A COMPARATIVE ANALYSIS OF REAL AND PREDICTED INFLATION CONVERGENCE IN CEE COUNTRIES DURING THE ECONOMIC CRISIS

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Abstract: *The main objective of this study is to make a comparative analysis of inflation convergence in Central-Eastern European countries (CEE countries) during the economic crisis over 2008-2013. For Bulgaria, Czech Republic, Hungary, Poland, Romania and Slovakia the inflation convergence has decreased in the analyzed period, the coefficient of variation (64.22%) showing strong divergence compared to the slow divergence indirectly predicted by the European Commission. The negative catch-up rates for Bulgaria, Poland and Slovakia explain the large negative consequences of the actual economic crisis for these countries. The Fisher-type test for panel data indicated no convergence for real and predicted inflation convergence. The analysis based on random effects models indicated an inflation convergence rate of 15.47% in CEE economies compared to a predicted convergence rate of 2.04%.*

Keywords: convergence; forecasts; accuracy; catch-up rate; panel unit root test.
JEL Classification: C53; E37; E52.

INTRODUCTION

The main purpose of this study is to make a comparative analysis between the registered convergence during the economic crisis and the predicted convergence based on European Commission forecasts for Central-Eastern European countries. Therefore, the degree of convergence was assessed using classical indicators like coefficient of variation. The catch-up rates were also computed and panel unit root tests were employed to check the convergence hypothesis. In this research the convergence in inflation rate was analyzed.

The paper is structured in several sections. In the second section there is a description of main findings in literature and the methodological framework is presented. The next section consists in a presentation of the convergence process in CEE countries and the differences with the anticipations based on European Commission forecasts for these countries. All the approaches conduct us to the conclusion that the convergence process was wrongly predicted during the crisis, the real data indicating an increase in divergence over 2008-2013. In the end some conclusions are drawn.

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1. LITERATURE REVIEW AND METHODOLOGICAL FRAMEWORK

There are few studies interested in analyzing the achievement of inflation convergence mainly in European Union, but there are not researches that assess the predicted degree of convergence starting from the forecasts provided by different forecasters. Only OECD provided some scenarios for OECD countries and showed that each country converges to its own steady-state for GDP per capita. The cause of this convergence is represented by specific structural conditions and policies correlated to the technological developments. This prediction of convergence refers to 2011-2050 when poor economies will experience a stronger convergence. However, an ex-post evaluation of convergence has not been made. For 1996-2006, Bouis, Duval and Murtin (2011) have anticipated a convergence speed of 6% between OECD and non-OECD countries.

The financial and economic crisis started in 2008 has affected the economic convergence in the European Union. Halmai and Vásáry (2012) assessed the real convergence, the catch-up processes and the economic growth trends during the recent crisis. The countries have been affected differently by the recession. The Member States were classified into four groups: 'Developed' countries, 'Mediterranean' countries, 'Catch-up' countries and 'Vulnerable' countries, the last three groups being convergence countries.

Archibugi and Filippetti (2011) detected convergence in EU states in the innovative potential before the crisis (2004-2008), but the actual crisis have increased the disparities in innovative capabilities. Some policies are proposed by the authors in order to facilitate the cohesion.

A monetary policy framework has been proposed by Orlowski (2008) that targeted a relative inflation prediction for the economies that converge to euro. The author applied several empirical tests are conducted to assess the feasibility of adopting an instrument rule for some CEE countries like Czech Republic, Hungary and Poland, showing it is possible to adopt the targeting framework.

Strauch (2004) analyzed the performance of the growth and budgetary predictions made in the context of stability and convergence programmes of the European Union countries.

Kočenda and Papell (1996) studied the inflation convergence in European Union and they tested if the Exchange Rate Mechanism accelerated the inflation. Holmes (2002) checked the inflation convergence in most of the European Union countries utilizing unit root and co-integration tests. Using monthly data the author obtained a strong evidence of convergence, the macro-economic independence being explained by the ERM from 90s years.

Dupor, Han and Tsai (2009) showed that the differential response of inflation to the technological shocks and monetary policy is difficult to eliminate without information about rigidities.

Middeldorp (2011) showed that the predictability is influenced by the banks' transparency, observing that a higher transparency brings an improvement in interest rate predictions and diminishes the volatility.

The neoclassical model of Solow influenced a lot the new models by diminishing the gap between the real conditions of the economy and the various variants. The economic growth is supported by investments which bring positive externalities in accordance with the human capital development. The convergence achievement might also be determined by human and physical capital and the technologic process.

