The Academy of Economic Studies, Bucharest
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Business Cycles Synchronization with Euro Area. Empirical Evidence for Romania in Comparison with other CEECs

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Motivation

- Romania and the other CEECs have to adopt the common currency at some point in the future, as there is no opt-out clause
- The Optimal Currency Area theory (Mundell, 1961; McKinnon, 1963) points out that if real convergence is not met, the possibility that asymmetric shocks occur is high, thus resulting in significant costs of giving up the independence of monetary policy and the exchange rate instrument
- Between the most important real convergence criteria, OCA theory mentions: business cycles synchronization, correlation of demand and supply shocks, market flexibility etc.

Objectives

- To assess the degree of business cycles synchronization between Romania and the euro area using two different approaches (classical and deviation cycle) and to compare it to the one of other CEECs: Bulgaria, Czech Republic, Hungary, Lithuania, Latvia and Poland
- To analyze how synchronization of BCs evolved in time
- To identify aggregate demand and supply shocks in the CEECs and compute correlation coefficients in order to assess the degree of symmetry with those of the euro area

Literature Review

- **Deviation Cycle Approach:** Lucas (1997), Canova (1998), Darvas and Szapáry (2005, 2008), Afonso and Furceri (2007,2009), Van Aarle et al. (2008)
- **Classical Cycle Approach:** Burns and Mitchell (1946), Hamilton (1989), Harding and Pagan (2002), Artis (2004)
- **Demand and supply shocks correlation:** Blanchard and Quah (1989), Bayoumi and Eichengreen (1992), Frenkel and Nickel (2002), Babetski, Boone and Maurel (2004)

Data

- **Variables:**

  -real GDP, nominal GDP, exports, GVA industry – quarterly data, in constant prices (2000=100)

  -inflation: GDP deflator=(Nominal GDP)/(Real GDP)*100

- **Sample:**

  -real GDP (1998Q1:2012Q4)

  -exports (2000Q1:2012Q4)

  -GVA industry (2000Q1:2011Q1)

- **Countries included in the analysis:** Bulgaria, Czech Republic, Hungary, Lithuania, Latvia and Poland

- All series were seasonally adjusted using the procedure Demetra (TRAMO/SEATS)
- **Data source:** Eurostat

Methodology and theoretical considerations

- **Business cycles synchronization**

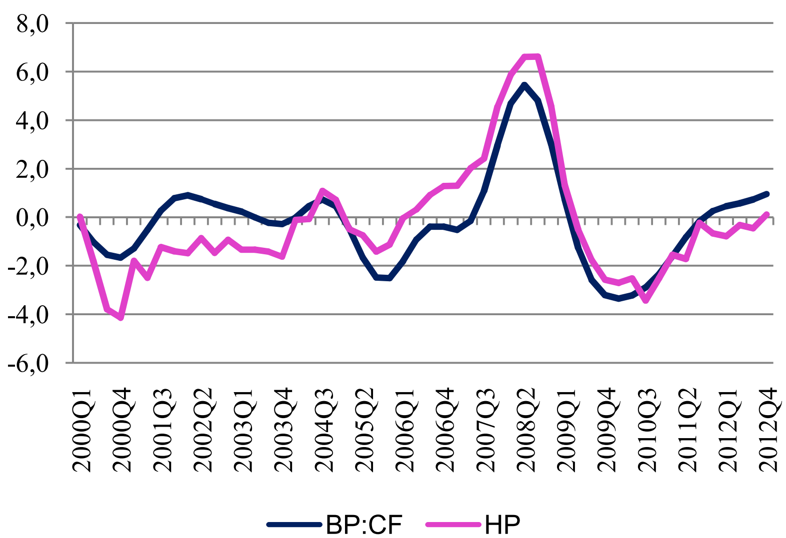
  - *Deviation cycle approach:* we extracted the cyclical component of real GDP by applying two detrending techniques – Hodrick-Prescott filter (1997) and Band Pass filter: Christiano-Fitzgerald approximation (2003)

  - *Classical Cycle Approach:* to identify the turning points, we employed univariate Markov switching (MS) models with 2 regimes on the variables in growth rates

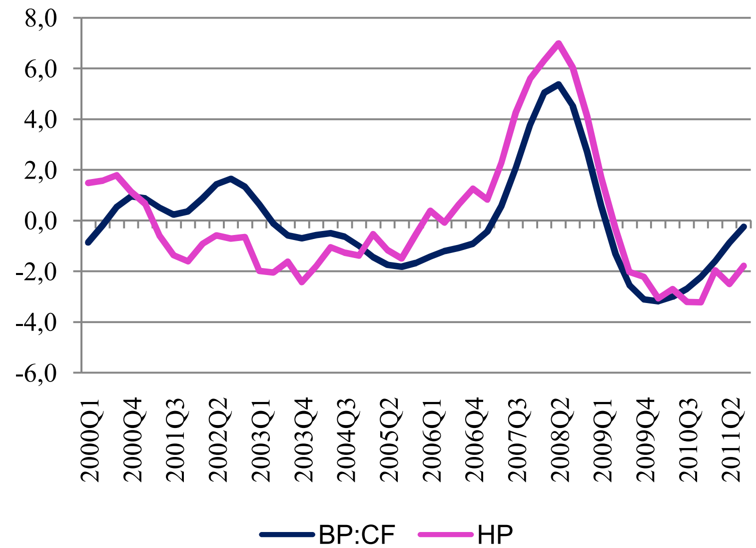
- **Correlation of demand and supply shocks:** we estimated SVAR models with two variables (growth rate of real GDP and inflation rate) identified by imposing Blanchard and Quah (1989) long term restriction that aggregate demand disturbances have a temporary effect on output

