3. TESTING THE UNEMPLOYMENT HYSTERESIS IN G7 COUNTRIES: A FRESH EVIDENCE FROM FOURIER THRESHOLD UNIT ROOT TEST

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Abstract

In this study, we test the validity of unemployment hysteresis in G7 countries over the period of 1991 – 2019 using monthly data by suggesting a new unit root test that considers both structural breaks and nonlinearity that we entitled as Fourier Threshold Unit Root (FTUR) test. The results of the test show that unemployment rates of Canada, Japan, and the USA are nonlinear. Thus, for these countries we apply the FTUR test, while for the remaining series, we employ the Fourier ADF unit root test. The results of unit root tests show that unemployment hysteresis holds in Canada, France, and the United Kingdom, while Non-Accelerating Inflation Rate of Unemployment applies in Germany, and Italy. We could not reject the null of a unit root for Japan and the USA only in the second regime, where the unemployment series are rising. So, we conclude that the policymakers of Japan and the USA should follow fiscal stabilization policies only in recession periods.

Keywords: unemployment rates; nonlinearity; structural breaks; threshold autoregressive

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1. Introduction

There has been a considerable increase in the number of studies to understand the characteristics of unemployment rates from the first oil shock, especially in the developing countries. These studies generally examine the structure of unemployment rates to find out how unemployment is affected by the crises and whether the effect of shocks is permanent or not.

In the natural unemployment rate hypothesis that was put forward by Friedman (1968) and Phelps (1967, 1968), unemployment is considered a stable process. According to this theory, shocks have a temporary effect on unemployment, and the level of unemployment is close to the level of natural unemployment in the long term. Thus, shocks and crises would not change the structure of unemployment in the long term, and unemployment rates would be constant in the long-run. Thus, if the unemployment rates of a country are stationary, then this case is referred to as the Non-Accelerating Inflation Rate of Unemployment (NAIRU).

On the other hand, the hysteresis hypothesis, which was suggested by Blanchard and Summers (1968) suggests that periodic shocks would affect unemployment rates in the long term, and this effect would be permanent. There are many reasons for the existence of the unemployment hysteresis: in one view, the decrease in the physical capital stock adversely affects the demand for labor in the next period, and this leads to an increase in the unemployment period (see Sneessens, 1981; Sneessens and Dreze, 1986; Burda, 1988, and Sarac, 2014, among others). On the other hand, Blanchard and Summers (1986) claim that the crises in the earlier years in the European Community had reduced the capacity utilization rates, and this had a negative impact on unemployment rates and caused hysteresis. Another view argues that long term unemployment causes hysteresis because there is a possibility that workers can lose their abilities and hopes for finding a job (see Phelps, 1972; Heap, 1980, and Pissarides, 1992). Blanchard and Summers (1986) state that wages are determined between employees and employers (insiders) and that the unemployed people (outsiders) have no impact on the process. In the case of the economic crisis, a certain wage level would not cause employees to leave the job, and hence it would not reduce the unemployment rate. Lindbeck and Snower (1988, 2001) argue that during the crisis, employers continue to employ existing workers, avoiding the hiring and dismissal costs. So, unemployment of outsiders would continue. Phelps (1994) argues that structural changes in the economy could change the natural rate of unemployment, but the shocks have only a temporary effect, and unemployment rates tend to return to a long-run mean over time.

These opposite theories (Unemployment hysteresis vs. NAIRU) have been examined for different countries in the literature. While the rejection of the null hypothesis of a unit root provides evidence for the NAIRU, the non-rejection of the null shows the validity of unemployment hysteresis. Therefore, there is a vast number of studies, using unit root tests to examine the stationarity characteristics of unemployment rates. Mitchell (1993) utilizes Perron's (1989) unit root test, and concludes that there is unemployment hysteresis for a few OECD countries. Roed (1996), using data from 1970 to 1994, empirically explores the unemployment hysteresis in 16 OECD countries. The results give support for the hysteresis hypothesis in Australia, Canada, Japan, and also in a few European countries, but the hypothesis is rejected for the United States. Koustas and Veloce (1996) use ARFIMA models to test the stationarity behavior of unemployment rates of Canada, and the findings confirm the hysteresis in unemployment. Papell *et al.* (2000)

