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THE IMPACT OF ECONOMIC CRISIS ON INFLATION CONVERGENCE IN THE EUROPEAN UNION. A PANEL DATA APPROACH[25]

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Abstract

The aim of this research is to assess the convergence rate of the inflation in European Union 28 (EU-28) and to evaluate the impact of recent economic crisis on the convergence process in inflation. Therefore, a panel data approach was used, the unit root tests for stationary indicating enough evidence for convergence in the period from 2002 to 2013. However, a decline in the convergence process was observed during the economic crisis (2008-2013) compared to the previous period of the same length (2002-2007), the convergence rate decreasing with 3.98 percentage points.

Keywords: *inflation convergence, unit root tests, economic crisis, panel data, inflation, convergence rate*

Introduction

Inflation convergence in the European Union is a popular topic in literature, many researchers being interested in the degree of convergence regarding different macroeconomic indicators.

The inflation rate convergence was specified in the Maastricht treaty as an important requirement to accept a country as member of the European Monetary Union. This condition requires that a country has an inflation rate that is higher with no more than 1.5 percentage points compared to the average of the three lowest inflation rates in the European Monetary System.

The objectives of this research is to assess the convergence rate in EU-28 and to check if there was a decline in convergence process during the recent economic crisis compared to the period before this crisis.

25) This paper presents some results from the study "Convergence in the European Union. Theory and applications" coordinated by Academician Lucian-Liviu Albu, being part of the research program for 2014 of the Institute for Economic Forecasting of the Romanian Academy.

The panel data approach and the unit root tests for panels are applied in this study.

The paper is structured in several sections, after a brief literature review, an extended methodology being presented. The empirical study refers to the members of the EU-28, obtaining a decline in convergence rate during the crisis compared to the previous period.

Literature review

The unit root testing procedure proposed by (Quah, 1992) proposed the unit root testing procedure using panel data, while (Levin & Lin, 1993) came with a test that is specific for individual effects panel. (Im, Pesaran, & Shin, 1995) started from Dickey-Fuller's test, proposing another test for which the statistic average is based on N elements.

(Islam, 1995) adapted the usual equation for convergence to dynamic panel approach. The advantage of panel approach is related to the fact that it permits differences in the aggregate production function. (Kočenda & Papell, 1996) studied the inflation convergence in European Union and they tested if the Exchange Rate Mechanism accelerated the inflation. (Harris & Tzavalis, 1996) developed the panel data procedure for normalized bias of the Least Squares estimator.

(Gaulier, Hurlin & Jean-Pierre, 1999) presented the tests for convergence based on panel data approach. The authors proposed a procedure to characterize different types of convergence, the analyzed samples referring to OECD, World and Europe. (Lee, Longmire, Matyas & Harris, 1998) applied the panel data approach for Solow model to analyze the convergence process in OECD countries. The results showed that there is a likely convergence to the stable state of about 2%-4%.

(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.

(Weeks & Yudong Yao, 2003) analyzed the income convergence in China's regions using the Solow model for growth. The authors used panel data approach, solving the estimation problem with generalized method of moments. The conclusion was that during the reform period in China there was an obvious divergence process. (Badinger, Müller, & Tondl, 2004) assessed the income convergence for NUTS2 regions, proposing a procedure for dynamic panels. Using system generalized moments method for filtered variables the authors computed a convergence speed of 7%. (Kutan & Yigit, 2009) used a panel data analysis for 8 new members of the European Union and showed that human capital is the most important factor that determined productivity growth during 1995-2006. (Lee, 2009) used the dynamic panel approach to make a comparative analysis between trade and foreign direct investment in the convergence framework. The results of panel unit root approach consist in confirming the convergence regarding the long-term productivity in manufacturing for 25 analyzed countries. (Ucar & Guler, 2010) used a seasonal variant of Solow-Swan model to analyze the convergence in some OECD countries. It was introduced a new statistic for which critical values were generated. (Arnold, Bassanini, & Scarpetta, 2011) computed the convergence speed in 21 OECD countries being consistent with augmented Solow model and Uzawa-Lucas model. (Nath & Hegwood, 2012) utilized panel unit root tests with structural breaks to study the price convergence in USA, obtaining an obvious price index convergence between towns in USA.