Deviation cycle approach – Estimation of Romania's business cycle

Real GDP



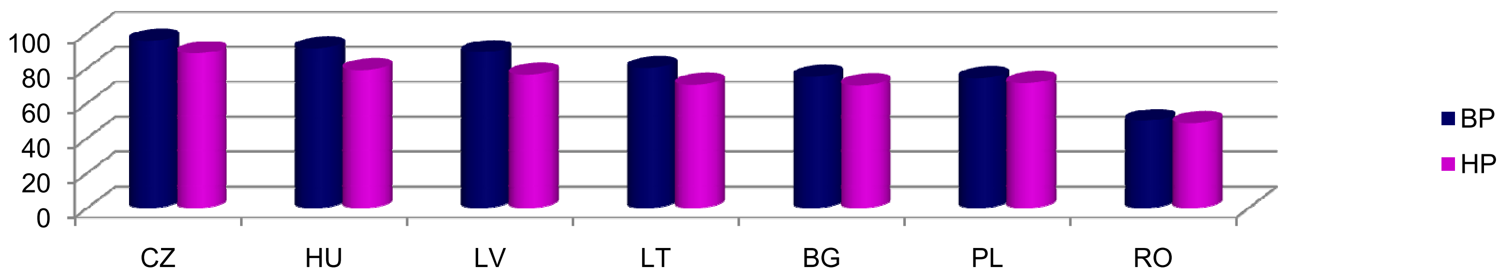
Real GDP without agriculture



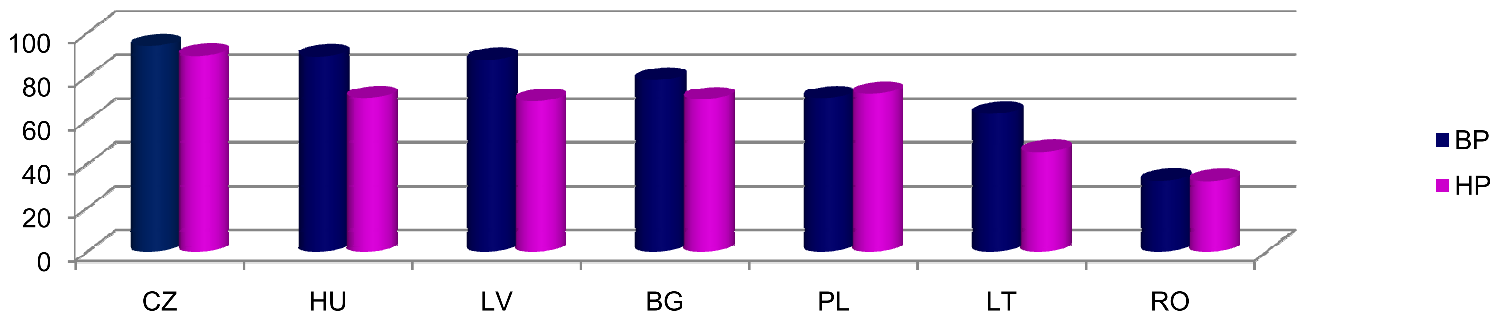
- ❑ similar business cycles, irrespective of the applied filter
- ❑ Romania's BC: expansion in 2004, weaker performance in 2005, expansion (2006-2008), aggressive recession in 2008, and slightly recovery in 2011
- ❑ significant effect of agriculture
- ❑ same pattern for the other CEEC's

Correlation of CEECs business cycles with the euro area (2000Q1-2012Q2)

Pearson



Spearman



- ❑ similar ranking of countries using the two detrending methods
- ❑ as intuitively expected, Czech Republic and Hungary appear as the best synchronized with the euro area, while Romania is at the bottom of the ranking

Business cycles synchronization: CEECs-Euro Area

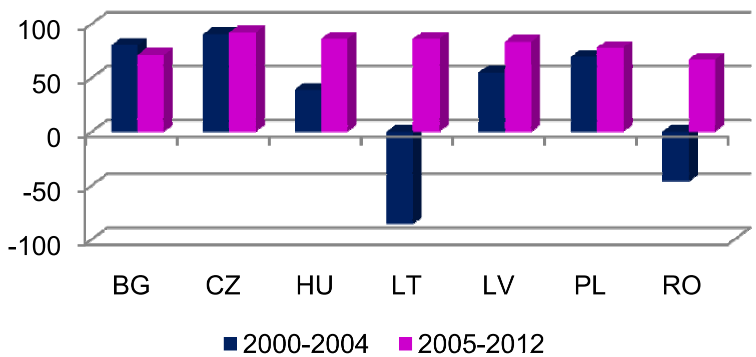
Correlation	HP_BG	HP_CZ	HP_EA	HP_HU	HP_LT	HP_LV	HP_PL	HP_RO
HP_BG	1							
HP_CZ	0.79	1						
HP_EA	**0.70**	**0.88**	1					
HP_HU	0.66	0.81	**0.79**	1				
HP_LT	0.82	0.75	**0.70**	0.81	1			
HP_LV	0.78	0.76	**0.76**	0.82	0.94	1		
HP_PL	0.65	0.69	**0.71**	0.44	0.44	0.46	1	
HP_RO	0.86	0.65	**0.48**	0.58	0.81	0.71	0.49	1

