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Article

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Revisit Hysteresis Unemployment in Eastern European Countries using Quantile Regression

Hong XIE – Tsangyao CHANG** – Adriana GRIGORESCU*** – Ken HUNG*****

Abstract

This study revisits hysteresis unemployment hypothesis for 9 Eastern European countries (i.e., Bulgaria, Czech Republic, Hungary, Lithuania, Latvia, Poland, Romania, Russia and Slovakia) over 2000M1 – 2016M8. We apply Quantile unit root tests with and without smooth multiple breaks through Fourier function. These Quantile tests have been proved with good power and size when the data follows heavy-tailed distribution. Empirical results from Quantile unit root tests demonstrate hysteresis unemployment holds in Hungary and Romania two countries only and shocks to the unemployment of each country are asymmetric. Our study has important policy implications for government conducting fiscal or monetary policy to stabilize economic fluctuations in Eastern European countries.

Keywords: *hysteresis unemployment, Quantile unit root test, Fourier function, smooth breaks, Eastern European Countries*

JEL Classification: C20, J60

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Introduction

Testing hysteresis unemployment hypothesis is critical not only for empirical researchers but also for policymakers alike. Hysteresis Unemployment hypothesis has become a prominent research topic in economic literature because of the important policy implications the issue entails. As we know that unemployment has emerged as one of the thorniest socio-economic issues around the world since global financial crisis hits the world at the end of 2000s. Shocks from this crisis have negatively affected labour market conditions around the world especially for the Central and Eastern European (CEE) transition countries. The unemployment rates for most of the transition countries all reach a record high. Many countries have been suffering from unemployment persistence problem and this phenomenon is known as "jobless recover" (Furuoka, 2014). According to literature, high persistence in unemployment is referred to as "hysteresis unemployment". According to Jiang and Chang (2016), if unemployment is a non--stationary process (with high persistence), then the shocks affecting the series will have permanent effects, thus shifting the unemployment equilibrium from one low level to another high level. From the policy point of view, policymaker should take some policy actions to return unemployment rate to its original equilibrium level. On the other hand, if unemployment is a stationary process (without high persistence), then the effect of the shock is merely transitory, and as a result, policy action is not mandatory because unemployment will eventually return to its original equilibrium level. In other words, these cyclical fluctuations in an economy can influence unemployment only in the short run and without any government interventions the shocks will eventually die out. (Smyth, 2003; Furuoka, 2014). Previous literature refers to the second case as the Non-Accelerating Inflation Rate of Unemployment (NAIRU) hypothesis for it characterizes unemployment dynamics as a mean reversion process. Because hysteresis is associated with non-stationary unemployment rates, unit root tests have been widely used in literature to empirically investigate its validity.

However, previous studies usually focus on the average behaviour of unemployment without considering the influence of various sizes of shocks on unemployment. In other words, the speed of adjustment in unemployment toward its equilibrium is usually assumed to be constant, regardless of the size or sign of the shocks. As a result, the commonly used conventional unit root tests possibly lead to a widespread failure in the rejection of the unit-root null hypothesis for unemployment rates. On the other hand, Perron (1989) and Bahmani-Oskoee, Chang and Rajnbar (2015) have pointed out that failure to account for structural break in data series might be contributed to the failure of unit root tests. In this paper, we intend to deal with the above deficiency by employing a newly developed

Quantile-based unit root test in Koenker and Xiao (2004) mixed with smooth multiple breaks as proposed by Bahmani-Oskoee, Chang and Ranjbar (2015), and Bahmani-Oskoee et al. (2017) to enhance estimation accuracy. As indicated by Chang and Lee (2011), Bahmani-Oskoee, Chang and Ranjbar (2015) and Bahmani-Oskoee et al. (2017), for low frequency data, it is more likely that structural changes take the form of large swings which cannot be captured well using only dummies. Breaks should therefore be approximated as smooth and gradual processes (Leybourne et al., 1998; Bahmani-Oskoee, Chang and Ranjbar (2015). These arguments also motivate the use of a recently developed set of unit root and stationary tests that avoid this problem. Both Becker, Enders and Hurn (2004) and Becker, Enders and Lee (2006) and Bahmani-Oskoee, Chang and Ranjbar (2015) develop tests which model any structural break of an unknown form as a smooth process via means of Flexible Fourier transforms. In this study we use Quantile-based unit root test considering smooth multiple breaks to reinvestigate hysteresis in unemployment rate for 9 transition countries during 2000M1 to 2016M8. There are several advantages in the usage of a Quantile-based unit root test with smooth breaks. First of all, a Quantile-based unit root test could allow for the possibility that shocks of different sign and magnitude have different impacts on unemployment rate. Second, this methodology is not restricted to a specific number of regimes, but allows generally for differences in the transmission of all kinds of different shocks. Third, this methodology could avoid the estimation of additional regime parameters and therefore reduces estimation uncertainty. Fourth, the Quantile-based unit root test has higher power than conventional unit root tests as shown by Koenker and Xiao (2004). Fifth, the Quantile-based unit root test is superior to standard unit root tests in case of departure from Gaussian residuals. Final but not the less, Quantile-based unit root test mixed with smooth break functions can capture any smooth form of structural breaks (Bahmani-Oskoee, Chang and Ranjbar, 2015; Bahmani-Oskoee et al., 2017).

This study contributes to this line of research by determining whether hysteresis in unemployment is a characteristic of Eastern European labour market. The issue of unemployment has undoubtedly been the transition countries' most pressing problem since the global financial turmoil of 2008 – 2009; in February 2010, the unemployment rates in Bulgaria, Latvia, Lithuania and Poland all reached a record high of 18%, a level not seen since 2002. The transition countries in our sample have recently moved from centrally planned economies toward market-driven economies that motivate us to investigate the behaviour of unemployment in these countries. Testing whether unemployment hysteresis prevails in these 9 transition countries has become an important focus for empirical work; also in addition, it has drastic policy implications. While previous studies mostly focus on conventional unit root tests, we test the hypothesis of hysteresis in unemployment for transition countries data sets for the first time using the Quantile unit root test mixed with smooth breaks as proposed by Bahmani-Oskoee, Chang and Ranjbar (2015), Bahmani-Oskoee et al. (2017) and we hope our study can bridge the gap in the unemployment literature.

