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ECONOMETRIC TESTING OF UNEMPLOYMENT HYSTERESIS IN SELECTED CEE COUNTRIES: LESSONS FOR THE SERBIAN ECONOMY

Ekonometrijsko testiranje hipoteze o efektu histerezisa u stopi nezaposlenosti izabranih zemalja Centralne i Istočne Evrope – pouke za privredu Srbije

Abstract

The paper investigates the empirical relevance of the unemployment hysteresis hypothesis in the following CEE countries: Bulgaria, Croatia, Romania, Hungary and Slovenia. Monthly time series are considered over the 2004-2015 period.

The econometric analysis is based on several techniques. Apart from employing conventional unit root tests, the Fourier ADF test is computed to capture non-linear pattern of the deterministic component, and the Lee-Strazicich test to control for up to two endogenously determined structural breaks. These two tests are also used in the two-step approach to increase testing efficiency. Finally, to allow for more flexible treatment of the unemployment rate dynamics, the ARFIMA models are estimated.

The unit root presence was clearly detected in Hungary and Slovenia, supporting the empirical validity of the unemployment hysteresis hypothesis and suggesting that random shocks have permanent impact on the evolution of unemployment rates. The unit root is rejected in the unemployment rates of Bulgaria, Croatia and Romania, but their trend components were under the long-lasting influence of great shocks. Impulse responses of these variables are more persistent than in purely stationary cases.

Results for the analyzed CEE countries which have been part of the EU for a longer time indicate the necessity of implementing demand-side policies in order to reduce unemployment. New EU members in the same region may achieve satisfactory results in lowering their unemployment rates by combining supply-side and demand-side measures. Given the similar institutional background of the Serbian economy, we would expect that our results might be useful in considering the issue of reducing the unemployment rate in Serbia.

Keywords: *unemployment rate, unit root, non-linear trend, structural break, ARFIMA.*

Sažetak

U radu su izloženi rezultati testiranja empirijske relevantnosti hipoteze o efektu histerezisa u nezaposlenosti za sledeće zemlje Centralne i Istočne Evrope: Bugarska, Hrvatska, Rumunija, Mađarska i Slovenija. Mesečne vremenske serije su korišćene u periodu: 2004-2015.

Ekonometrijsku analizu čini nekoliko procedura. Pored primene standardnih testova jediničnog korena, određene su i vrednosti Furijeovog ADF testa, kojim se obuhvataju nelinearne promene determinističkog trenda, kao i vrednosti Li-Stražičićevog testa, kojim se na endogeni način inkorporira postojanje do dva strukturna loma. Ova dva testa smo obuhvatili i dvofaznom procedurom u cilju povećanja efikasnosti testiranja. Na kraju, dinamiku stope nezaposlenosti modelirali smo na osnovu ARFIMA specifikacije, koja pruža veći stepen fleksibilnosti od testova jediničnog korena.

Utvrđeno je postojanje jediničnog korena u stopama nezaposlenosti mađarske i slovenačke ekonomije. Time se sugeriše trajan uticaj slučajnih šokova na kretanje stopa nezaposlenosti, odnosno empirijska valjanost hipoteze o histerezisu u Mađarskoj i Sloveniji. Nismo ustanovili prisustvo jediničnog korena u stopama nezaposlenosti Bugarske, Hrvatske i Rumunije. Međutim, sistemska komponenta trenda je pod trajnim uticajem snažnih šokova. Ove vremenske serije ipak ispoljavaju veći stepen perzistentnosti od čisto stacionarnih veličina.

Dobijeni rezultati ukazuju na neophodnost primene mera ekonomske politike na strani tražnje kako bi se redukovala nezaposlenost u razmatranim zemljama Centralne i Istočne Evrope koje su ranije ušle u EU. Kombinacija mera na strani ponude i tražnje može biti uspešna u snižavanju stope nezaposlenosti u ekonomijama novih članica EU iz istog regiona. Imajući u vidu sličan institucionalni okvir srpske ekonomije, izloženi rezultati mogu biti od koristi u sagledavanju mera za smanjenje stope nezaposlenosti u Srbiji.

Ključne reči: *stopa nezaposlenosti, jedinični koren, nelinearni trend, strukturni lom, ARFIMA.*

Introduction

Dynamics of the unemployment rate has been an extensively discussed topic in macroeconomics due to its crucial influence on key macroeconomic variables. Additionally, in economic theory, there is no unique opinion on the path and evolution of the unemployment rate. Two fundamental theories of unemployment are: the theory of unemployment hysteresis and the natural rate of unemployment theory.

The Blanchard-Summers [2], [1] theory of unemployment hysteresis implies that, in the long run, the unemployment rate depends on the past trends of the actual unemployment rate. Therefore, influences of unexpected random shocks on unemployment produce long-lasting effects on its equilibrium level. The Friedman-Phelps [10], [21], [22] natural rate of unemployment theory is based on the assumption that, in the long run, the unemployment rate is determined by labor market institutions and is not affected by the actual level of unemployment. It is assumed that unexpected shocks in the labor market make the actual unemployment rate different from the equilibrium level. However, this deviation is only temporary, since changes in the inflation rate caused by these shocks will induce the return of the actual level to the equilibrium level of unemployment.