Correlation	BP_BG	BP_CZ	BP_EA	BP_HU	BP_LT	BP_LV	BP_PL	BP_RO
BP_BG	1							
BP_CZ	0.80	1						
BP_EA	**0.75**	**0.96**	1					
BP_HU	0.65	0.90	**0.91**	1				
BP_LT	0.80	0.81	**0.80**	0.76	1			
BP_LV	0.82	0.87	**0.89**	0.79	0.93	1		
BP_PL	0.57	0.62	**0.74**	0.75	0.73	0.72	1	
BP_RO	0.80	0.55	**0.49**	0.47	0.82	0.69	0.48	1

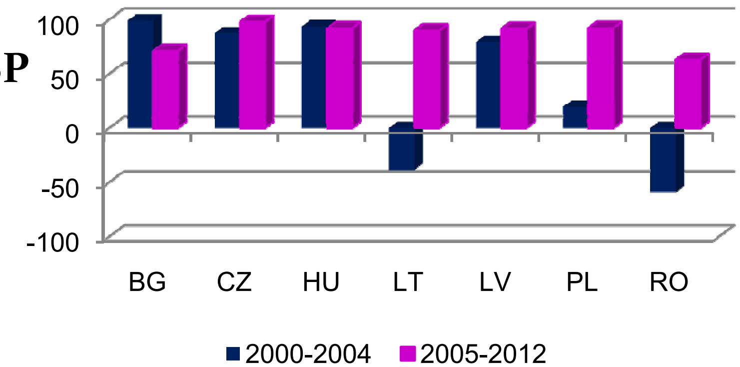
Dynamic evolution of the degree of synchronization

- **Sub-periods analysis – Pearson correlation coefficient**

HP

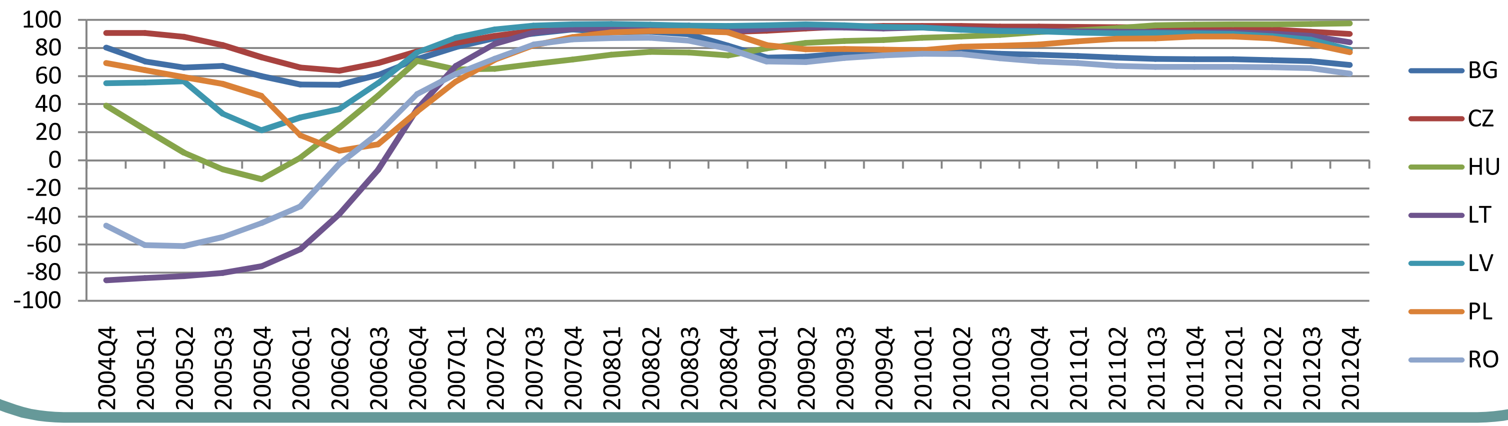


BP



- higher correlations in the latest period (2005-2012), due to favorable evolution of CEECs until 2008 and also due to economic turbulences starting at this point

- **5 years rolling window -HP**



Classical Cycle Approach - MS Model (Hamilton 1989): components

- an unobservable state variable (S_t) which makes the variable of interest shift between several regimes according to a first order Markov chain
- the transition probability matrix that governs the transition from one state to another
- the joint conditional probability of future states is obtained as a function of the joint conditional probability of the current states and the transition probabilities
- through Hamilton's filter (1989) conditional probabilities of future states are obtained, filtering by the transition probability matrix the input of conditional probabilities of current states

Methodology (1) - Markow Switching Regime Model

- $n_t = \alpha_0 + \alpha_1 S_t + n_{t-1}$

where: n_t is the trend of the series, S_t=0 or 1 denotes the unobserved state of the system

