.82	0.58	

6 The P-value is written in italics to describe the significance level.

III: *b) P-values for the correlation coefficients in table III.*
Source: Author's calculations

	AT	**GER**	**EUR**	**FRA**	**ESP**	**POR**	**IRL**	**GRE**	**CR**	**HU**	**POL**	**SLO**	**SVK**	**EE**	**LT**	**LV**
AT		0.000	0.002	0.000	0.000	0.003	0.015	0.626	0.136	0.003	0.068	0.005	0.569	0.038	0.980	0.233
GER	0.000		0.000	0.000	0.000	0.029	0.000	0.055	0.105	0.007	0.332	0.000	0.191	0.001	0.500	0.484
EUR	0.000	0.000		0.000	0.000	0.030	0.000	0.017	0.415	0.001	0.236	0.001	0.097	0.000	0.107	0.035
FRA	0.000	0.000	0.000		0.000	0.005	0.001	0.288	0.648	0.000	0.047	0.000	0.130	0.001	0.053	0.005
ESP	0.000	0.000	0.000	0.000		0.000	0.000	0.012	0.123	0.000	0.107	0.000	0.109	0.000	0.024	0.007
POR	0.000	0.000	0.000	0.000	0.000		0.062	0.845	0.424	0.041	0.150	0.045	0.914	0.065	0.239	0.387
IRL	0.000	0.000	0.000	0.000	0.000	0.001		0.503	0.435	0.001	0.024	0.044	0.072	0.001	0.896	0.006
GRE	0.831	0.671	0.799	0.429	0.078	0.435	0.223		0.511	0.047	0.236	0.266	0.679	0.021	0.001	0.245
CR	0.001	0.000	0.000	0.000	0.000	0.053	0.000	0.307		0.785	0.692	0.075	0.202	0.088	0.303	0.156
HU	0.012	0.241	0.094	0.001	0.000	0.461	0.000	0.007	0.001		0.915	0.014	0.078	0.000	0.141	0.003
POL	0.000	0.001	0.065	0.000	0.003	0.001	0.014	0.023	0.762	0.459		0.567	0.188	0.331	0.435	0.763
SLO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.368	0.000	0.090	0.002		0.251	0.021	0.034	0.063
SVK	0.591	0.906	0.409	0.097	0.298	0.460	0.320	0.747	0.550	0.198	0.933	0.618		0.797	0.078	0.264
EE	0.285	0.017	0.009	0.137	0.001	0.424	0.000	0.020	0.002	0.000	0.363	0.010	0.039		0.000	0.000
LT	0.081	0.407	0.506	0.158	0.911	0.251	0.793	0.001	0.710	0.011	0.580	0.698	0.000	0.000		0.001
LV	0.017	0.028	0.002	0.002	0.000	0.099	0.000	0.047	0.001	0.000	0.272	0.001	0.058	0.000	0.000	

Eurozone–average (or to Germany) than the current CEECs and Baltic countries. The CEE countries also reveal relatively low mutual business cycles similarity. Despite recent adoption of Euro in Slovakia (January 2009), Slovak economy is negatively correlated to the Eurozone and Germany with using both data stylizing methods. Except form the indicated correlation the table gives some evidence of the impact of

IV: *Cross correlations of IP in the Eurozone members and CEECs in 1993–2008*
Source: IFS IMF, author's calculations
Note: The upper triangle denotes the correlation coefficients (with p-values) of the input data – logs of seasonally adjusted monthly IP stylized with the first order differencing technique (FOD) and the lower part data is stylized with the Hodrick–Prescott filter (λ = 14 400).