Alternative unemployment theories suggest a key difference in characteristics of the unemployment rate time series. Theory of unemployment hysteresis predicts high level of persistence in this variable, so that influences of unexpected random shocks on the unemployment rate have long-lasting effects. Within time series econometric analysis, such property is commonly described by the existence of at least one unit root. Therefore, the unemployment rate should behave like a unit root process for the theory of unemployment hysteresis to be accepted as empirically valid. On the other side, the natural rate of unemployment theory implies that the unemployment rate fluctuates within the expected range around an equilibrium level, because unexpected shocks have only short-lived impacts. Such a path in time series most likely describes a stationary time series. Hence, no evidence of unit root in unemployment rate time series would support the relevance of the natural rate of unemployment theory.

The validity of the unemployment hysteresis hypothesis was investigated for a number of countries and regions over different time intervals. Some recent works include: Gali [14], Caporale, Gil-Alana & Lovcha [3], Furuoka [11], [13] and Ghoshray & Stamatogiannis [15]. The econometric framework has been frequently based on the application of unit root tests. However, the employment of conventional unit root tests may be biased and could lead to incorrect conclusions if additional important features of unemployment rate time series are neglected. Two properties that are often detected in empirical works are: 1. non-linear deterministic trend and/or 2. the presence of structural breaks. These characteristics are not covered by competing theories on the unemployment rate, although there are some discussions of hysteresis being a non-linear phenomenon [19].

There are several reasons that make testing for unemployment hysteresis hypothesis relevant for countries in Central and Eastern Europe (CEE). Firstly, these countries underwent substantial labor market reforms that would appear partially inefficient if the unemployment rate proves to be well-described by the hysteresis hypothesis. Secondly, different responses of unemployment rates across countries in the EU to the common negative structural shock may indicate migration activity toward Western Europe if the unemployment persistence is higher in the CEE region. Thirdly, in respect of the recent economic crisis in Europe, the validity of the hysteresis hypothesis would support the implementation of policies that are designed to increase aggregate demand in order to reduce unemployment at least for a short period of time.

Empirical studies on the hysteresis hypothesis were mainly performed for the developed economies. Unemployment rates in European emerging economies were not often considered. Existing results shall now be briefly summarized. Leon-Ledesma & McAdam [17] have quantified the degree of persistence in 12 countries in Central and Eastern Europe over the period of early transition: 1992-2001. For almost all the economies, the speed of adjustment was estimated to be greater than in the EU. Camarero, Carrion-i-Silvestre & Tamarit [4], [5]

investigated unemployment rates for the 1991-2003 period in nine European economies that joined the EU in 2004. Their results refuted the hysteresis hypothesis and indicated up to four structural breaks that could be explained by institutional changes due to the implementation of market-oriented reforms. Cuestas & Ordonez [6] examined the unemployment rates of eight emerging European economies over the 1998-2007 period. In five countries, unemployment was found to be a stationary process with highly persistent structural changes. Identical data set is considered in Cuestas, Gil-Alana & Staehr [7], along with the unemployment rate for the EU15. The level of persistence is estimated to be high, although it differs substantially between countries in the sample. Furuoka [12] quantified the level of unemployment persistence in Estonia across five different regions during the 1993-2011 period. The hysteresis hypothesis was not empirically supported. Mladenović & Anić [18] evaluated the persistence of the unemployment rate in 10 countries that joined the EU in 2004 by employing data from the 2004-2015 period. The results were benchmarked against the EU15. The estimated persistence in three cases was of greater magnitude than in the EU15. The findings suggested that the dynamics of unemployment rates were characterized by different patterns, indicating that country-specific measures of economic and employment policies should be implemented.

Econometric investigation of all the reviewed papers includes the application of unit root tests. However, different versions of tests were employed. Ordinary univariate or/and panel unit root tests were regularly calculated. To control for one structural break or more than one structural change in time series, modified versions of unit root test were also frequently employed. Tests that account for smooth non-linearity or fractionally integrated alternatives were implemented once. Apart from unit root testing, explicit modelling of unemployment rate dynamics was performed in some papers. Linear autoregressive and autoregressive fractionally integrated moving average (ARFIMA) models were used in Cuestas, Gil-Alana & Staehr [7]. The Markov-switching autoregressive model was estimated in Leon-Ledesma & McAdam [17] and Mladenović & Anić [18]. The latter two specifications allow for flexibility in capturing adjustment of unemployment rate to random shocks,

and they frequently outperform the quality of the linear autoregressive model in describing the unemployment rate evolution over time.

The purpose of this paper is to evaluate the empirical relevance of the unemployment hysteresis hypothesis in the three countries in CEE that were the last to join the EU. These are Croatia, Bulgaria and Romania. Monthly time series are considered over the January 2004 – July 2015 period. These unemployment rates have been mostly neglected in the existing empirical literature on hysteresis. Additionally, data for Hungary and Slovenia are included on the account of these being countries from the same region, but which acceded to the EU during an earlier period, in 2004. According to the findings in Mladenović & Anić [18], the unemployment persistence in Hungary and Slovenia is of greater magnitude than in the EU15. By reevaluating these data, we aim at examining their dynamic properties within different methodological set-ups. This enables comparison of results obtained by applying different econometrics techniques, but also a general assessment of the reliability of the econometric approach followed in this paper.

