

Hysteresis in EU Member States: A Comprehensive Analysis Using the Fourier Approach

Yağmur SAĞLAM (<https://orcid.org/0000-0001-6465-0297>), Sinop University, Türkiye;
yagmur.saglam@sinop.edu.tr

Sultan SALUR-KÜÇÜK (<https://orcid.org/0000-0001-9314-3526>), Sinop University, Türkiye;
ssalur@sinop.edu.tr

AB Üyesi Ülkelerde Histerezis: Fourier Yaklaşımıyla Kapsamlı Bir Analiz

Abstract

This study examines the persistence of inflation and unemployment in European Union (EU) member states between 1991 and 2023, focusing on hysteresis effects and the applicability of the Non-Accelerating Inflation Rate of Unemployment (NAIRU) framework. The EU represents a unique empirical setting due to the diversity of its national labour markets and fiscal structures within a shared economic space. These asymmetries increase the likelihood of long-term macroeconomic imbalances, making the analysis of hysteresis particularly relevant. The study addresses this issue using nonlinear econometric techniques, specifically the Fourier KPSS test and ECM-based bootstrap cointegration analysis, to detect smooth structural changes and long-run relationships between inflation and unemployment. The empirical results indicate strong evidence of inflation hysteresis across most EU countries and selective unemployment hysteresis in specific cases such as Germany, Hungary, and Ireland. Moreover, a significant long-term cointegration between inflation and unemployment is observed, challenging the conventional assumptions of the Phillips Curve. The study contributes methodologically by integrating advanced testing procedures and empirically by offering a comprehensive, comparative perspective across member states. These findings highlight the need for flexible, country-specific policy strategies to mitigate persistent inflation and labour market rigidities, thereby fostering long-term macroeconomic stability and convergence within the EU.

Keywords : Inflation Persistence, Unemployment Hysteresis, NAIRU, the EU, Panel Data Analysis.

JEL Classification Codes : E24, E31, C22.

Öz

Bu çalışma, 1991-2023 yılları arasında Avrupa Birliği (AB) üye ülkelerinde enflasyon ve işsizliğin kalıcılığını ve histerezis etkilerini incelemektedir. Histerezis, ekonomik şokların uzun vadeli etkilerini vurgulayarak, özellikle para ve maliye politikalarının tasarımıyla geleneksel yaklaşımların ötesine geçilmesi gerektiğini ortaya koymaktadır. Bu bağlamda çalışmada, geleneksel birim kök testlerinin ötesine geçen ve yapısal değişimleri daha esnek bir şekilde yakalayan Fourier KPSS testi ile ECM Bootstrap eşbütünlüşme analizi kullanılmıştır. Elde edilen bulgular, birçok AB ülkesinde enflasyonun kalıcı olduğunu ve Almanya, Macaristan, İrlanda gibi bazı ülkelerde işsizlikte de histerezis etkisinin belirgin olduğunu göstermektedir. Ayrıca, enflasyon ve işsizlik arasında uzun dönemli bir eşbütünlüşme ilişkisinin bulunduğu tespit edilmiştir. Bu durum, geleneksel Phillips Eğrisi yaklaşımını sorgulamakta ve politika yapıcılar açısından ülke bazlı, esnek politika çerçevelerine olan ihtiyacı vurgulamaktadır.

Anahtar Sözcükler : Sürekli Enflasyon, İşsizlik Histerezisi, NAIRU, Avrupa Birliği, Panel Veri Analizi.

1. Introduction

Understanding hysteresis in inflation and labour markets is essential for the EU member states because it challenges the traditional belief that economic shocks have only short-term effects. Instead, hysteresis indicates that disruptions, such as financial crises, pandemics, or structural shifts, can lead to long-lasting changes in unemployment and inflation, making recovery more complicated and uneven across member states. This is particularly important in the EU, where economies vary greatly in labour market flexibility, wage-setting methods, and vulnerability to external shocks. As shown in this study, inflation rates in many EU countries are non-stationary, and unemployment exhibits hysteretic behaviour in several cases, including Germany, Hungary, and Ireland. These results suggest that standard policy tools may be inadequate or inappropriate if they do not consider persistent effects. Therefore, a detailed understanding of hysteresis is vital for creating effective, country-specific monetary and fiscal policies. It also highlights the significance of active labour market policies, structural reforms, and enhanced labour mobility to reduce long-term damage. Ultimately, managing hysteresis is key to maintaining employment stability, price consistency, and fostering deeper economic convergence within the EU.