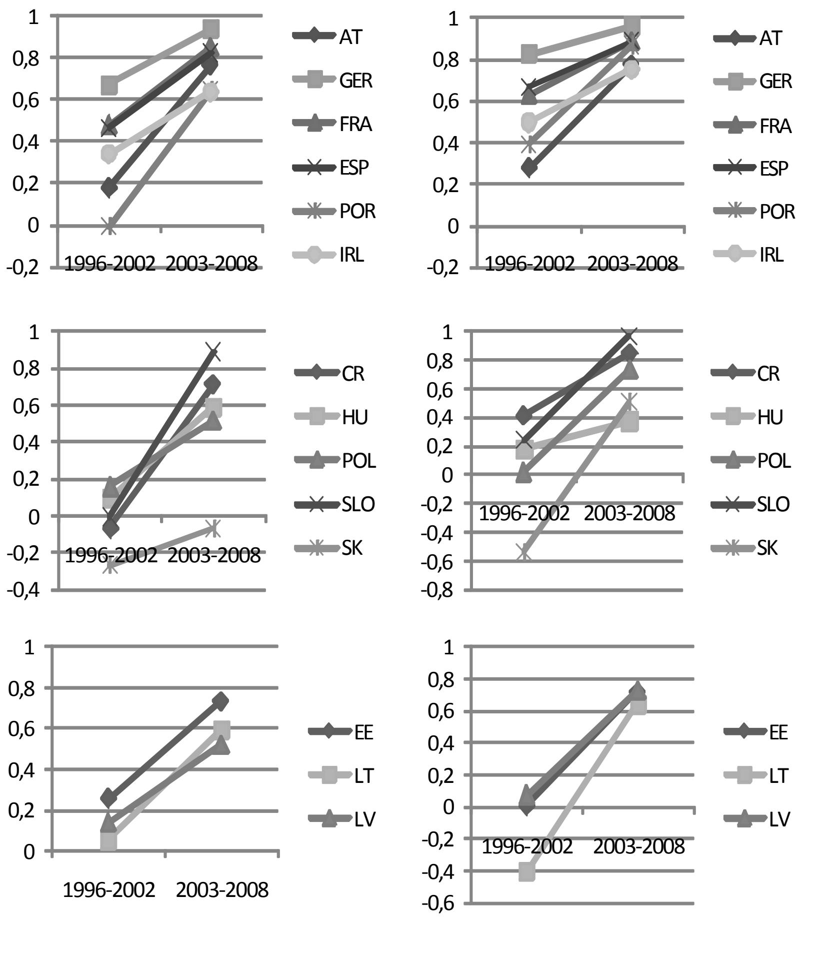
	AT	GER	FRA	ESP	POR	IRL	CR	HU	POL	SVK	SLO
AT		0.179	0.253	0.126	0.046	–0.023	0.085	0.055	0.195	0.085	0.293
		0.013	0.000	0.082	0.531	0.757	0.243	0.453	0.007	0.240	0.000
GER	0.639		0.280	0.242	0.066	0.176	0.136	0.220	0.054	0.258	0.335
	0.000		0.000	0.001	0.364	0.015	0.061	0.002	0.463	0.000	0.000
FRA	0.585	0.738		0.354	0.252	0.198	0.165	0.210	0.203	0.193	0.262
	0.000	0.000		0.000	0.000	0.006	0.022	0.004	0.005	0.008	0.000
ESP	0.555	0.704	0.758		0.356	0.045	0.207	0.226	0.312	0.197	0.115
	0.000	0.000	0.000		0.000	0.539	0.004	0.002	0.000	0.006	0.114
POR	0.060	0.118	0.226	0.203		–0.086	0.172	0.112	0.313	0.112	0.077
	0.408	0.102	0.002	0.005		0.235	0.018	0.123	0.000	0.122	0.293
IRL	0.236	0.345	0.447	0.277	0.213		0.001	0.058	–0.209	–0.119	–0.053
	0.001	0.000	0.000	0.000	0.003		0.990	0.422	0.004	0.102	0.467
CR	0.375	0.600	0.616	0.477	0.192	0.209		0.195	0.395	0.405	0.064
	0.000	0.000	0.000	0.000	0.008	0.004		0.007	0.000	0.000	0.380
HU	0.517	0.728	0.703	0.648	0.104	0.325	0.472		0.098	0.159	0.071
	0.000	0.000	0.000	0.000	0.152	0.000	0.000		0.179	0.028	0.328
POL	0.409	0.454	0.515	0.499	0.197	0.064	0.502	0.478		0.451	0.225
	0.000	0.000	0.000	0.000	0.006	0.378	0.000	0.000		0.000	0.002
SVK	0.316	0.537	0.613	0.495	0.294	0.214	0.506	0.442	0.494		0.154
	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000		0.034
SLO	0.582	0.748	0.641	0.593	0.064	0.224	0.452	0.611	0.469	0.462	
	0.000	0.000	0.000	0.000	0.379	0.002	0.000	0.000	0.000	0.000	

a different detrending technique application on the resultant correlation. The Hodrick Prescott and Baxter-King band pass filters[7] produce generally higher coefficients comparing to First order differencing (FOD).