- Transition probabilities:

  $Prob[S_t=1|S_{t-1}=1]=p$

  $Prob[S_t=0|S_{t-1}=1]=1-p$

  $Prob[S_t=0|S_{t-1}=0]=q$

  $Prob[S_t=1|S_{t-1}=0]=1-q$

- The AR model for the cycle: $\Delta y_t^c = A^c(L)\Delta y_{t-1}^c + e_t^c$, where

$e_t^c \sim \text{iid}\, \mathrm{N}(0, \sigma_c^2)$

Methodology (2) - Hamilton's filter

1) $P[S_t=s_t, S_{t-1}=s_{t-1},\dots,S_{t-r}=s_{t-r} \mid \Delta y_{t-1},\Delta y_{t-2,\dots}]=P[S_t=s_t \mid S_{t-1}=s_{t-1}]xP[S_{t-1}=s_{t-1}, S_{t-2}=s_{t-2},\dots,S_{t-r}=s_{t-r} \mid \Delta y_{t-1},\Delta y_{t-2,\dots}]$

2) Compute the joint probability of Δy_t and $(S_t, S_{t-1},..,S_{t-r})$

$f(\Delta y_{t,} S_t=s_{t,} S_{t-1}=s_{t-1},\dots,S_{t-r}=s_{t-r} \mid \Delta y_{t-1},\Delta y_{t-2,\dots})=f(\Delta y_t \mid St=s_{t,} S_{t-1}=s_{t-1},\dots,S_{t-r}=s_{t-r},\Delta y_{t-1},\Delta y_{t-2,\dots}]xP(S_t=s_{t,} S_{t-1}=s_{t-1},\dots,S_{t-r}=s_{t-r} \mid \Delta y_{t-1},\Delta y_{t-2,\dots}]$

3) Compute the predictive density of Δy_t based on t-1 information:

$$f(\Delta y_t \mid \Delta y_{t-1,}\Delta y_{t-2\dots})= \sum_{s_t=0}^{1} \sum_{s_{t-1}=0}^{1} \cdots \sum_{s_{t-r}=0}^{1} f(\Delta y_{t,}\ S_t=s_{t,} S_{t-1}=s_{t-1},\dots,S_{t-r}=s_{t-r} \mid \Delta y_{t-1},\Delta y_{t-2,\dots})$$

Methodology (3) - Hamilton's filter

4) Apply Bayes theorem to obtain:

$$P[S_t=s_t, S_{t-1}=s_{t-1},\dots,S_{t-r}=s_{t-r}|\Delta y_t,\Delta y_{t-1},\dots] = \frac{f(\Delta y_t, S_t = s_t, S_{t-1} = s_{t-1},\dots, S_{t-r} = s_{t-r} \mid \Delta y_{t-1}, \Delta y_{t-2},\dots)}{f(\Delta y_t \mid \Delta y_{t-1}, \Delta y_{t-2},\dots)}$$

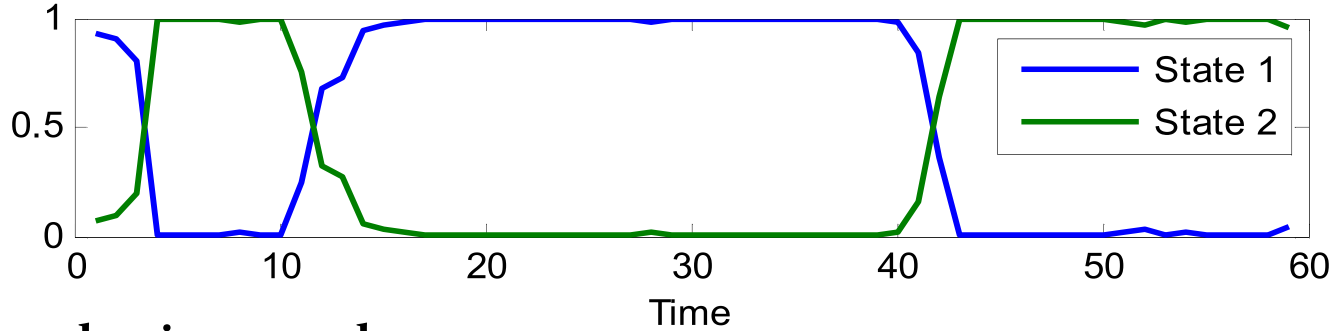
5) Obtain the desired output:

$$P[S_t=s_t, S_{t-1}=s_{t-1},\dots,S_{t-r+1}=s_{t-r+1}|\Delta y_t,\Delta y_{t-1},\dots]= \sum_{S_{t-r}=0}^{1} P[S_t = s_t, S_{t-1} = s_{t-1},\dots, S_{t-r} = s_{t-r} \mid \Delta y_t, \Delta y_{t-1},\dots]$$