test the validity of unemployment hysteresis using the unit root test introduced by Perron and Vogelsang (1992), in 16 OECD countries and conclude that the hysteresis is not valid for ten of 16 countries. Strazicich *et al*. (2001) examine the presence of hysteresis in unemployment rates in 19 OECD countries using panel LM unit root test and find that the hysteresis hypothesis exists in these countries. Chang *et al*. (2005) examine the unemployment hysteresis hypothesis in ten European countries using panel SURADF unit root test and find that the hypothesis is confirmed for all countries in the sample except Belgium and the Netherlands. Caporale and Gil-Alana (2008) investigate whether shocks have permanent effects on unemployment rates or not in Japan, the United Kingdom, and the USA. They conclude that the NAIRU is valid for Japan and the USA. On the other hand, unemployment hysteresis is valid for only the United Kingdom. Lin *et al*. (2008) use the threshold unit root test of Caner and Hansen (2001) to reinvestigate hysteresis in unemployment for OECD countries, and their empirical results support the hysteresis of unemployment only for Australia, Finland, France, Germany, Japan, and the United States. Yilanci (2008) approaches to the unemployment hysteresis in a nonlinear way. Yilanci (2008) examines the stationarity characteristics of unemployment rates of 17 OECD countries using KSS unit root test and concludes the validity of the natural rate of unemployment in seven countries. Lee *et al*. (2010) use the unit root tests that allow for structural breaks and test unemployment hysteresis in nine Asian countries. Empirical results support unemployment hysteresis in only Hong Kong, Indonesia, South Korea, Singapore, and Taiwan. However, the traditional unit root tests without structural breaks support the hysteresis of unemployment for the nine Asian countries. Chang and Lee (2011) use the threshold unit root test to examine the validity of unemployment hysteresis in G7 countries from 1992M1 to 2008M9 and find the hysteresis in unemployment for France, Germany, and Italy. Bolat *et al*. (2014) test the validity of hysteresis in 17 European countries using panel KSS unit root test with Fourier function and conclude that unemployment series follow a nonlinear path in 11 countries. Furuoka (2017) examine the hysteresis in the Baltic countries from 2000 to 2014 using a Fourier unit root test with a structural break and find that the unemployment rates are stationary, so the findings of the study support the evidence of the natural rate hypothesis in the countries. Using unit root tests based on linear and nonlinear models, Akdogan (2017) examines the hysteresis effect in unemployment rates for 31 European countries, Japan, and the USA. He finds that the hysteresis hypothesis is not valid for nearly 60% of the countries. Jiang *et al*. (2018) test the validity of unemployment hysteresis in G7 countries using the Quantile unit root test and find the unemployment rates as stationary. Albulescu and Tiwari (2018) employ a bounded unit root test to examine the hysteresis effect in eight European Union countries for the period of 1965–2013. The findings confirm the hysteresis effect for all the countries. Kilic *et al*. (2018) employ a unit root test that considers structural breaks and test the hysteresis hypothesis in France, Germany, and Turkey. They find that unemployment rates have a unit root in all countries in the sample. Obradović *et al*. (2018) explore the dynamics of unemployment rates in ten countries of Southeast Europe using both linear and nonlinear unit root tests. The findings of the study reveal that the unemployment hysteresis is accepted only in FYR Macedonia and Serbia. Jiang *et al*. (2019) contribute to this line of research by determining whether hysteresis in unemployment is a characteristic of the G7 labor market. Employing the quantile unit root test, they conclude that hysteresis does not hold in G7 countries. Nsenga *et al*. (2019) focus on the stochastic properties of unemployment rates in eight New Industrialized Economies using quarterly data from 2002:Q1 to 2017:Q1. By considering asymmetries and structural breaks, they find that unemployment rates are stationary only in the Philippines and Thailand. Yaya *et al*. (2019) explored the unit root characteristics of unemployment rates of 42 African countries by employing the Fourier ADF unit root test. They found evidence of hysteresis only in seven countries. Khraief *et al*. (2020) revisit the hysteresis effect using second-generation panel unit root tests that allow structural breaks for 29 OECD countries over the period 1980–2013. The results show that the unemployment rates are stationary when taking into account of cross-sectional dependence and structural breaks. Omay *et al*. (2020) revisit the unemployment hysteresis using second-generation panel unit root tests and confirm that the natural rate hypothesis is valid for most of the US states.