Due to a short time series of IP Eurozone (average) available the reference country was Germany in the IP analysis. The results of industrial production cross correlations does not provide as clear picture as the GDP cycles. Whereas the similarity resulted from usage of HP filter seems to be high (more than 0.5 in case of France, Spain, Czech Rep., Hungary and Slovenia) the application of FOD provides with much lower coefficients. Also Slovakia and Hungary reveal weak or negative correlation when using BK-BP filter[8], but there the p-value shows low significant level. The table IV and table VIII confirm low similarity of business cycles in Portugal, Ireland and Poland though we should look on the BK-BP results rather more critically with respect to shorter input time series.

b) Convergence trends

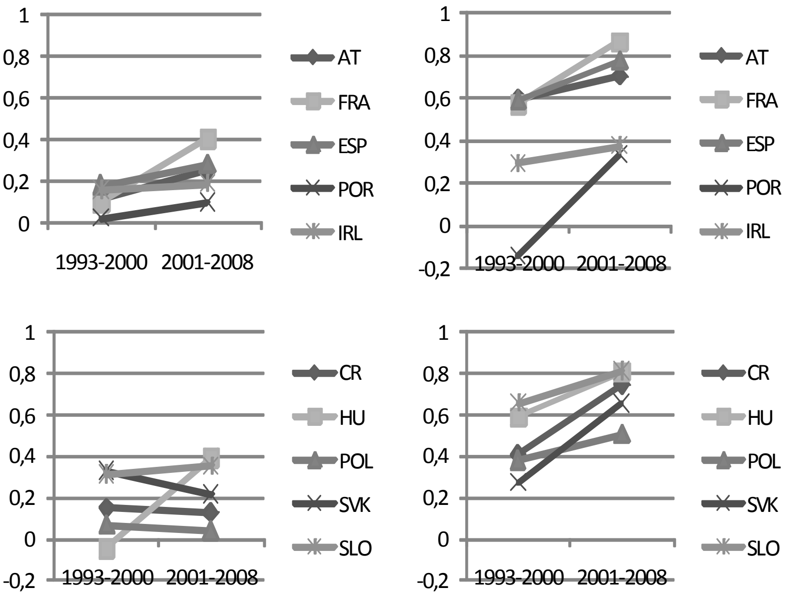
To measure the convergence in business cycles similarity the time period was divided in two consecutive parts. A higher correlation coefficient and the latter period indicate an increase in business cycle similarity comparing to the previous time. All countries reveal an increase in GDP cycles similarity in analysed period. Moreover, all economies, (apart



1: *The convergence trends in the GDP cycles in the Eurozone member countries, CEEC and Baltics towards the Eurozone average*
Source: Eurostat, author's calculations
Note: The figure depicts the correlation coefficients of the input data – logs of adjusted quarterly GDP stylized with the first order differencing technique (FOD) in the left part and the Hodrick–Prescott filter (HP, λ = 1 600) in the right part.

7 The cross correlations measured on the time series stylised with the Baxter–King band pass filter are depicted in table VII and VIII in the appendix.

8 See table VIII in the appendix.



2: *The convergence trends in the IP cycles in the Eurozone member countries and CEEC towards Germany*
Source: IFS IMF, author's calculations
Note: The figure depicts the correlation coefficients of the input data – logs of adjusted monthly IP stylized with the first order differencing technique (FOD) in the left part and the Hodrick–Prescott filter (HP, λ = 14 400) in the right part.