Econometric analysis in this paper is conducted in five steps. The first four steps follow the basic idea of algorithm advanced recently in Furuoka [13], which was used to analyze unemployment rates in four Nordic countries. Firstly, a set of conventional unit root tests is employed (ADF, KPSS and ERS). These tests assume the linear deterministic component of time series which cannot always be justified, especially when the data cover pre- and post-2008 period. Secondly, to test for possible non-linear behavior of the deterministic component and to obtain correct results if non-linearity is an issue, the Fourier ADF test (FADF) of Enders & Lee [8], [9] is computed. This approach is efficient in capturing unknown structural breaks or unattended non-linearity in the deterministic component. The FADF test has not been previously used on unemployment rates in the CEE region. Thirdly, an ADF test that handles up to two endogenously determined structural breaks [16] is calculated in order to control for possible abrupt changes in the level and slope of the deterministic trend component. Fourthly, steps two and three are combined in the following way: data are adjusted

for the Fourier trend approximation, after which the unit root test with structural break is performed. By doing this, two frequently dominant features of unemployment rates are simultaneously taken into account, which may improve the reliability of the testing procedure. Finally, step five represents robustness check of the empirical findings based on the estimation of the fractionally integrated parameter. By estimating the ARFIMA models of annual changes in the unemployment rates, we evaluate the significance of the long-memory parameter, which is an alternative approach to assess the presence of hysteresis.

The rest of the paper is organized as follows. The results of using ordinary and the Fourier ADF unit root tests are presented in the following section. Testing that involves structural break presence is given in the third section, while the fourth section describes the ARFIMA modelling. The last section summarizes results and offers some conclusions.

Unit root testing: Linear and smooth non-linear trend

Monthly observations of the unemployment rates in Croatia, Bulgaria, Romania, Hungary and Slovenia are obtained from the EUROSTAT. Data are examined for the period from January 2004 to July 2015 (139 observations). Empirical results are obtained by employing RATS 8.2 and EViews 9.5.

To learn if these data are stationary or non-stationary in terms of unit root presence in the first stage of our analysis, several traditional unit root tests are calculated

and the results presented in Table 1. These clearly indicate that unemployment rates are unit root processes in all the economies. This finding would strongly support the unemployment hysteresis hypothesis. However, when we observe actual data in comparison with the deterministic linear trend assumed by these tests, it is evident that the deterministic linear trend poorly approximates the unemployment rate dynamics (Figure 1). Evolution of unemployment rates in all the countries is characterized by deterministic components with multiple changes both in the level and in the slope.

All unemployment rates, except the one in Hungary, declined sharply over the first part of the sample, from 2004 to the second half of 2008, reflecting mostly the high economic growth during the respective period. As a consequence of the 2008 economic crisis, these unemployment rates followed a strong upward trend over the following year, 2009, after which the growth decelerated in Croatia, Bulgaria and Slovenia. This shift to the downward trend was observed in the last part of the sample, although the timing and the dynamics were not unique across countries. In Romania, the upward trend from 2008 was halted in the mid-2010 and the unemployment rates have remained at approximately the same level ever since. In the case of Hungary, the rise of the unemployment rate was evident from the beginning of the sample that started earlier due to the loss of competitiveness. Upon reaching the highest value at the beginning of 2010, unemployment rates remained at a similar level until the end of 2012, after which they decreased sharply.

Table 1: Results of the conventional unit root testing

Country	Test for unit-root in	ADF	Number of lags	KPSS	ERS
Bulgaria	Level	-1.96	1	0.24	-1.21
	1st difference	-4.34	0	0.35	-4.17
Croatia	Level	-1.76	3	0.32	-0.83
	1st difference	-6.25	2	0.43	-4.89
Romania	Level	-2.15	12	0.22	-0.81
	1st difference	-4.38	11	0.29	-0.41
Hungary	Level	0.01	1	0.29	-0.25
	1st difference	-6.30	0	0.70	-6.32
Slovenia	Level	-2.07	1	0.26	-1.52
	1st difference	-5.83	0	0.28	-5.08

Note: The model with a constant and a trend is used for unit root testing at the level of time series, while the model with a constant when testing is performed for the first difference. The 5% critical values in the model with a constant and a trend are -3.44, 0.15 and -2.99 respectively for the ADF, the KPSS and the ERS test. When only a constant is included, the 5% critical values are -2.88, 0.46 and -1.94 respectively. The number of lags refers to a number of correction elements included in the application of the ADF and the ERS test. The truncation parameter in calculating the Newey-West correction for the KPSS test is either set to 8 or 9, or it corresponds to the number of corrections in the ADF test.

Since the tests performed do not account for such changes, it is no surprise that some of them even indicate two unit roots (the KPSS test for Hungary and the ERS test for Romania), and even mild explosiveness (the ADF test with a constant and a trend takes positive value in the case of Hungary) in one case.