The variation is determined for more units (regions, countries) by utilizing simple indicators (range, deviation) and synthetic indicators (coefficient of variation, average linear deviation, dispersion or variance, standard deviation). Synthetic indicators show the distance between the values of a variable for each element and mean. The convergence at a certain time is measured with a variation indicator that shows how far the elements of the entire are from the average towards the values of the indicator converges.

In the dynamic approach, if the variation decreases there are enough evidence to conclude that we have a convergence process. The coefficient of variation is used in convergence analysis, because it is used in making comparisons. The variance is determined as:

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y})^2 \qquad (1)$$

y_i- the analyzed variable

i-index for units (regions, countries)

$\bar{y}$- arithmetic mean ($\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$)

The variance or dispersion indicates the values' degree of variation with respect to the average, being influenced by outliers and by the unit of measurement. In case of small samples the denominator is (n-1). The variance is utilized to determine the standard deviation ($\sigma = \sqrt{\sigma^2}$) and the coefficient of variation ($CV = \frac{\sigma}{\bar{y}}$). (Villaverde Castro, 2004) argued that the coefficient of variation is used in convergence analysis because it is independent of the unit of measurement and the order of indicators.

A decrease in time of the standard deviation shows the achievement of convergence for the variable *y*, this being known as σ convergence. It is useful to employ the coefficient of variation based on the population weight:

$$CV' = \frac{\sqrt{\sigma'^2}}{\bar{y}} \quad (2)$$

$$\sigma'^2 = \frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y})^2 (p_i - 1)$$

p_i- population weight

For measuring the convergence different analytical tools are employed and it is observed the decrease of differences with respect to the mean or of differences between two or more time series:

$$\lim_{t\to\infty}(x - y) = c \quad (3)$$

The sigma convergence characterizes the convergence level by assessing the dispersion of GDP per capita for one year. The cross-section data are employed for those regions or countries. The sigma convergence is useful in case of comparisons. For analyzing the trend of convergence, the time series are utilized on a discrete interval [t; t+T]. At a certain moment when the variable variance decreases, the convergence was achieved: $\sigma_{t+T} < \sigma_t$. When the variance increases the divergence was achieved: $\sigma_{t+T} > \sigma_t$.

The theoretical hypothesis that should be tested using a representative sample is:

$$\frac{1}{T}\log\left(\frac{y_{i'{t_0}+T}}{y_{i'{t_0}}}\right) = c - \left(\frac{1-e^{-\beta T}}{T}\right)\log\left(y_{i,t_0}\right) + \varepsilon_{i'{t_0},t_0+T} \quad (4)$$

The catch up of the rich economies is confirmed by the decrease of the GDP/capita degree of variation between countries, but also by the negative sign of the annual convergence rate of the GDP/capita of countries in the sample, these countries arriving at the same time in the steady state.

The catch-up rate is used to measure the pace of catching-up more developed regions. Some authors, like Cuaresma, Havettová and Lábaj (2013), have shown that convergence and catch-up do not express the same concept. The dynamics of the two variables are different, because the convergence shows the degree of progress, while the catch-up indicates the distance to be achieved towards convergence. For GDP growth it is useful to extend the catch-up for narrower residual difference and the convergence will be lower. The catch-up rate is defined as:

$$CR = 100 \cdot \frac{\Delta(y_{i,t} - y_t^*)}{(y_{i,t-1} - y_{t-1}^*)} \quad (5)$$

$y_{i,t}$ −GDP per capita in purchasing power standard (PPS) at moment t for country i

$y_t^* -$mean of GDP

Δy_t- difference between GDP at time t and GDP at time t-1

The indicator is usually computed for historical actual rates, being used for ex-post analysis of dynamics of catch-up rates.

If we have negative value for catch-up rates, then we can state that the disparities between countries have decreased.

The inflation rate for each country at time t is determined using the harmonized index of consumer prices:

$$ir_t = ln\frac{HICP_t}{HICP_{t-1}} \cdot 100 \qquad (6)$$

An autoregressive model of order 1 is proposed for the inflation rate:

$$ir_{i,t} = \alpha + \beta \cdot ir_{i,t-1} + \varepsilon_{i,t} \quad (7)$$

The average inflation corresponding to the group of countries in a certain time period t is computed as:

$$\overline{ir_t} = \alpha + \beta \cdot \overline{ir_{t-1}} + \varepsilon_t \qquad (8)$$

where the average inflation is calculated as: $\overline{ir_t} = \frac{1}{n}\sum_{i=1}^{n} ir_{i,t}$

n- number of countries

For convergence analysis we have to work with inflation differential, which is the difference between the inflation in each country and the average inflation in the entire group at time t. the average of inflation differentials is zero for all countries and time periods.

