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UNEMPLOYMENT HYSTERESIS IN G7 COUNTRIES: LINEAR AND NONLINEAR EVIDENCE

G7 Ülkelerinde İşsizlik Histerisi: Doğrusal ve Doğrusal Olmayan Kanıtlar

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Unemployment Hysteresis, NAIRU, Structural Breaks.

JEL Codes:
E24, C22, J64, E32.

Abstract

The unemployment hysteresis hypothesis suggests that macroeconomic shocks may generate persistent effects on unemployment rates. This study investigates the validity of unemployment hysteresis in G7 countries by accounting for linearity, structural breaks, and nonlinear adjustment dynamics. Monthly, seasonally adjusted unemployment rates covering January 2000–December 2024 are analyzed. Linearity is first examined using the Harvey et al. (2008) test, which identifies nonlinear dynamics in Canada and Italy, while unemployment series in the remaining G7 countries display linear behavior. For linear cases, stationarity is assessed using the Augmented Dickey–Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests, together with Perron (1989) and Zivot–Andrews (1992) tests allowing for structural break. Nonlinear series are analyzed using the Kapetanios–Shin–Snell (KSS), Kruse (2011), and Hepsag (2021) tests. The results indicate persistent unemployment in linear economies, nonlinear mean reversion in Canada, and strong hysteresis in Italy, highlighting heterogeneous unemployment dynamics across G7 countries.

Anahtar Kelimeler:
İşsizlik Histerisi, NAIRU, Yapısal Kırılmalar.

JEL Kodları:
E24, C22, J64, E32.

Öz

İşsizlik histerisi hipotezi, makroekonomik şokların işsizlik oranları üzerinde kalıcı etkiler yaratabileceğini ileri sürmektedir. Bu çalışma, G7 ülkelerinde işsizlik histerisinin geçerliliğini doğrusal ve doğrusal olmayan birim kök testleri kullanarak incelemektedir. Analizde, Ocak 2000–Aralık 2024 dönemine ait aylık ve mevsimsellikten arındırılmış işsizlik oranları kullanılmıştır. Öncelikle Harvey vd. (2008) doğrusal olmayanlık testi uygulanmıştır. Sonuçlara göre Kanada ve İtalya doğrusal olmayan dinamikler sergilerken, diğer G7 ülkelerinde doğrusal yapı hakimdir. Doğrusal seriler için Augmented Dickey–Fuller (ADF), Phillips–Perron (PP) ve Kwiatkowski–Phillips–Schmidt–Shin (KPSS) birim kök testleri uygulanmış; ayrıca yapısal kırılmaya izin veren Perron (1989) ve Zivot–Andrews (1992) testlerinden yararlanılmıştır. Doğrusal olmayan serilerde ise Kapetanios–Shin–Snell (KSS), Kruse (2011) ve Hepsag (2021) testleri kullanılmıştır. Bulgular, doğrusal yapı gösteren ülkelerde yapısal kırılmalar dikkate alındığında dahi işsizlik oranlarının durağan olmadığını ve şokların kalıcı etkiler yarattığını göstermektedir. Doğrusal olmayan ülkelerden Kanada'da ortalamaya dönüş gözlenirken, İtalya'da işsizlik oranı durağanlık göstermemekte ve histerisi hipotezini desteklemektedir. Genel olarak sonuçlar, işsizlik histerisinin G7 ülkelerinde ülkeye özgü kurumsal yapı ve uyum mekanizmalarına bağlı olarak farklılaştığını ortaya koymaktadır.

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1. Introduction

The unemployment hysteresis hypothesis suggests that macroeconomic shocks may have lasting effects on unemployment rates, implying that labor markets do not automatically return to their natural levels. The hypothesis gained prominence after the oil shocks of the 1970s, when many advanced economies experienced persistently high unemployment. It was formally introduced by Blanchard and Summers (1986), who argued that adverse shocks can permanently affect unemployment dynamics through institutional rigidities, labor market frictions, and path dependence.

Whether unemployment shocks are temporary or persistent remains a key issue for both economic theory and policy design. If unemployment follows a stationary process, cyclical stabilization policies may be sufficient to restore labor market equilibrium. If hysteresis prevails, however, shocks may leave long-lasting effects, making structural and long-term policy interventions necessary. For this reason, identifying the persistence properties of unemployment plays an important role in evaluating labor market policies.

This study examines unemployment hysteresis in G7 countries by analyzing the stationarity properties of unemployment rates under both linear and nonlinear frameworks. The empirical strategy begins with testing the linearity of the unemployment series using the Harvey et al. (2008) approach. Based on this classification, linear unit root tests and unit root tests allowing for a single structural break are applied to series exhibiting linear dynamics, while nonlinear unit root tests are employed for series characterized by nonlinear adjustment mechanisms. This stepwise strategy follows the structure of the data rather than imposing a single econometric framework.

The motivation for this study stems from the relatively limited number of empirical analyses focusing specifically on G7 countries and from the widespread reliance on a single class of unit root tests in the existing literature. Such approaches may lead to misleading conclusions when the underlying adjustment dynamics are misspecified. By combining linearity testing with linear and nonlinear unit root methods, this study aims to provide more reliable evidence on unemployment persistence in advanced economies.

Accordingly, this study addresses the following research questions:

(i) Do unemployment rates in G7 countries exhibit hysteresis, or do they display mean-reverting behavior when linear and nonlinear dynamics are taken into account?

(ii) To what extent do structural breaks affect the persistence properties of unemployment rates in G7 countries, and are these effects sufficient to eliminate hysteresis?

(iii) Are unemployment dynamics homogeneous across G7 countries, or do they differ depending on whether linear or nonlinear adjustment mechanisms prevail?

The remainder of the paper is organized as follows. Section 2 reviews the theoretical background and related literature. Section 3 describes the data and methodology. Section 4 presents the empirical findings. Section 5 discusses the results, and Section 6 concludes with policy implications.

