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Does Hysteresis Exist in Unemployment? New Findings from Fourteen Regions of the Czech Republic*

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Abstract
The present study chose 14 regions of the Czech Republic as case studies to examine the existence of unemployment hysteresis. To carry out the empirical analysis, it used the SURADF test and the FADF test. The empirical findings from the ADF tests suggested that unemployment in all 14 regions could be described as a non-stationary process. However, the results obtained from the more powerful SURADF test and the non-linear FADF test indicated that the unemployment rates in nine regions could have a unit root in accordance with the hysteresis hypothesis. These regions are Prague-city (Praha), Plzeň (Plzeňský), Karlovy Vary (Karlovarský), Ústí (Ústecký), Liberec (Liberecký), Hradec Králové (Královohradecký), Pardubice (Pardubický), South Moravia (Jihomoravský) and Olomouc (Olomoucký). By contrast, unemployment in the remaining five regions, namely Central Bohemia (Středočeský), South Bohemia (Jihočeský), Vysočina, Zlín (Zlínský) and Moravia-Silesia (Moravskoslezský), could be described as a stationary process in line with the natural rate hypothesis. This means that unemployment hysteresis was not found in these five regions.

1. Introduction

Unemployment has emerged as one of the thorniest socio-economic issues around the world. The global financial crisis that began at the end of the 2000s negatively affected labor market conditions in many economies, including Central and Eastern European transitional economies. In the aftermath of the financial crisis of 2008–2009, many countries have been suffering from unemployment persistence; this phenomenon is known as a "jobless recovery". In macroeconomics literature, persistence in the unemployment rate is known as unemployment hysteresis.

Unemployment hysteresis is a much discussed topic in macroeconomics and there is an ongoing academic debate about whether hysteresis exists in the unemployment rate time series. Basic macroeconomics textbooks assume that the unemployment rate will eventually revert to the equilibrium level. This means that an economic shock will not have a lasting effect on the labor market and hysteresis does exist in the unemployment rate time series. The set of such assumptions about unemployment dynamics is known as the natural rate hypothesis. The proponents of the natural rate hypothesis believe in the mean reversion property of the unemployment rate and they deny the existence of unemployment hysteresis.

The natural rate hypothesis assumes that the equilibrium level for the unemployment rate is determined by the labor market institutions and is not affected by the actual unemployment rate. Furthermore, unexpected movements in labor demand

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and supply, which happen from time to time, would necessarily lead to deviations from the equilibrium level of unemployment and change the situation with the actual unemployment rate. These deviations trigger changes in the rate of inflation, which eventually leads to a return to the equilibrium level of unemployment or the non-accelerating inflation rate of unemployment (NAIRU) (Phelps, 1967; Friedman 1968). In other words, supporters of the natural rate hypothesis believe that cyclical fluctuations in an economy can influence unemployment in the short run; however, the unemployment rate will revert to the NAIRU in the long run even without government interventions (Smyth, 2003).

In contrast to the natural rate hypothesis, a higher-than-normal level of unemployment often does not revert to a normal level. This implies that some economic shocks have long-lasting impacts on the labor market. If this is the case, then hysteresis should be present in unemployment. The set of such assumptions is known as the hysteresis hypothesis. Proponents of the hysteresis hypothesis deny the existence of the mean reversion property in unemployment because the hysteresis hypothesis assumes that equilibrium unemployment is dependent on past trends in the actual unemployment rate. For example, Blanchard and Summers (1986a) have observed that between the mid-1970s and the mid-1980s actual unemployment in European labor markets went up in tandem with equilibrium unemployment as estimated by the Phillips Curve relationship. They argued that this phenomenon supported the alternative theory of unemployment or the hysteresis hypothesis. Unemployment hysteresis simply means that the equilibrium level of unemployment tends to depend on the actual path of unemployment and, therefore, the equilibrium rate of unemployment is *path-dependent* (Carlin and Soskice, 1990:440–445). In other words, under the hysteresis hypothesis cyclical fluctuations in an economy do have permanent effects on the level of unemployment (Smyth, 2003). This implies that without government interventions to address the unemployment problem, high unemployment rates will not revert to the NAIRU in the long run.

Several theoretical frameworks have been developed to explain hysteresis in unemployment. The most widely accepted among them is the so-called membership theory (Lindbeck and Snower, 1985; Blanchard and Summers, 1986a; Blanchard and Summers, 1986b; Gregory, 1986). The membership theory assumes that wage setting is mainly determined by the insiders in a firm rather than by outsiders. The employment function is expressed as:

$$n_t = n_{t-1} + (m - em) \tag{1}$$

where n_t is employment in the year t, m is the nominal money, em is the expected nominal money. Thus, employment at a certain point in time is equal to employment in the previous period plus a random disturbance. In Equation (1) the disturbance is equal to the unanticipated movement in the nominal money. Implications of this equation are quite drastic as the formula assumes that employment would follow a random walk (Blanchard and Summers, 1986a).

From an econometric perspective, the hysteresis hypothesis views unemployment as a near non-stationary process where unemployment will not revert to the NAIRU. This means that the unemployment time series contain a unit root. Contrary to this perspective, the natural rate hypothesis views unemployment as a stationary process in which the level of unemployment will eventually revert to

the NAIRU. Therefore, the unemployment time series do not contain a unit root. There exists yet another hypothesis about the unemployment dynamics, which is the persistence hypothesis. It is similar to the hysteresis hypothesis because it postulates that it would take many periods for the unemployment rate to revert to the NAIRU. Under the persistence hypothesis unemployment could be described as a near unit root process (Smyth, 2003).