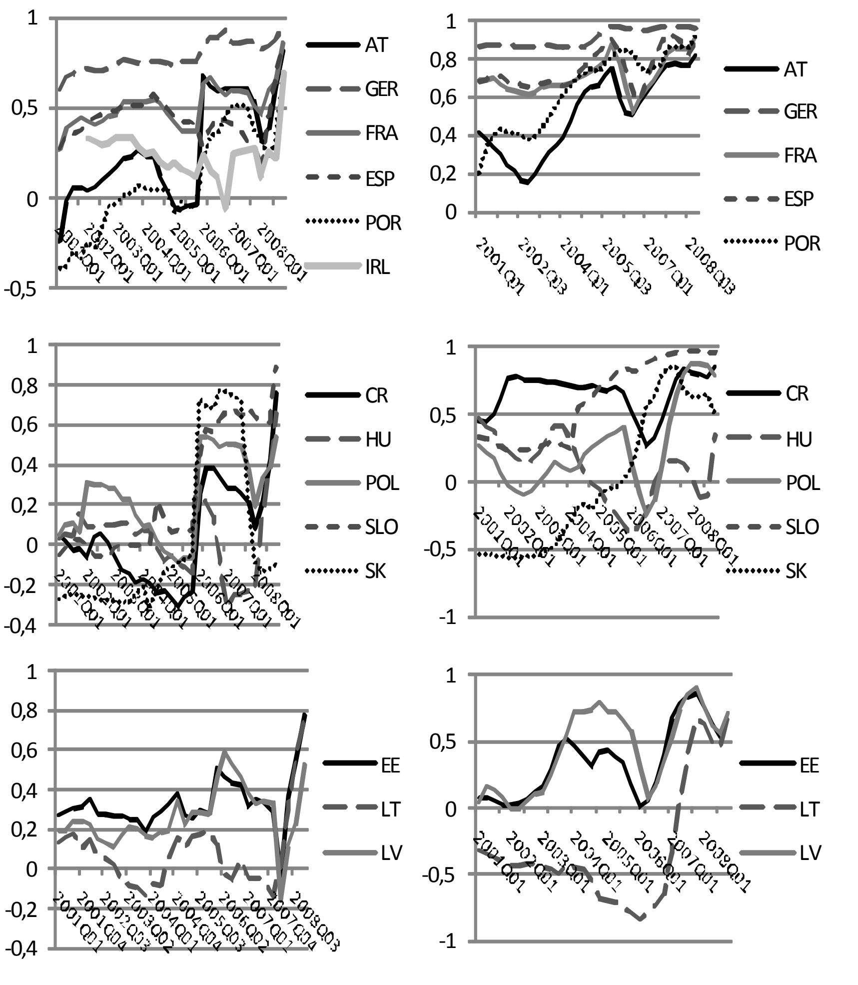
from Hungary and Slovakia when using HP and FOD respectively) show the correlation coefficient over 0.5 in the period 2003–2008). It is questionable, how much the current world financial crisis, which pushes all economies down to the recession phases, influences the results. A significant correlation is apparent in the Baltic economies and Slovenia. They increased the actual correlation from a stance of a low or negative correlation. Among the Eurozone members Portugal and Austria reached most significant level of convergence. A similar picture can be seen when looking the convergence of IP cycles. All countries except from Czech Rep. and Poland (FOD cycles) have more correlated IP cycles to Germany in the second period. The level of IP cycles similarity is relatively high but lower than in case of GDP cycles. Similarly to previous measuring of actual cross correlation, the results of both cycles correlations, particularly coefficients of IP cycles similarity, give an evidence of generally higher correlation coefficients in case of HP filter comparing to FOD. It is very clear from the figure 1 illustrating the convergence tendencies in case of all 4 types of cycles.

c) Rolling window correlation

A rolling window correlation describes a short or middle-term dynamics of the business cycle convergence. It identifies the short term trends of the convergence or divergence during the whole analysed period. The time-varying coefficients measure a correlation of moving periods rolling during the whole time periods. The analysis includes five-year rolling window correlation of GDP cycles and three-year rolling window correlation of IP cycles. Thus a concrete coefficient refers to a correlation of previous five- or three-year sample.

The figure 3 shows clear convergence tendencies of all selected Eurozone member countries during the whole analysed period, though the FOD cycles reveal relatively lower levels of short term correlations (except form last few years). FOD cycles also give some evidence of some diverging trends of Ireland, Spain and Portugal (the EU-periphery countries) until 2006–7. The actual levels of convergence are very high close to range 0.8–1.