Therefore, it seems necessary to capture the deterministic component in a less restricted way so that unit root test is not derived from a possible misspecified model. Enders & Lee [8], [9] have recently developed a unit root test based on the Fourier form that is capable of capturing several smooth structural changes (the FADF test). The deterministic component is approximated by the low frequency of the Fourier expansion that enables unit root testing without an a priori definition of the exact form of the trend. Standard equation for the ADF test is enlarged by the new component that represents time

dependent function defined in the following way:

$$\alpha_0 + \sum_{k=1}^{n} \alpha_k \sin(2\pi kt / T) + \sum_{k=1}^{n} \beta_k \cos(2\pi kt / T), \; n \le T / 2.$$ The

number of frequencies included in the approximation is denoted by n, while k represents particular frequency. T is the sample size and $\alpha_0, \alpha_1,..., \alpha_n, \beta_1,..., \beta_n$ are parameters. If $\alpha_1 = \beta_1 = ... = \alpha_n = \beta_n = 0$, then linear time series models are adequate, implying no need for trigonometric components. However, a break or a non-linear trend will make at least one Fourier frequency relevant in the testing equation. Enders & Lee [8], [9] suggest that in the practical work, the single frequency component should be selected (k ranging from 1 to 5). Additionally, the new set-up provides framework for formal testing of whether non-linearity in the deterministic component is statistically significant. During the second phase of our analysis, the FADF test is employed in two versions (with and without the linear

Figure 1: Unemployment rates and the ADF trends
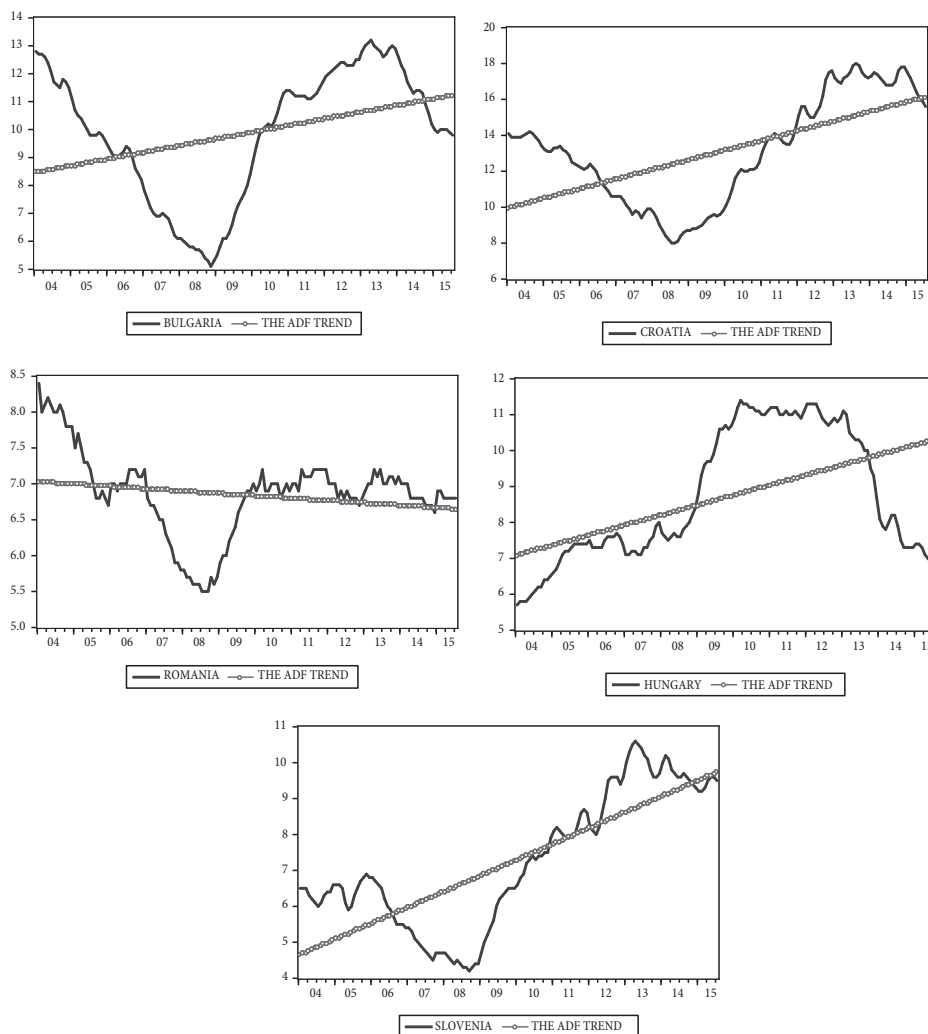
trend component), along with the formal test for non-linearity in the deterministic component.

Strong non-linearity in the deterministic component is observed in the data for Croatia and Slovenia, while unemployment rates in Bulgaria and Hungary were found to exhibit non-linear trend only at the 10% significance level. These findings question the reliability of ordinary unit root tests and justify the use of those modifications

that account either for smooth or sudden changes in the deterministic component. The application of the FADF test suggests that the unemployment rate in Croatia does not contain a unit root, while it appears to be present in the rest of the sample. The unemployment rate dynamics is certainly better described by the trend component derived from the FADF approach, as evident in Figure 2. We may argue that approximation is the least successful

Table 2: Results of the FADF unit root and non-linearity testing

Country	Model	FADF	Number of lags	Non-linearity test	Non-linearity evidence
Bulgaria	With linear trend	-3.02	5	6.87*	Yes
	Without lin.trend	-1.86	5	4.43	No
Croatia	With linear trend	-4.10**	2	13.75***	Yes
	Without lin.trend	-4.28**	2	15.69***	Yes
Romania	With linear trend	-3.83	5	3.65	No
	Without lin.trend	-3.20	5	1.22	No
Hungary	With linear trend	-2.95	1	7.65	No
	Without lin.trend	-3.20	1	7.42*	Yes
Slovenia	With linear trend	-2.73	4	8.49**	Yes
	Without lin.trend	-2.87	4	9.55**	Yes

Note: ***, ** and * denote respectively the significance at 1%, 5% and 10% level. Parameter *k* is set to one according to the results of the algorithm advocated in Enders & Lee [8].