2. Theoretical Framework and Literature Review

In the economics literature, the persistence of unemployment following macroeconomic shocks is generally discussed within three main theoretical frameworks. The first framework is the natural-rate hypothesis, associated with Friedman (1968) and Phelps (1967). According to this view, unemployment fluctuates over the business cycle but eventually converges to a long-run equilibrium, known as the natural rate. This equilibrium level cannot be permanently altered by policy interventions (Papell et al., 2000). The closely related concept of the NAIRU, developed in the 1970s, similarly assumes a unique unemployment rate consistent with stable inflation. Within this framework, demand-side shocks affect unemployment only temporarily (Modigliani and Papademos, 1975; Ball and Mankiw, 2002).

A second perspective is the hysteresis hypothesis introduced by Blanchard and Summers (1986). This approach highlights the role of labor market rigidities in shaping long-term unemployment dynamics. When adjustment is slow, and unemployment depends strongly on its past values, temporary shocks may generate permanent effects. Mechanisms such as skill erosion, declining employability, and institutional inertia can prevent unemployment from returning to its pre-shock level. From an empirical standpoint, hysteresis implies that unemployment follows a non-stationary, unit-root process.

A third framework, often described as the structuralist approach, emphasizes the importance of structural breaks. Pissarides (1992) and Phelps (1994, 1999) argue that shocks may have prolonged effects, but unemployment can eventually revert to its natural rate once structural adjustments take place. In this context, unemployment may appear non-stationary if structural breaks are ignored, whereas allowing for breaks can restore stationarity.

These theoretical distinctions carry clear policy implications. If hysteresis dominates, short-term stabilization policies are unlikely to be sufficient, and structural reforms become necessary. If shocks are transitory, countercyclical policies may play a more effective role. For this reason, empirical research on unemployment persistence has relied extensively on unit root testing. Yet the conclusions of such tests are highly sensitive to assumptions regarding linearity, structural breaks, and adjustment dynamics. Ignoring these features can lead to serious model misspecification and misleading inference (Enders and Granger, 1998).

Aligned with the theoretical framework of this study, the main contributions in the relevant literature are summarized below.

After the mid-1970s oil shocks, Blanchard and Summers (1986) provided the first systematic empirical analysis of unemployment hysteresis. Using DF and ADF tests (Dickey and Fuller, 1979; 1981) for unemployment series in France, Germany, the United Kingdom, and the United States over the period 1953–1984, they reported persistent unemployment dynamics in European economies but not in the United States. Their findings initiated a large empirical literature that revisited the hysteresis hypothesis using different samples and econometric approaches.

A key limitation of early studies is the neglect of structural breaks. Papell (2000) showed that allowing for breaks substantially reduced unemployment persistence in 16 OECD countries during the post-war period. In the U.S. case, unemployment increased sharply in the 1970s but declined during the 1980s. Caner and Hansen (2001) addressed nonlinear adjustment by applying

a threshold autoregressive (TAR) unit root test to monthly U.S. unemployment data and documented strong threshold effects in short-run dynamics, outperforming standard ADF tests.

Panel-based studies that incorporate structural breaks yield mixed evidence. Christopoulos and León-Ledesma (2007) rejected hysteresis for 12 EU countries using second-generation panel unit root tests. Lee et al. (2009) found that unemployment shocks were temporary in 19 OECD countries based on panel LM tests with heterogeneous breaks. Similarly, Khraief et al. (2020) reported stationary unemployment series in 25 of 29 OECD countries. For transition economies, however, Güriş et al. (2020) documented widespread hysteresis, with Kazakhstan and Slovakia as notable exceptions.

Evidence from European countries remains diverse. Kizilkaya et al. (2024) applied ADF, PP, LM, and RALS-LM tests to ten EU countries and rejected hysteresis in only one case. Using fractional integration methods, Cuestas and Gil-Alana (2024) showed that unemployment hysteresis is weaker among women and university graduates. Alpağut (2024), employing Flexible Fourier ADF and Fractional Frequency Flexible Fourier ADF tests for Türkiye and EU countries, detected nonlinear dynamics but did not support the hysteresis hypothesis.

Nonlinear and Fourier-based approaches have gained prominence in recent years. Yilanci (2008), using the nonlinear KSS test for 17 OECD countries, reported country-specific results supporting either hysteresis or the natural rate hypothesis. Cheng (2022) applied the Park and Shintani test to Asian and OECD economies and identified both hysteresis and long-term structural shifts. Yıldırım et al. (2015) emphasized the role of seasonality, showing that seasonal unit root tests can produce results that differ from conventional approaches.

Using a Fourier panel stationarity test, Pata (2020) found evidence of hysteresis only in Germany, Türkiye, and Spain. In Germany, the Hartz IV labor market reforms implemented between 2003 and 2005 altered unemployment benefit structures and labor supply incentives, contributing to unemployment stationarity (Immel, 2021). Yılmaz (2023) applied ADF, PP, and FFFF-ADF tests to EU-15 and EU-28 countries and confirmed hysteresis in both groups. More recently, Corakci et al. (2022) employed a panel framework allowing for nonlinear adjustment and gradual structural breaks and reported weak hysteresis effects in the Eurozone.

Broader cross-country evidence also points to persistent unemployment dynamics. Ball and Onken (2022) documented hysteresis across 29 OECD economies. Özbek and Türkmen (2021), using PANICCA and Panel Fourier LM tests, reported hysteresis for both E7 and G7 country groups. Similarly, Marques et al. (2017), relying on rolling-window unit root tests and impulse responses, found persistent unemployment behavior in OECD countries, the EU-28, the Euro Area, and the G7.

Studies focusing explicitly on the G7 are relatively limited. Jiang et al. (2019), using a quantile unit root test, found no evidence of hysteresis in the G7. In contrast, Yilanci et al. (2020), applying a Fourier-based FTUR test, reported hysteresis in Canada, France, and the United Kingdom, NAIRU behavior in Germany and Italy, and recession-specific hysteresis in the United States and Japan. Mota (2023) showed that hysteresis effects intensify during periods of heightened demand uncertainty. Using fractional integration techniques, Gil-Alana et al. (2025) identified long memory and high persistence in G7 unemployment rates, consistent with hysteresis in the absence of mean reversion.

Taken as a whole, the literature suggests that unemployment hysteresis varies across countries, time periods, and demographic groups. The persistence of unemployment following major shocks highlights the importance of country-specific adjustment mechanisms and labor market structures. At the same time, prior studies demonstrate that empirical evidence on hysteresis is highly sensitive to methodological choices, underscoring the need for a data-driven testing strategy that jointly accounts for linearity, nonlinearity, and structural change—an approach adopted in this study for the G7 economies.