In view of the fact that there are many contradictory opinions about the behavior of the unemployment rate and that persistent higher-than-normal unemployment entails serious socio-economic and political consequences, the question of whether unemployment hysteresis exists is an important topic in economic literature. The present study chooses 14 regions of the Czech Republic as case studies to examine the existence of hysteresis in their unemployment rates. For this purpose it uses the SURADF test and the FADF test. These tests are chosen for two reasons. Firstly, robust economic and business ties between the regions entail high interdependence and deep integration between their labor markets. Therefore, the SURADF test is more suitable for the analysis because it employs the Seemingly Unrelated Regression (SUR) method which takes into account contemporaneous cross-correlations of the error term (Breuer et al., 2001, 2002). Secondly, a nonlinear Fourier ADF test is employed because, according to Enders and Lee (2012a, 2012b), a Fourier approximation could be used to capture unknown structural breaks or unattended nonlinearity in the deterministic component of a model. Recently, methods that incorporate a Fourier function into a unit root test have generated a considerable interest among researchers.[1]

This article has the following structure: subsequent to this introduction, Section 2 offers a review of relevant empirical studies on unemployment hysteresis. Section 3 explains the data collection method and the research method, while Section 4 reports the findings from the statistical analyses. A discussion of these findings is offered in Section 5. Section 6 examines unemployment dynamics and the existence of unemployment hysteresis in the contexts of nine Central and Southeast European countries, namely Austria, Bulgaria, the Czech Republic, Greece, Hungary Poland, Romania, Slovakia and Slovenia. Section 7 contains concluding remarks.

2. Literature Review

Numerous research studies have investigated the issue of unemployment. Edmund S. Phelps was the first economist to challenge one the basic tenets of macroeconomics, the natural rate hypothesis. In the seminal book "Inflation and Unemployment Theory", Phelps proposed that there exists hysteresis in employment (Phelps, 1972, pp. 77–80). He defined unemployment hysteresis as a situation in which equilibrium unemployment is determined by the path of the actual unemployment rate.

Blanchard and Summers (1986b) have significantly contributed to the hysteresis hypothesis by systematically examining the unemployment rates in Europe. They defined unemployment hysteresis as a situation in which the current unemploy-

[1] For example, a study by Becker et al. (2006) employed a nonlinear KPSS-type stationarity test; Rodrigues and Taylor (2012) adopted the DF-GLS de-trending method while Enders and Lee (2012b) used the Lagrange Multiplier de-trending method. For a more detailed discussion, see Chang et al. (2012).

ment rate is determined mainly by past unemployment rates. The researchers stated that traditionally "unemployment exhibits hysteresis when current unemployment depends on past values […] We shall instead use hysteresis more loosely to refer to the case where the degree of the past is very high." (Blanchard and Summers, 1986b:17)

There is a wealth of empirical studies on unemployment hysteresis; however, their findings are contradictory and inconclusive. Some papers provided empirical evidence in support of the natural rate hypothesis (Røed, 1996; Song and Wu, 1998; Camarero and Tamarit, 2004; Chang et al., 2005; Christopoulos and León-Ledesma, 2007; Romero-Ávila and Usabiaga, 2007a; Lee et al., 2009; Ener and Arica, 2011). These findings are counterbalanced by the results of the studies that found evidence in support of the hysteresis hypothesis (Phelps, 1972; Blanchard and Summers, 1986a; Blanchard and Summers, 1986b; Neudorfer et al., 1990; Brunello, 1990; Mitchell, 1993; Sephton, 2009; Lee et al., 2010; Furuoka, 2012).

The inconsistencies in the results could be due to the differences in the methodological approaches. The research studies that used univariate unit root tests, such as the ADF test, the PP test or their modified versions, tended to fail to reject the null hypothesis of a unit root (Neudorfer et al., 1990; Brunello, 1990; Mitchell, 1993). By contrast, the academic inquiries based on the panel methods tended to reject the null hypothesis (Song and Wu, 1998; Camarero and Tamarit, 2004; Chang et al., 2005; Christopoulos and León-Ledesma, 2007). The only exception is a study by Furuoka (2012), who detected hysteresis in the Asia-Pacific countries' unemployment rates. Recently, some researchers have begun incorporating structural breaks and non-linearity into their analyses. These studies, for the most part, rejected the null hypothesis of hysteresis (Romero-Ávila and Usabiaga, 2007b; Lee et al., 2009; Ener and Arica, 2011). Only one study, by Lee et al. (2010), has detected hysteresis in the unemployment rates in East Asian countries.

To give more details on the studies mentioned above, Neudorfer et al. (1990) detected a unit root in the unemployment time series in Austria while Brunello (1990) found the existence of unemployment hysteresis in Japan. An inquiry by Mitchell (1993) revealed that the unemployment rates in Europe and the United States were non-stationary. By contrast, Røed (1996), who focused on 16 OECD countries and employed a method similar to these studies, was unable to reject the null hypothesis of unemployment hysteresis for most of the European countries as well as Australia, Canada and Japan.

Song and Wu (1998) used a panel unit root test (LLC test) to examine unemployment in OECD countries and they rejected the null hypothesis of unemployment hysteresis. Among other researchers who employed a panel unit root test in order to increase the test power, Christopoulos and León-Ledesma (2007) focused on 12 EU countries over the period 1988–1999, and they rejected the null hypothesis. Chang et al. (2005) employed a panel SURADF test to examine unemployment hysteresis in Europe over the period 1961–1999. The panel SURADF test indicated that, with the exception of Belgium and the Netherlands, the hysteresis hypothesis was supported for all of the countries. Camarero and Tamarit (2004) used the MADF and the SURADF tests to examine unemployment hysteresis in 19 OECD countries between 1956 and 2001. They concluded that the unemployment rates were stationary and that unemployment hysteresis did not exist in the majority of the selected OECD countries.