Figure 2: Unemployment rates and the FADF trends
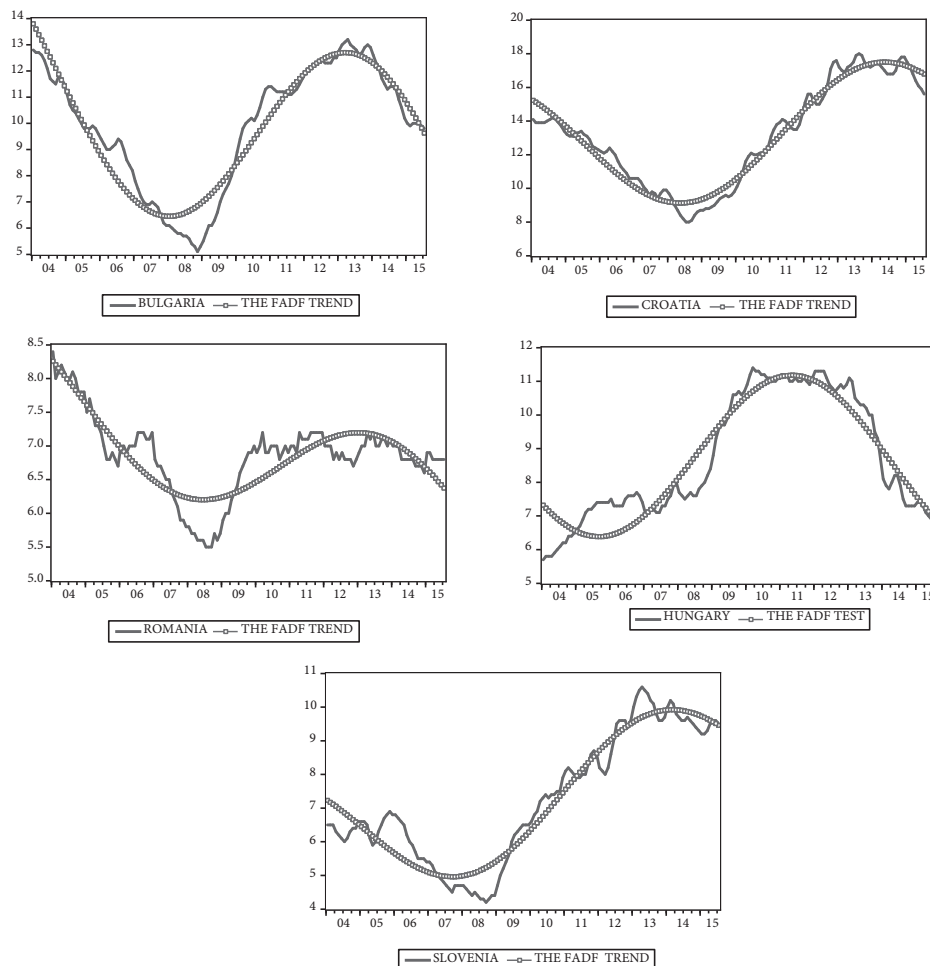
for the Romanian unemployment rate, which would be in line with the reported result in Table 2 that the FADF non-linearity test is insignificant in both versions of the model only for this time series.

Unit root testing and structural breaks: Two approaches

In order to control for the non-linear behavior due to the possible structural break presence, we carried out the Lee-Strazicich (LS) unit root test [16] which assumes endogenous search for structural change. Contrary to the first generation of unit root tests with structural breaks (for example Zivot & Andrews [23] and Perron [20]), within the LS approach, breaks are incorporated by both the null and the alternative hypotheses, so that the rejection of the null hypothesis unambiguously implies stationarity [16]. Also, the LS test allows for up to two structural breaks, making it convenient given the dynamic properties of our data.

In the third step of our empirical work, we calculate the values of the LS statistics based on the model with the deterministic component characterized by changes in both intercept and slope. This is the most general set-up under this framework that eliminates erroneous specification from variable omission. Results are reported in Table 3. The hypothesis of the unit root presence in the unemployment rate is again confirmed in Slovenia and Hungary. However, it is refuted for Bulgaria, Croatia and Romania. This evidence is strong for Bulgaria (at the 5% level) and supportive for Romania and Croatia (at the 10%). Some shocks produce strong influence on these unemployment rates, causing long-lasting changes of their trend components.

Figure 3 displays actual unemployment rates and the linear trend with break points identified by the LS test. We may notice that this trend estimation is more precise than in the ADF model, but it leaves substantial part of the systematic component in the unemployment rates unexplained.

Finally, both the FADF and the LS approaches are implemented within the two-step procedure. Original time series are first detrended by using the approximation of the low frequency Fourier expansion. Then the LS test is conducted on series corrected for such a trend. We try to improve testing efficiency in this way by capturing at the same time two possible forms of non-linearity. In other words, the Fourier trend estimation does not account for sharp structural shifts as, on the other side, controlling only for such breaks neglects smooth changes in the trend that have been verified for most economies in our sample.