Despite extensive research, evidence on unemployment hysteresis remains mixed and highly sensitive to methodological choices. Many studies rely on a single class of unit root tests and do not explicitly distinguish between linear and nonlinear adjustment processes. Moreover, studies focusing specifically on the G7 are relatively scarce and often overlook the joint role of structural breaks and nonlinear dynamics.

This study addresses these gaps by applying a parsimonious yet comprehensive empirical strategy that first identifies the underlying data-generating process and then employs appropriate linear and nonlinear unit root tests with structural breaks. In doing so, it provides new evidence on the heterogeneous nature of unemployment persistence across G7 economies.

3. Methodology and Data

This section describes the data set and outlines the econometric methodology employed in the analysis. The empirical strategy follows a stepwise testing framework designed to ensure that the selected unit root tests are consistent with the underlying dynamics of each unemployment series. The methodological flow of the study is summarized in Figure 1.

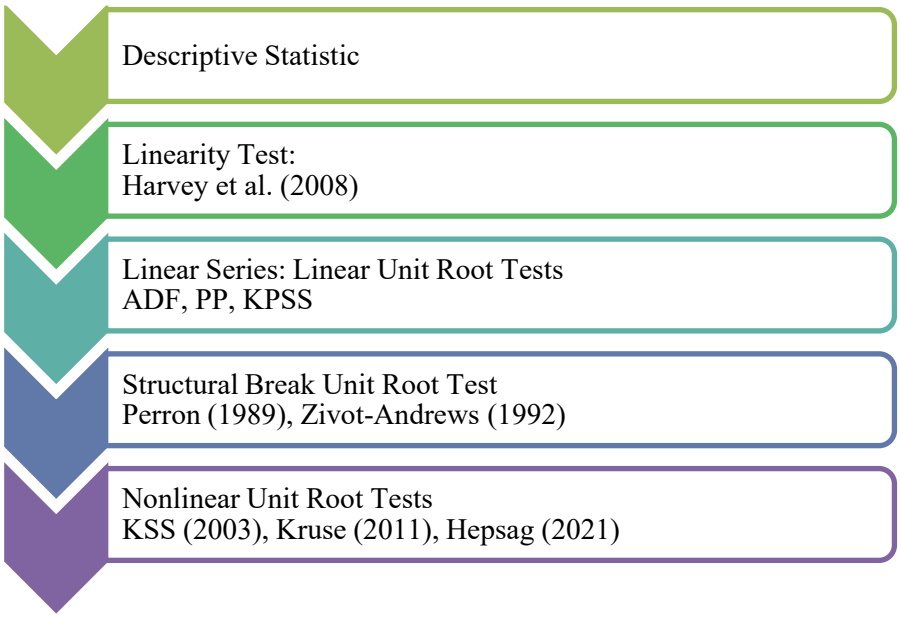

Figure 1. Methodological Flow of the Study

As illustrated in Figure 1, the empirical analysis follows a stepwise procedure. The process begins with descriptive statistics and a linearity test proposed by Harvey et al. (2008). Based on

the linearity results, the series are classified as linear or nonlinear. Linear series are analyzed using conventional unit root tests and structural break tests, whereas nonlinear series are examined using nonlinear unit root tests. This framework ensures that the selected econometric methods are consistent with the underlying data-generating process.

In this framework, the Harvey et al. (2008) test evaluates the null hypothesis of linearity against the alternative of nonlinear dynamics and is valid regardless of the integration properties of the series. Based on the test results, the series are classified as linear or nonlinear, which determines the subsequent unit root testing strategy.

For the unemployment series classified as linear, stationarity is examined using the ADF, PP, and KPSS tests. The ADF test developed by Dickey and Fuller (1979, 1981) and the PP test proposed by Phillips and Perron (1988) are both based on the null hypothesis that the series contains a unit root. By contrast, the KPSS test introduced by Kwiatkowski et al. (1992) adopts stationarity as the null hypothesis. Owing to these opposing hypotheses, the joint use of ADF, PP, and KPSS tests provides a more reliable assessment of the persistence properties of unemployment rates. Consistent conclusions across these tests strengthen inference, while conflicting results signal the need for further investigation. This complementary testing strategy helps to reduce potential biases arising from reliance on a single unit root test.

Perron (1989) proposed a unit root test that allows for a single structural break at a known point in time. Under the null hypothesis, the series follows a unit root process while permitting a structural break, whereas under the alternative hypothesis, the series is stationary around a structural break. Depending on the nature of the break, Perron (1989) considers different specifications that allow for shifts in the intercept, the trend, or both.

In this study, the two most commonly used specifications—Model A and Model C—are employed (Perron, 1989; Yılancı, 2009). Model A allows for a one-time shift in the intercept and is specified as follows:

$$y_t = \mu + \alpha y_{t-1} + \delta_1 D(TB)_t + u_t \quad (1)$$

Model C permits simultaneous changes in both the intercept and the trend and is given by:

$$y_t = \mu + \alpha y_{t-1} + \delta_1 D(TB)_t + \delta_2 DU_t + u_t \quad (2)$$

In Equations (1) and (2), $D(TB)_t$is a pulse dummy that captures a discrete change in the level at the break date T_B, while $DU_t$is a step dummy that takes the value of one after the break and zero otherwise. As emphasized by Perron (1989), and supported by subsequent empirical applications, Models A and C are particularly suitable for capturing abrupt structural changes associated with major macroeconomic events and for distinguishing between genuine unit root behavior and persistence arising from structural breaks (Yılancı, 2009).