The remainder of this paper is organized as follows. Section 1 presents the data used in our study. Section 2 first briefly describes the Quantile unit root test with smooth breaks as proposed by Bahmani-Oskoee, Chang and Ranjbar (2015) and Bahmani-Oskoee et al. (2017). Section 3 first presents our empirical results then discuss some policy implications. Last section concludes the paper.

1. Data

Our empirical analysis covers the 9 transition countries: Bulgaria, the Czech Republic, Hungary, Latvia, Lithuania, Poland, Romania, the Russia and Slovakia. Monthly data are employed in our empirical study and the time span is from 2000M1 to 2016M8. All data series are taken from the Datastream. A summary of the statistics is given in Table 1.

Table 1

Summary Statistics (original data)

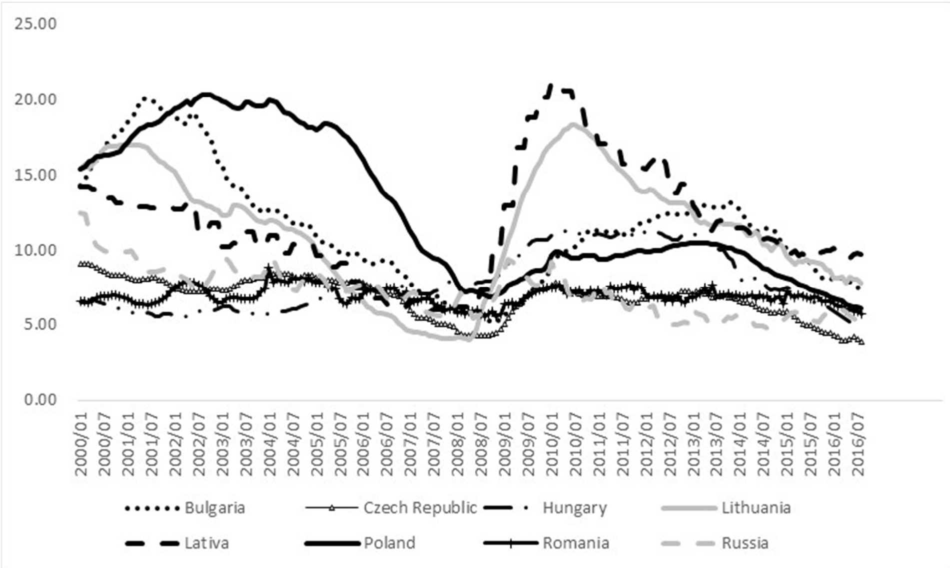
	Bulgaria	Czech	Hungary	Lithuania	Latvia	Slovakia	Poland	Romania	Russia
Mean	11.462	6.8145	7.832	11.5695	12.107	13.761	12.626	7.0535	7.1365
Median	11.2	7.1	7.4	11.65	11.75	14.3	10.2	7	7.05
Maximum	19.9	9.2	11.4	18.3	20.6	19.3	20.6	8.8	12.1
Minimum	4.9	3.8	5	4	5.4	7.9	5.9	5.5	4.8
Std. Dev.	3.8672	1.3161	2.044204	4.1341	3.7207	2.964	4.8021	0.6978	1.5189
Skewness	0.5465	–0.5894	0.536693	–0.1732	0.3488	–0.1927	0.3844	0.0116	0.4947
Kurtosis	2.6161	2.4771	1.842476	2.0646	2.7336	2.3198	1.52577	3.1456	2.5853
Jarque-Bera	11.184	13.86	20.76684	8.2912	4.6478	5.1444	23.0366	0.1812	9.59226
Probability	0.0037	0.0009	0.000031	0.0158	0.0978	0.0763	0.00001	0.9133	0.00826

Source: Datastream and all number are calculated by author(s).

We find Slovakia and the Czech Republic have the highest and lowest mean unemployment rates of 13.761 and 6.81, respectively. Jarque-Bera test results also indicate that all of the unemployment rates are approximately non-normal with the exception of Romania. Figures 1 and 2 demonstrate the time paths of the unemployment rate for these 9 transition countries. We can clearly observe structural shifts in the trend of the data, and we also find several peaks in the unemployment rate during some sample periods. We find that the most negative shocks to the unemployment rate, such as the 2002 – 2003 and 2009 – 2010 are corresponding with several major historical events. For example, 2008 – 2009 global financial crisis this increase the unemployment rate in these 9 transition countries.

F i g u r e 1

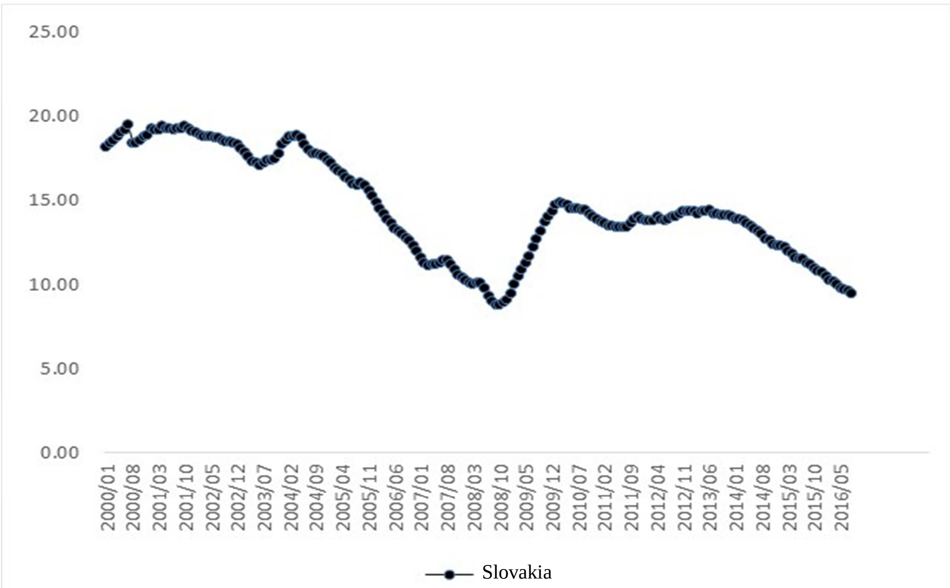
Plots of Unemployment in 8 Eastern European Countries



Source: Datastream.