The short-term convergence tendencies are not in case of CEE countries as clear as in the Eurozone countries. Apart from last 3 years the converging as well as diverging trends are changing. The influence of FOD and HP filters is obvious. First order differencing technique produces lower correlations similarly to previous two correlation techniques (actual cross-correlation and correlation in two consecutive periods). FOD cycles in all CEE countries also reveal long periods of diverging trends. The levels of correlation at the beginning of the period are also very high in the similar range as in the Eurozone countries. The Baltic countries converge at the end of analysed period. The lowest levels of convergence show Lithuania that was diverging to the Eurozone in most of the analysed period. A rapid increase in correlation in the end of analysed period in all countries possibly reflects negative GDP performance of the overall economies. The crises moved all developed economies in the phase of recession which increased the business cycles similarity. That con-

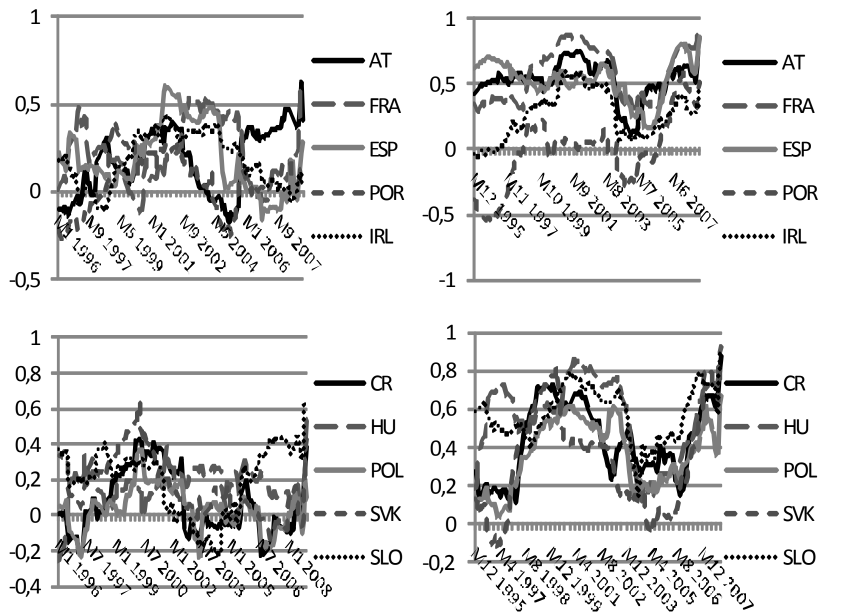


3: *Five-year rolling windows correlations of GDP cycles of the Eurozone member countries, CEEC and Baltics towards the Eurozone average*
Source: Eurostat, author's calculations
Note: The figure depicts the five-year rolling window correlation of the input data – logs of adjusted quarterly GDP stylized with the first order differencing technique (FOD) in the left part and the Hodrick–Prescott filter (HP, λ = 1 600) in the right part.

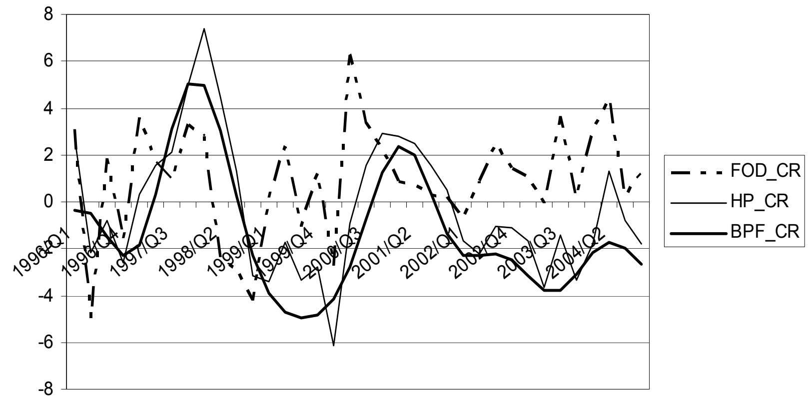
clusion could be also proven when looking at three-year rolling window correlation of the IP cycles. All analysed countries even the Eurozone members went through the phases of short-term convergence and divergence. Portugal cycle was diverging most of the time. Also IP cycles of CEE countries changed the recession and contraction phases. All countries converged significantly to the end of the period. In a sense of the OCA theory the world economic crises is a kind of a symmetric shock. This situation paradoxically increases a business cycles correlation and predicates a better preparedness of the candidate countries to join the Eurozone. The IP cycles analysis also indicates a potential influence of detrending. The FOD cycles show lower time-varying coefficients comparing to HP cycles.