Among the more recent studies, Romero-Ávila and Usabiaga (2007a) tested the hysteresis hypothesis in the context of the United States over the period 1976––2004. When the individual Lagrange Multiplier (LM) test was used, the study failed to reject the null hypotheses for 40 of the American states. However, the null hypothesis was rejected by the Panel LM test. These findings led the researchers to the conclusion that the unemployment rates in the American states could be described as a stationary process. In their following study, Romero-Ávila and Usabiaga (2007b) analyzed and compared the stationarity property of the unemployment rates in Spain and the United States for the period 1976–2004. The findings from the minimum Lagrange Multiplier (LM) unit root test with two structural breaks indicated that the unemployment rate time series in Spain could have a unit root, which supported the hysteresis hypothesis. By contrast, the American unemployment rate could be characterized as a stationary process in accordance with the natural rate hypothesis. Sephton (2009) re-examined the existence of unemployment hysteresis in the American states using the Wald test for fractional integration. The findings from the fractional integration test supported the hysteresis hypothesis when only one break was incorporated into the analysis. However, when two breaks were incorporated the unemployment rates in the American states could be described as a stationary process. Based on these results, Sephton concluded that the unemployment rates in the United States could be best described as a stationary fluctuation around a shifting trend.

Lee et al. (2009) examined the hysteresis hypothesis in the context of 19 OECD countries between 1960 and 2004. They used the panel Lagrange Multiplier (LM) unit root tests with heterogeneous structural breaks in which two structural breaks were incorporated into the analysis. The findings from the panel LM test rejected the null hypothesis of unemployment hysteresis. As Lee et al. (2009) concluded, shocks to the unemployment rates in the selected OECD countries were temporary and unemployment would revert to the natural level in the long run. Ener and Arica (2011) analyzed the hysteresis hypothesis in 15 OECD countries over the period of 1985–2004. They employed a panel unit root test that allowed for cross-sectional dependency and a panel unit root test with structural breaks. The results obtained from the tests were contradictory. The findings from the first panel root test indicated that the unemployment rates in the 15 OECD countries could be described as a non-stationary process. However, the findings from the second test suggested that the unemployment time series could be described as a stationary process. The researchers concluded that their findings supported the natural rate hypothesis where the unemployment rate would revert to an equilibrium level in the long run.

It should be noted that the majority of the previous studies have focused on developed countries in Western Europe and North America. Two notable exceptions are the studies by Lee et al. (2010) and Furuoka (2012) that explored the hysteresis hypothesis in the context of the Asia-Pacific region. Lee et al. (2010) employed the Lagrange Multiplier (LM) unit root test and the panel unit root test that took account of structural breaks. The findings failed to reject the null hypothesis of hysteresis even after considering the structural breaks. Furuoka (2012) applied the MADF test and the SURADF test to examine unemployment hysteresis in 12 Asia-Pacific countries. The empirical results confirmed the presence of unemployment hysteresis,

except for South Korea and New Zealand. Also, the results of Furuoka's study indicated that the equilibrium rate of unemployment in the Asia-Pacific region tended to be path-dependent and that cyclical fluctuations in these economies could have a permanent effect on the level of unemployment. The present study extends the research on unemployment hysteresis to the context of the Czech Republic.

3. Data and Research Method

The unemployment rate database compiled by the Czech Statistical Office (CZSO) was the source of data on unemployment for 13 regions of the Czech Republic and its capital, Praha (Prague). The present study used quarterly data from the first quarter of 2005 to the first quarter of 2013 (CZSO, 2013).

The behavior of the unemployment rates was examined by the SURADF test and the FADF test. First of all, the SURADF test can be considered as an extension of the univariate unit root test. A widely used procedure to test the unit root hypothesis is the ADF test (Dickey and Fuller, 1979). A standard version of an individual ADF test is based on the following regression (MacKinnon, 2002):

$$\Delta y_t = \alpha + \beta y_{t-1} + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + \varepsilon_t \tag{2}$$

where α, β, and δ_j are the coefficients, p is the lag order of the autoregressive process and ε_t is the error term.

In a time-series analysis, the autoregressive coefficient, β, captures unemployment dynamics. Hysteresis in unemployment is present if the autoregressive coefficient is equal to zero or the null hypothesis of a unit root in the unemployment rate cannot be rejected. In such an outcome, a higher-than-normal unemployment rate will not revert to the equilibrium level and the high unemployment rates will persist. On the other hand, if the autoregressive coefficient is non-zero or the null hypothesis can be rejected, there is no hysteresis in unemployment. This means that higher-than-normal unemployment will revert to the lower level.

The SURADF tests employ seemingly unrelated regressions (SUR) to estimate the ADF statistic. In this study, the system of the ADF equations can be expressed as:

$$\Delta y_{1,t} = \alpha_1 + (\beta_1 - 1) y_{1,t-1} + \sum_{i=1}^{p} \delta_i \Delta y_{2,t-i} + u_{1,t}$$

$$\Delta y_{2,t} = \alpha_2 + (\beta_2 - 1) y_{2,t-1} + \sum_{i=1}^{P} \delta_i \Delta y_{2,t-i} + u_{2,t}$$

$$\Delta y_{N,t} = \alpha_N + (\beta_N - 1) y_{N,t-1} + \sum_{i=1}^{p} \delta_i \Delta y_{n,t-i} + u_{N,t}$$

where β_i is the autoregressive coefficient for series i. Breuer et al. (2001, 2002) have suggested that one lagged augmentation is sufficient to address any problem arising from the serial correlation. Therefore, the lag length in the present study was set as one. In the SURADF procedure, the significance of each ($\beta_i - 1$) can be tested. Breuer et al. (2001, 2002) maintained that the SURADF test can examine the unit-root null hypothesis for each individual panel member. The current study estimated

critical values for the individual ADF tests and the SURADF test by Monte Carlo simulations with 10,000 replications.

Furthermore, Enders and Lee (2012a) have developed an ADF-type unit root test that uses a selected frequency component of a Fourier function to approximate the deterministic component of the model. They suggested using a Fourier approximation to capture unknown structural breaks or unattended nonlinearity in the deterministic component of the model. The nonlinear Fourier ADF statistic (τ_{DF}) is based on the following equation:

$$y_t = \beta y_t + c_0 + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \sum_{i=1}^{l} c_i \Delta y_{t-i} + e_t \qquad (3)$$

where k is the selected frequency for the Fourier approximation, γ are the parameters for the Fourier approximation, t is the trend term, and T is the number of observations, $\pi = 3.1416$. The Fourier ADF statistic (τ_{DF}) is the *t*-statistic for the null hypothesis $\rho = 0$ in Equation (3).