Results from the combined approach are reported in Table 4. The unemployment hysteresis hypothesis is strongly rejected for Bulgaria and Croatia, which confirms the findings of the FADF test for Croatia and the LS test for Bulgaria. The unit root is detected in the unemployment rates for Romania, Hungary and Slovenia.

Approximation of the unemployment rates movement by trends estimated within the two-step approach is presented in Figure 4. Visual inspection suggests that this approach outperforms other trend estimations carried out in this paper, except that for Romania the last two methods yield almost identical pictures. This general observation has been formally confirmed by the lowest values of the residual sum of squares being the criterion advocated in the empirical works of Furuoka [11], [13]. Two break points in each time series make the distinction between three different trend regimes.

Table 3: Results of the LS unit root testing

Country	Number of lags	LS	Estimated break points
Bulgaria	12	-6.62***	2006:12, 2011:9
Croatia	9	-5.04*	2008:4, 2012:12
Romania	12	-5.02*	2007:6, 2010:4
Hungary	9	-4.33	2008:8, 2012:1
Slovenia	1	-4.71	2007:10, 2013:4

Note: *** and * respectively denote the statistical significance at 1% and 10% level. Number of lags is chosen by "general to specific" approach, starting with a maximum of 12 lags.

Table 4: Results of the LS unit root testing on the FADF corrected data

Country	Number of lags	LS	Estimated break points
Bulgaria	12	-6.21***	2007:12, 2011:2
Croatia	1	-7.11***	2006:4, 2009:9
Romania	12	-4.05	2009:3, 2011:10
Hungary	9	-4.63	2007:11, 2009:10
Slovenia	1	-4.92	2007:1, 2009:8

Note: *** denotes the statistical significance at 1% level. Number of lags is chosen by "general to specific" approach, starting with a maximum of 12 lags.

To sum up the results from four testing procedures and trend analyses, we may conclude that the unemployment hysteresis hypothesis is not empirically confirmed for Bulgaria and Croatia. These findings indicate that evolutions of the respective unemployment rates are stationary, but follow smooth non-linear trends that display structural breaks in slope and in intercept. Some shocks produce strong influence on these unemployment rates, causing long-lasting changes of their trend components. Nevertheless, short-term fluctuations are stationary. On the other side, unemployment rates in Slovenia and Hungary have a unit root according to all calculations, thus suggesting empirical validity of the unemployment hysteresis hypothesis. Both long-term movements and short-term variations of these time series are under the persistent influence of random shocks. The results are inconclusive for Romania. Only one approach implies stationarity (the LS test), but it is the framework that best captures changes in the trend component.

Robustness analysis: ARFIMA estimation

Instead of restricting our analysis to the issue of whether a series is stationary (integrated of order 0) or has a unit root (integrated of order 1), in this section we apply a more flexible methodology that allows for the possibility of fractional order of integration. Parameter of fractional integration, denoted by d, is incorporated within the ARMA set-up which gives the ARFIMA class of models. This implies that results will be derived from the explicit modelling of the unemployment rate dynamics. Depending on the value of d, we can assess how a time series reacts to the impact of unexpected random shocks which has relevant implications for the testing of hysteresis in unemployment (see, for example, [7] and [3]).

To make the fractional integration approach plausible in our data set, we use annual changes of monthly unemployment rates. Such transformation ensures more