After subtracting the last equation from the previous one, we will obtain:

$$ir_{i,t} - \overline{ir_t} = \beta \cdot \left(ir_{i,t-1} - \overline{ir_{t-1}}\right) + \varepsilon_{i,t} \quad (9)$$

The convergence condition implies a decrease in time of the inflation differentials. Therefore, the estimate of the parameter β should be less than 1. A value higher than 1 for this estimate implies divergence. Actually, β is in this case the convergence coefficient.

The estimate of β is used to compute the actual convergence rate within a certain group of countries. If the difference $ir_{i,t} - \overline{ir_t}$ is denoted by $d_{i,t}$, we assume that the inflation differentials diminish in time as:

$$d_{i,t} = d_0 \cdot e^{-rt} \quad (10)$$

where r- convergence rate

The convergence rate can be determined taking into account the convergence coefficient:

r=- ln(β) (11)

The Dickey-Fuller (DF) test is used to calculate the convergence coefficient for a group of countries. The Augmented-Dickey-Fuller (ADF) test deletes the eventual auto-correlation in data. The difference of inflation differential is $\Delta d_{i,t} = d_{i,t} - d_{i,t-1}$ and the equation corresponding to ADF test is:

$$\Delta d_{i,t} = (\beta - 1) \cdot d_{i,t-1} - \sum_{j=1}^{k} \gamma_j \Delta d_{i,t-j} + \varepsilon_{i,t} \quad (12)$$

where i=1,2,…, k is the index for countries in a certain group.

This equation checks the presence of unit root in the panel. If the convergence coefficient is different from 1, then the null hypothesis of unit root is rejected.

A parametric method is utilized to compute the number of lagged differences (k). A maximum value of k is a start value for the procedure. After the regression estimation, the significance of the parameter γ_j is tested. In case of non-significance, the value of k decreases with one unit and the regression (7) is estimated again till we get a k for which the parameter is significant. If we did not find a significant parameter, then k will take the value 0 and the standard Dickey-Fuller test is applied.

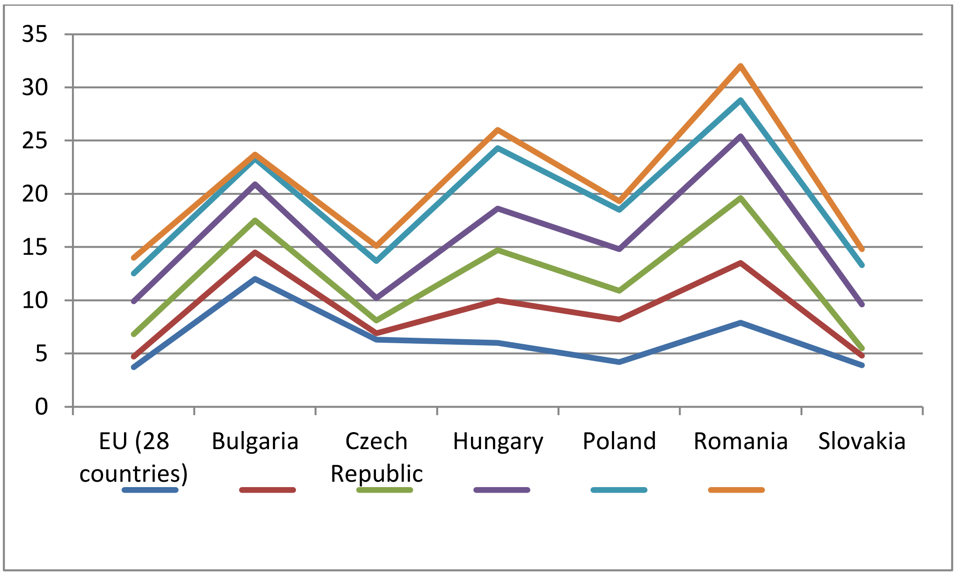
In panel data analysis the most used critical values are those proposed by Levin, Lin and Chu (2002), but these critical values do not take into account the errors' auto-correlation, not being suitable for small samples. Therefore, Kočenda and Papell (1996) proposed higher critical values using Monte Carlo simulations in order to take into account the errors' serial correlation.

The critical values were determined using Monte Carlo method. Autoregressive (AR) models were estimated and the best AR model was chosen using Schwarz criterion. These models actually represent the errors' data generating process for each panel. The pseudo-samples are built using the best AR models that are independent and identically distributed with the null average and variance equaled to σ^2. Then, t test is applied in order to check the significance of (1- β) with a lag length equaled to k.