Methodology

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

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

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

$$ir_{i,t} = \alpha + \beta \cdot ir_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

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

$$\overline{ir_t} = \alpha + \beta \cdot \overline{ir_{t-1}} + \varepsilon_t \qquad \overline{ir_t} = \frac{1}{n}\sum_{i=1}^{n} ir_{i,t} \quad (3)$$

where the average inflation is calculated as:

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:

$$ir_{i,t} - \overline{ir_t} = \beta \cdot \left(ir_{i,t-1} - \overline{ir_{t-1}}\right) + \varepsilon_{i,t} \quad (4)$$

The last equation is essential in convergence methodology of Ben-David (1996). 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 supposes 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:

$$d_{i,t} = d_0 \cdot e^{-rt} \quad (5)$$

where r- convergence rate

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

$$r = -\ln(\beta) \quad (6)$$

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:

$$\Delta d_{i,t} = (\beta - 1) \cdot d_{i,t-1} - \sum_{j=1}^{k} \gamma_j \Delta d_{i,t-j} + \varepsilon_{i,t} \quad (7)$$

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 γj 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, 1992), but these critical values do not take into account the errors' auto-correlation, not being suitable for small samples. Therefore, (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.

A large number of replications is used and the vector of replications was sorted, representing the critical values of the sample repartitions. The selected significance levels were 1%, 5% and 10%. Later this test was improved by (Levin, Lin, & Chu (2002) that computed an adjusted t-statistic. (Harris & Tzavalis, 1999) used the unit root test for fixed time periods (T) and large number of groups (N). A homogeneous panel is considered:

$$y_{it} = \varphi \cdot y_{it-1} + v_{it} \quad (8)$$

The coefficient is zero under the null hypothesis. The, we consider a unit root process with non-homogenous drift:

$$y_{it} = \alpha_i + \varphi \cdot y_{it-1} + v_{it} \quad (9)$$

The last model has linear trend and heterogeneous drift:

$$y_{it} = \alpha_i + \beta_i \cdot t + \varphi \cdot y_{it-1} + v_{it} \quad (10)$$

For the null hypothesis $\omega = 1$ and $\beta i = 0$.

The OLS estimator is computed as:

$$\hat{\varphi} - 1 = [\Sigma_{i=1}^{N} y'_{i,\ 1} Q_T y_{i,\ 1}]^{-1} [\Sigma_{i=1}^{N} y'_{i,\ 1} Q_T v_i] \quad (11)$$

Q_T - projection matrix

$$y_{i,-1} = (y_{i0}, \ldots, y_{iT-1})$$
$$v'_i = (v_{i1}, \ldots, v_{iT})$$

Testing the inflation convergence before and during the economic crisis in EU-28

The annual average rate of change (%) based on harmonized index of consumer prices for period is provided by Eurostat for each of the 28 countries in the European Union. The data was partitioned in two time periods: before the recent economic crisis (2002-2007) and during the economic crisis (2008-2013) when the convergence hypothesis is analyzed separately during two distinct periods. The two time intervals have the same number of years (6).

Firstly, the Harris-Tzavalis unit-root test was applied for inflation rate during 2002-2013 (number of panels=28 and number of years=12). The assumptions for this test are:

Ho (null hypothesis): Panels have unit roots

Ha (alternative hypothesis): Panels are stationary

The autoregressive parameter is common, the panels means are included, but not the time trend. If all the panels are stationary, then a convergence tendency in inflation is identified.