In this study, we aim to test the unemployment analysis in G7 countries (Canada, France, Germany, Italy, Japan, the US, and United Kingdom) by suggesting a new unit root test that allows multiple structural breaks and possible nonlinearity. We follow the two-step approach of Christopoulos and León-Ledesma (2010). In the first step of their approach, they estimate a model with a Fourier function and obtain the residuals to remove the effects of structural breaks. In the second step, they estimate nonlinear models with the residuals to test the stationarity of the series. In this study, instead of using a STAR type unit root test at the second step, we prefer to use a threshold type unit root test. So, we can test the validity of unemployment hysteresis during times of recessions or expansions. Although there have been a number of studies that test the unemployment hysteresis using unit root tests that allow structural breaks such as Zivot-Andrews, Lumsdaine-Papell unit root tests, or consider threshold type nonlinearity, this is the first study that considers both structural breaks and threshold effects while examining the unemployment hysteresis. We outline the study as follows: section 2 explains the Fourier threshold unit root test. Section 3 gives information about the dataset and reports the empirical results, and section 4 concludes the paper.

2. Econometric Methodology

Most of the unit root tests use dummy variables to allow structural breaks, and therefore they have some disadvantages such as detecting only sharp breaks, and determining the number of the structural breaks a priori. As well as not allowing structural changes, to allow the wrong number of structural breaks can cause the results to be incorrect. For example, testing the stationarity of a series that has been affected by two structural breaks by using the Zivot-Andrews unit root test, which allows one structural change in the data generation process, would cause the results to be incorrect. On the other hand, as stated by Hyndman (2014), "most things change slowly over time" but dummy variables incapable of modeling such breaks. To circumvent these situations, Becker *et al*. (2006) suggest using a Fourier function to take structural changes into account when examining the stationarity of the series. The power of this test is not affected by the number, location, and form of the breaks. In this study, we follow the two-step methodology of Christopoulos, and León-Ledesma (2010) to allow the structural breaks while testing the stationarity of the series. Following Christopoulos and León-Ledesma (2010), we consider that the data generating process as:

$$Y_t = \beta_1 + \beta_2 \sin\left(\frac{2\pi kt}{T}\right) + \beta_3 \cos\left(\frac{2\pi kt}{T}\right) + u_t \tag{1}$$

In Equation (1), t is a trend term, T shows the sample size, $\pi = 3.1416$ and k shows the number of frequencies of the Fourier function. Since the true value of k is generally unknown, we find the optimal k by choosing the value that produces the minimum sum of squared residuals (SSR). After determining the optimal value of k, we test the null of the insignificance of trigonometric terms, $H_0: \beta_2 = \beta_3 = 0$, by using the usual F test statistic. The necessary critical values for the test are tabulated in Becker *et al*. (2006). If the null cannot be rejected, we apply the standard Augmented Dickey-Fuller unit root test. Otherwise, we pass the second stage of the test, where we obtain the OLS residuals of Equation 1:

$$\hat{u}_t = Y_t - \left(\hat{\beta}_1 + \hat{\beta}_2 \sin\left(\frac{2\pi \hat{k} t}{T} \right) + \hat{\beta}_3 \cos\left(\frac{2\pi \hat{k} t}{T} \right) \right) \tag{2}$$

Christopoulos and León-Ledesma (2010) apply Dickey-Fuller, Kapetanios *et al*. (2003), Kilic, and de Jong (2006) unit root tests to the residuals that obtained from Equation 2 at the second stage of their study. These tests are called; Fourier ADF unit root test, Fourier KSS unit root test, and Fourier KJ unit root test, respectively. Instead of using these unit root tests, we implement the test methodology of Caner and Hansen (2001), at the second stage and call this test as Fourier Threshold Unit Root (FTUR) test.

To apply FTUR test, we estimate the following model:

$$\Delta \hat{u}_t = \theta_1' \hat{u}_{t-1} 1_{\{Z_{t-1} < \lambda\}} + \theta_2' \hat{u}_{t-1} 1_{\{Z_{t-1} \geq \lambda\}} + e_t \tag{3}$$

In Equation (3), $\hat{u}_t$ is the residual that is obtained from Equation (2) and $\hat{u}_{t-1} = \left(\hat{u}_{t-1} r_t' \Delta \hat{u}_{t-1}, \ldots, \hat{u}_{t-k} \right)'$ where r_t shows deterministic component vector, including an intercept and possibly a trend term. Z_{t-1} is the threshold variable, defined as $\hat{u}_t - \hat{u}_{t-m}$ for $m \geq 1$. On the other hand, λ shows the unknown threshold parameter that takes the values in the interval $\lambda \in \Lambda[\lambda_1, \lambda_2]$ where λ_1 and λ_2 are chosen so that $P(Z \leq \lambda_1) = \pi_1 > 0$ and $P(Z \leq \lambda_2) = \pi_2 < 1$. π_1 and π_2 treated as symmetrically so that $\pi_1 = 1 - \pi_2$. By following the suggestion of Andrews (1998), we set $\pi_1 = 0.15$ and $\pi_2 = 0.85$. On the other hand, $1_{\{\cdot\}}$ shows the indicator function that takes the value 0 when $Z_{t-1} < \lambda$ and 1 when $Z_{t-1} \geq \lambda$.