2. THE IMPACT OF ECONOMIC CRISIS ON FORECASTS ACCURACY

In this study the inflation rate evolution in CEE countries (Bulgaria, Czech Republic, Hungary, Poland, Romania and Slovakia) is analyzed in parallel with the forecasts made by European Commission. The trends tend to keep the same for all the countries, even if there are different inflation levels for the various countries. For the entire European Union (EU-28), there are higher inflation rates during 2008-2013 compared to the CEE economies.

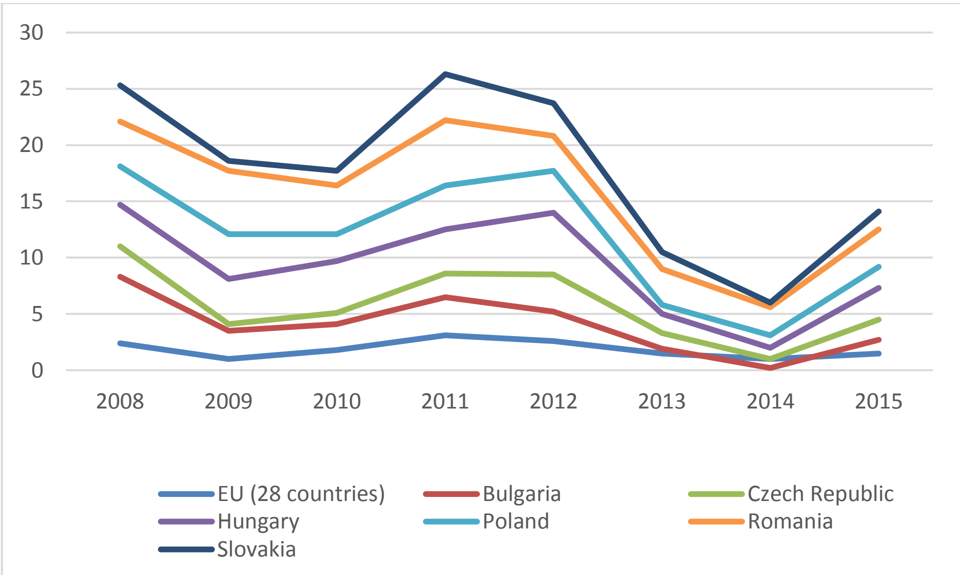
Figure 1 - The evolution of the actual inflation rate in CEE economics and EU-28 during 2008-2013



Source: author's compilation

The predictions made for the entire European Union (EU-28) are lower than those made for CEE countries, excepting some values for Bulgaria. At the beginning and at the end of the horizon (2008-2013), the predictions tend to decrease for all countries, but another increase is anticipated for 2014-2015.

Figure 2 - The evolution of the predicted inflation rate in CEE economics and EU-28 during 2008-2013



Source: author's compilation

The values of the coefficient of variation show an evident divergence in 2008 for CEE countries, in 2013 the divergence being higher. In predictions for 2008 indicate a slow convergence in inflation while for 2013 a slow divergence is predicted.

Table 1 - The coefficient of variation for actual and predicted values during the economic crisis (2008-2013)

Indicator	Value in 2008	Value in 2013
CV actual values	44.30%	64.22%
CV predicted values	29.14%	37.62%

Source: author's computations

The catch-up rate measures the absolute disparity. The negative catch-up rates for Bulgaria, Poland and Slovakia explain the large negative consequences of the actual economic crisis for these countries. Higher catch-up rates were predicted for these states and for Hungary, while for Czech Republic and Romania the EC predicted lower rates when actually the disparities are larger.

Table 2 - Average catch-up rates (%) in CEE countries in 2008-2013

Country	Catch-up rate actual values	Catch-up rate predicted values
Bulgaria	-6.33	-5.45
Czech Republic	13.21	10.2
Hungary	2.1	2.28
Poland	-6.59	-3.27
Romania	10.1	9.21
Slovakia	-11.6	-7.33

Source: author's computations

The values of all the statistics indicate that we do not enough evidence to reject the null hypothesis. So, at 5% level of significance we can state that all the panels contain unit root and consequently there is no convergence between CEE countries.

Table 3 - The results of Fisher-type unit root test for inflation rate in CEE countries based on augmented Dickey-fuller tests

Statistic	Statistic's value	p-value
Inverse chi-squared	13.2686	0.3498
Inverse normal	-0.1072	0.4573
Inverse logit t	-0.1480	0.4416
Modified inverse chi-squared	0.2590	0.3978

Source: own computations

The same test is applied for checking the stationary that is implied by the EC's predictions for CEE countries.