F i g u r e 2

Unemployment Rate of Slovakia



Source: Datastream.

Visual inspection of these unemployment rates for these 9 countries reveal significant upward and downward trend for most of the transition countries. From Figures 1 and 2, for most of the series, there seems to exhibit some non--linear adjustment patterns.

2. Methodology – Fourier Quantile Unit Root Test

We assume an unemployment time series $\{Ue_t\}_{t=1}^{T}$ has the following data generating process (DGP) as

$$Ue_t = \alpha(t) + \xi_t \tag{1}$$

where

$\alpha(t) = Z_t\lambda + \sum_{k=1}^{n}\gamma_{1,k}\sin(\frac{2\pi kt}{T}) + \sum_{k=1}^{n}\gamma_{2,k}\cos(\frac{2\pi kt}{T})$ and $\alpha(t)$ is a time-varying deterministic component. In order to obtain a global approximation from the smooth transition and unknown number, and to equip deterministic components with breaks, we follow Gallant (1981) approach by employing the Fourier approximation and putting both terms of $\sum_{k=1}^{n}\gamma_k\sin(\frac{2\pi kt}{T})$ and $\sum_{k=1}^{n}\gamma_k\cos(\frac{2\pi kt}{T})$ into the model. The reason to select both $\sin(\frac{2\pi kt}{T})$ and $\cos(\frac{2\pi kt}{T})$ in the model is based on the fact that a Fourier expression is capable of approximating absolutely integrable functions to any desired degree of accuracy. Where *k*, *T*, and *t* are the number of frequencies of the Fourier function, sample size, and a trend term, respectively, and $\pi = 3.1416$. Z is an optional exogenous regressor which consists of a constant term in our case; n denotes the number of frequencies contained in the approximation and $n \le \frac{T}{2}$ should be satisfied.

The estimation of equation (1) involves two parameters choice – the choice of *n* and the choice of *k*. As noted by Becker, Enders and Hurn (2004), it is reasonable to restrict *n* = 1 because the joint null hypothesis of γ s is rejected for one frequency (i.e., $\gamma_{1,k} = \gamma_{2,k} = 0$), and time invariance hypothesis is also rejected. Similarly, Enders and Lee (2012) note that the restriction *n* = 1 is useful to save the degrees of freedom and prevents the over-fitting problem. Hence we respecify equation (1) as follows:

$$Ue_t = Z_t\lambda + \gamma_1\sin(\frac{2\pi kt}{T}) + \gamma_2\cos(\frac{2\pi kt}{T}) + \xi_t \tag{2}$$

where $\gamma = [\gamma_1, \gamma_2]'$ measures the amplitude and displacement of the frequency component. Particularly the standard linear specification is a special case of equation (2) while setting $\gamma_1 = \gamma_2 = 0$. There must be at least one of the both frequency components existed if a structural break is appeared. Becker, Enders and Hurn (2004) utilize this property of equation (2) to develop a more powerful test to detect structural breaks under an unknown form than that of Bai and Perron (2003) test.

In determining an optimal k, we set the maximum of k equal to 5. For any *K* = *k*, we estimate equation (2) employing ordinary least squares (OLS) method and save the sum of squared residuals (SSR). Frequency *k** is setting as optimum frequency at the minimum of SSR. With above assumption and respect to the deterministic components, we test the following null hypothesis:

$$H_0: \ \xi_t = \upsilon_t, \qquad \upsilon_t = \upsilon_{t-1} + u_t \tag{3}$$

where u_t is assumed to be an I(0) process with zero mean. To test the null hypothesis, we follow Christopoulos and Leon-Ledesma (2010) to calculate the statistic via three steps shown in following.

First step: we set a maximum k equals to 5, and then find out the optimal frequency of *k** by employing the methodology described above. We compute the OLS residuals as that:

$$\begin{aligned} e_t &= Ue_t - \hat{\alpha}(t) \\ \hat{\alpha}(t) &= Z_t\hat{\lambda} + \hat{\gamma}_1 \sin\left(\frac{2\pi \overset{*}{k} t}{T}\right) + \hat{\gamma}_2 \cos\left(\frac{2\pi \overset{*}{k} t}{T}\right) \end{aligned} \tag{4}$$