Figure 3: Unemployment rates and the LS trends
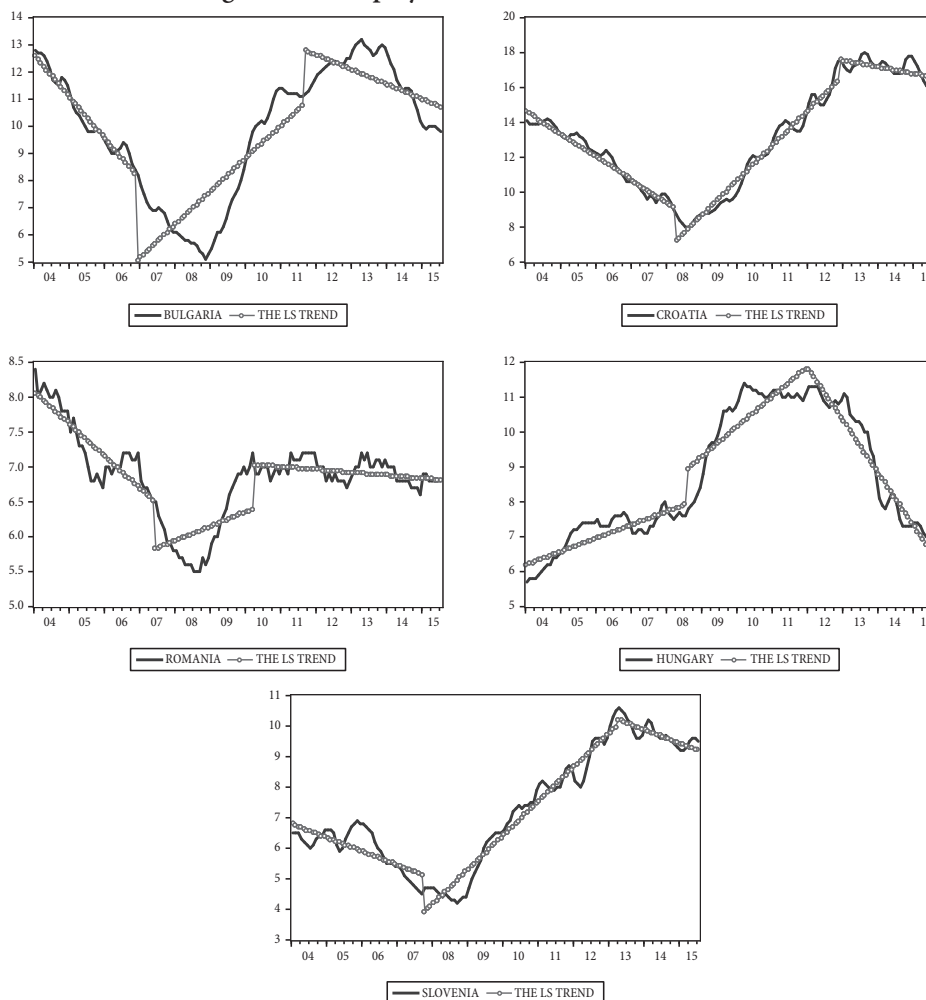
precision in establishing the extent of random shocks persistence, because it eliminates a priori the monthly deterministic and stochastic trend component. For example, if $0<d<0.5$, the series is stationary, but its response to unexpected impulses resembles the reaction of a unit root process. Such time series is known as long-memory process, and parameter d as a long-memory parameter. If $0.5 \leq d<1$, the series is no longer stationary, although it remains mean reverting (the value of d could be greater than 1, which is unlikely in our data set, since we already transformed the data by computing annual differences). Therefore, testing for empirical validity of the unemployment hysteresis hypothesis in our sample of yearly changes is based on the estimation of the ARFIMA models and on the determination of whether the parameter of fractional integration is statistically significant. Furthermore, higher estimates within the interval [0,1] would be more in favor of accepting the unemployment hysteresis hypothesis.

Additionally, we estimate models for the sample that starts in January 2008, making our research focused on the subsample characterized by the shocks from the 2008-2009 global crisis. Changes both in the technique and the data set represent robustness check of our previous findings. Results are given in Table 5.

Fractionally integrated parameter is estimated to be highly significant in the annual changes of unemployment rates in Hungary and Slovenia, with values 0.46 and 0.48 respectively. This parameter is marginally significant (at the 10% level) in the annual changes of unemployment rates in Croatia and Romania – estimates are respectively 0.50 and 0.37. Parameter of fractional integration is insignificant for the Bulgarian data. Again, long-lasting influence of random shocks in the movements of unemployment rates was detected in Hungarian and Slovenian economies. New results also confirm our finding that random shocks have only temporary impact on the Bulgarian unemployment rate.
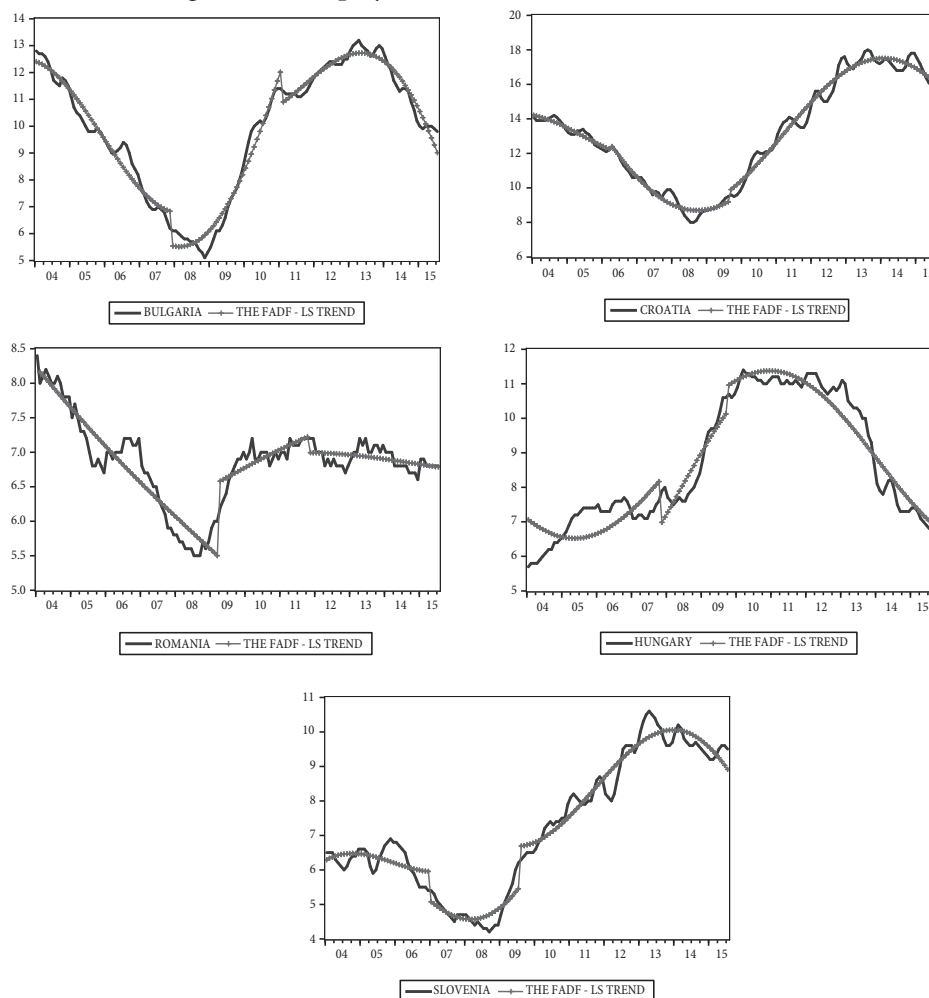
Figure 4: Unemployment rates and the FADF-LS trends