Table 1 The results of Harris-Tzavalis unit-root test for all the countries (2002-2013)

	Statistic	Z	p-value
Rho	0.3357	-9.7597	0.00

Source: own computations

The p-value is 0, the null hypothesis being rejected. So, the panels are stationary. The average annual convergence rate in inflation for EU-28 during 2002-2013 is 9.15%. This implies that on the entire period we have evidence of convergence in inflation in EU-28. Indeed, the new members of EU (Croatia, Romania, Bulgaria, Slovenia, Slovakia, Malta, Czech Republic) had made efforts to get and maintain low inflation before and after the entrance in EU. The disparities between countries regarding inflation evolution are quite low on the entire period. The Fisher type unit root test for inflation is also applied for the entire period in order to check the convergence in inflation.

Table 2 The results of Fisher-type unit root test for inflation based on augmented Dickey-fuller tests

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Fisher-type unit-root test for inflation
Based on augmented Dickey-Fuller tests
-------------------------------------------
Ho: All panels contain unit roots          Number of panels  =     28
Ha: At least one panel is stationary       Number of periods =     12

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(56)    P       167.6312       0.0000
 Inverse normal             Z        -7.2255       0.0000
 Inverse logit t(144)       L*       -7.9137       0.0000
 Modified inv. chi-squared  Pm       10.5482       0.0000
-------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
-------------------------------------------------------------------
```

Source: own computations

The Fisher type unit root test indicated that at least one panel is stationary. The result of this test is in accordance with Harris-Tzavalis unit-root test. It confirms the convergence in inflation during 2002-2013.

Moreover, the Augmented Dickey-Fuller (ADF) test is applied to the average inflation rate of the entire EU-28. This time we do not take into consideration the individual evolution of inflation rate in each distinct country from European Union by using a panel data. We test the stationary of a time series for average inflation rate in EU-28. We suspect that the data aggregation made when the average is computed, might generate different results. Moreover, another perspective of convergence process is analyzed: the tendencies of the inflation values in EU as a whole to its average.

According to ADF test for the entire EU-28, we do not have enough evidence for convergence process at 5% level of significance. Indeed, the time series for average inflation in EU is not stationary and the convergence hypothesis is not confirmed. In this case the overall inflation in EU does not converge to a certain average.

Table 3 The results of Augmented Dickey Fuller for inflation of the entire EU-28

ADF Test Statistic (intercept included in test equation)	-4.565156	1% Critical Value*	-4.3260
		5% Critical Value	-3.2195
		10% Critical Value	-2.7557
ADF Test Statistic (trend and intercept included in test equation)	-4.154058	1% Critical Value*	-5.2735
		5% Critical Value	-3.9948
		10% Critical Value	-3.4455
ADF Test Statistic (no trend and no intercept included in test equation)	-0.549254	1% Critical Value*	-2.8622
		5% Critical Value	-1.9791
		10% Critical Value	-1.6337

Source: own computations

We run a fixed effects and a random effects model and a pooled OLS regression, the tests indicating than the pooled OLS regression model is the best. The application of Hausman test we got that model fitted on these data fails to meet the asymptotic assumptions of the Hausman test. Therefore, seemingly unrelated estimation is applied. For the OLS regression model, the errors' homoscedasticity and independence were checked. In the 28 countries of the European Union 44.14% of the variation in inflation is explained by the evolution in the previous period of the same indicator.

Table 4 The results of pooled OLS regression for inflation in EU-28

Source	SS	df	MS
Model	875.526384	1	875.526384
Residual	1108.0236	334	3.31743594
Total	1983.54999	335	5.92104474

Number of obs	= 336
F(1, 334)	= 263.92
Prob > F	= 0.0000
R-squared	= 0.4414
Adj R-squared	= 0.4397
Root MSE	= 1.8214

inflation	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
inflation1	.6155853	.0378926	16.25	0.000	.541047	.6901236
_cons	1.025133	.1538652	6.66	0.000	.7224664	1.3278

Source: own computations

The Harris-Tzavalis unit-root test was applied for the entire EU-28 before and during the crisis in order to observe if the convergence process declined during the crisis compared to the period before the actual economic crisis started in 2008. Previous studies made for GDP per capita convergence, like those of Albu(2012) and Simionescu(2014), showed that the economic crisis slowed the convergence in output. We suspect that this impact of economic crisis on convergence might be valid also for inflation.