Can identification of the business cycles with detrending influence the results of measured cycles' synchronicity?

The results of the pervious analysis of business cycles correlations gave some evidence of a different results produced by using the first order differencing technique (FOD) for identification of classical cycles and Hodrick-Prescott filter (HP) or Baxter-King band-pass filter (BK-BP) identifying the growth cycles. The first two filters produce quite similar cycles comparing to FOD (see figures 5 and 6). The resultant correlation coefficients in case of FOD are always lower than in case of HP or BK-BP filters. This can play an important role for an interpretation of results. The missing strict value of sufficient correlation incorporates high rate of subjectivism when authors interpret the results in sense of preparedness of a country to adopt a common currency.

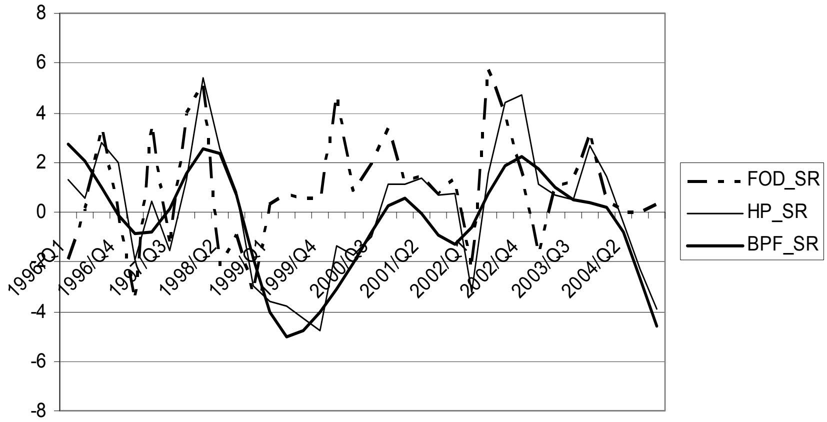


4: *Three-year rolling window correlations of IP cycles of the Eurozone member countries and CEEC towards Germany*
Source: Eurostat, author's calculations
Note: The figure depicts the three-year rolling window correlation of the input data – logs of adjusted quarterly GDP stylized with the first order differencing technique (FOD) in the left part and the Hodrick–Prescott filter (HP, λ = 14 400) in the right part.



5: *IP cycle in the Czech Republic identified with different detrending techniques*
Source: IFS IMF, author's calculations
Note: The cycle is identified from input data of adjusted quarterly IP stylized with the first order differencing technique (FOD), part and the Hodrick–Prescott filter (HP, λ = 1 600) and Baxter - King band–pass filter (BPF) in 1993–2007.

The difference between three techniques could be demonstrated in the tables V, VI and figures 5, 6. Whereas the latter two filters reveal similar and higher standard deviation and produce similar cycles, FOD usually reveals a lower volatility in the series with higher frequencies. According to Baxter-King (1999) the frequent turning points result from the fact, that FOD emphasises the high frequencies and down weights the lower frequencies of the initial time series. HP filter works as a high-pass filter which leaves the higher frequencies component in the time series whereas the BK-BP removes them. HP produces little higher volatility than BK-BP because GDP and other indicators of aggregate economic activity do not have much of high frequency components. The lower correlation in FOD cycles is due to removing the low frequencies of the time series and overweighs the high frequencies with very low intensity of association. This is why the FOD time series reveal very low autocorrelation within the analysed time series and also low correlations of the input time series (see tables V and VI).



6: *IP cycle in Slovakia identified with different detrending techniques*
Source: IFS IMF, author's calculations
Note: The cycle is identified from input data of adjusted quarterly IP stylized with the first order differencing technique (FOD), part and the Hodrick–Prescott filter (HP, λ = 1600) and Baxter-King band-pass filter (BPF) in 1993–2007.