The Zivot–Andrews (1992) test endogenizes a single break date T_b, instead of fixing it ex ante. It estimates three specifications: Model A (intercept shift), Model B (trend–slope shift), and Model C (simultaneous level and slope shifts) (see Güriş et al., 2020). The models A, B, and C can be written compactly as:

$$\Delta y_t = \mu + \beta T + \delta Y_{t-1} + \theta DU_t(T_b) + \sum_{i=1}^{m} a_i \Delta Y_{t-i} + \varepsilon_t \quad (3)$$

$$\Delta y_t = \mu + \beta T + \delta Y_{t-1} + \gamma DT(T_b) + \sum_{i=1}^{m} a_i \Delta Y_{t-i} + \varepsilon_t \quad (4)$$

$$\Delta y_t = \mu + \beta T + \delta Y_{t-1} + \theta DU_t(T_b) + \gamma DT_t(T_b) + \sum_{i=1}^{m} a_i \Delta Y_{t-i} + \varepsilon_t \quad (5)$$

The lagged difference terms ΔY_{t-i} are included to ensure that the residuals ε_t are free from autocorrelation. The variables DU_t and DT_t are dummy variables that capture the effects of the structural break:

$DU_t = 1$ if $t > T_b$, and 0 otherwise

$DT_t = t - T_b$ if $t > T_b$, and 0 otherwise

Within this framework, the presence of a unit root is assessed through the significance of the lagged level term y_{t-1}. If the absolute t-statistic for δ exceeds its critical value, the null of a unit root is rejected, indicating trend stationarity with a structural break.

Kapetanios et al. (2003) develop a nonlinear unit root test that allows the null hypothesis of a unit root to be tested against an alternative of nonlinear stationarity consistent with an ESTAR process. Since the nonlinear adjustment parameter is not identifiable under the null hypothesis, the test is implemented using an auxiliary regression obtained via a first-order Taylor expansion of the ESTAR model (Kapetanios et al., 2003; Güriş, 2020). The regression estimated in practice is given in Equation (6):

$$\Delta y_t = \delta y_{t-1}^3 + \sum_{j=1}^{p} \rho_j \, \Delta y_{t-j} + \varepsilon_t \tag{6}$$

In Equation (6), lagged difference terms are included to control for serial correlation. The null hypothesis states that the series contains a unit root, while rejection implies nonlinear stationarity consistent with an ESTAR process. Inference is based on the nonlinear t-statistic t_{NL}, which evaluates the statistical significance of the estimated nonlinear adjustment coefficient $\hat{\delta}$. If the calculated t_{NL}statistic exceeds the critical values reported by Kapetanios et al. (2003), the null hypothesis is rejected, indicating nonlinear mean reversion. As noted by Hepsağ (2022), this framework captures symmetric adjustment toward the long-run equilibrium following positive or negative shocks.

Kruse (2011) proposes a nonlinear unit root test that extends the KSS (2003) framework by allowing for asymmetric adjustment within an ESTAR process. Since the nonlinear parameters are not identifiable under the null hypothesis, the test is implemented using an auxiliary regression obtained via a first-order Taylor expansion. The regression estimated in practice is given in Equation (7):

$$\Delta y_t = \delta_1 y_{t-1}^3 + \delta_2 y_{t-1}^2 + \sum_{j=1}^{p} \alpha_j \, \Delta y_{t-j} + \varepsilon_t \tag{7}$$

In Equation (7), lagged difference terms are included to control for serial correlation. The null hypothesis states that the series contains a unit root, while the alternative hypothesis implies nonlinear stationarity consistent with an ESTAR process. Under the alternative hypothesis, asymmetric adjustment is allowed through the joint behavior of the nonlinear terms.

Inference is based on a modified Wald-type test statistic, given in Equation (8), which jointly evaluates the nonlinear adjustment coefficients:

$$\tau = \left(\hat{\psi}_{22} - \frac{\hat{\psi}_{21}^2}{\hat{\psi}_{11}}\right)\left(\hat{\delta}_2 - \hat{\delta}_1 \frac{\hat{\psi}_{21}}{\hat{\psi}_{11}}\right)^2 + 1(\hat{\delta}_1 < 0)\frac{\hat{\delta}_1^2}{\hat{\psi}_{11}} \tag{8}$$

If the calculated test statistic exceeds the critical values reported by Kruse (2011), the null hypothesis of a unit root is rejected in favor of nonlinear stationarity. As noted by Kruse (2011), deterministic components are not included directly in the test regression; instead, the test can be applied to raw, demeaned, or detrended series depending on the structure of the data.

Hepsag (2021) proposes a nonlinear unit root test that jointly accounts for smooth structural breaks and nonlinear adjustment dynamics. Smooth breaks are modeled through a logistic smooth transition function, while nonlinearity is captured using the ESTAR framework of Kruse (2011). Following the Leybourne, Newbold, and Vougas (1998) approach, three alternative deterministic specifications are considered, given in Equations (9)–(11):

$$y_t = \alpha_1 + \alpha_2 S_t(\lambda, \tau) + v_t \tag{9}$$

$$y_t = \alpha_1 + \beta_1 t + \alpha_2 S_t(\lambda, \tau) + v_t \tag{10}$$

$$y_t = \alpha_1 + \beta_1 t + \alpha_2 S_t(\lambda, \tau) + \beta_2 t S_t(\lambda, \tau) + v_t \tag{11}$$

In this context, $S_t(\lambda, \tau)$represents the logistic smooth transition function, defined as $S_t(\lambda, \tau) = [1 + \exp\{-\lambda(t - \tau T)\}]^{-1}$, where $\lambda > 0$determines the speed of transition between regimes, and τcorresponds to the timing of the smooth structural break. The variable $t$denotes the deterministic trend component, and Trepresents the total number of observations.

In the second step, residuals obtained from the above specifications are assumed to follow a nonlinear ESTAR process. Applying a first-order Taylor expansion yields the auxiliary regression given in Equation (12):

$$\Delta\hat{v}_t = \delta_1 \hat{v}_{t-1}^3 + \delta_2 \hat{v}_{t-1}^2 + \sum_{i=1}^{k} a_i \, \Delta\hat{v}_{t-i} + \varepsilon_t \tag{12}$$

The null hypothesis of a unit root is defined as $\delta_1 = \delta_2 = 0$, while the alternative hypothesis implies nonlinear stationarity under an ESTAR-type smooth transition with structural breaks. Since the restrictions involve both one-sided and two-sided conditions, inference is conducted using a modified Wald-type statistic, reported in Equation (13). If the test statistic exceeds the critical values provided by Hepsag (2021), the null hypothesis of a unit root is rejected.

$$\tau_{SNL} = \tau_{SNL\alpha(\beta)} + \tau_{SNL\alpha\beta} = (\hat{\psi}_{22} - \frac{\hat{\psi}_{21}^2}{\hat{\psi}_{11}})(\hat{\delta}_2 - \hat{\delta}_1 \frac{\hat{\psi}_{21}}{\hat{\psi}_{11}})^2 + 1(\hat{\delta}_1 < 0)\frac{\hat{\delta}^2}{\hat{\psi}_{11}} \tag{13}$$

In Equation (13), different test statistics correspond to Models A, B, and C, with their values derived from the variance–covariance matrix and the estimated coefficients of Equation (12). If the statistic exceeds the critical value reported by Hepsag (2021), evidence supports stationarity under an ESTAR-type smooth transition with structural breaks; otherwise, the unit root null cannot be rejected.