The components of parameter vectors can be shown as follows;

$$\theta_1 = \begin{pmatrix} \rho_1 \\ \beta_1 \\ \alpha_1 \end{pmatrix} \text{ and } \theta_2 = \begin{pmatrix} \rho_2 \\ \beta_2 \\ \alpha_2 \end{pmatrix}$$

where: (ρ_1, ρ_2) are the slope coefficients on $\hat{u}_{t-1}$; (β_1, β_2) are the slope coefficients on the deterministic components and (α_1, α_2) are the slope coefficients on the lagged differences of the dependent variable.

For each value of the threshold parameter, we estimate Equation 3, using least squares:

$$\Delta \hat{u}_t = \hat{\theta}_1(\lambda)' \hat{u}_{t-1} 1_{\{Z_{t-1} < \lambda\}} + \hat{\theta}_2(\lambda)' \hat{u}_{t-1} 1_{\{Z_{t-1} \geq \lambda\}} + \hat{e}_t(\lambda) \tag{4}$$

The least-square estimator of λ can be obtained by minimizing the residual variance $\sigma^2(\lambda)$

$$\hat{\lambda} = \underset{\lambda \in \Lambda}{\arg\min}\, \hat{\sigma}^2(\lambda)$$

After estimating Equation (4), we first test the null hypothesis of linearity, $H_0 : \theta_1 = \theta_2$ against the alternative of the threshold model using the Wald statistic;

$$W_T = T\left(\hat{\sigma}_0^2 / \hat{\sigma}^2 - 1\right)$$

where: $\hat{\sigma}_0^2$ is the residual variance under the null hypothesis.

In the case of linearity, we use the Fourier ADF unit root test. On the other hand, In the case of rejection of the null, we begin testing the stationarity of the series in the TAR model framework. First, the null of the unit root in both regimes, $H_0 : \rho_1 = \rho_2 = 0$, can be tested against the alternative of stationary $H_1 : \rho_1 < 0, \rho_2 < 0$, using the following one-sided Wald statistic:

$$R_T = t_1^2 1_{(\hat{\rho}_1 < 0)} + t_2^2 1_{(\hat{\rho}_2 < 0)}$$

In the equation above, t_1 and t_2 are t statistics for the slope coefficients of $\hat{u}_{t-1}$. However, there is a possibility of a partial unit root case; that is, the series can be stationary in only one of the regimes. To consider this possibility, we use t-statistics (t_1 and t_2). The necessary critical values are obtained using bootstrap simulations, as suggested by Caner and Hansen (2001).

3. Data and Results

In this study, we test the unemployment hysteresis by considering both smooth structural breaks and also the nonlinearity in G7 (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) countries using monthly series from 1991 to 2019. We obtain the data from the OECD.Stat. At the first step of the analysis, we search for the optimal frequency that minimizes the SSR using the interval $k = [0.1, 0.2, ..., 4.9, 5]$ and tabulate the chosen k along with the SSR, and the F statistics in Table 1.

Table 1

Significance of Fourier Transformation

Countries	k	Min. SSR	F
Canada	0.1	218.4494	510.9299*
France	1.6	290.6255	239.6708*
Germany	0.7	218.4261	1146.146*
Italy	1.6	104.7578	1627.781*
Japan	0.2	58.4138	834.5743*
United Kingdom	1.7	253.8104	587.8941*
United States	1.5	343.5106	286.3154*

Note: * shows the significance of trigonometric terms at the 1% level. Critical value at the 1% level is 6.730.

The second column of Table 1 shows that optimal frequencies are found as fractional for all unemployment series. Thus, we can conclude that the effect of the structural breaks is permanent for all the unemployment rates of G7 countries. In the last column of the table, we tabulate the F statistics to test the significance of the trigonometric terms. Results confirm that the Fourier functions are statistically significant for all series. So, first we estimate Equation 2 and obtain the residuals. Then, we proceed to the next step, where we test the linearity of the unemployment series that refined from the effect of structural breaks. The second column of Table 2 shows the results of the linearity test[4].