Table 5: Modelling annual changes in the unemployment rates within the ARFIMA set-up

Country	Estimate of the fractionally integrated parameter	Included AR and MA components	Specification tests
Bulgaria	0.21	AR(1,3,4,12), MA(8,12)	Q(24)=14.89(0.60), Q^2(12)=4.42(0.98), JB=1.24(0.54)
Croatia	0.50*	AR(1,2,4,6,7,12), MA(2,12)	Q(24)=9.36(0.90), Q^2(12)=13.24(0.35), JB=1.00(0.61)
Romania	0.37*	AR(1,2,3,12)	Q(24)=24.18(0.19), Q^2(12)=7.66(0.81), JB=2.47(0.29)
Hungary	0.46***	AR(1,6,12)	Q(24)=24.52(0.27), Q^2(12)=11.14(0.52), JB=4.29(0.12)
Slovenia	0.48***	AR(1,10,12), MA(1,2)	Q(24)=19.73(0.35), Q^2(12)=13.56(0.33), JB=1.47(0.48)

Note: ***, and * respectively denote the statistical significance at 1% and 10% level. AR and MA components are included if their significance was less than or equal to 10% level. The AR(12) component is multiplicative in the case of Hungary and Romania. The MA(12) component is multiplicative in the Croatian data. Q denotes the Box-Ljung statistic for testing the autocorrelation of order 24. Q^2 refers to the Box-Ljung statistic for testing the autocorrelation of order 12 in the squared residuals. JB denotes the Jarque-Bera normality test. Corresponding p-values are given in parentheses. Estimation is done by the method of maximum likelihood.

The application of the unit root tests revealed that the dynamics of the Croatian unemployment rate is best described by stationarity around smoothly non-linear trend and structural breaks. The examination of its annual difference in the post-2008 period indicates the relative importance of the long-memory parameter. Therefore, we may argue that the Croatian unemployment rate is stationary, but with slowly decaying responses to unexpected random shocks. Similarly, we do not have clear-cut results for the Romanian unemployment rate. Evidence of stationarity with a structural break was marginal, as was the finding that long-memory existed. These mixed results may support stationarity of the unemployment rate in Romania, but with the substantial impact of shocks described by structural breaks. Additionally, short-term variations of annual changes are, to some extent, subject to relatively important influences of unexpected shocks.

Conclusion

The paper offers results of testing the unemployment hysteresis hypothesis in the selected CEE countries by using monthly data of unemployment rates over the 2004-2015 period. Empirical assessment is derived from the unit root testing that controls for smooth non-linearity and structural breaks. ARFIMA modelling was also performed on annual changes for the 2008-2015 subsample.

Unemployment rates were found to be highly sensitive to random shocks in Hungary and Slovenia. Since the unit root presence has been accepted by all the tests employed, the hysteresis hypothesis is confirmed in these two economies. The estimation of the long-memory parameter supports the conclusion. Our evidence differs from findings previously reported in Cuestas, Gil-Alana & Staehr [7] that covers the same economies, but over the sample ending in 2007. As we analyze the dynamics during and after the Great Recession, it could be argued that the dynamic properties of the unemployment rates in Hungary and Slovenia have changed significantly as a consequence of the 2008-2009 crisis. This was already highlighted in Mladenović & Anić [18], where similar conclusions were drawn by estimating the Markov-switching autoregressive model.

The presence of unit root in the unemployment rate is empirically rejected for Bulgaria, Croatia and Romania when taking into account the findings of those tests that capture time series evolution in the most appropriate way. As unemployment rates in these countries follow a path characterized by smooth non-linear trend and/or several structural breaks, some huge shocks are identified to have a long-lasting influence. Additionally, significance (albeit marginal) of the long-memory parameter in the latter two economies suggests that unemployment rate reacts to random shocks with more inertia than the purely stationary variables. Therefore, one should be careful in making interpretations of the unit root testing results for Croatia and Romania. The rejection of the unit root presence does not necessarily imply that the unemployment hysteresis hypothesis has no empirical content whatsoever, given the relevance of the changing deterministic trend and structural breaks.

The degree of unemployment rate persistence in Croatia and Romania is estimated to be higher than in Bulgaria, but lower than in Hungary and Slovenia. Thus, substantial heterogeneity in the unemployment rate dynamics is observed. Nevertheless, the results for the analyzed CEE countries in which have been members of the EU for a longer period of time indicate the necessity of following demand-side policies to reduce unemployment.

New EU members in the same CEE region may achieve satisfactory results in lowering their unemployment rates by combining the supply-side and demand-side measures. Given the similar institutional background of the Serbian economy, we would expect our results to shed some light on the issue of reducing unemployment rate in Serbia.

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