Second step: a unit root on the OLS residuals given from equation (4) is tested by using Quantile regression frameworks which was introduced by Koenker and Xiao (2004). The test is an extension of Augmented Dickey-Fuller (ADF) type unit root test and has much more power than standard ADF test when a given shock exhibits heavy-tailed behaviour. Another advantage of the test is that it allows for different adjustment mechanism towards the long-run equilibrium at different quantiles. To illustrate the test, we start with standard ADF test:

$$e_t = \rho_1 e_{t-1} + \sum_{k=1}^{k=l} \rho_{1+k} \Delta e_{t-k} + \varepsilon_t \tag{5}$$

where stochastic variable of concern, e_t is estimated residuals from equation (4). In (5) ρ_1 is the AR coefficient and reflect the persistence degree. $|\rho_1| < 1$ is required for mean reverting properties of unemployment rate (hereafter, *Ue*) and for ruling out explosive behaviour. Koenker and Xiao (2004) define the τ_{th} conditional quantile of e_t as follows:

$$Q_{e_t}\left(\tau \mid \xi_{t-1}\right)=\alpha_0\left(\tau\right)+\rho_1\left(\tau\right)e_{t-1}+\sum_{k=1}^{k=l}\rho_{1+k}\left(\tau\right)\Delta e_{t-k}+\vartheta t \qquad (6)$$

where $Q_{e_t}(\tau \mid \xi_{t-1})$ is τ_{th} quantile of e_t conditional on the past information set, $\xi_{t-1}.\alpha_0(\tau)$ is τ_{th} conditional quantile of ϑ_t and as noted by Tsong and Lee (2011), its estimated values captures the magnitude of *Ue* shocks in each quantile. $\rho_1(\tau)$ measures the speed of mean reversion of e_t within each quantile. Using $\rho_1(\tau)$, we can measure the persistence of a shock to Ue series through the half lives in each quantile, which is formulated as $\ln\left(0.5\right)/\ln(\widehat{\rho}_1\left(\tau\right)$. Optimum lags are selected by the AIC information criteria.

The coefficients of $\alpha_0\left(\tau\right)$, $\rho_1(\tau)$, and $\rho_2(\tau)$, …, $\rho_{k+1}(\tau)$ are estimated by minimizing sum of asymmetrically weighted absolute deviations:

$$\min\sum_{t=1}^{n}\left(\tau-I\left(e_t<\alpha_0\left(\tau\right)+\rho_1\left(\tau\right)e_{t-1}+\sum_{k=1}^{k=l}\rho_{1+k}\left(\tau\right)\Delta e_{t-k}\right)\right) \left|e_t-\alpha_0\left(\tau\right)+\rho_1\left(\tau\right)e_{t-1}+\sum_{k=1}^{k=l}\rho_{1+k}\left(\tau\right)\Delta e_{t-k}\right| \qquad (7)$$

where $I = 1$ if $e_t<(\alpha_0\left(\tau\right)+\rho_1\left(\tau\right)e_{t-1}+\sum_{k=1}^{k=l}\rho_{1+k}\left(\tau\right)\Delta e_{t-k})$ and $I = 0$, otherwise. As sugested by Koenker and Xiao (2004), after solving equation (7), we can test the stochastic properties of e_t within the τ_{th} quantile by using the following *t* ratio statistic:

$$t_n\left(\tau_i\right)=\frac{\widehat{f}\left(F^{-1}\left(\tau_i\right)\right)}{\sqrt{\tau_i\left(1-\tau_i\right)}}\left(E_{-1}^{'}P_xE_{-1}\right)^{1/2}\left(\widehat{\rho_1}\left(\tau_i\right)-1\right) \qquad (8)$$

In (8) E_{-1} is the vector of lagged dependent variables (e_{t-1}), P_x is the projection matrix onto the space orthogonal to $X=(1,\Delta e_{t-1},\ldots,\Delta e_{t-k})$. $\widehat{f}\left(F^{-1}\left(\tau_i\right)\right)$ is a consistent estimator of $f\left(F^{-1}\left(\tau_i\right)\right)$. Koenker and Xiao (2004) suggest that it can be expressed as:

$$\widehat{f}\left(F^{-1}\left(\tau_i\right)\right)=\frac{\left(\tau_i-\tau_{i-1}\right)}{x^{'}\left(\beta\left(\tau_i\right)-\beta\left(\tau_{i-1}\right)\right)} \qquad (9)$$

where $\beta(\tau_i)$ = $(\alpha_0(\tau_i),\ \rho_1(\tau_i),\ \rho_2(\tau_i),\ldots,\rho_{1+k}(\tau_i))$ and $\tau_i \in \left[\underline{\lambda},\ \overline{\lambda}\right]$. In this paper, we set $\underline{\lambda} = 0.1$ and $\overline{\lambda} = 0.9$. As can be seen, using $t_n(\tau_i)$ statistics, we are able to test the unit root hypothesis in each quantile while ADF and other conventional unit root tests examine the unit root only on the conditional central tendency.

To assess the unit root behaviour over a range of quantiles, Koenker and Xiao (2004) recommend following the Quantile Kolmogorov-Smirnov (*QKS*) test:

$$QKS = \sup_{\tau_i \in \left[\underline{\lambda},\overline{\lambda}\right]} \left| t_n(\tau) \right| \tag{10}$$

In this paper, we construct the *QKS* statistics by choosing maximum $\left|t_n(\tau)\right|$ statistics over range $\tau_i \in [0.1,\ 0.9]$. As noted by Koenker and Xiao (2004), the limiting distributions of $t_n(\tau_i)$ and *QKS* test statistics are nonstandard and depend on nuisance parameters. Hence, to derive critical values for the above mentioned test, we implement the re-sampling procedures of Koenker and Xiao (2004) as follows:

1. We run the following k-order autoregression by ordinary least square:

$$\Delta e_t = \sum_{k=1}^{k=l} \rho_k \Delta e_{t-k} + \in_t \tag{11}$$

2. We save the fitted values $\Delta \hat{e}_t = \sum_{k=1}^{k=l} \hat{\rho}_k \Delta \hat{e}_{t-k}$ and residuals $\hat{\in}_t$, and then create the bootstrap residuals ($\in_t^b$) with replacement from the centered residuals $\hat{\in}_t = \hat{\in}_t - \frac{1}{n-l} \sum_{t=l+1}^{n} \hat{\in}_t$.