Focusing on the EU member states is especially relevant in the context of hysteresis because the EU represents a unique economic and institutional environment characterised by a shared monetary policy managed by the European Central Bank (ECB), alongside nationally diverse labour markets and fiscal systems. This structural asymmetry makes the region particularly vulnerable to persistent shocks, as member states lack independent monetary tools to address localised crises. Additionally, the EU has faced multiple major disruptions in recent decades, from the 2008 financial crisis to the sovereign debt crisis and the COVID-19 pandemic, all of which have had uneven and lasting impacts across countries. These events offer valuable opportunities to analyse how inflation and unemployment dynamics change under hysteresis. Furthermore, the EU's focus on convergence and cohesion adds urgency: if hysteresis effects vary greatly across countries, they could threaten broader goals of integration and economic stability. This makes the EU not only a relevant but a crucial case for understanding the long-term impacts of macroeconomic shocks and the limitations of traditional policy responses.

The relationship between inflation and unemployment has long intrigued economists, beginning with Phillips (1958), who identified a non-linear, inverse connection between the two. This concept evolved with contributions from Phelps (1967) and Friedman (1968), who argued that monetary policy could influence unemployment only in the short run, introducing the idea of adaptive expectations and the NAIRU, and who later earned Nobel Prizes. The NAIRU reflects the natural rate of unemployment that does not accelerate inflation, and it is closely linked to hysteresis, in which unemployment or inflation

persistently deviates from its long-run path after a shock (Blanchard & Summers, 1986). In labour markets, this is often driven by structural issues such as reduced bargaining power, high firing costs, or long-term skill erosion among the unemployed. The insider-outsider theory (Blanchard & Summers, 1986; 1987) and wage-setting dynamics (Gottfries & Horn, 1987; Lindbeck & Snower, 2001) explain how insiders maintain job security while outsiders struggle to re-enter the labour market. Critics like Rowthorn (1999) and Haltmaier (2012) argue that demand-side factors also play a role. Meanwhile, prolonged unemployment can reduce employability and suppress deflation, particularly in sluggish economies (Meloni et al., 2022). As Furlanetto et al. (2021) show, employment tends to react more to output declines than productivity shifts, with labour productivity often offsetting demand shocks to maintain stable output per employee.

Fourier analysis is especially effective at identifying hysteresis because it captures smooth, gradual structural changes over time without needing predefined breakpoints, unlike traditional unit root tests. Its flexibility allows it to detect non-linear patterns and ongoing deviations typical of hysteresis. By accurately modelling cyclical and irregular shifts, the Fourier method improves the reliability of stationarity tests, making it particularly useful in complex, evolving economic environments like those of EU member states. What distinguishes this research is its application of the Fourier methodology, addressing a notable gap in the literature by exploring both inflation and unemployment hysteresis within EU member states and their long-run interaction. By incorporating this advanced approach, the study brings a fresh analytical dimension to a topic that has received limited comprehensive treatment. This study employs nonlinear dynamic models to examine the degree of linkage between persistent trends in unemployment and inflation across EU members. The research is organised into three key sections: the first presents an overview of key studies on the EU; the second delves into recent empirical developments; and the third details the research methodology, presents the findings, and explores their policy implications.

2. Empirical Literature

Hysteresis describes a situation where the effects of an economic shock linger even after the initial cause has disappeared. In other words, the system doesn't revert to its previous state but instead settles into a new, altered path. For instance, if a recession causes a sharp increase in unemployment, hysteresis suggests that unemployment could stay high even after economic growth resumes, because long-term joblessness damages workers' skills and discourages participation in the labour market. This concept challenges the traditional view that economies naturally recover to full employment and is especially relevant when examining persistent inflation or unemployment trends in EU member states.

The empirical literature on hysteresis in unemployment across EU member states shows both widespread confirmation and notable differences. Studies such as Jump and Stockhammer (2018) and Caporale et al. (2022) consistently find strong evidence of unemployment persistence using methods such as maximum likelihood estimation and fractional integration, especially after major economic shocks. These results support the

hysteresis hypothesis, which states that unemployment does not automatically return to its natural rate following a shock. However, other research points to significant exceptions.