There is an important assumption in the FADF testing framework which concerns the smoothness of the transition process in the time series. As Enders and Lee (2012a, 2012b) have argued, if the time series is less volatile and the changes on the deterministic component are gradual, a Fourier approximation could be a suitable method to capture the smooth transition. The transition path of the unemployment rates is a smooth process compared to the movement of such highly volatile time series as stock market prices and exchange rates. The smoothness in the transition process in the unemployment time series is due to several factors. First of all, employers often consider layoffs of workers as the last resort during an economic crisis and even then some layoffs are temporary. Secondly, people who lose their jobs try to immediately find new employment. Thirdly, to keep unemployment in check, governments and policymakers come up with a variety of policies and measures aimed at alleviating high unemployment.

Clearly, the standard ADF test is a special case of the Fourier ADF test in which the trigonometric terms are set as zero (i.e. $\lambda_1 = \lambda_2 = 0$). According to Enders and Lee (2012a), the usual *F*-statistic can be used to test whether the trigonometric terms should be included in the model. Under the null hypothesis of linearity, the *F*-statistic can be calculated as follows:

$$F(k) = \frac{\left(SSR_0 - SSR_1\right)/q}{SSR_1(k)/(T-k)} \qquad (4)$$

where SSR_1 is the sum of squared residuals (SSR) from Equation (3), SSR_0 is the SSR from Equation (3) without the trigonometric terms, q is the number of restrictions, and k is the number of regressors in the regression.

As Equation (3) shows, the *FADF* statistic depends on the frequency (k) and the lag length (l). Following Enders's and Lee's (2012a) suggestion that a Fourier function with $k = 1$ or $k = 2$ can serve as a reasonable approximation to capture many types of unknown structural breaks, the maximum frequency (k_{max}) in the current study was set as 2. The optimal frequency ($\tilde{k}$) was selected by the data-driven

method. The optimal frequency is a selected frequency that produces the smallest sum of the squared residuals (SSR) among the different specifications in Equation (3). To keep the data analysis tractable, this study set the lag length as 1.

Four steps were implemented in this study to examine the behavior of the unemployment rates in the 14 regions of the Czech Republic. In the first step, a linear unit root test, the Dickey-Fuller (*ADF*) test, was used to examine stationarity of the unemployment rates. In the second step, the SURADF tests based on the seemingly unrelated regression (SUR) was employed for the estimation. The SURADF test can yield better empirical results because it employs the SUR to capture economic interdependency among the regions. The third step of the analysis determined the optimal frequency ($\tilde{k}$) for the Fourier ADF (FADF) test. The optimal frequency was selected using the RSS from Equation (3). After the frequency is selected, the *F*-test can be applied to analyze whether the trigonometric terms should be incorporated into the model. If the *F*-test rejects the null hypothesis of linearity, a nonlinear FADF test would be an appropriate method for the analysis. Otherwise, a standard linear ADF test should be used. In the final step of the analysis, the FADF test was applied to determine whether unemployment could be described as a stationary process. For this, appropriate modeling to capture unknown structural breaks or unattended nonlinearity in the model was done.

4. Empirical Results

Empirical findings from the ADF test are reported in *Table 1*. The ADF tests examined whether the unemployment rates in the 14 regions of the Czech Republic (including the capital city, Prague) had a unit root. Despite some minor discrepancies, the tests failed to reject the null hypothesis of a unit root for all of the regions. In other words, the empirical results from the individual linear unit root tests implied that unemployment in the Czech regions could be described as a non-stationary process at levels.

Empirical findings from the second step of the analysis, the SURADF test, are reported in *Table 2*. The test failed to reject the null hypothesis of a unit root in the unemployment rates for ten regions, namely Prague-city, South Bohemia, Plzeň, Karlovy Vary, Ústí, Liberec, Hradec Králové, Pardubice, South Moravia and Olomouc. For the remaining four regions, the SURADF test was able to reject the null hypothesis of a unit root. These regions are Central Bohemia, Vysočina, Zlín and Moravia-Silesia.

The results obtained from step 1 and step 2 of the analysis show that both the ADF test and the SURADF test failed to reject the null hypothesis of a unit root for ten regions of the Czech Republic. These regions are Prague-city, South Bohemia, Plzeň, Karlovy Vary, Ústí, Liberec, Hradec Králové, Pardubice, South Moravia and Olomouc. This means that the unemployment rates in these regions could be characterized as a non-stationary process. It should be noted that there are some minor discrepancies in the findings from the first two steps of the analysis. These concern four regions, namely Central Bohemia, Vysočina, Zlín and Moravia-Silesia. Thus, the findings from step 1 indicated that the ADF tests *did not* reject the null hypothesis of a unit root. However, the findings from step 2 suggested that the SURADF tests *did* reject the null hypothesis. It should be noted that the SURADF test is

Table 1 ADF Test and Its Critical Value

Regions	ADF statistic	Critical values		
		1 percent	5 percent	10 percent
Prague-city	-1.881	-3.769	-3.020	-2.653
Central Bohemia	-1.624	-3.734	-2.997	-2.630
South Bohemia	-1.741	-3.629	-2.947	-2.595
Plzeň	-1.552	-3.689	-2.971	-2.613
Karlovy Vary	-1.616	-3.636	-2.970	-2.624
Ústí	-1.981	-3.631	-2.956	-2.619
Liberec	-1.196	-3.687	-2.937	-2.616
Hradec Králové	-1.013	-3.690	-2.977	-2.648
Pardubice	-0.774	-3.721	-2.978	-2.620
Vysočina	-1.404	-3.600	-2.935	-2.635
South Moravia	-1.470	-3.731	-2.954	-2.622
Olomouc	-1.375	-3.654	-2.952	-2.618
Zlín	-1.800	-3.686	-2.973	-2.638
Moravia-Silesia	-2.317	-3.668	-2.984	-2.618

Note: Critical values were estimated by Monte Carlo simulations with 10,000 replications.