3. We then calculate the bootstrap sample of observations e_t^b as follows:

$$e_t^b = e_{t-1}^b + \Delta e_t^b \tag{12}$$

$$\text{With} \begin{cases} \Delta e_t^b = \sum_{k=1}^{k=l} \hat{\rho}_k \Delta e_{t-k}^b + \in_t^b; \\ \Delta e_j^b = \Delta e_j \text{ for } j = 1, 2, \ldots, l; \\ e_1^b = e_1 \end{cases}$$

We construct the $\alpha_0(\tau)$, and $\rho_1(\tau)$ based on equation (6), $t_n(\tau)$ statistics based on equation (8), and *QKS* statistics based on equations (10).

4. We repeat steps 2 and 3 through 5 000 times and the collection of realized $t_n(\tau)$ and *QKS* statistics provides us an approximation to the cumulative distribution functions of them. Also, to construct the 95% confidence intervals for the $\alpha_0(\tau)$ and $\rho_1(\tau)$, we use their empirical distribution functions.

3. Empirical Results and Policy Implications

3.1. Results from Traditional Unit Root Tests

For comparison purpose, we also incorporate three conventional unit root tests – ADF, PP and KPSS tests. The results in Table 2 clearly indicate that both the ADF and the PP tests fail to reject the null of non-stationary unemployment rate for these 9 transition countries. KPSS test get similar results, unemployment hysteresis prevails in these 9 transition countries, when conventional unit root tests are conducted. As pointed by Koenker and Xiao (2004), the Quantile unit root test has higher power than conventional unit root tests, because the Quantile unit root test is superior to standard unit root tests in case of departure from Gaussian residuals. Because we find our unemployment data exists non-normality for most of the countries with the exception of Romania (see Table 1), therefore we proceed to test hysteresis unemployment using Quantile unit root tests.

T a b l e 2

Univariate Unit Root Tests (LN)

	Level			**1st difference**		
	ADF	PP	KPSS	ADF	PP	KPSS
Bulgaria	–1.345 [1]	–1.008 [8]	0.578 [11]**	–5.715 [0]***	–6.207 [22]***	0.170 [8]
Czech	–0.776 [2]	–0.812 [9]	0.765 [11]***	–4.979 [1]***	–9.737 [8]***	0.128 [9]
Hungary	–0.263 [1]	–0.457 [9]	0.813 [11]***	–7.274 [0]***	–7.134 [3]***	0.613 [9]**
Lithuania	–1.912 [2]	–1.547 [10]	0.214 [11]	–4.202 [1]***	–5.349 [1]***	0.128 [10]
Litvia	–2.217 [4]	–1.507 [7]	0.157 [11]	–3.636 [3]***	–5.425 [52]***	0.128 [7]
Poland	–0.400 [1]	0.038 [9]	1.322 [11]***	–4.669 [0]***	–4.453 [6]***	0.231 [9]
Romania	–1.848 [3]	–1.744 [7]	0.681 [11]**	–6.425 [2]***	–17.475 [8]***	0.068 [7]
Russia	–2.494 [1]	–2.431 [1]	1.414 [11]***	–9.579 [0]***	–9.422 [5]***	0.094 [0]
Slovakia	–1.5100[2]	–1.4467[8]	0.44133[11]*	–5.638[2]***	–9.471[5]***	0.2339[8]

Note: ***, ** and * indicate significance at the 0.01, 0.05 and 0.1 level, respectively. The number in parenthesis indicates the lag order selected based on the recursive t-statistic, as suggested by Perron (1989). The number in the brackets indicates the truncation for the Bartlett Kernel, as suggested by the Newey-West test (1987).

Source: Datastream.

3.2. Results from Quantile Unit Root Test

Due to the deficiency of conventional unit root test, in the following we first employ a more powerful Quantile unit root test proposed by Koenker and Xiao (2004), without considering smooth breaks. Results for the Quantile unit root test without considering smooth breaks are reported at Table 3.

Table 3

Quantile Unit Root Test Results

Quantile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
BULGARIA									
$\alpha(\tau)$	1.01	1.01	1.01	1.001	0.997	0.996	0.99	**0.983**	**0.979**
t-stat.	1.34	2.87	1.55	0.71	–0.511	–0.67	–2.3	**–3.3**	**–2.47**
C.V.	–2.28	–2.27	–2.42	–2.58	–2.48	–2.54	–2.59	**–2.33**	**–2.12**
H-L								**39.72**	**33.6**
QKS test	**3.305**								
CZECH Republic									
$\alpha(\tau)$	1.036	1.033	1.018	1.009	1.003	1	0.993	0.977	0.975
t-stat.	2.301	**2.99**	2.073	0.971	0.321	–0.001	–0.77	–1.781	–1.35
C.V.	–2.29	**–2.44**	–2.55	–2.68	–2.719	–2.636	–2.728	–2.643	–2.59
H-L									
QKS test	**2.993**								
HUNGARY									
$\alpha(\tau)$	0.98	0.99	0.99	0.99	0.99	0.99	0.99	1.01	1.01
t-stat.	–1.46	–1.13	–1.66	–1.82	–0.65	–0.259	–0.539	0.54	0.37
C.V.	–2.21	–2.42	–2.54	–2.67	–2.63	–2.561	–2.472	–2.54	–2.58
H-L									
QKS test	1.818								
LITHUANIA									
$\alpha(\tau)$	1.002	1.001	0.999	0.99	**0.985**	**0.983**	**0.982**	**0.978**	**0.972**
t-stat.	0.37	0.184	–0.044	–2.2	**–3.72**	**–4.274**	**–3.76**	**–3.46**	**–3.23**
C.V.	–2.28	–2.28	–2.45	–2.59	**–2.52**	**–2.65**	**–2.62**	**–2.69**	**–2.55**
H-L					**45.55**	**41.92**	**39.03**	**31.3**	**24.32**
QKS test	**4.274**								
LATVIA									
$\alpha(\tau)$	1.014	1.001	1.001	0.999	0.995	0.993	0.98	0.981	**0.966**
t-stat.	1.25	0.168	0.113	–0.058	–0.624	–0.907	–2.35	–2.06	**–2.476**
C.V.	–2.36	–2.55	–2.62	–2.64	–2.67	–2.617	–2.722	–2.66	**–2.31**
H-L									
QKS test	2.476								
POLAND									
$\alpha(\tau)$	1.006	1.007	1.002	1.001	1.002	1.005	0.996	0.993	0.99
t-stat.	1.581	2.14	0.694	0.599	0.103	0.22	–1.101	–1.67	–1.58
C.V.	–2.52	–2.68	–2.65	–2.613	–2.579	–2.51	–2.411	–2.38	–2.33
H-L									
QKS test	2.14								
ROMANIA									
$\alpha(\tau)$	0.935	0.46	0.95	0.964	0.961	0.975	0.948	0.959	0.931
t-stat.	–1.65	–1.73	–1.98	–1.52	–1.68	–1.1	–2.22	–1.52	–1.311
C.V.	–2.33	–2.47	–2.53	–2.576	–2.66	–2.77	–2.735	–2.57	–2.41
H-L									
QKS test	2.22								
RUSSIA									
$\alpha(\tau)$	0.975	0.99	1.004	0.98	0.98	0.97	0.96	0.96	0.92
t-stat.	–1.65	–0.33	0.22	–0.62	–0.82	–1.35	–1.84	–1.31	–2.06
C.V.	–2.33	–2.43	–2.57	–2.55	–2.48	–2.55	–2.38	–2.23	–2.31
H-L									
QKS test	2.06								
SLOVAKIA									
$\alpha(\tau)$	0.981	0.983	0.987	0.993	0.998	0.994	0.992	0.995	1 001
t-stat.	**–2.7***	**–3.48***	**–2.58***	–1.425	–0.311	–1.243	–1.401	–531	0.035
C.V.	–2.33	–2.43	–2.57	–2.55	–2.48	–2.55	–2.38	–2.23	–2.31
H-L	**36.13**	**40.42**	**52.97**						
QKS test	**3.5****								