Table 4 - The results of Fisher-type unit root test for inflation rate predictions in CEE countries based on augmented Dickey-fuller tests

Statistic	Statistic's value	p-value
Inverse chi-squared	16.2531	0.1799
Inverse normal	-0.3459	0.3647
Inverse logit t	-0.4904	0.3135
Modified inverse chi-squared	0.8682	0.1927

Source: own computations

According to Fisher-type test there is no evidence of convergence for the forecasts made by EC for CEE countries.

The convergence rate was calculated by running some panel data regression models. The fixed-effects model was not valid for actual and predicted data, the Hausman test indicating that the random effects GLS regression model is more suitable. The results of estimations are described in Appendix 2. The average divergence rate for the registered inflation in CEE countries was about 15.47%. However, according to predictions analysis, the forecasted average convergence rate is 2.04%. Actually, the convergence was wrongly predicted.

CONCLUSIONS

The inflation convergence is an important criterion of the European Union. In this study we were interested to assess the degree of convergence in countries located in Central-Eastern Europe. These are post-communist countries with similar evolutions and trends of the inflation rate. The convergence was analyzed during the economic crisis period and it was compared to predicted convergence based on European Union anticipations of inflation rates in CEE states.

Even if the European Union anticipated a decrease in convergence, the results indicate that there are evidence of large convergence during the crisis, the shocks in the economic could not be clearly identified.

APPENDIX 1

FISHER-TYPE UNIT ROOT TESTS

```
Fisher-type unit-root test for inflation
Based on augmented Dickey-Fuller tests
----------------------------------------
Ho: All panels contain unit roots            Number of panels  =      6
Ha: At least one panel is stationary         Number of periods =      6

AR parameter: Panel-specific                 Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                   ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(12)    P       13.2686       0.3498
 Inverse normal             Z       -0.1072       0.4573
 Inverse logit t(34)        L*      -0.1480       0.4416
 Modified inv. chi-squared Pm        0.2590       0.3978
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------

Fisher-type unit-root test for inflationp
Based on augmented Dickey-Fuller tests
-----------------------------------------
Ho: All panels contain unit roots            Number of panels  =      6
Ha: At least one panel is stationary         Number of periods =      6

AR parameter: Panel-specific                 Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                   ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(12)    P       16.2531       0.1799
 Inverse normal             Z       -0.3459       0.3647
 Inverse logit t(34)        L*      -0.4904       0.3135
 Modified inv. chi-squared Pm        0.8682       0.1927
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

APPENDIX 2

FIXED-EFFECTS AND RANDOM EFFECTS MODELS

```
Fixed-effects (within) regression               Number of obs      =        30
Group variable: country                         Number of groups   =         6

R-sq:  within  = 0.0259                         Obs per group: min =         5
       between = 0.1617                                        avg =       5.0
       overall = 0.0181                                        max =         5

                                                F(1,23)            =      0.61
corr(u_i, Xb)  = -0.0936                        Prob > F           =    0.4424
```

dd	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
t	.1827919	.2338337	0.78	0.442	-.3009299	.6665137
_cons	-.8863837	.9603642	-0.92	0.366	-2.873048	1.100281
sigma_u	.54742435					
sigma_e	2.0966941					
rho	.06381734	(fraction of variance due to u_i)				

```
F test that all u_i=0:     F(5, 23) =      0.34              Prob > F = 0.8847
```

```
Fixed-effects (within) regression               Number of obs      =        30
Group variable: country                         Number of groups   =         6

R-sq:  within  = 0.0005                         Obs per group: min =         5
       between = 0.0002                                        avg =       5.0
       overall = 0.0004                                        max =         5

                                                F(1,23)            =      0.01
corr(u_i, Xb)  = -0.0060                        Prob > F           =    0.9158
```

ddp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
t	-.0219173	.2049487	-0.11	0.916	-.4458859	.4020513
_cons	.3418841	.8417323	0.41	0.688	-1.399372	2.08314
sigma_u	.46159111					
sigma_e	1.8376935					
rho	.05934692	(fraction of variance due to u_i)				

```
F test that all u_i=0:     F(5, 23) =      0.32              Prob > F = 0.8986
```

```
Random-effects GLS regression                   Number of obs      =        30
Group variable: country                         Number of groups   =         6

R-sq:  within  = 0.0005                         Obs per group: min =         5
       between = 0.0002                                        avg =       5.0
       overall = 0.0004                                        max =         5

                                                Wald chi2(1)       =      0.01
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.9139

------------------------------------------------------------------------------
         ddp |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           t |  -.0203984   .1885664    -0.11   0.914    -.3899817    .3491849
       _cons |   .3361628   .7767165     0.43   0.665    -1.186174    1.858499
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  1.8376935
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

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