The presence or absence of hysteresis seems connected to structural features, such as employment protection laws, the strength of collective bargaining, and the effectiveness of activation policies. For example, Mladenovic (2016) and Özdemir (2020) present mixed results for the Eurozone and Central and Eastern European countries, showing that the magnitude and duration of hysteresis effects vary across countries.

Beyond unemployment, recent research highlights hysteresis in inflation dynamics. Reichlin and Zettelmeyer (2024) emphasise that supply-side shocks and structural adjustments, such as those experienced during the COVID-19 pandemic, can entrench inflation expectations if policy responses are delayed or poorly calibrated. These insights reinforce the findings of Meloni et al. (2022), who show that prolonged unemployment reduces employability and can prevent expected deflation from materialising, thus complicating monetary policy responses.

Taken together, these studies underscore that while hysteresis is a widespread phenomenon in the EU, its intensity and persistence are uneven, shaped by country-specific labour market designs, macroeconomic frameworks, and institutional capacities. Understanding these differences is essential for designing effective, tailored policies to counteract long-term economic scarring and support convergence within the EU. Despite this extensive body of literature, several notable gaps persist. First, most studies analyse either inflation or unemployment hysteresis in isolation, often overlooking their potential long-term interdependence. Second, many rely on linear or fractional integration methods, which may fail to capture smooth, gradual structural changes that characterise real-world macroeconomic processes.

In addressing these shortcomings, recent research has increasingly turned to causality and persistence testing frameworks that better account for non-linearities. For example, Jump and Stockhammer (2018) and Caporale et al. (2022) employ panel unit root and long-memory models to test for hysteresis. Similarly, Doganer (2022) utilize unit root tests with structural breaks. However, most of these approaches assume abrupt structural changes or fixed time points of shift. In contrast, the Fourier KPSS test, as implemented in the present study, allows for flexible modelling of smooth structural evolution, thereby capturing gradual transitions and non-linear adjustments without requiring a priori specification of breaks.

Moreover, this study enhances robustness by integrating ECM-based bootstrap cointegration techniques, which are particularly useful in small-sample contexts and account for cross-sectional dependencies typical of interconnected EU economies. Thus, by employing these advanced methods and jointly analysing inflation and unemployment hysteresis in a unified framework, this research offers a more dynamic, realistic, and nuanced understanding of macroeconomic persistence. In doing so, it responds to the critical need for

methodological innovation and comparative depth in the study of hysteresis across heterogeneous EU labour markets.

3. Data & Methodology

The nonlinear Fourier KPSS test and the ECM bootstrap cointegration method are particularly well-suited for analysing hysteresis and asymmetries in macroeconomic time series. The Fourier KPSS test enhances traditional stationarity analysis by allowing for smooth, gradual structural breaks without requiring pre-specified breakpoints. This flexibility makes it especially effective in capturing the slow-moving, non-linear shifts characteristic of hysteresis, which may be driven by institutional reforms, evolving expectations, or gradual policy adjustments. Similarly, the ECM bootstrap cointegration approach offers robust inference in the presence of cross-sectional dependence and small sample biases, enabling a reliable assessment of long-run relationships between inflation and unemployment across heterogeneous EU economies. These methods are critical for uncovering subtle but persistent patterns that conventional linear models may overlook.

The data used in this study were obtained from the World Bank's World Development Indicators database and consist of annual observations on inflation and unemployment for EU member states from 1991 to 2023. Data before 1991 were unavailable or incomplete for many countries, particularly those that underwent major structural transitions or joined the EU later, thereby limiting the temporal scope of the analysis but ensuring consistency and comparability across the panel.

The model is represented as follows:

$$U_t = U_{t-1} + e_t \quad (1)$$

Here, U_t represents the unemployment rate at a given time, and e_t denotes the error term, which captures any external shocks to the unemployment rate.

The equation of expectations is:

$$E_{t-1}(U_{t+\tau}) = U_{t-1} \quad (2)$$

For all ($\tau = 0, 1, \dots$), the expected value based on observations at time ($t-1$) is expressed as (E_{t-1}). Any temporary shock to the unemployment variable is represented by e_t , which leads to a lasting break in the expected unemployment rate. Consequently, $E_{t-1}(U_{t+\tau})$ does not return to its pre-shock level, reflecting the presence of hysteresis and the persistence of unemployment shocks over time.