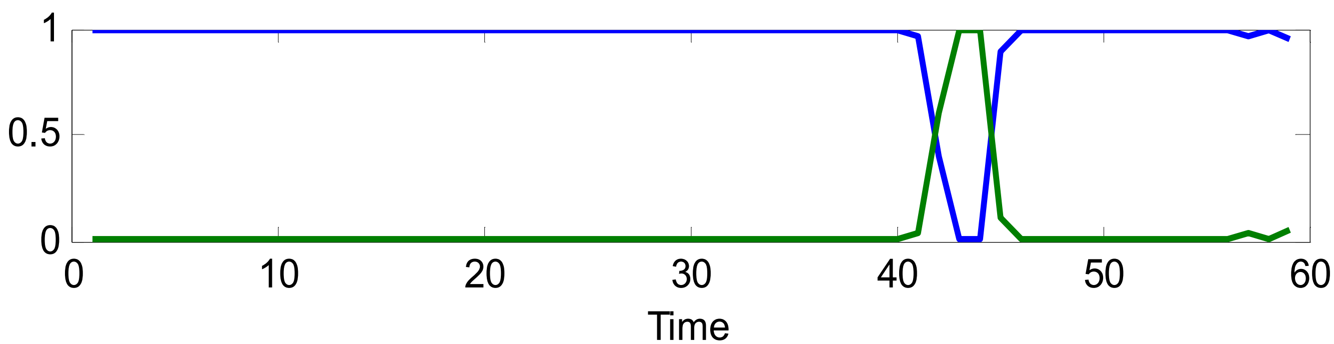
When there are only two regimes, $S_t \in \{0,1\}$: the observation will be assigned to the first regime if $\Pr(S_t=0 \mid y_T) > 0.5$ and to the second if $\Pr(S_t=0 \mid y_T) < 0.5$

Empirical results – Classical cycle approach

Romania's business cycle 1998 Q1-2012 Q4



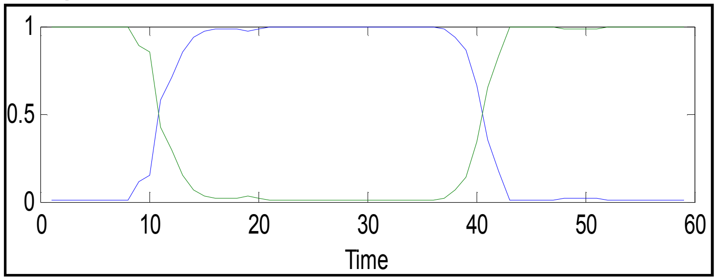
Eurozone business cycle



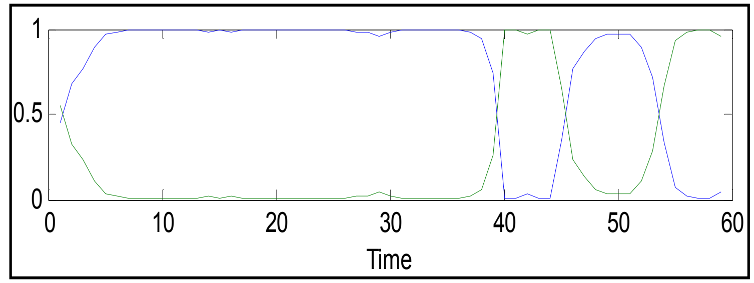
- ❑ the model captures correctly the main evolutions in the aggregate output in all the analyzed economies
- ❑ Romania: two significant turning points which mark the recovery process after 2000, and the recession in 2008