Table 5 The results of Harris-Tzavalis unit-root test for EU-28 during the crisis period (2008-2013) compared to the previous period (2002-2007)

	Statistic	Z	p-value
Rho	-0.3535	-3.0997	0.0010

Source: own computations

The rate of convergence during the crisis (2008-20013) decreased with 3.98 percentage points compared to the ante-crisis period (2002-2007). During the crisis we have a slow convergence rate than on the entire period. This is due to the high convergence rate in the period before crisis start (2000-2007). Like in the case of GDP per capita, the economic crisis slowed the inflation convergence. Indeed, the convergence analysis is dependent on the considered time period. World food prices increased dramatically in 2007-2008, reaching a maximum in 2011. However, different policy measures have been implemented in the various countries of EU to face the price instability, but the impact was different. Therefore, the convergence rate was affected and it decreased during the crisis period compared to previous period or to the entire period.

Conclusions

The inflation rate convergence in EU is a process under observation of many economic actors. The stability of prices criterion should be achieved on the basis of inflation convergence. According to Maastricht treaty regarding the inflation convergence, the inflation rate of a candidate to Economic and Monetary Union should not surpass the threshold of 1.5% of the average of the first 3 countries with the lowest inflation from euro area. After the euro adoption as common currency, a clear process of divergence was observed in the euro zone. Most of the studies analysed the inflation convergence for euro zone, but this study brings as novelty the problem of inflation convergence in the entire European Union (EU-28).

For studying the inflation convergence, there is a various methodology presented in literature, employing complex statistical and econometric methods: models with variable coefficients in time, principal components analysis, co-integration approach, unit root test that consider the countries' correlations. However, the results of the convergence analysis in EU depend on time horizon and institutional changes. There are two tendencies that act in different senses: the Exchange Rate Mechanism has to ensure the inflation convergence while a common monetary policy and the unique currency bring the inflation divergence.

Moreover, the economic crisis generated an obvious decline in the convergence process of prices. The decrease in the convergence rate was assessed and the statistical results confirmed this hypothesis. The rate of convergence during the crisis in European Union decreased with 3.98 percentage points compared to the ante-crisis period. During the crisis we have a divergence process according to inflation evolution in EU-28. It would be interesting to check the convergence of other macroeconomic indicators before and during the crisis in a future research.

APPENDIX 1

Fixed effects and random effects models for the inflation rate

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Fixed-effects (within) regression               Number of obs      =       336
Group variable: country                         Number of groups   =        28

R-sq:  within  = 0.2187                         Obs per group: min =        12
       between = 0.9881                                        avg =      12.0
       overall = 0.4414                                        max =        12

                                                F(1,307)           =     85.95
corr(u_i, Xb)  = 0.6228                         Prob > F           =    0.0000
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inflation	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
inflation1	.4568419	.049276	9.27	0.000	.3598805	.5538033
_cons	1.517285	.1821803	8.33	0.000	1.158805	1.875765
sigma_u	.68064395					
sigma_e	1.819317					
rho	.12278102	(fraction of variance due to u_i)				

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F test that all u_i=0:     F(27, 307) =     1.03                 Prob > F = 0.4297

Random-effects GLS regression                   Number of obs      =       336
Group variable: country                         Number of groups   =        28

R-sq:  within  = 0.2187                         Obs per group: min =        12
       between = 0.9881                                        avg =      12.0
       overall = 0.4414                                        max =        12

                                                Wald chi2(1)       =    263.92
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000
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inflation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
inflation1	.6155853	.0378926	16.25	0.000	.5413171	.6898535
_cons	1.025133	.1538652	6.66	0.000	.7235631	1.326704
sigma_u	0					
sigma_e	1.819317					
rho	0	(fraction of variance due to u_i)				

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