Notes: The table shows point estimates, t-statistics and critical values for the 5% significance level. If the *t*-statistic is numerically smaller than the critical value then we reject the null hypothesis of $\alpha(\tau) = 1$ at the 5% level. QKS is the quantile Kolmogorov-Smirnov test. 2.7837 is 5 % critical value for QKS based on 10 000 bootstrapping simulations. H-L = $\ln(0.5)/\ln(\alpha(\tau))$.

Source: Datastream.

Results from Tables 3 demonstrate that hysteresis unemployment hypothesis can be rejected for Bulgaria, the Czech Republic, Lithuania and Slovakia four countries and hysteresis unemployment holds in the other five countries (i.e., Hungary, Latvia, Poland, Romania and Russia) based on QKS. Table 3 also calculates the Half-Life of a shock for these three countries where hysteresis unemployment hypothesis is rejected. We find that the estimated Half-Life based on quantile autoregressive model is about 24.32 – 52.94 months (2 years to 4.1 years).

3.3. Results from Fourier Quantile Unit Root Test

As we mentioned earlier that failure to account for structural break in unemployment rate is said to contribute to failure of rejecting hysteresis unemployment hypothesis. In this paper, we intend to deal with this deficiency by employing a newly developed Quantile-based unit root test with Fourier Function as proposed by Bahmani-Oskoee, Chang and Ranjbar (2015), and Bahmani-Oskoee et al. (2017) to enhance estimation accuracy. As pointed by Bahmani-Oskoee, Chang and Ranjbar, Chang and Ranjbar (2015), and Bahmani-Oskoee et al. (2017) this Fourier Quantile unit root test has higher power and good size compared to Quantile unit root test without Fourier function when the data follow heavy tailed distribution.

Empirical results based on Fourier Quantile unit root test are reported at Table 4. Results from Tables 4 show that we can reject hysteresis unemployment hypothesis for the Czech Republic, Latvia, Lithuania, Poland, Russia and Slovakia six countries and hysteresis unemployment only holds in the rest of 3 countries, Bulgaria, Hungary and Romania, which is based on QKS. Table 4 also calculates the Half-Life of a shock for these 8 transition countries and we find that the estimated Half-Life based on quantile autoregressive model is about 2.82 – 42.97 months (3 months to 3.5 years). Based on empirical findings from both Tables 3 and 4 we find some interesting insights into the behaviour of unemployment rates in these 9 transition countries.

We can divide these 9 countries into 2 groups: Group 1 countries (i.e., Hungary and Romania) where hysteresis unemployment was detected; Group 2 countries (i.e., Bulgaria, the Czech Republic, Latvia, Lithuania, Poland, Russia and Slovakia) where hysteresis unemployment was not found. This means that high unemployment rates in Hungary and Romania tended to persist over longer spans of time. By contrast, the findings indicated that unemployment hysteresis was absent in Bulgaria, the Czech Republic, Latvia, Lithuania, Poland, Russia and Slovakia. Therefore, high unemployment rates in these countries had a tendency to revert to the equilibrium level.

T a b l e 4

Fourier Quantile Unit Root Test Results (taking into account breaks)