Business cycles of the CEECs – Classical approach

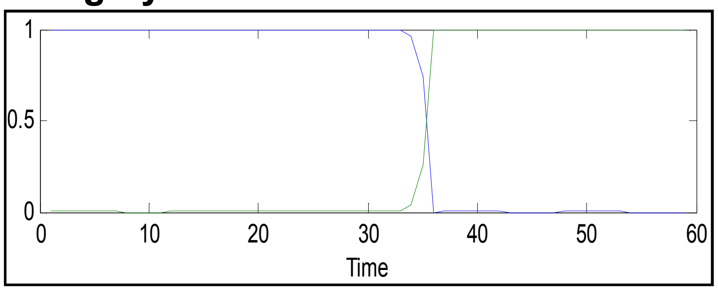
Bulgaria



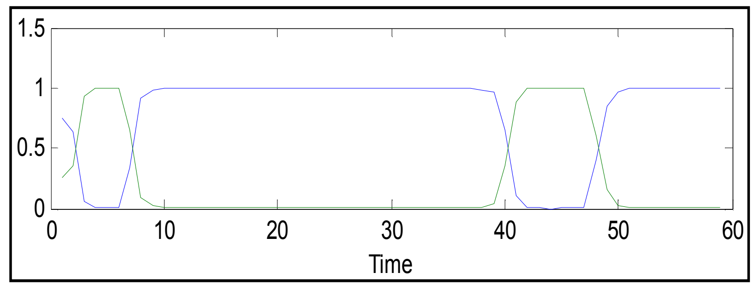
Czech Republic



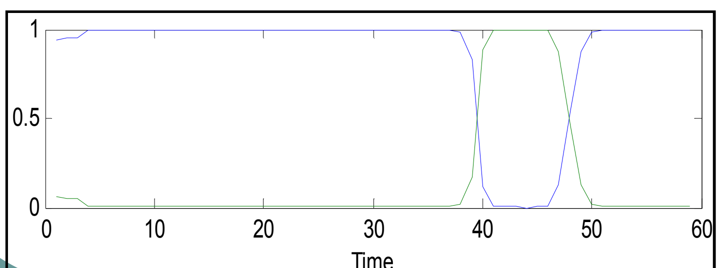
Hungary



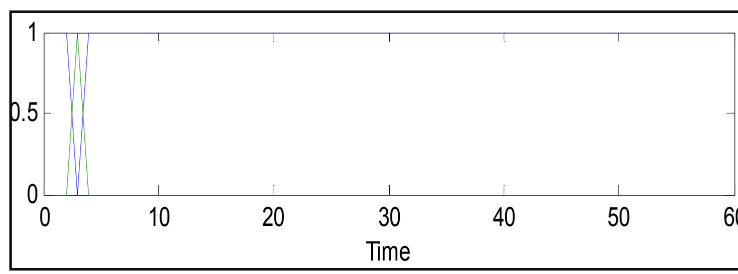
Lithuania



Latvia



Poland



Parameters estimation – Markow Switching Regime model (real GDP)

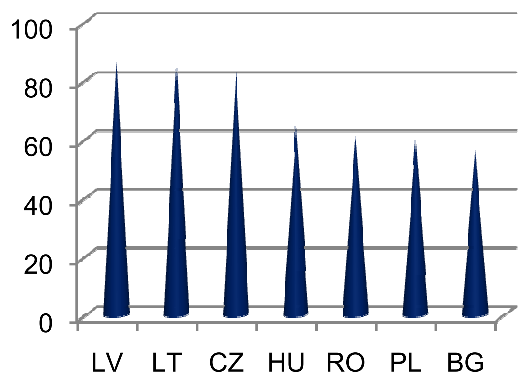
	Regime 1					Regime 2					
Country	σ	Std error (p-value)	n_t value (Growth rate)	Std error (p-value)	Duration (quarters)	σ	Std error (p-value)	n_t value (Growth rate)	Std error (p-value)	Duration (quarters)	Transition probabi-lities
EA	0.000027	0.0000 (0.00)	0.0045	0.0007 (0.00)	49.02	0.00012	0.0001 (0.33)	-0.0194	0.0097 (0.05)	2.63	p11=0.98 p12=0.38 p21=0.02 p22=0.62
RO	0.000054	0.0000 (0.00)	0.0158	0.0013 (0.00)	15.63	0.00016	0.0001 (0.00)	-0.0025	0.0030 (0.40)	21.37	p11=0.94 p12=0.05 p21=0.06 p22=0.95

- the annual growth rates of all analyzed CEECs in the first regime lie between 4% and 6,5%, while in euro area this rate is only 1,8%: *catching-up* process
- duration of regimes: Romania and Bulgaria lasted longer in the second regime, while Poland, Hungary , Czech Republic, and of course, the euro area had a faster recovery

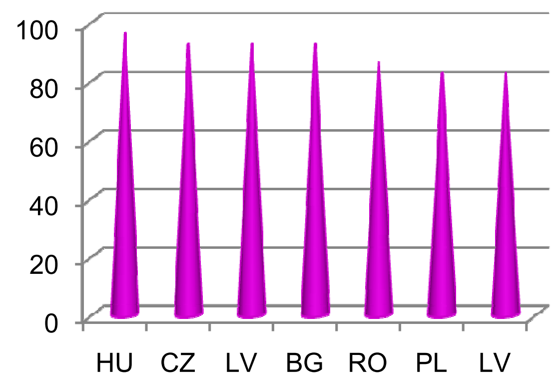
Synchronization indicators between the BC of CEECs and that of the Euro Area – Classical Approach