Table 1 reports the main characteristics of the unemployment rate series used in the analysis for the G7 countries. The dataset consists of monthly, seasonally adjusted unemployment rates for individuals aged 15 and above, covering the period from January 2000 to December 2024.

Table 1. Data

Country	US	Germany	Canada	France	UK	Italy	Japan
Code	LRHUTTTTUSM156S	LRHUTTTTDEM156S	LRHUTTTTCAM156S	LRHUTTTTFRA156S	LRHUTTTTGBR156S	LRHUTTTTITA156S	LRHUTTTTJPN156S
Monthly Frequency	✓	✓	✓	✓	✓	✓	✓
Seasonally Adjusted	✓	✓	✓	✓	✓	✓	✓
Age 15+	✓	✓	✓	✓	✓	✓	✓

Note: Sample period: January 2000 – December 2024.
Source: Federal Reserve Economic Data (FRED).

All series are obtained from the FRED database. The use of a common data source and harmonized definitions ensures cross-country comparability and enhances the reliability of the empirical results.

4. Empirical Results

The descriptive statistics reported in Table 2 provide an overview of the level and distributional properties of monthly unemployment rates across G7 countries over the sample period. The results indicate considerable cross-country heterogeneity in unemployment dynamics.

Table 2. Descriptive Statistics

	US	Germany	Canada	France	UK	Italy	Japan
Mean	5.695667	6.010000	6.973333	8.824667	5.438000	9.186667	3.820333
Median	5.100000	5.100000	7.000000	8.900000	5.100000	8.700000	3.950000
Maximum	14.80000	11.20000	14.20000	10.50000	8.500000	13.30000	5.500000
Minimum	3.400000	2.900000	4.800000	6.900000	3.600000	5.800000	2.200000
Std. Dev.	1.960807	2.602604	1.146708	0.958813	1.345607	1.885738	1.004348
Skewness	1.245470	0.455294	1.979286	-0.092664	0.877256	0.321422	-0.003622
Kurtosis	4.443171	1.823108	12.87250	2.132851	2.568077	2.091583	1.624493
Jarque-Bera	103.5941	27.67807	1414.206	9.828684	40.81085	15.48090	23.65088
Probability	0.000000	0.000001	0.000000	0.007341	0.000000	0.000435	0.000007
Sum	1708.700	1803.000	2092.000	2647.400	1631.400	2756.000	1146.100
Sum Sq. Dev.	1149.584	2025.290	393.1667	274.8775	541.3868	1063.247	301.6060
Observations	300	300	300	300	300	300	300

Descriptive statistics in Table 2 indicate notable differences in unemployment dynamics across G7 countries. Italy and France record the highest average unemployment rates, whereas Japan exhibits the lowest mean and median values. The dispersion of unemployment rates also varies across countries, with Germany and the United States displaying relatively higher standard deviations compared to France and Japan.

Skewness statistics suggest that most series are positively skewed, indicating occasional episodes of elevated unemployment. France shows slight negative skewness, while Japan's distribution is nearly symmetric. Kurtosis values point to deviations from normality in several countries, most notably in Canada, where a very high kurtosis indicates pronounced peakness and the presence of extreme observations. In contrast, other countries display distributions closer to a mesokurtic or mildly platykurtic structure.

The Jarque–Bera test statistics strongly reject the null hypothesis of normality for all series at the 1% significance level. Collectively, these findings highlight substantial differences in both the level and distributional characteristics of unemployment across G7 economies, supporting the need for flexible econometric methods that can accommodate non-normality, nonlinearity, and structural change in subsequent analyses.

Prior to the unit root analysis, the unemployment series were examined for linearity using the test proposed by Harvey et al. (2008). The results are reported in Table 3, where the test statistics are evaluated against the corresponding critical values.

Table 3. Linearity Test

Variables	Harvey et al. (2008)	5%	Decision
US	0.53	5.99	Linear
Germany	0.12	5.99	Linear
Canada	6.98**	5.99	Nonlinear
France	0.12	5.99	Linear
UK	3.14	5.99	Linear
Japan	3.68	5.99	Linear
Italy	8.26**	5.99	Nonlinear

Note: The null hypothesis (H_0) corresponds to linearity, while the alternative hypothesis (H_1) implies nonlinearity. Following Harvey et al. (2008), the 5% critical value is 5.99; series exceeding this threshold are classified as nonlinear.

Table 3 indicates that the null hypothesis of linearity cannot be rejected for the United States, Germany, France, the United Kingdom, and Japan, as the test statistics remain below the 5% critical value. In contrast, the test statistics for Canada and Italy exceed the 5% critical threshold, providing evidence in favor of nonlinear dynamics in these countries' unemployment series.

Based on these findings, the subsequent stationarity analysis follows a dual strategy. For countries identified as linear (the United States, Germany, France, the United Kingdom, and Japan), conventional linear unit root tests are applied. For Canada and Italy, which exhibit nonlinear characteristics, nonlinear unit root tests are employed. This approach ensures that the choice of econometric methodology is consistent with the underlying time-series properties of each country.

Since the unemployment series were classified as linear, stationarity is first examined using conventional linear unit root tests, namely the Augmented Dickey–Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests. The results are reported in Table 4. The ADF and PP test results indicate that, at levels, the null hypothesis of a unit root cannot generally be rejected for the unemployment series across countries. After first differencing, both tests strongly reject the null hypothesis, providing evidence in favor of stationarity.