V: *Characteristics of the IP cycle in the Czech Republic identified with different detrending techniques*
Source: IFS IMF, author's calculations

	Standard dev.	Autocorrelation		
		1.	2.	3.
FOD_CR	2.3804	0.0013	0.1384	–0.1911
HP_CR	2.8028	0.6574	0.3622	0.0335
BPF_CR	2.5854	0.8687	0.5459	0.1590

VI: *Characteristics of the IP cycle in Slovakia identified with different detrending techniques*
Source: IFS IMF, author's calculations

	Standard dev.	Autocorrelation		
		1.	2.	3.
FOD_SR	2.2687	–0.3556	–0.1216	–0.0894
HP_SR	2.5426	0.9121	0.8257	0.7410
BPF_SR	2.1428	0.7918	0.4543	0.1199

Baxter and King (1999) recommend using the HP and BK-BP filters rather than the FOD technique. However, the first order differencing of a logarithms of the input data produces the growth rates of the indicators. The correlation of growth rates of real output as well as detrending techniques belong to the most used techniques of measuring the GDP cycles similarity by the central bank as well as academic researchers. Therefore we might assume that the studies on business cycle similarity will still produce the different results and interpretations. On the contrary, we can provide with the recommendation to take into account all the possible spurious effects of used techniques upon numeric results and particularly to interpret the final resultant coefficients indicating the business cycle similarity in the close context to used methodology.

CONCLUSION

The analysis in the text provides some evidence of the business cycles correlations in the CEEC and Baltic countries towards the Eurozone. The results of the cross correlation show higher GDP and IP cycles synchronicity of the Eurozone countries than in the CEE and Baltic countries towards the Eurozone average. The convergence trends measured with the correlation in the two consecutive periods were clearly indicated. Correlation coefficients in the latter analysed period are higher in almost all countries than in the first period, which gives evidence about active converging trends. The influence of the world economic crises, which drives the business cycles of all developed countries into the recession phase, on the indicated convergence is questionable. However, we can hardly deny a possible influence of the world economic crises on the rolling window correlation measuring the short term dynamics and convergence trends. Whereas the Eurozone countries reveal stable or rising short term correlation, the CEEC and Baltic countries went through phases of short term convergence and divergence (measured on five-year GDP and three-year IP rolling windows) during the whole time period. For all countries the time varying correlation increased rapidly at the end of analysed time period. The same effect of world economic crises upon the business cycles of the candidate and Eurozone countries raises short term actual similarity and paradoxically contributes to identification of better preparedness of countries to adopt Euro.

The results of the analysis also showed potential influence of selected indicator, detrended technique and correlation measure upon the resultant correlation coefficients. Particularly, influence of different detrending techniques on the numeric results is discussed in the text. The first order differencing technique (FOD) produces different business cycles than the Hodrick-Prescott and Baxter-King band pass filters. Also the correlation coefficients measured with FOD are reasonably lower when applied on the GDP and other indicators of aggregate economic activity than HP and BK-BP filters. This might play a significant role when interpreting data to evaluate the actual preparedness to adopt Euro. Considering the possible undesirable effects of used methodology upon the resultant correlation the study provides a recommendation to interpret the numeric results of measured business cycles similarity in the close context to used methodology and other possible external impacts.

SUMMARY

The paper deals with a topic of the monetary integration process of Central and Eastern European Countries (CEEC) towards the Eurozone. The main aim of the paper is to measure the business cycle similarity and convergences of selected CEEC and Eurozone member countries in order to asses their preparedness to join the Eurozone. The paper also focuses on methodological issues of the measuring process and raises the hypothesis that the detrending techniques can influence the resultant correlation coefficients and related economic interpretation. The methodology how to use the criteria such as business cycle similarity defined in a frame of the Currency Areas Theory differs in a variety of studies dealing with this characteristic in temporary literature. Accordingly, two economic activity indicators and three detrending techniques were used to measure the business cycles correlation. The cross correlation, historical correlation and rolling window correlation techniques were used to indicate the business cycle similarity and convergence. The results point out stable correlation tendencies of the Eurozone member countries towards the Eurozone average whereas CEEC went through phases of relative convergence as well as divergence. Final part of the analysed period shows a possible influence of the global economic downturn, which increases the world business cycle synchronicity. The analysis of an impact of various detrending techniques shed some light on a possible influence of different filters used on resultant coefficients. The paper concludes that the results should be interpreted in the context with used methodology.