Table 2 SURADF Test and Its Critical Values

Regions	SURADF statistic	Critical values		
		1 percent	5 percent	10 percent
Prague-city	-2.794	-5.684	-4.545	-3.979
Central Bohemia	-4.036*	-5.562	-4.528	-4.007
South Bohemia	-3.840	-5.689	-4.508	-3.917
Plzeň	-3.873	-5.607	-4.472	-3.914
Karlovy Vary	-3.381	-5.621	-4.475	-3.918
Ústí	-2.550	-5.538	-4.474	-3.922
Liberec	-2.377	-5.691	-4.507	-3.955
Hradec Králové	-3.158	-5.590	-4.480	-3.928
Pardubice	-3.539	-5.643	-4.487	-3.918
Vysočina	-4.337*	-5.548	-4.457	-3.890
South Moravia	-3.736	-5.587	-4.427	-3.912
Olomouc	-2.364	-5.564	-4.487	-3.920
Zlín	-4.324*	-5.667	-4.456	-3.960
Moravia-Silesia	-4.424*	-5.528	-4.458	-3.925

Notes: * indicates significance at the 10% level.
Critical values were estimated by Monte Carlo simulations with 10,000 replications.

considered a more powerful test than the ADF test (Breuer et al., 2001, 2002). Based on this notion, the unemployment rates in the four regions could be described as a stationary process.

In the next step of the analysis, the optimal frequency ($\tilde{k}$) was determined using the RSS from Equation (3). As *Table 3* shows, the optimal frequency was set as 2 for ten regions: Central Bohemia, Plzeň, Karlovy Vary, Ústí, Hradec Králové,

Table 3 Nonlinear FADF Test Results

Regions	$\tilde{k}$	$F(\hat{k})$	τ_{DF}
Prague-city	1	2.629	-2.390
Central Bohemia	2	3.820*	-0.903
South Bohemia	1	6.014*	-3.556*
Plzeň	2	4.103*	-1.499
Karlovy Vary	2	7.142***	-1.743
Ústí	2	3.224*	-2.208
Liberec	1	2.155	-2.142
Hradec Králové	2	3.175	-0.873
Pardubice	2	3.327*	-0.408
Vysočina	1	3.318	-2.184
South Moravia	2	2.428	-1.211
Olomouc	2	8.066***	-1.021
Zlín	2	3.035	-1.736
Moravia-Silesia	2	5.196**	-2.467

Notes: The optimal frequency ($\tilde{k}$) was selected by using the data-driven grid-search method in which the frequency minimized the SSR from Equation 3.

*** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

Pardubice, South Moravia, Olomouc, Zlín and Moravia-Silesia. For the remaining four regions (Prague-city, Liberec, South Bohemia and Vysočina) the optimal frequency was set as 1.

The *F*-test was used to test the null hypothesis $\gamma_1 = \gamma_2 = 0$ in Equation (3). The null hypothesis of linearity was rejected for eight regions, namely Central Bohemia, South Bohemia, Plzeň, Karlovy Vary, Ústí, Pardubice, Olomouc and Moravia-Silesia. The null hypothesis of linearity was not rejected for six regions: Prague-city, Liberec, Hradec Králové, Vysočina, South Moravia and Zlín. This means that the linear unit root test, the ADF test, should be used to analyze the unemployment rates in these regions.

The results obtained from step 3 of the analysis indicated that the FADF test *did* reject the null hypothesis of a unit root in the unemployment rate of South Bohemia only (see *Table 3*). Also, the *F*-test *did* reject the null hypothesis of linearity for this region. These findings indicate that unemployment in South Bohemia could be best described as a stationary process. By contrast, while the *F*-test *did* reject the null hypothesis of linearity for other seven regions, namely Central Bohemia, Plzeň, Karlovy Vary, Ústí, Pardubice, Olomouc and Moravia-Silesia, the FADF tests *did not* reject the null hypothesis of unit root. These findings indicate that unemployment in these regions could be best described as a non-stationary process.

In short, the linear unit root tests indicated that unemployment in all 14 regions of the Czech Republic could be described as a non-stationary process, which is in line with the hysteresis hypothesis. However, the empirical findings from a more powerful SURADF test and the newly developed nonlinear FADF test suggested that unemployment could be considered as a stationary process in only five regions,

namely Central Bohemia, South Bohemia, Vysočina, Zlín and Moravia-Silesia. This finding supports the natural rate hypothesis. On the other hand, unemployment in the remaining nine regions (Prague-city, Plzeň, Karlovy Vary, Ústí, Liberec, Hradec Králové, Pardubice, South Moravia and Olomouc) could be best described as a non-stationary process, which lends empirical evidence to the hysteresis hypothesis.

5. Discussion

The findings of the present study allow some interesting insights into the behavior of the unemployment rates in the Czech regions. The regions can be divided into two groups: (1) regions where unemployment hysteresis was not found and (2) regions where unemployment hysteresis was detected. Group 1 includes Central Bohemia, South Bohemia, Vysočina, Zlín and Moravia-Silesia. Unemployment in these regions could be described as a stationary process in line with the natural rate hypothesis. Group 2 includes Prague-city, Plzeň, Karlovy Vary, Ústí, Liberec, Hradec Králové, Pardubice, South Moravia and Olomouc. The unemployment rates in these regions had a unit root in accordance with the hysteresis hypothesis. These findings give rise to some pertinent questions, such as these: Why do the differences exist in the unemployment dynamics between the Czech regions? What factors contribute to these differences?

It should be noted that the behavior 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. Therefore, it is impossible to pinpoint the exact reasons for the differences in the unemployment dynamics. A more viable approach would be through identifying the nature of these differences. An alternative question could be posed: What common characteristics do the regions with similar unemployment dynamics have?