Consistent with these findings, the KPSS test rejects the null hypothesis of stationarity for the level series in most countries, supporting the presence of a unit root in unemployment rates. Taken together, the results reported in Table 4 indicate that the unemployment series are integrated of order one, I(1). The KPSS test is applied only to demeaned or detrended level series, as it examines stationarity around a constant or a deterministic trend. Since differenced series do

not contain such deterministic components, applying the KPSS test to first differences would be methodologically inappropriate.

Table 4. **Traditional Tests**

		ADF		PP		KPSS	
Country	**Model**	**τ-stat**	**5 % Critical**	**τ-stat**	**5 % Critical**	**τ-stat**	**5 % Critical**
US	C	-2.938126**	-2.870996	-2.740150**	-2.870996	0.330529	0.463000
	C&T	-3.058907	-3.424926	-2.856834	-3.424926	0.259178	0.146000
	Δ C	-16.84017**	-2.871029	-17.45212**	-2.871029		
	ΔC&T	-16.82499**	-3.424977	-17.48865**	-3.424977		
Germany	C	-0.809178	-2.871095	-0.589059	-2.870996	1.821750	0.463000
	C&T	-2.221572	-3.425080	-1.655457	-3.424926	0.196559	0.146000
	Δ C	-4.246209**	-2.871095	-13.59232**	-2.871029		
	ΔC&T	-4.242396**	-3.425080	-13.58239**	-3.424977		
France	C	-1.588955	-2.871061	-1.671223	-2.870996	0.407872	0.463000
	C&T	-1.666850	-3.425028	-1.719840	-3.424926	0.334479	0.146000
	Δ C	-11.34819**	-2.871061	-11.56228**	-2.871029		
	ΔC&T	-11.32945**	-3.425028	-11.51504**	-3.424977		
UK	C	-1.154003	-2.871061	-1.173243	-2.870996	0.557058	0.463000
	C&T	-1.362753	-3.425028	-1.347684	-3.424926	0.358378	0.146000
	Δ C	-7.538704**	-2.871061	-13.39208**	-2.871029		
	ΔC&T	-7.540435**	-3.425028	-13.37244**	-3.424977		
Japan	C	-0.751415	-2.870996	-0.647592	-2.870996	1.743944	0.463000
	C&T	-2.371024	-3.424926	-2.337784	-3.424926	0.140101	0.146000
	Δ C	-19.66521**	-2.871029	-19.59124**	-2.871029		
	ΔC&T	-19.63493**	-3.424977	-19.56333**	-3.424977		

Note: All tests are evaluated at the 5% significance level. For the ADF and PP tests, the null hypothesis is the presence of a unit root, whereas for the KPSS test the null hypothesis is stationarity. ** indicates rejection of the null hypothesis at the 5% level.

However, standard unit root tests are prone to size distortions in the presence of structural breaks. To address this limitation and ensure robust inference, the analysis is extended to unit root tests that explicitly allow for structural change, namely the Perron (1989) and Zivot–Andrews (1992) tests. While the Perron test allows for a single structural break under different model specifications, the Zivot–Andrews test endogenously determines the most likely break date. The joint application of these tests helps distinguish genuine unit root behavior from persistence driven by unmodeled structural shifts.

Next, to account for potential structural breaks, unit root tests proposed by Perron (1989) and Zivot–Andrews (1992) are applied. The order of integration is assessed based on the 5% critical values. The results of the structural break unit root tests reported in Table 5 indicate that unemployment dynamics across G7 countries are strongly influenced by major structural shifts. For the countries considered, the Perron (1989) and Zivot–Andrews (1992) tests generally fail to reject the null hypothesis of a unit root at the 5% significance level. This finding suggests that unemployment rates predominantly follow an I(1) process, implying persistent effects of shocks rather than short-run mean reversion.

The estimated break dates are economically meaningful and largely coincide with major global and country-specific events. Breaks clustered around 2008–2009 are consistent with the global financial crisis, which led to substantial and lasting disruptions in labor markets across advanced economies. More recent breaks observed during 2019–2020 align with heightened

global trade uncertainty and the onset of the COVID-19 pandemic, reflecting abrupt and persistent labor market adjustments.

Table 5. Structural Break Unit Root Test Results

Test		Perron			Zivot–Andrews		
Country	**Model**	**τ-stat**	**5 % Critical**	**Time Break (IO)**	**τ-stat**	**5 % Critical**	**Time Break**
USA	A	-5.273439	-4.443649	2020M04	-4.394835	-4.93	2008M05
	C	-5.431222	-4.859812	2020M04	-4.575921	-5.08	2008M05
Germany	A	-4.237283	-4.443649	2005M04	-3.622958	-4.93	2009M07
	C	-3.406696	-4.859812	2009M07	-3.091081	-5.08	2019M06
France	A	-3.160549	-4.443649	2020M08	-3.924878	-4.93	2008M10
	C	-3.901409	-4.859812	2008M09	-3.979082	-5.08	2008M11
UK	A	-2.486260	-4.443649	2013M01	-3.305213	-4.93	2013M08
	C	-3.288831	-4.859812	2013M07	-3.705946	-5.08	2008M05
Japan	A	-2.825279	-4.443649	2013M02	-3.444763	-4.93	2008M11
	C	-3.420246	-4.859812	2008M10	-3.447851	-5.08	2008M11

Note: The Perron (1989) test allows for a single structural break under the innovational outlier (IO) framework, assuming that the break date lies within the interior of the sample. The Zivot–Andrews (1992) test endogenously determines the break date and is implemented using the 15% trimming rule to limit the influence of extreme observations. Model A represents a break in the intercept, while Model C allows for breaks in both the intercept and trend. All critical values correspond to the 5% significance level. IO denotes an innovational outlier.

In several countries, earlier break points correspond to institutional and structural reforms or periods of economic adjustment, such as labor market reforms and post-crisis recovery phases. In combination, the consistency of break dates across countries highlights the dominant role of large macroeconomic shocks in shaping unemployment persistence within the G7. These findings reinforce the importance of accounting for structural breaks when assessing unemployment hysteresis and motivate the subsequent application of nonlinear unit root tests.