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Appendix

VII: *Cross correlations of GDP in the Eurozone members, CEEC and Baltic countries in 1996–2008*
Source: Eurostat, author's calculations
Note: The table contains the correlation coefficients (with p-values) of the input data – logs of seasonally adjusted quarterly GDP stylized with the Baxter-King band pass filter.

GER	0,674												
	0,000												
EUR	0,466	0,891											
	0,013	0,000											
FRA	0,885	0,829	0,704										
	0,000	0,000	0,000										
ESP	0,873	0,877	0,762	0,946									
	0,000	0,000	0,000	0,000									
POR	0,773	0,812	0,755	0,783	0,777								
	0,000	0,000	0,000	0,000	0,000								
CR	0,573	0,674	0,737	0,790	0,801	0,561							
	0,001	0,000	0,000	0,000	0,000	0,002							
HU	0,171	–0,097	–0,047	0,326	0,170	–0,029	0,511						
	0,383	0,622	0,813	0,091	0,388	0,883	0,006						
POL	0,709	0,509	0,201	0,712	0,660	0,463	0,270	0,159					
	0,000	0,006	0,305	0,000	0,000	0,013	0,164	0,419					
SLO	0,822	0,841	0,593	0,748	0,780	0,777	0,361	–0,298	0,627				
	0,000	0,000	0,001	0,000	0,000	0,000	0,059	0,124	0,000				
SVK	–0,231	–0,243	–0,237	–0,420	–0,438	–0,008	–0,490	–0,567	–0,317	0,032			
	0,236	0,213	0,225	0,026	0,020	0,968	0,008	0,002	0,100	0,873			
EE	–0,250	0,109	0,317	–0,016	–0,040	–0,030	0,481	0,349	–0,572	–0,247	–0,036		
	0,199	0,582	0,101	0,937	0,839	0,879	0,010	0,068	0,002	0,205	0,855		
LT	–0,885	–0,762	–0,600	–0,832	–0,859	–0,762	–0,470	0,027	–0,647	–0,840	0,388	0,339	
	0,000	0,000	0,001	0,000	0,000	0,000	0,012	0,893	0,000	0,000	0,042	0,078	
LV	0,074	0,110	0,385	0,154	0,148	0,227	0,485	0,196	–0,340	–0,018	0,319	0,595	0,147
	0,710	0,578	0,043	0,435	0,451	0,245	0,009	0,317	0,077	0,928	0,098	0,001	0,455
	AT	GER	EUR	FRA	ESP	POR	CR	HU	POL	SLO	SVK	EE	LT

VIII: *Cross correlations of Industrial Production in the Eurozone members and CEEC in 1993–2008*
Source: IFS IMF, author's calculations
Note: The table contains the correlation coefficients (with p-values) of the input data – logs of seasonally adjusted monthly Industrial production index stylized with the Baxter-King band pass filter.

GER	0,924									
	0,000									
FRA	0,942	0,885								
	0,000	0,000								
ESP	0,766	0,733	0,762							
	0,000	0,000	0,000							
POR	0,006	0,148	0,099	–0,015						
	0,949	0,107	0,284	0,875						
IRL	0,652	0,660	0,680	0,586	0,414					
	0,000	0,000	0,000	0,000	0,000					
CR	0,132	0,329	0,323	–0,037	0,093	0,201				
	0,151	0,000	0,000	0,687	0,315	0,027				
HU	0,908	0,863	0,844	0,778	0,030	0,787	0,073			
	0,000	0,000	0,000	0,000	0,749	0,000	0,431			
POL	0,314	0,472	0,342	0,461	–0,087	0,012	0,191	0,373		
	0,001	0,000	0,000	0,000	0,346	0,899	0,037	0,000		
SVK	–0,313	–0,098	–0,219	–0,067	0,409	0,037	0,318	–0,146	0,315	
	0,001	0,287	0,016	0,467	0,000	0,687	0,000	0,111	0,001	
SLO	0,759	0,883	0,674	0,556	0,058	0,423	0,241	0,767	0,686	–0,023
	0,000	0,000	0,000	0,000	0,533	0,000	0,008	0,000	0,000	0,808
	AT	GER	FRA	ESP	POR	IRL	CR	HU	POL	SVK

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