Table 2

Results of Fourier Threshold and Fourier ADF Unit Root Tests

Countries	$\hat{\lambda}$	m	Linearity Test W_T	Unit Root Tests R_T	t_1	t_2	FADF Unit Root Test
Canada	0.156	7	61.3 (0.000)*	4.7 (0.440)	1.61 (0.328)	1.45 (0.383)	
France	-0.021	1	29.5 (0.129)				-1.467
Germany	0.518	12	28.1 (0.554)				-3.892 *
Italy	0.252	3	27.0 (0.227)				-3.491*
Japan	0.214	9	53.3 (0.001)*	7.32 (0.227)	2.64 (0.077)***	0.586 (0.670)	
United Kingdom	0.430	11	31.4 (0.371)				-2.141
United States	0.341	7	49.3 (0.004)*	13.7 (0.044)**	3.05 (0.049)**	2.10 (0.194)	

*Note: Numbers in parentheses show the bootstrap p-values computed using 10 000 simulations. *, **, and *** show the significance at 1%, 5%, and 10% levels, respectively. The critical values at the 10% significance level for the FADF unit root test for values of k=0.5 and k=1.5 are -3.64, and -3.14, respectively.*

The Wald test statistics reveal that only the unemployment rates of Canada, Japan, and the USA are nonlinear, so we test the stationarity of these series using the FTUR test. On the other hand, we employ the FADF unit root test introduced by Christopoulos and León-Ledesma (2011) to examine the stationarity of unemployment rates for the remaining countries.

The results of the FTUR test show that while the unemployment rates of Canada have a unit root in both regimes, there is a partial unit root case for Japan and the USA. Both unemployment rates are stationary in the first regime, but they have a unit root in the second regime. On the other hand, the results of the FADF unit root test show that only the unemployment rates of Germany and Italy are stationary. So, these results show that unemployment hysteresis is valid for Canada, France, the United Kingdom, and partially valid for Japan and the US, on the other hand, we can conclude that NAIRU applies to Germany, Italy, and partially for Japan, and the United States. While, these results are consistent with the findings of Koustas and Veloce (1996), Chang *et al*. (2005), and Kilic *et al.* (2018), and different from the findings of Jiang *et al*. (2019). An important contribution of these results is that we can separate the periods that unemployment hysteresis hypothesis could be accepted or rejected. Since second regimes correspond to the time periods where unemployment rates are increasing, we can conclude during recessions, policymakers of Japan and the USA can implement expansionary policies to overcome the unemployment problem since a policy shock would have permanent effects.

[4] Results of least squares estimation of TAR model are available from corresponding author upon request.

4. Conclusion

The impact of shocks on unemployment rates is examined in literature mainly based on two theories; the Natural Unemployment Rate (NAIRU) and the hysteresis hypothesis. Researchers employ unit root tests to determine which theory does hold for a country. If unemployment rates of a country have a unit root, then hysteresis is considered to be valid. On the other hand, if unemployment rates of a country are stationary, then the NAIRU applies. In this study, we revisit the unemployment hypothesis for G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) over the period 1991M1 – 2019M12 by introducing a new unit root test. While most of the previous studies only consider structural breaks or nonlinearity, the proposed test has the advantage considers both structural breaks and nonlinearity. The unemployment rates of Canada, Japan, and the United States are found as nonlinear, so to examine the stationarity of these countries, we apply the Fourier Threshold unit root (FTUR) test. We use Fourier Augmented Dickey-Fuller (FADF) unit root test for testing the stationarity of remaining countries. The results of the FADF unit root test show that unemployment rates of France, Italy, and the United Kingdom have a unit root, while the unemployment rates of Germany, and Italy are stationary. The results of the FTUR test show that unemployment rates of Canada have a unit root, while unemployment rates of Japan and the United States are stationary in the first regime only. So, these results indicate that the unemployment hysteresis is valid in France, Italy, the United Kingdom, and in the second regime for Japan and the United States. We conclude that the policymakers of Germany, and Italy should follow fiscal stabilization policies, while the policymakers of Canada, France, and the United Kingdom should implement expansionary fiscal policies. On the other hand, only during recessions, the policymakers of Japan and the United States should take necessary measures in combating unemployment.

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