Quantile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
BUGLARIA									
$\alpha(\tau)$	0.992	0.986	**0.982**	0.988	0.996	1.001	0.997	0.992	0.997
t-stat.	–0.656	–1.895	**–2.433***	–1.806	–0.574	0.159	–0.399	–0.934	–0.298
H-L			**38.16**						
QKS test	2.433		Optimal Freq	1.5	**F**	**195.88**			
CZECH Republic									
$\alpha(\tau)$	0.976	0.982	0.987	0.982	0.989	0.988	0.976	0.971	**0.957**
t-stat.	–1.423	–1.082	–1.032	–1.415	–1.051	–0.93	–1.937	–2.058	**–3.20*****
H-L									**15.77**
QKS test	**3.20****		Optimal Freq	0.1	**F**	**80.24**			
HUNGARY									
$\alpha(\tau)$	0.965	0.974	0.986	0.989	0.988	**0.973**	**0.968**	0.982	0.983
t-stat.	–1.187	–1.77	–0.979	–0.86	–0.938	**–2.327****	**–2.552****	–1.229	–0.587
H-L						**25.32**	**21.31**		
QKS test	2.522		Optimal Freq	1.1	**F**	**655.49**			
LATVIA									
$\alpha(\tau)$	**0.936**	**0.96**	**0.96**	**0.964**	**0.963**	**0.969**	**0.965**	0.972	0.954
t-stat.	**–4.78*****	**–2.6****	**–2.5****	**–2.6****	**–2.9****	**–2.59****	**–2.93****	–1.669	–1.477
H-L	**10.48**	**16.97**	**16.97**	**18.9**	**18.38**	**22.01**	**19.45**		
QKS test	**4.77*****		Optimal Freq	1.6	**F**	**374.83**			
LITHUANIA									
$\alpha(\tau)$	0.966	**0.967**	**0.961**	0.972	0.972	**0.971**	**0.961**	0.969	0.954
t-stat.	–1.924	**–2.5****	**–2.4***	–2.02	–1.28	**–2.148***	**–3.43*****	–1.591	–1.363
H-L		**20.04**	**17.42**			**23.55**	**17.42**		
QKS test	**3.43****		Optimal Freq	1.7	**F**	**152.68**			
POLANDS									
$\alpha(\tau)$	0.986	**0.984****	**0.984***	0.988	0.993	0.988	**0.98***	0.987	0.985
t-stat.	–1.95	**–2.74****	**–2.37**	–2.02	–1.28	–2.15	**–3.21**	–1.59	–1.36
H-L		**42/97**	**42.97**		5.24		**42.97**		
QKS test	**3.21****		Optimal Freq	0.7	**F**	**352.67**			
ROMANIA									
$\alpha(\tau)$	0.912	0.956	0.967	0.977	0.971	0.61	0.951	0.921	0.967
t-stat.	–1.39	–0.988	–0.818	–0.687	–0.823	–1.37	–0.954	–1.624	–0.695
H-L							42.97		
QKS test	1.813		Optimal Freq	1.7	**F**	**81.82**			
RUSSIA									
$\alpha(\tau)$	0.782	0.883	0.89	0.87	0.876	0.892	0.994	0.923	0.943
t-stat.	**–5.299**	**–2.86****	**–2.73****	**–3.51*****	**–3.35*****	**–2.88****	–1.164	–1.554	–1.166
H-L	**2.82**	**5.57**	**5.95**	**4.98**	**5.24**	**6.6**			
QKS test	**5.295****		Optimal Freq	0.1	**F**	**249.53**			
SLOVAKIA									
$\alpha(\tau)$	0.937	0.966	0.976	0.974	0.981	0.979	0.984	1.01	0.992
t-stat.	**–3.55*****	**–2.83****	–2.16	–2.48	–2.07	–1.83	–0.998	0.472	–0.219
H-L	**10.65**	**20.04**							
QKS test	**3.55****		Optimal Freq	1.5	**F**	**465.31**			

Source: Datastream.

Tables 3 and 4 also demonstrate that the coefficients of each quantile for each country are quite different and we find that shocks to unemployment rate adjust more quickly at lower quantile levels than that of higher quantile levels in Hungary, Russia and Slovakia and adjust more quickly at higher quantile levels than that of lower quantile levels in Bulgaria, the Czech Republic, Latvia, Lithuania, Poland and Romania. This means shock effects to the unemployment rate in these 9 countries are asymmetric

Our empirical findings give rise to some pertinent questions, such as these: Why do the differences exist in the unemployment dynamics among these transition countries? What factors contribute to these differences? It should be noted that the behaviour of the unemployment rate is influenced by numerous factors embedded in the socio-economic fabric and the political reality of a country or an economy (Furuoka, 2014). Therefore, it is impossible to pinpoint the exact reasons for the differences in the unemployment dynamics. Further research will allow deeper insights concerning the behaviour of Eastern European unemployment rates and its causes. Future study will be in this direction.

3.4. Policy Implications

One major policy implication of our study is that hysteresis unemployment hypothesis only holds in Hungary and Romania two countries and for the rest of 7 countries (i.e., Bulgaria, the Czech Republic, Latvia, Lithuania, Poland, Russia and Slovakia) we can reject hysteresis unemployment hypothesis. These findings may appear counter-intuitive due to considerable differences in these countries' labour market institutions. The major policy implication of our empirical findings implies that a fiscal or monetary stabilization policy would possibly not have permanent effects on the unemployment rate in Bulgaria, the Czech Republic, Latvia, Lithuania, Poland, Russia and Slovakia.

Our empirical results are consistent with those found in Leon-Ledesma and McAdam (2004) and Cuestas and Gil-Alana (2009; 2018) that hysteresis in unemployment was not fund in most of the CEE countries. Our empirical results are also consistent with those found in Dursun (2017) that reject hysteresis unemployment in most of CEE countries with the exception of Hungary and Poland when Fourier ADF-SB test was conducted. However, our results are not consistent with those of Gozgor (2013) that hysteresis unemployment was hold in most CEE countries and Cuestas, Gil-Alana and Staehr (2011) that high persistent in unemployment hold in some CEE countries (i.e., the Czech Republic, Slovakia, Baltic states and Poland). Based on Cuestas, Gil-Alana and Staehr (2011) empirical findings that the degree of persistence appears to reflect the different levels of economic and institutional development in the countries and possibly also the role of the government. Our results seems to be consistent this finding.

A further examination of the Figures indicates that Fourier approximations (smooth beaks) seem reasonable and support the notion of long swings in unemployment rates. Our empirical results highlight the importance of modelling smooth breaks into quantile-based unit root test model.