To examine nonlinear unit root properties, three complementary tests are employed. First, the KSS test developed by Kapetanios et al. (2003) is used to analyze symmetric nonlinear mean reversion dynamics. Second, the Kruse (2011) test, which generalizes the KSS framework and offers higher power, is applied. Finally, the Hepsag (2021) unit root test is employed to account for asymmetric nonlinear adjustment, allowing for different responses to positive and negative shocks. Taken together, these tests provide a comprehensive assessment of nonlinear stationarity and unemployment hysteresis.

Since no clear deterministic trend is detected in the unemployment rates of Canada and Italy, specifications including deterministic trends are excluded from the nonlinear unit root analysis. Accordingly, the analysis focuses on demeaned series, which are more consistent with the underlying structural characteristics of the data.

The KSS test is applied to the demeaned unemployment series, and the results are reported in Table 6. The KSS test results reveal a clear divergence between Canada and Italy in terms of nonlinear dynamics. For Canada, the test statistic falls below the 5% critical value, indicating nonlinear ESTAR-type stationarity. In contrast, for Italy, the null hypothesis of a unit root cannot be rejected, suggesting that persistence remains even within a nonlinear framework. These

findings imply that nonlinear dynamics weaken unemployment hysteresis in Canada, whereas hysteresis remains strong in Italy.

Table 6. KSS (2003) Test Results

Country	Model	τ-stat	Lag	5 % Critical	Results
Canada	Demeaned	-8.65608	1	–2.93	Nonlinear ESTAR Stationary
Italy	Demeaned	-1.31090	1	–2.93	Unit Root

Note: The optimal lag length was automatically selected using the AIC. The critical values were obtained from the Kapetanios–Shin–Snell (2003) critical value tables.

To further assess nonlinear adjustment dynamics beyond the symmetric ESTAR framework of the KSS test, the Kruse test is applied to the demeaned unemployment series. This test allows for more flexible nonlinear behavior and provides higher power against nonlinear stationarity. The results reported in Table 7 reinforce the evidence obtained from the KSS test. For Canada, the Kruse test statistic exceeds the 5% critical value, leading to the rejection of the null hypothesis of a unit root and indicating nonlinear ESTAR-type stationarity. This finding suggests that unemployment shocks in Canada are transitory once nonlinear adjustment mechanisms are taken into account.

In contrast, for Italy, the test statistic remains well below the 5% critical threshold, and the null hypothesis of a unit root cannot be rejected. This result implies that unemployment persistence in Italy prevails even under a more flexible nonlinear specification. Overall, the Kruse test confirms that nonlinear mean reversion characterizes unemployment dynamics in Canada, whereas hysteresis effects remain strong in Italy.

Table 7. Kruse (2011) Test Results

Country	Model	τ-stat	Lag	5 % Critical	Results
Canada	Demeaned	77.18238	1	10.17	Nonlinear ESTAR Stationary
Italy	Demeaned	1.71274	1	10.17	Unit Root

Note: The optimal lag length is selected using the Akaike Information Criterion (AIC). Inference is based on Monte Carlo–simulated critical values reported by Kruse (2011).

Table 8 reports the results of the Hepsag (2021) test for the G7 countries under Model B. In this framework, the structural break date is determined endogenously. The reported value of "Break Coefficient × 300" is used to convert the estimated break fraction into a calendar month based on the total number of observations.

Table 8. Hepsag (2021) Test Results

Country	Model	τ-stat	Lag	5 % Critical	Break Point × T	Time Break
Canada	B	78.55135	1	12.73	0.67427× 300 = 203	2016M10
Italy	B	24.15922	0	12.73	0.45296× 300 = 136	2011M05

Note: The optimal lag length was automatically selected using the AIC. Critical values are simulated as in Hepsag (2021).

Table 8 reports the results of the Hepsag (2021) nonlinear unit root test applied to the demeaned unemployment series under Model B. This specification allows for smooth structural breaks in the intercept and is appropriate given the absence of a deterministic trend in the data.

For Canada, the τ-statistic exceeds the 5% critical value, leading to the rejection of the null hypothesis of a unit root. This result indicates nonlinear stationarity with smooth structural adjustment, suggesting that unemployment shocks in Canada are transitory once nonlinear dynamics are taken into account. The estimated break date of 2016M10 corresponds to a period marked by global commodity price adjustments and changing macroeconomic conditions.

For Italy, the τ-statistic exceeds the 5% critical value in the Hepsag test; however, this result should not be interpreted as evidence of strong mean reversion. Instead, the rejection indicates that unemployment adjusts to shocks around a time-varying equilibrium, rather than returning to a fixed long-run unemployment level. When evaluated jointly with the results from the KSS and Kruse tests, the overall evidence points to weak and incomplete mean reversion in Italy. The estimated break date of 2011M05 coincides with the European sovereign debt crisis, a period associated with persistent labor market disruptions. By contrast, the Hepsag test under Model B provides clear support for nonlinear mean reversion in Canada, highlighting substantial cross-country heterogeneity in unemployment dynamics

5. Discussion

This study revisits the unemployment hysteresis hypothesis for G7 countries by adopting a unified empirical strategy that explicitly accounts for linearity, structural breaks, and nonlinear adjustment dynamics. In contrast to earlier studies that rely on a single class of unit root tests, the present analysis first distinguishes between linear and nonlinear data-generating processes and then applies appropriate stationarity tests accordingly. This approach allows for a more accurate assessment of unemployment persistence and provides results that can be meaningfully compared with the existing literature.

The linearity test results indicate that unemployment dynamics are linear in the United States, Germany, France, the United Kingdom, and Japan, while Canada and Italy exhibit nonlinear behavior. This finding is consistent with Yilanci (2008) and Yilanci et al. (2020), who emphasize that nonlinear adjustment mechanisms are present only in a subset of advanced economies and should not be imposed uniformly across countries.

For the linear group, conventional ADF, PP, and KPSS tests consistently indicate that unemployment rates are nonstationary at levels but stationary in first differences. These results remain robust when structural breaks are incorporated using the Perron (1989) and Zivot–Andrews (1992) tests. In line with Blanchard and Summers (1986), Papell (2000), and Ball and Onken (2022), the evidence suggests that unemployment shocks in these countries tend to have long-lasting effects, supporting the hysteresis hypothesis rather than rapid mean reversion.