Several similar features can be distinguished in the unemployment patterns of the regions in Group 1. Among them are: 1. a low unemployment rate, 2. low female labor force participation and 3. low unemployment among highly skilled workers. First and foremost, unemployment rates in these regions were lower than the national average of 6.49 percent, with the exception of Zlín and Moravia-Silesia (see *Table 4*). By contrast, the unemployment rates tended to be higher than the national average level in the majority of the regions in Group 2, with the exception of Prague-city, Plzeň, Pardubice and Hradec Králové. Among the seven regions with higher than national average unemployment rates only in two regions—Zlín and Moravia-Silesia—unemployment could be characterized as a stationary process. In the remaining five regions it could be described as a non-stationary process. Thus, despite some minor discrepancies, the important common characteristics of the regions where unemployment was a stationary process are their relatively efficient labor markets and low unemployment rates.

Secondly, the five regions in Group 1 tended to have lower female labor force participation rates. As *Table 5* shows, in these regions, except for Central Bohemia, female labor force participation was lower than the overall national average level of 49.3 percent. This could be indicative of the fact that labor markets in these regions were efficient enough to provide adequate job opportunities for male spouses and ensure that household incomes are sufficient. Therefore, married women had the option

Table 4 Main Characteristics of Unemployment Rate

Regions	Mean	Range	Standard
Prague-city	3.01	2.80	0.80
Central Bohemia	4.35	3.40	1.05
South Bohemia	4.45	4.50	1.13
Plzeň	4.90	3.90	1.07
Karlovy Vary	9.59	5.00	1.58
Ústí	11.28	7.70	2.27
Liberec	6.70	4.80	1.14
Hradec Králové	5.70	5.20	1.56
Pardubice	5.48	5.60	1.33
Olomouc	7.80	6.20	1.48
Moravia-Silesia	10.12	7.70	2.17
South Moravia	6.84	4.70	1.44
Zlín	7.03	6.90	1.91
Vysočina	5.58	5.00	1.41
Czech Republic average	6.49	4.20	1.23

Source: Czech Statistical Office (2012)

Table 5 Gender and Labor Force Participation (percent) in 2010

Regions	Female	Male	Total
Prague-city	52.6	72.5	62.2
Central Bohemia	50.1	69.7	59.7
South Bohemia	48.9	67.6	58.0
Plzeň	50.4	68.0	59.0
Karlovy Vary	53.8	69.9	61.7
Ústí	47.3	68.1	57.5
Liberec	47.7	68.8	58.0
Hradec Králové	48.9	66.5	57.5
Pardubice	48.4	67.0	57.5
Olomouc	46.9	65.0	55.7
Moravia-Silesia	47.7	66.2	56.7
South Moravia	49.8	67.0	58.1
Zlín	48.1	66.1	56.8
Vysočina	49.1	67.4	58.1
Czech Republic average	49.3	68.0	58.4

Source: Czech Statistical Office (2012)

to forgo employment in the marketable production sectors; instead, they could be engaged in non-marketable production activities, such as household activities.

Finally, it is interesting to note that the regions in Group 1 tended to have lower unemployment rates among highly skilled workers. *Table 6* shows that in these regions, with the exception of South Bohemia and Zlín, the share of unemployed people with tertiary education was lower than the overall national average of 6.67 percent. This indicates that these regions had relatively healthy labor markets because

Table 6 Education and Unemployment (percent) in 2010

Regions	Basic	Secondary	Tertiary
Prague-city	12.50	65.23	22.26
Central Bohemia	15.56	78.74	5.68
South Bohemia	17.26	75.59	7.14
Plzeň	15.78	77.77	6.43
Karlovy Vary	39.18	60.81	2.28
Ústí	34.14	64.09	1.76
Liberec	20.39	73.68	5.92
Hradec Králové	19.25	77.00	3.74
Pardubice	21.62	73.51	4.86
Olomouc	17.26	75.89	6.83
Moravia-Silesia	22.63	71.49	5.86
South Moravia	13.54	78.10	8.35
Zlín	18.36	72.65	8.97
Vysočina	19.88	76.13	3.97
Czech Republic average	20.72	72.60	6.67

Source: Czech Statistical Office (2012)

workers with tertiary education tend to have highly specialized firm-specific knowledge. Due to this they tend to experience longer periods of unemployment during economic downturns compared to workers with basic or secondary education whose skills are more general and transferable in nature.

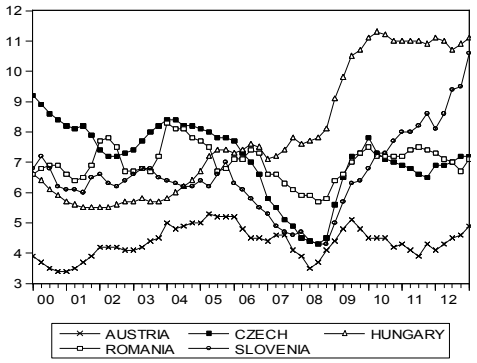
6. Unemployment Hysteresis in Central and Southeast Europe

This section gives a descriptive analysis of the behavior of unemployment rates in Central and Southeast European countries including Austria, Bulgaria, the Czech Republic, Greece, Hungary, Poland, Romania, Slovakia and Slovenia. It also reports the results of several unit root tests that examined unemployment dynamics and the existence of hysteresis in these countries. In this section, the quarterly unemployment rates of these nine European countries from the first quarter of 2000 to the first quarter of 2013 were used for the purpose of the empirical analysis. The source of data is the "Eurostat Database" complied by the European Commission (2013).[2]

For the descriptive analysis, the countries were divided into two groups. Group A consisted of the countries with relatively low unemployment (below 10 per-

[2] The country-level time series dataset of the unemployment rates in the nine European countries, including the Czech Republic, were used for the country-wide empirical analysis conducted in this section. On the other hand, in the analyses and the discussion provided in Section 4 and Section 5 of this article, a panel dataset of the unemployment rates in the 14 Czech regions was used for the estimation. There are differences in the sources of data and the number of observations in the datasets. Thus, the time-series dataset of the unemployment rates in the European countries was compiled by the European Commission (2013); it contains data on quarterly unemployment rates from the first quarter of 2000 to the first quarter of 2013, and the number of observations is 53. The dataset consists of country-level data only and there is no region-level data, including data on the 14 Czech regions. On the other hand, data on the unemployment rates in the 14 Czech regions were compiled by the Czech Statistical Office (2013). This detailed dataset covers a shorter period of time from the first quarter of 2005 to the first quarter of 2013, and the number of observations is 33.