In contrast, in a non-hysteretic model, U_t follows a stationary process. For large τ values, the expected unemployment rate remains constant and equal to the NAIRU represented by $E_{t-1}(U_{t+\tau}) = U_{t-1}$.

Phillips indicates that the connection between inflation and the unemployment rate is given by (Santomero & Seater, 1978):

$$D_w/w = bU^c \quad (3)$$

The Phillips curve, with “w” denoting the gross wage rate and the unemployment rate always positive, cannot be linear, as unemployment cannot take negative values.

The impact of unit roots in economic time series has been widely studied by Taylor (1989), Lee and Enders (2004), and Becker et al. (2004, 2006), who emphasise that breaks and shocks can cause persistent deviations from long-term trends. To address this, traditional unit root tests evolved to account for these structural changes, first by detecting level or trend breaks, and later by using the Fourier method, which models gradual shifts through frequency selection rather than specific break dates.

Enders and Lee (2012) introduced the Fourier KPSS test for single-frequency analysis, and Karul (2016) expanded it to multiple frequencies, improving the detection of structural changes. The panel test statistic is computed by averaging individual LM statistics across countries. Statistics are established via Monte Carlo simulations, with results showing that the test's asymptotic distribution depends on the frequency parameter (k). The Akaike Information Criterion typically guides frequency selection, with lower k values preferred to capture structural shifts, as highlighted by Becker et al. (2004).

In the Fourier KPSS framework, the null hypothesis (H_0) assumes stationarity, while the alternative hypothesis (H_1) indicates non-stationarity and the presence of a unit root. Therefore, rejection of the null hypothesis provides evidence in favour of hysteresis. The LM statistics are calculated for each cross-sectional unit and evaluated using the critical values reported by Becker et al. (2006). Since hysteresis implies the persistence of shocks over time, rejection of stationarity is interpreted as evidence supporting the hysteresis hypothesis.

Table: 1
Preliminary Test Outcomes

Delta Test (INF and UNP)	T-stats.	p-value
$\hat{\Delta}$ (small sample)	2.791	0.003*
$\hat{\Delta}_{adjusted}$	2.932	0.002*
CDLM Test (UNP)	T-stats.	p-value
(Breusch & Pagan, 1980) LM	43.252	0.003*
(Pesaran-2004)-CDLM1	3.434	0.000*
(Pesaran-2004)-CDLM2	-3.762	0.000*
(Pesaran et al. 2008)Bias-adjCD	-0.877	0.810
CDLM Test (INF)	T-stats.	p-value
(Breusch & Pagan, 1980) LM	57.224	0.000*
(Pesaran-2004)-CDLM1	5.589	0.000*
(Pesaran-2004)-CDLM2	-3.622	0.000*
(Pesaran et al. 2008)Bias-adjCD	2.749	0.000*

* indicates statistical significance at the 5%. Table 1 presents the preliminary test results assessing the stationarity and cross-sectional dependence of inflation (INF) and unemployment (UNP) across EU member states from 1991 to 2023.

The Delta test statistics for both variables are statistically significant at the 1% level ($p < 0.01$). The significant Delta statistics reject the null hypothesis of slope homogeneity and indicate cross-sectional heterogeneity among EU member states. Cross-sectional dependence is also strongly evident. For unemployment, the Breusch-Pagan LM and Pesaran's CDLM1 and CDLM2 tests yield significant results ($p < 0.01$), although the bias-adjusted CD test is not statistically significant. In contrast, all four tests for inflation, including the bias-adjusted CD test, indicate significant cross-sectional dependence ($p < 0.001$). These findings confirm that macroeconomic variables in EU countries are not only persistent over time but also interdependent across borders, justifying the use of second-generation panel methods that account for both non-stationarity and cross-country spillovers in the analysis of hysteresis.