The estimated structural break dates provide important economic insights. Breaks around 2008–2009 are common across countries and coincide with the global financial crisis, which caused sharp contractions in output, disruptions in credit markets, and persistent labor market slack. Similar break dates have been documented by Marques et al. (2017) and Özbek and Türkmen (2021) for OECD and G7 economies. Additional breaks observed during 2019–2020 align with the COVID-19 pandemic, reflecting abrupt employment losses and prolonged recovery periods despite large-scale fiscal and monetary interventions. The persistence observed after these episodes indicates that policy responses, while mitigating short-run damage, were often insufficient to fully eliminate long-term unemployment effects.

For Canada and Italy, where nonlinear dynamics are detected, the results reveal a clear divergence in unemployment adjustment. For Canada, the KSS (2003), Kruse (2011), and Hepsag (2021) tests consistently reject the unit root hypothesis, indicating nonlinear mean reversion. This finding is in line with Yilanci et al. (2020), who report nonlinear adjustment and limited hysteresis for Canada, and with panel-based evidence in Lee et al. (2009) and Khraief et al. (2020), which suggests that unemployment shocks can be transitory in economies with more flexible labor markets.

The identified break date for Canada around 2016 corresponds to a period of sharp declines in global commodity prices, particularly oil, combined with exchange rate depreciation and accommodative monetary policy. These developments significantly affected employment in energy-intensive regions but were followed by a gradual labor market recovery. The nonlinear adjustment captured by the tests suggests that shocks initially generate large deviations in unemployment but are eventually absorbed through market-driven and policy-supported mechanisms.

In contrast, Italy's unemployment rate remains nonstationary even under nonlinear and smooth-transition frameworks, pointing to strong and persistent hysteresis effects. This result is consistent with the findings of Yılmaz (2023), Çorakcı et al. (2024), and Gil-Alana et al. (2025), who document high persistence and long memory in Southern European labor markets. The structural break identified around 2011 coincides with the European sovereign debt crisis, a period characterized by fiscal austerity, tightening credit conditions, and limited policy space. Unlike Canada, Italy's labor market rigidities, such as strict employment protection, segmented contracts, and weak labor mobility, appear to have amplified the long-term impact of the shock, preventing unemployment from reverting to its pre-crisis level.

Overall, the findings reinforce the view that unemployment hysteresis is not a uniform phenomenon across advanced economies but depends critically on country-specific institutions, policy responses, and adjustment mechanisms. While large global shocks generate persistent unemployment effects across most G7 countries, nonlinear mean reversion can emerge in economies with greater labor market flexibility. By jointly considering linearity, structural breaks, and nonlinear dynamics, this study contributes to the literature by providing a more nuanced and internally consistent explanation of unemployment persistence in advanced economies.

Taken together, the findings provide clear answers to the main research questions of the study. The results indicate that unemployment rates in most G7 countries exhibit persistent behavior, suggesting that macroeconomic shocks tend to have long-lasting effects rather than being absorbed through short-run adjustments. At the same time, nonlinear dynamics play a crucial role in differentiating between hysteresis and mean reversion, as evidenced by the contrasting cases of Canada and Italy. The identified structural break dates largely coincide with major global economic events, such as the global financial crisis and the COVID-19 pandemic, highlighting the importance of accounting for structural changes in unemployment dynamics. Furthermore, the results demonstrate that different econometric approaches may lead to different conclusions, underscoring the necessity of adopting a data-driven methodology that aligns with the underlying properties of the series.

6. Conclusion and Policy Implications

This study examines unemployment hysteresis in G7 countries using a unified empirical framework that accounts for linearity, structural breaks, and nonlinear adjustment dynamics. By first distinguishing between linear and nonlinear data-generating processes and then applying appropriate unit root tests, the analysis provides a consistent and comprehensive assessment of unemployment persistence.

The results indicate that unemployment dynamics differ substantially across countries. For most G7 economies, unemployment rates are found to be nonstationary, implying that macroeconomic shocks tend to have persistent effects rather than being absorbed through short-run adjustments. Structural break tests further show that major global events, such as the global financial crisis and the COVID-19 pandemic, have played a decisive role in shaping long-term unemployment dynamics.

For countries exhibiting nonlinear behavior, the findings reveal important heterogeneity. Canada displays nonlinear mean reversion, suggesting that unemployment shocks are ultimately transitory once nonlinear adjustment mechanisms are taken into account. In contrast, Italy continues to exhibit strong persistence even under nonlinear and smooth-transition frameworks, pointing to pronounced hysteresis effects.

Viewed jointly, the evidence confirms that unemployment hysteresis is not a uniform phenomenon across advanced economies but depends critically on country-specific adjustment mechanisms and institutional structures. Overall, the results suggest that "one-size-fits-all" employment policies are unlikely to be effective. Policy design should reflect country-specific labor market structures and the nonlinear adjustment dynamics identified in this study. By jointly considering linearity, structural breaks, and nonlinear dynamics, this study offers a more nuanced and internally consistent explanation of unemployment persistence in G7 countries.

The results show that unemployment persistence in G7 countries is closely linked to country-specific labor market structures and policy frameworks. In countries where hysteresis remains strong, such as Italy, the United Kingdom, and Japan, short-term demand-support policies alone are not sufficient. Rigid labor market institutions, segmented employment contracts, and low labor mobility tend to prolong the effects of negative shocks. In these cases, policies should prioritize reducing structural rigidities, strengthening active labor market programs, and improving job matching for long-term unemployed workers.

In contrast, the evidence of nonlinear mean reversion in Canada suggests that more flexible labor market arrangements, together with supportive macroeconomic policies, help absorb shocks over time. Policies that promote skill adaptation, regional mobility, and wage flexibility appear effective in preventing temporary shocks from becoming permanent unemployment.

For countries such as the United States and France, where unemployment shows persistence but adjustment mechanisms remain partly effective, timely countercyclical policies are essential. Rapid fiscal support, well-designed unemployment benefits, and training programs can limit long-term labor market damage during crisis periods.

Declaration of Research and Publication Ethics
This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement
I am a single author of this paper. My contribution is 100%.

Declaration of Researcher's Conflict of Interest
There is no potential conflicts of interest in this study.

Declaration of Artificial Intelligence Usage
The author did not use any artificial intelligence tools during the preparation of this manuscript.

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