Figure 1 Patterns of Unemployment Dynamics in Countries with Lower Unemployment Rates



Source: European Commission (2013)

Table 7 Descriptive Analysis of Unemployment Rates

Countries	Mean	Median	Maximum	Minimum	Standard
Austria	4.35	4.40	5.30	3.40	0.503
Bulgaria	11.77	11.30	19.80	5.20	4.201
Czech Republic	7.13	7.30	9.20	4.30	1.196
Greece	11.96	10.30	26.60	7.40	4.900
Hungary	7.95	7.40	11.30	5.50	2.139
Poland	13.75	13.40	20.30	6.90	4.748
Romania	6.99	7.00	8.30	5.70	0.581
Slovakia	15.23	14.60	19.50	8.90	3.168
Slovenia	6.55	6.40	10.60	4.30	1.320

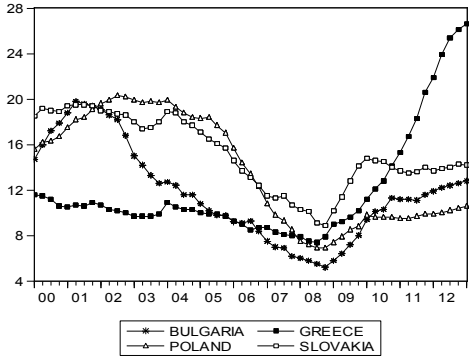
Source: European Commission (2013)

cent), such as Austria, the Czech Republic, Hungary, Romania and Slovakia. Group B was formed by the countries with relatively high unemployment (above 10 percent), namely Bulgaria, Greece, Poland and Slovakia.

As *Figure 1* and *Table 7* indicate, some similar patterns can be identified in the unemployment dynamics of Group A countries. At the beginning of the 2000s, these countries had relatively high unemployment rates, with the sole exception of Austria. In the middle of the 2000s, their unemployment rates became lower—except for Hungary—before experiencing a sharp rise caused by the Euro crisis at the end of the decade. In the case of the Czech Republic, in 2000, its unemployment rate was the highest (9.2 percent) among Group A countries. In 2013, with an unemployment rate of 7.3 percent, the country fared better than its neighbors Slovenia and Hungary.

Similar patterns can be observed in the unemployment dynamics of Group B countries (see *Figure 2* and *Table 7*). Just before the Euro crisis broke out, these countries had enjoyed the lowest levels of unemployment in a decade. In the aftermath of the crisis, their unemployment rates went up. As *Figure 2* shows, Greece has experienced the most adverse consequences of the Euro crisis. In 2000, it had the lowest unemployment rate (11.6 percent) among Group B countries. In the after-

Figure 2 Patterns of Unemployment Dynamics in Countries with Higher Unemployment Rates



Source: European Commission (2013)

math of the crisis, the country's unemployment rate rapidly increased from 15.3 percent in 2011 to 21.9 percent in 2012, before reaching the alarming rate of 26.6 percent at the beginning of 2013.

Next, the present study examined unemployment hysteresis in all these Central and Southeast European countries. It employed several linear unit root tests for this purpose, such as: the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981); the generalized least square Dickey-Fuller (DF-GLS) test (Elliott et al., 1996); the Phillips-Perron Z_t (PP) test (Phillips and Perron, 1988); the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test (Kwiatkowski et al., 1992) and the Ng-Perron modified Z_t (NP) test (Ng and Perron, 2001). The findings from the tests are reported in *Table 8* and *Table 9*.

First of all, the augmented Dickey-Fuller (ADF) test did not reject the null hypothesis of a unit root for all countries, except for Bulgaria and Romania. This means that unemployment hysteresis existed in Austria, the Czech Republic, Greece, Hungary, Poland, Slovakia and Slovenia. In the cases of Bulgaria and Romania, no hysteresis was detected, which means that their higher-than-normal unemployment rates would eventually revert to the equilibrium level.

Secondly, the generalized least square Dickey-Fuller (DF-GLS) test confirmed the findings from the ADF test. The DF-GLS test revealed that unemployment hysteresis existed in Austria, the Czech Republic, Hungary, Poland, Slovakia and Slovenia and could not be detected in Bulgaria and Romania. In the case of Greece, both the ADF test and the DF-GLS produced inconsistent result. The results obtained from the ADF test supported the existence of hysteresis in Greece while the DF-GLS indicated otherwise.

Thirdly, the findings from the Phillips-Perron Z_t (PP) test supported the existence of the hysteresis hypothesis for all nine Central and Southeast European countries. This means that their higher-than-normal unemployment rates were not expected to revert to the equilibrium level. Fourthly, the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test investigated the null hypothesis that there is no unit root in the unemployment time series. In other words, the findings from the KPSS

Table 8 Results of Unit Root Tests

Countries	ADF	DF-GLS	PP	KPSS
Austria	-2.706(6)	-1.507(4)	-2.019[3]	0.215[5]
Bulgaria	-3.010(3)*	-2.419(3)*	-1.196[5]	0.472[9]
Czech Republic	-2.573(2)	-1.690(1)	-2.124[4]	0.418[6]
Greece	-1.706(3)	-2.042(3)*	-2.529[5]	0.149[5]
Hungary	-0.357(1)	-0.187(1)	-0.954[4]	0.766[6]*
Poland	-1.708(2)	-1.665(2)	-0.825[5]	0.640[6]**
Romania	-3.075(1)*	-2.888(1)**	-2.234[0]	0.093[5]
Slovakia	-1.869(1)	-1.378(1)	-1.285[4]	0.571[6]*
Slovenia	0.629(4)	-0.468(3)	0.626[4]	0.302[5]

Notes: Numbers in parentheses indicate the optimal lag lengths suggested by the Akaike Information Criterion (AIC), except for the NP statistic. Ng and Perron (2001) suggested using a modified AIC (MAIC) for the lag length section. Numbers in square brackets indicate the optimal bandwidth suggested by the Newey-West bandwidth section method (Newey and West, 1994).