Table: 2
Fourier KPSS Test Result for Inflation (Consumer Prices % Annual)

Countries	intercept (k=1)	int. & trend (k=1)	intercept (k=2)	int. & trend (k=2)	intercept (k=3)	int. & trend (k=3)
Austria	0.1596	0.0371	0.3110	0.0584	0.3915	0.1160
Belgium	0.1530	0.0439	0.1003	0.0852	0.1501	0.1211
Bulgaria	0.0672	0.0602	0.3285	0.1251	0.1888	0.0431
Croatia	0.1468	0.0418	0.0762	0.0877	0.0758	0.1104
Cyprus	0.0670	0.0472	0.1463	0.0576	0.1235	0.0449
Czechia	0.1423	0.0443	0.1490	0.1128	0.1695	0.1289
Denmark	0.0583	0.0529	0.0392	0.0342	0.0549	0.2299
Estonia	0.1314	0.0370	0.0970	0.0802	0.1446	0.1082
France	0.1826*	0.0353	0.1998	0.0698	0.1610	0.0478
Finland	0.1275	0.0279	0.1084	0.0798	0.1698	0.1174
Germany	0.0532	0.0422	0.2506	0.0558	0.1837	0.0821
Greece	0.0805	0.0423	0.0479	0.0486	0.0615	0.1116
Hungary	0.0641	0.0492	0.2262	0.0643	0.0859	0.0910
Ireland	0.2683*	0.0651	0.1920	0.1634	0.2153	0.1441
Italy	0.1074	0.0945	0.1194	0.0966	0.2022	0.1402
Latvia	0.0802	0.0424	0.0477	0.0484	0.0611	0.0672
Lithuania	0.1055	0.0413	0.1199	0.0953	0.2028	0.1115
Luxembourg	0.1296	0.0472	0.0802	0.0847	0.0932	0.1368
Malta	0.2060*	0.0567	0.1717	0.0821	0.1122	0.0287
Netherlands	0.1580	0.0458	0.1190	0.0927	0.1724	0.1466
Poland	0.0723	0.0565	0.2928	0.0749	0.1442	0.0666
Portugal	0.1010	0.0288	0.0991	0.0712	0.1576	0.1341
Romania	0.0660	0.0426	0.2536	0.0345	0.2425	0.1018
Slovenia	0.1232	0.0265	0.1000	0.0753	0.1679	0.1214
Slovak Rep.	0.0922	0.0572	0.1792	0.1555	0.1679	0.0696
Spain	0.2824*	0.0690	0.1506	0.1651	0.1669	0.1313
Switzerland	0.1192	0.0416	0.1750	0.0539	0.1839	0.0441
Sweden	0.1695	0.0304	0.1257	0.1059	0.1726	0.1465
Probability Values	0.0000*	0.0000*	0.3050	0.0000*	0.4558	0.0000*
Panel Stat. F-KPSS	5.8669	6.9734	0.5102	4.3666	0.1110	5.7941

* indicates statistical significance at the 5% level based on critical values from Becker et al. (2006). Panel test statistics are calculated using the Bartlett Kernel and assume normality, according to Becker et al. (2006: 389, Table 1). For the model with an intercept, the critical values at the 5% significance level are 0.1720 for $k=1$, 0.4152 for $k=2$, and 0.4480 for $k=3$. For the model with c and t (trend), the critical values at the 5% significance level are 0.0546 for $k=1$, 0.1321 for $k=2$, and 0.1423 for $k=3$.

Table 2 reports the results of the Fourier KPSS panel stationarity tests for inflation across EU member states under alternative frequency specifications ($k = 1, 2$, and 3) and model forms including intercept and intercept with trend. Since the null hypothesis of the Fourier KPSS test assumes stationarity, statistically significant test statistics imply rejection of stationarity and support the presence of inflation hysteresis.

At the panel level, the Fourier KPSS statistics are statistically significant in most model specifications, particularly for the models with trend components. These findings indicate that inflation does not follow a stationary process across the EU member states and that inflationary shocks tend to have persistent effects over time. Therefore, the results provide strong evidence in favour of inflation hysteresis at the panel level.

The findings suggest that inflation dynamics within the EU are characterised by long-lasting responses to macroeconomic shocks rather than rapid adjustment toward equilibrium. This persistence may reflect structural rigidities, evolving inflation expectations, and country-specific institutional factors. Overall, the results support the view that inflationary disturbances in EU member states are not purely temporary and may generate lasting effects on macroeconomic performance.