Conclusions

This study revisits hysteresis unemployment hypothesis for 9 Eastern European countries (i.e., Bulgaria, Czech Republic, Hungary, Lithuania, Latvia, Poland, Romania, Russia and Slovakia) over 2000M1 – 2016M8. Hysteresis unemployment hypothesis is a prominent research topic in economic literature because of the important policy implications the issue entails. To carry out the empirical analysis, we apply Quantile unit root tests both with and without Fourier function considering smooth multiple breaks. Empirical findings from Quantile unit root tests demonstrate the absence of hysteresis unemployment in Bulgaria, Czech Republic, Lithuania, Latvia, Poland, Russia and Slovakia seven countries indicating unemployment in these six countries could be described as a stationary process in line with the natural rate hypothesis. On the other hand, hysteresis unemployment was detected in Hungary and Romania. The unemployment rates in these 2 countries contained a unit root and could be described as a non-stationary process in accordance with the hysteresis hypothesis. Finally, our empirical findings also demonstrate shocks to the unemployment of each country are asymmetric. Our study has important policy implications for government conducting fiscal or monetary policy to stabilize economic fluctuations in these 9 Eastern European countries. The findings of our study will further give economists additional insights into unemployment dynamics in the context of the transition economy.

References

BAHMANI-OSKOEE, M. – CHANG, T. Y. – RANJBAR, O. (2015): Fourier Quantile Unit Root Test with Application for PPP Hypothesis. [Working Paper, No. 201601.] Taichung: Department of Finance, Feng Chia University.

BAHMANI-OSKOEE, M. – CHANG, T. Y. – ELMI, Z. – GELAN, A. – OMID RANJBAR (2017): Non-linear Quantile Unit Root Test and PPP: More Evidence from Africa. Applied Economics Letters. [Forthcoming.]

BAI, J. – PERRON, P. (2003): Computation and Analysis of Multiple Structural Change Models. Journal of Applied Econometrics, *18*, No. 1, pp. 1 – 12.

BECKER, R. – ENDERS, W. – HURN, S. (2004): A General Test for Time Dependence in Parameters. Journal of Applied Econometrics, *19*, No. 7, pp. 899 – 906.

BECKER, R. – ENDERS, W. – LEE, J. (2006): A Stationarity Test in the Presence of an Unknown Number of Smooth Breaks. Journal of Time Series Analysis, *27*, No. 3, pp. 381 – 409.

CHANG, T. – LEE, K.-Ch. (2011a): Flexible Fourier Stationary Test in Unemployment for G-7 Countries. Economic and Finance Review, *1*, No. 2, pp. 1 – 12.

CHANG, T. – LEE, Ch.-H. (2011b): Hysteresis in Unemployment for G-7 Countries: Threshold Unit Root Test. Romanian Journal of Economic Forecasting, *14*, No. 4, pp. 5 – 14.

CHRISTOPOULOS, D. – LEON-LEDESMA, M. (2010): Currently Account Sustainability in the US: What did We Really Know about It. Journal of International Money and Finance, *29*, No. 3, pp. 44 – 459.

CUESTAS, J. C. – GIL-ALANA, L. A. (2009): Unemployment Hysteresis, Structural Changes, Non-linearities and Fractional Integration in Central and Eastern Europe. [Working Paper, 91190.] Nottingham: Notttingham Trent University.

CUESTAS, J. C. – GIL-ALANA, L. A. – STAEHER, K. (2011): A Further Investigation of Unemployment Persistence in European Transition Economies. Journal of Comparative Economics, *39*, No. 2, pp. 514 – 532.

CUESTAS, J. C. – GIL-ALANA, L. A. (2018): Oil Price Shocks and Unemployment in Central and Eastern Europe. Economic Systems. [Forthcoming.]

DURSUN, G. (2017): Unemployment Hysteresis in Central and Eastern European Countries: Further Evidence from Fourier Unit Root Test. Rome: Econ-World2017@Rome Proceedings, January 25 – 27, 2017.

ENDERS, W. – LEE, J. (2012): A Unit Root Test Using Fourier Series to Approximate Smooth Breaks. Oxford Bulletin of Economics and Statistics, *74*, No. 4, pp. 574 – 599.

FURUOKA, F. (2014): Are Unemployment Rates Stationary in Asia-Pacific Countries? New Findings from Fourier ADF Test. Economic Research, *27*, No. 1, pp. 34 – 45.

GOZGOR, G. (2013): Testing Unemployment Hysteresis in Central and Eastern European Countries. International Journal of Economics and Financial Issues, *13*, No. 3, pp. 694 – 700.

JIANG, Y. – CHANG, T. (2016): Bring Quantile Unit Root Test Back in Testing Hysteresis in Unemployment for the United States. Romanian Journal of Economic Forecasting, *16*, No. 1, pp. 5 – 13.

KOENKER, R. – XIAO, Z. (2004): Unit Root Quantile Autoregression Inference. Journal of the American Statistical Association, *99*, No. 467, pp. 775 – 787.

LEON-LEDESMA, M. – McADAM, P. (2004): Unemployment, Hysteresis and Transition. Scottish Journal of Political Economy, *51*, No. 3, pp. 377 – 401.

LEYBOURNE, S. – NEWBOLD, P. – VOUGAS, D. (1998): Unit Roots and Smooth Transitions. Journal of Time Series Analysis, *19*, No. 1, pp. 83 – 97.

PERRON, P. (1989): The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis. Econometrica, *55*, No. 12, pp. 277 – 302.

SMYTH, R. (2003): Unemployment Hysteresis in Australian States and Territories: Evidence from Panel Data Unit Root Tests. Australian Economic Review, *36*, No. 5, pp. 181 – 192.

TSONG, C. C. – LEE, C. F. (2011): Asymmetric Inflation Dynamic: Evidence from Quantile Regression. Journal of Macroeconomics, *33*, No. 4, pp. 668 – 680.