** indicates significance at the 1% level; * indicates significance at the 5% level.

Table 9 Results of NP Test

Country	MZ_α	MZ_t	*MSB*	MP_t
Austria	-3.782	-1.231	0.325	6.854
Bulgaria	-6.436	-1.793	0.278	3.807
Czech Republic	-5.595	-1.648	0.294	4.450
Greece	-22.405**	-3.257**	0.152**	1.192**
Hungary	-0.492	-0.250	0.509	17.852
Poland	-6.950	-1.795	0.277	3.796
Romania	-17.167**	-2.920*	0.170**	1.460**
Slovakia	-3.156	-1.209	0.383	7.696
Slovenia	-21.676**	-3.011**	0.138**	2.066**

Notes: MZ_α is the modified Z_α test (Phillips and Perron, 1988); MZ_t is the modified Z_t test (Phillips and Perron, 1988); *MSB* is the modified Sargan-Bhargava (*SB*) test (Sargan and Bhargava, 1983), $MZ_t = MZ_\alpha \times MSB$, MP_t is the modified P_t test (Elliot et al., 1996).

** indicates significance at the 1% level; * indicates significance at the 5% level.

test could complement the findings from the other three unit root tests: the null hypothesis in the previous tests was that a unit root was present in the unemployment time series. The KPSS test rejected the null hypothesis for three countries, namely Hungary, Poland and Slovakia.

Despite some minor discrepancies, the findings obtained from the four unit root tests indicated that unemployment hysteresis existed in Austria, the Czech Republic, Hungary, Poland, Slovakia and Slovenia. This means that high unemployment rates in these countries tended to persist over longer spans of time. By contrast, the findings indicated that unemployment hysteresis was absent in Bulgaria and Romania. Therefore, high unemployment rates in these countries had a tendency to revert to the equilibrium level. As for Greece, the four unit root tests produced ambiguous results. Two tests—namely the ADF test and the PP test—indicated the existence of hysteresis while the DF-GLS and KPSS tests yielded the opposite results.

In order to confirm these findings, the present study employed the Ng-Perron (NP) unit root test. This is because the limited number of observations (39) in the dataset could lead to the small-sample problem. The NP test has better small-sample performance because it is based on the generalized least squares (GLS) detrending procedure (Camarero et al., 2005). The findings from the NP test are reported in *Table 9*. The results largely supported the findings from the four previously performed unit root tests. For example, the results provided empirical evidence for the existence of unemployment hysteresis in Austria, the Czech Republic, Hungary, Poland and Slovakia. At the same time, the NP test did not detect the presence of unemployment hysteresis in Bulgaria and Romania.

In the case of Greece, while the previous tests had produced contradictory results, the NP statistics (i.e., MZ_{α} statistic, MZ_t statistic, *MSB* statistic *and* MP_t statistic) uniformly rejected the null hypothesis of a unit root. This finding is indicative of a possibility that there was no hysteresis in the country's unemployment rate. In other words, the high unemployment rate in Greece could be expected to revert to the equilibrium level. On the other hand, in the case of Bulgaria, the NP test produced inconsistent results. The four previously conducted unit root tests had indicated that there was no hysteresis in the country's unemployment rate. However, the NP statistics failed to reject the null hypothesis of a unit root.

These findings allow some interesting insights. First of all, unemployment hysteresis was found to exist in the majority of the Central and Southeast European countries, just as it was found to prevail among the Czech Republic's regions. Secondly, the results indicated that only three Central and Southeast European countries and only five Czech regions had dynamic labor markets where no unemployment hysteresis was detected. Thirdly, hysteresis was found to exist in the unemployment rates in all of the Visegrád Group countries (i.e., the Czech Republic, Hungary, Poland and Slovakia).

7. Conclusion

Unemployment hysteresis is a prominent research topic in economic literature because of the important policy implications that the issue entails. The present study chose 14 regions of the Czech Republic as case studies to examine the existence of unemployment hysteresis. To carry out the empirical analysis, this study employed the SURADF test and the FADF test.

According to the findings from the ADF tests, unemployment in all 14 regions of the Czech Republic could be described as a non-stationary process. However, a further empirical investigation employing a more powerful SURADF test and the newly developed nonlinear FADF test indicated the absence of unemployment hysteresis in five regions, namely Central Bohemia, South Bohemia, Pardubice, Moravia-Silesia and Vysočina. This means that unemployment in these regions could be described as a stationary process in line with the natural rate hypothesis. On the other hand, unemployment hysteresis was detected in Prague-city, Plzeň, Karlovy Vary, Ústí, Liberec, Hradec Králové, Olomouc, South Moravia and Zlín. The unemployment rates in these nine regions contained a unit root and could be described as a non-stationary process in accordance with the hysteresis hypothesis.

Empirical evidence obtained in this study suggests the existence of unemployment hysteresis in the majority of the Czech Republic's regions. There are at least

two possible reasons for this. First of all, the output time series can generally be described as a non-stationary process. According to Okun's law, there exists a close linkage between output and unemployment. Therefore, the behavior of the unemployment rates can be strongly influenced by the non-stationary process of output. Secondly, due to a fact that the Czech economy is firmly integrated into the global economy, the economic condition and the labor market situation in the country are strongly influenced by fluctuations in international trade earnings. The terms of trade (TOT) time series can be considered as a non-stationary process. Therefore, it is also possible that unemployment dynamics in the Czech regions would be influenced by the non-stationary process of the TOT.

The present study used quarterly data on unemployment in the Czech Republic over the period from the first quarter of 2005 to the first quarter of 2013. Future studies on unemployment hysteresis in the country may want to seek longer time-series data. The findings of such studies will give economists additional insights into unemployment dynamics in the context of the Czech economy.

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