Table: 3
Fourier KPSS test results for Unemployment

Countries	Intercept (k=1)	int. & trend (k=1)	intercept (k=2)	int. & trend (k=2)	intercept (k=3)	int. & trend (k=3)
Austria	0.0945	0.0286	0.2995	0.0802	0.3870	0.0792
Belgium	0.1619	0.0365	0.2797	0.0401	0.4325	0.0534
Bulgaria	0.0441	0.0417	0.2356	0.0601	0.2981	0.0545
Croatia	0.0570	0.0514	0.0939	0.0896	0.1133	0.0813
Cyprus	0.1404	0.0301	0.4243*	0.1189	0.4720*	0.1056
Czechia	0.1371	0.0455	0.3660	0.2333	0.3392	0.1847
Denmark	0.0760	0.0615	0.3685	0.1136	0.4459	0.1121
Estonia	0.2391	0.0570	0.3809	0.1188	0.4012	0.1220
France	0.1172	0.0573	0.3043	0.1591	0.3994	0.1578
Finland	0.1667	0.0488	0.2707	0.0787	0.3548	0.1014
Germany	0.2407*	0.0346	0.3303	0.1645	0.3517	0.1613
Greece	0.0449	0.0398	0.4408*	0.1642	0.3279	0.1818
Hungary	0.2028*	0.0277	0.4063	0.1339	0.4911*	0.1468
Ireland	0.2566*	0.0509	0.2096	0.1448	0.2756	0.1567
Italy	0.2032*	0.0528	0.4518*	0.1773	0.4370	0.1740
Latvia	0.1117	0.0483	0.2120	0.0374	0.4133	0.0413
Lithuania	0.2028	0.0403	0.5022	0.1614	0.6120*	0.1722
Luxembourg	0.0947	0.0599	0.4815*	0.1171	0.2251	0.1121
Malta	0.2651*	0.0430	0.5710*	0.1862	0.5444*	0.1863
Netherlands	0.0291	0.0210	0.4203*	0.1988	0.4608*	0.2072
Poland	0.2648*	0.0592	0.2882	0.1410	0.2943	0.1414
Portugal	0.0888	0.0469	0.5461*	0.0486	0.6158*	0.0608
Romania	0.1019	0.0501	0.4196*	0.1299	0.5506*	0.1251
Slovenia	0.1957*	0.0519	0.5250*	0.0857	0.5403*	0.0929
Slovak Rep.	0.3016*	0.0496	0.3092	0.1896	0.3158	0.1781
Spain	0.1093	0.0566	0.2168	0.1338	0.2315	0.1241
Switzerland	0.0361	0.0361	0.1581	0.0418	0.2275	0.0415
Sweden	0.0748	0.0376	0.2831	0.1258	0.3422	0.1412
Probability Values	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Panel Stat. F-KPSS	7.7776	6.3564	8.3297	9.8076	8.7234	8.3396

Table 3 reports the results of the Fourier KPSS stationarity tests for unemployment across EU member states, using models with an intercept and trend for different frequencies ($k = 1, 2, 3$). The null hypothesis of the KPSS test assumes stationarity; rejection implies non-stationarity, indicating hysteresis. Panel-level probability values for all models (across $k = 1, 2$, and 3 , both intercept-only and trend-included) are all significant at the 1% level ($p < 0.01$), rejecting the stationarity hypothesis and suggesting widespread evidence of non-stationarity and potential hysteresis in unemployment across the EU. However, when

analysing individual country-level results, several exceptions emerge. Countries such as Germany, Hungary, Ireland, Italy, Malta, Slovenia, and Poland consistently show statistically significant KPSS values that exceed critical thresholds (e.g., > 0.172 for the intercept model with $k=1$ at the 5% level), indicating strong evidence of unemployment hysteresis. In contrast, countries like Austria, Belgium, and the Netherlands show lower KPSS statistics, failing to reject the null in some model variants, implying stationary behaviour and supporting the NAIRU hypothesis. The significance of * (at the 5% level) highlights these individual deviations. Overall, the results reveal that while the average panel behaviour points toward hysteresis, the phenomenon is not uniform; it varies significantly by country and model specification, underlining the importance of structural and institutional differences across EU labour markets.