Concordance index

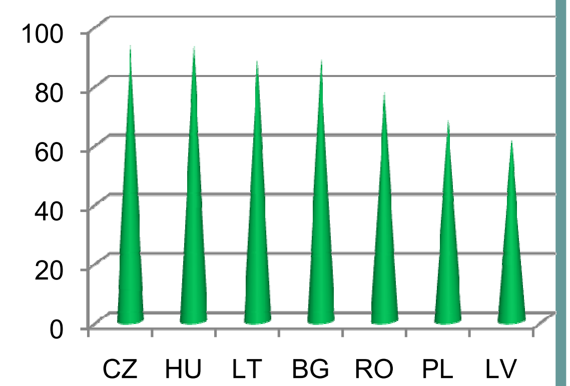
Real GDP



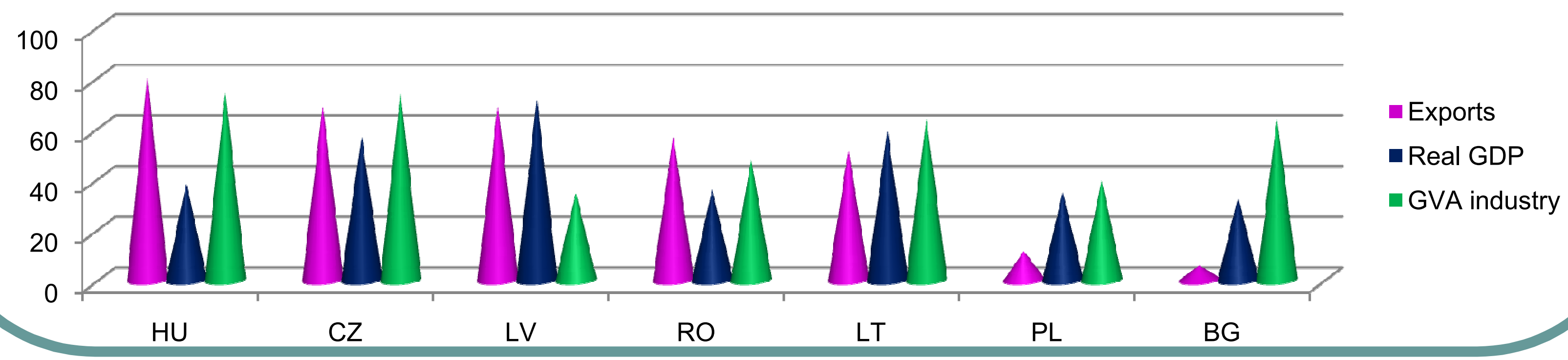
Exports



GVA industry



Contingency coefficient



Synchronization in terms of exports and GVA industry – Deviation Cycle Approach

Pearson correlation coefficient

Exports	BG	CZ	HU	LT	LV	PL	RO
BP:CF	64.8	96.5	97.1	70.8	91.1	87.2	70.2
	7	2	1	5	3	4	6
HP	54.6	89.0	91.8	64.5	87.7	70.9	64.3
	7	2	1	5	3	4	6
GVA industry	**BG**	**CZ**	**HU**	**LT**	**LV**	**PL**	**RO**
BP:CF	75.6	81.8	96.7	88.8	88.4	65.9	88.2
	6	5	1	2	3	7	4
HP	70.5	77.7	93.4	83.4	85.1	64.4	76.1
	6	4	1	3	2	7	5

Remarks:

- the results from the classical approach mostly confirm the ones based on deviation cycle approach, Romania and Bulgaria being the least correlated in terms of real GDP
- higher correlations in terms of exports – euro area: main trade partner
- Romania: better position in terms of exports (~70% degree of correlation)
- GVA industry: results are similar in terms of ranking, with Hungary and Czech Republic as leaders

The SVAR model

- X_t - vector that contains the two variables that compose the VAR: $X_t = \begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix}$

$$BX_t = \Gamma_0 + \Gamma_1 X_{t-1} + \ldots + \Gamma_p X_{t-p} + \varepsilon_t$$

Where ε_t is the vector of the two structural errors (demand and supply)

- assuming that B is invertible, we can rewrite the VAR model in its reduced form:

$$X_t = B^{-1}\Gamma_0 + B^{-1}\Gamma_1 X_{t-1} + \ldots + B^{-1}\Gamma_p X_{t-p} + B^{-1}\varepsilon_t$$

$$X_t = A(L)X_t + e_t$$

- the bivariate moving average representation of VAR:

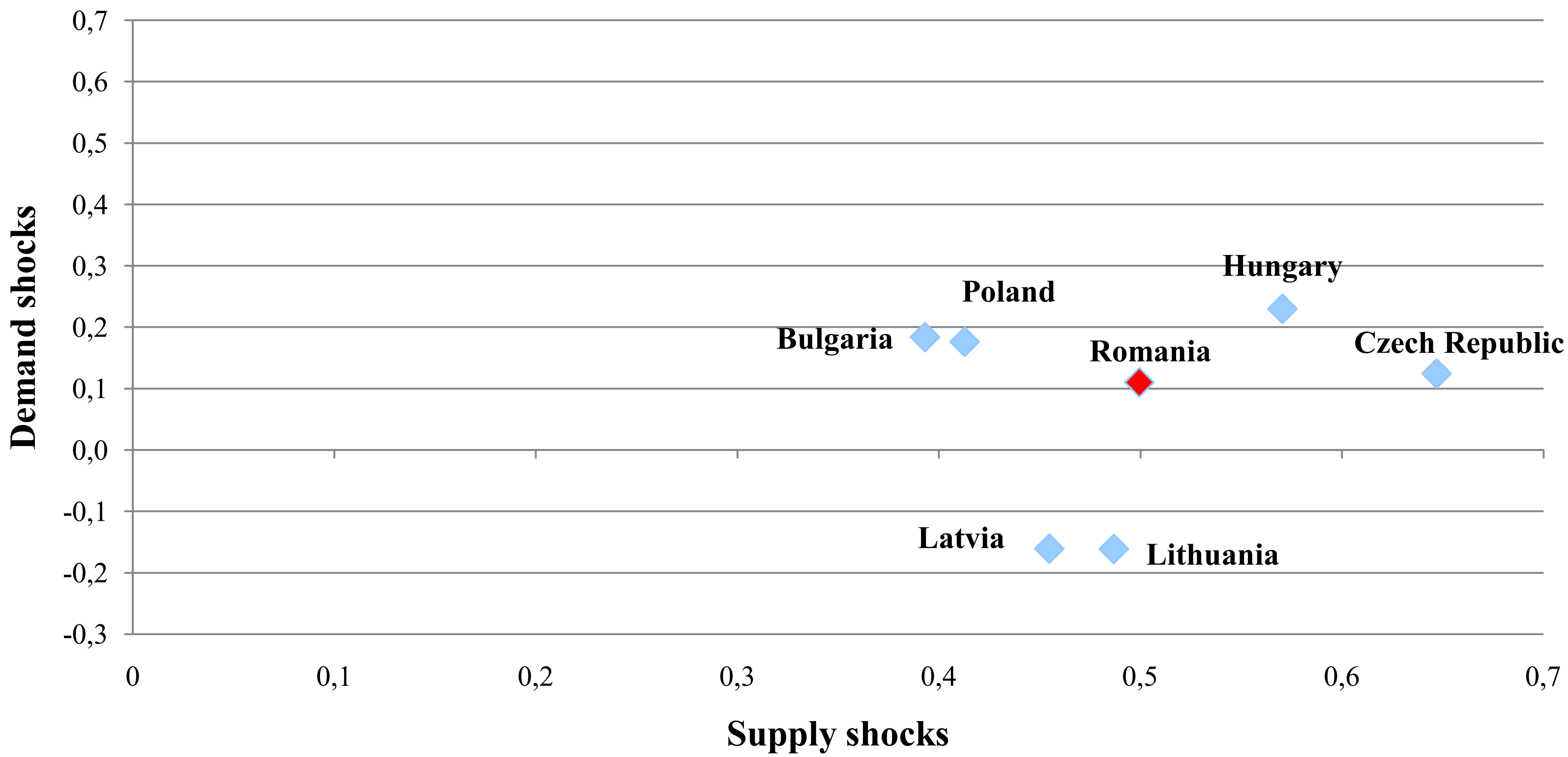
$$\begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix} = \sum_{i=0}^{\infty} L^i \begin{bmatrix} b_{11i} & b_{12i} \\ b_{21i} & b_{22i} \end{bmatrix} \begin{bmatrix} \varepsilon_{st} \\ \varepsilon_{dt} \end{bmatrix}$$