Table: 4
ECM Boot Co-Integration Test Results for the Intercept and Trend Model

For all models	t-statistics	Bootstrap P. Values
g_t Group mean	-10.440	0.019*
g_a Group mean	-11.695	0.040*
p_t Panel	-10.140	0.002*
p_a Panel	-17.056	0.002*

* indicates statistical significance at the 5%.

The Error Correction Mechanism (ECM) cointegration test (Westerlund, 2007) evaluates whether a stable long-run interaction of variables exists over time and across different cross-sectional entities. According to Westerlund (2007), the null hypothesis posits the absence of cointegration. However, the bootstrap results at the 5% threshold reject this assumption, indicating a lasting connection between inflation and unemployment across EU member states. These outcomes challenge conventional perspectives by confirming an enduring relationship, further reinforced by unit root tests that highlight structural shifts in both variables over time.

4. Conclusion

This study provides strong empirical evidence that inflation in the EU member states demonstrates persistent, non-stationary behaviour, supporting the hysteresis hypothesis across most member states. While unemployment appears stationary in some country-specific specifications, several EU member states, including Germany, Hungary, Ireland, Italy, Malta, Poland, and Slovenia, exhibit significant evidence of unemployment hysteresis, indicating that the effects of macroeconomic shocks may persist in labour markets over the long run. These results contrast with the traditional NAIRU-based expectation of mean reversion and instead align with recent findings by Caporale et al. (2022) and Meloni et al. (2022), who argue that structural changes and long-term scarring increasingly shape macroeconomic variables in Europe. The confirmation of a stable long-run cointegration relationship between inflation and unemployment across the EU member states further challenges the conventional Phillips Curve framework, reinforcing the need to reconsider short-termist models of stabilisation.

A central contribution of this study lies in its methodological innovation. By applying the Fourier KPSS test and ECM bootstrap cointegration analysis, we can capture smooth, nonlinear structural changes that are often missed by traditional unit root and cointegration tests. Unlike earlier works that tend to treat inflation and unemployment separately, this study integrates both dimensions to reveal how their joint persistence complicates macroeconomic management. Furthermore, by disaggregating country-level results, we demonstrate the heterogeneity of hysteresis effects within the EU member states, a nuance often overlooked in studies that focus on aggregate or regional averages. This granular approach allows for more precise interpretation and supports the call for differentiated, context-specific policy responses.

In light of these findings, several key economic policy recommendations emerge for EU member states. First, monetary policy, especially under the European Central Bank's unified framework, should be more responsive to structural inflation dynamics. Inflation targeting must be supplemented with tools that address supply-side constraints and persistent shocks, such as investment in energy resilience, housing supply, and technological infrastructure. Second, countries exhibiting unemployment hysteresis should prioritise active labour market policies, including retraining programs, mobility support, and incentives for the reintegration of the long-term unemployed. Labour market duality, such as the divide between permanent and temporary contracts, should be minimised to avoid locking workers out of recovery. Moreover, the European Commission should consider revising fiscal rules to allow greater counter-cyclical space for member states facing persistent macroeconomic imbalances, especially amid high debt levels and structural unemployment.

Future research should deepen the exploration of institutional and structural factors that drive heterogeneity in hysteresis effects across countries. Specifically, the interaction between monetary policy frameworks, wage-setting institutions, and labour market regulations warrants further examination. There is also scope for studying how digital transformation, automation, and climate transition policies affect inflation-unemployment dynamics in the long run. Expanding the dataset beyond 2023 and integrating quarterly or sectoral data could improve the temporal and thematic granularity of the analysis. Ultimately, as the EU members continue to navigate post-crisis recovery and long-term transformation, understanding the persistent effects of shocks on macroeconomic variables remains critical for designing inclusive and resilient policy responses.

References

- Becker, R. et al. (2004), "A general test for time dependence in parameters", *Journal of Applied Econometrics*, 19(7), 899-906.
- Becker, R. et al. (2006), "A stationarity test in the presence of an unknown number of smooth breaks", *Journal of Time Series Analysis*, 27(3), 381-409.
- Blanchard, O.J. & L.H. Summers (1986), "Hysteresis and the European Unemployment Problem", in: S. Fischer (ed.), *NBER Macroeconomics Annual 1986 Vol. 1* (15-90), MIT Press.

- Blanchard, O.J. & L.H. Summers (1987), "Hysteresis in unemployment", *European Economic Review*, 31(1-2), 288-295.
- Breusch, T.S. & A.R. Pagan (1980), "The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics", *The Review of Economic Studies*, 47(1), 239-253.
- Caporale, G.M. et al. (2022), "Unemployment persistence in Europe: Evidence from the 27 EU member states", *Heliyon*, 8(2), e08898.
- Doganer, A. (2022), "Determining Unemployment Hysteresis in European Countries Using Linear and Nonlinear Unit Root Tests: The 1991-2020 Period", *Istanbul Journal of Economics*, 72(2), 753-785.
- Enders, W. & J. Lee (2012), "A unit root test using a Fourier series to approximate smooth breaks", *Oxford Bulletin of Economics and Statistics*, 74(4), 574-599.
- Friedman, M. (1968), "The role of monetary policy", *American Economic Review*, 58(1), 1-17.
- Furlanetto, F. et al. (2021), "Estimating hysteresis effects", *CEPR Discussion Paper No. DP16558*.
- Gottfries, N. & H. Horn (1987), "Wage formation and the persistence of unemployment", *The Economic Journal*, 97, 877-884.
- Haltmaier, J. (2012), "Do recessions affect potential output?", *International Finance Discussion Papers*, No. 1066.
- Jump, R.C. & E. Stockhammer (2018), "New evidence on unemployment hysteresis in the EU", *EUROF18 Euroframe*, Conference Sessions, January 12.
- Karul, Ç. (2016), "Esnek Fourier fonksiyonlu yeni bir panel birim kök testi önerisi ve OECD örneği", *Master's Thesis*, Denizli: Pamukkale Üniversitesi.
- Lee, J. & W. Enders (2004), "Testing for a unit root with a nonlinear Fourier function", in: *Econometric Society 2004 Far Eastern Meetings 457*, Econometric Society.
- Lindbeck, A. & D. Snower (2001), "Insiders versus outsiders", *Journal of Economic Perspectives*, 15(1), 165-188.
- Meloni, W.P. et al. (2022), "Inflation and the NAIRU: Assessing the role of long-term unemployment as a cause of hysteresis", *Economic Modelling*, 113, 105900.
- Mladenović, Z. (2016), "Econometric testing of unemployment hysteresis in selected CEE countries: Lessons for the Serbian economy", *Ekonomika Preduzeća*, 64(7-8), 403-413.
- Özdemir, O. (2020), "Hysteresis in unemployment: New evidence from 19 Euro area countries", *International Journal of Entrepreneurship and Management Inquiries*, 4(7), 101-124.
- Pesaran, H.M. & T. Yamagata (2008), "Testing slope homogeneity in large panels", *Journal of Econometrics*, 142(1), 50-93.
- Pesaran, H.M. (2004), "General diagnostic tests for cross-section dependence in panels", *Cambridge Working Papers in Economics*, No. 0435.
- Phelps, E.S. (1967), "Phillips curves, expectations of inflation and optimal unemployment over time", *Economica*, 34(3), 254-281.
- Phillips, A.W. (1958), "The relation between unemployment and the rate of change of money wage rates in the United Kingdom: 1861-1957", *Economica*, 25(2), 283-299.
- Reichlin, L. & J. Zettelmeyer (2024), "The European Central Bank must adapt to an environment of inflation volatility", *Bruegel Policy Brief*, <<https://www.bruegel.org/analysis/european-central-bank-must-adapt-environment-inflation-volatility>>, 02.03.2025.

- Rowthorn, R. (1999), "Unemployment, wage bargaining, and capital-labour substitution", *Cambridge Journal of Economics*, 23(4), 413-425.
- Santomero, A.M. & J.J. Seater (1978), "The inflation-unemployment trade-off: A critique of the literature", *Journal of Economic Literature*, 16(2), 499-544.
- Taylor, J. (1989), "The evolution of ideas in macroeconomics", *The Economic Record*, 65(2), 185-189.
- Westerlund, J. (2007), "Panel cointegration tests of the Fisher effect", *Journal of Applied Econometrics*, 23(2), 193-233.
- World Bank Group (N/A), *DataBank, World Bank Development Indicators (WDI)*, <<https://databank.worldbank.org/source/world-development-indicators>>, 02.03.2025.