SVAR-steps for correct identification of the model:

- applied stationarity tests: ADF, KPSS – all series are I(1) therefore we used the first difference of real GDP and GDP deflator
- we chose the optimal no of lags based on informational criteria AIC, SC, HQ
- checked the VAR stability condition: no root lies outside the unit circle
- imposed the long run restriction (Bayoumi and Eichengreen, 1992) in order to obtain the aggregate demand and supply shocks: *an aggregate demand shock does not have a permanent effect on output*
- checked that impulse responses respect the macroeconomic correlations
- after obtaining the structural shocks, we used the series to compute correlation coefficients

Results: Correlation of demand and supply disturbances between CEECs and the euro area

1998Q4:2012:Q4



Correlation of aggregate demand shocks

Correlation	BG	CZ	EA	HU	LT	LV	PL	RO
BG	1							
CZ	0.090961	1						
EA	**0.183868**	**0.124239**	1					
HU	-0.028632	0.315562	**0.229685**	1				
LT	-0.350656	0.03547	**-0.161625**	-0.096237	1			
LV	-0.059833	-0.125319	**-0.16104**	0.088045	0.485311	1		
PL	-0.072583	0.505537	**0.176071**	0.433376	0.134494	0.027147	1	
RO	-0.322628	-0.00048	**0.109998**	0.366601	0.221407	0.056137	0.409922	1

Correlation of aggregate supply shocks

Correlation	BG	CZ	EA	HU	LT	LV	PL	RO
BG	1							
CZ	0.258577	1						
EA	**0.393048**	**0.647011**	1					
HU	0.264835	0.591289	**0.570557**	1				
LT	0.361068	0.551684	**0.486827**	0.533705	1			
LV	0.272216	0.397181	**0.454731**	0.486284	0.721871	1		
PL	0.276343	0.494677	**0.412744**	0.285417	0.173849	0.258322	1	
RO	0.368282	0.56347	**0.499403**	0.546305	0.587523	0.345965	0.277835	1

Correlation of demand and supply disturbances - Remarks

- The CEECs are more correlated in terms of supply shocks
- The lower correlation in terms of demand shocks can be explained by the fact that this type of disturbances are usually related to changes in economic and monetary policy or exchange rate regime frequently encountered by the CEECs in the analyzed period
- Validation of previous results: in terms of supply shocks, Czech Republic and Hungary appear as most correlated
- Romania: relatively high similarity of supply shocks with the euro area (49.9%), but instead the demand shock correlation is one of the lowest (only 11%), due to different exchange rate regimes, different internal policies in the context of transition to the market economy

Conclusions (1)

- irrespective of the addressed definition of cycle (classical or deviation approach) the results show the same evidences: Czech Republic and Hungary have a tendency to move towards synchronization with euro area, while Romania and Bulgaria are still among the least synchronized candidate countries
- CEECs business cycles are more synchronized with euro area in terms of real exports (also the case of Romania)
- there is strong evidence that business cycles became more synchronized after the crisis episode in 2008, when all CEECs faced strong GDP contractions
- high correlation in respect of supply shocks for all CEECs and very low or negative correlation as regard demand shocks (changes in economic and monetary policy or exchange rate regime)

Conclusions (2)

- **Major finding:**

  As the OCA theory mentions business cycle synchronization between the most important real convergence criteria in order for an accession country to join the euro area without significant macroeconomic costs, we consider that Romania still has to make significant progresses in order to avoid the occurrence of asymmetric shocks which are difficult to deal with in the absence of independence of monetary policy and exchange rate instrument.

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Thank you!