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Validity of the Phillips Curve in OECD Countries: Panel Data Analysis

Araştırma Makalesi /Research Article

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ABSTRACT: *The main objective of the study is to analyze the validity of the Phillips curve for 38 OECD countries using annual unemployment rate and inflation rate data covering the period 1991-2023. For this purpose, in the analysis part of the study, the cointegration relationship between unemployment and inflation variables is tested with the Panel Fourier cointegration test. Panel IFE method was used for the long-run coefficient estimates between the variables. According to the results of the analysis, it is concluded that there is an econometrically significant and negative relationship between inflation and unemployment variables. Therefore, it is determined that the Phillips curve is valid for OECD countries. Based on the findings, policymakers in OECD countries should consider the inflation risk when implementing expansionary policies to reduce unemployment or be prepared for an increase in unemployment when implementing contractionary policies to reduce inflation.*

Keywords: *Inflation, Unemployment, Phillips Curve, Panel Data Analysis.*

OECD Ülkelerinde Phillips Eğrisinin Geçerliliği: Panel Veri Analizi

ÖZ: *Çalışmanın temel amacı, 1991-2023 dönemini kapsayan yıllık işsizlik oranı ve enflasyon oranı verilerini kullanarak 38 OECD ülkesi için Phillips eğrisinin geçerliliğini analiz etmektir. Bu amaçla çalışmanın analiz kısmında, işsizlik ve enflasyon değişkenleri arasındaki eşbütünleşme ilişkisi Panel Fourier eşbütünleşme testi ile test edilmiştir. Değişkenler arasındaki uzun dönem katsayı tahminleri için Panel IFE yöntemi kullanılmıştır. Analiz sonuçlarına göre, enflasyon ile işsizlik değişkenleri arasında ekonometrik olarak anlamlı ve negatif bir ilişkinin olduğu sonucuna ulaşılmıştır. Dolayısıyla OECD ülkeleri için Phillips eğrisinin geçerli olduğu tespit edilmiştir. Bulgulardan hareketle OECD ülkelerinde politika yapıcılar işsizliği azaltmak için genişletici politikalar uygularken enflasyon riskini göz önünde bulundurmalı veya enflasyonu düşürmek için daraltıcı politikalar uygularken işsizlik artışına hazırlıklı olmalıdır.*

Anahtar Kelimeler: *Enflasyon, İşsizlik, Phillips Eğrisi, Panel Veri Analizi.*

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1. Introduction

Unemployment and inflation are critical economic challenges faced by both developed and developing countries. Unemployment occurs when individuals actively seeking employment are unable to find suitable jobs. Inflation, on the other hand, refers to a sustained increase in the general price level. The Phillips Curve (PC), which posits an inverse relationship between inflation and unemployment, highlights the difficulty of simultaneously addressing these two intertwined economic issues.

The theoretical underpinnings of the PC can be traced back to A.W. Phillips' (1958) seminal work, which observed an inverse relationship between wage growth and unemployment. Lipsey (1960) further refined this concept by linking it to labor market dynamics, particularly excess demand for labor. Subsequently, Samuelson and Solow (1960) extended Phillips' work by translating the relationship between wage growth and unemployment into a relationship between inflation and unemployment (Kırca and Canbay, 2020: 132). The PC hypothesis asserts that inflation rates will rise if unemployment rates are reduced, while inflation rates will fall if unemployment rates are increased. This led to a debate that would continue for years (Şeker, 2023: 457).

The original PC proposed by Phillips (1958) suggested an inverse relationship between inflation and unemployment. However, with the inclusion of inflation expectations in the model by Phelps (1967) and Friedman (1968), the "natural rate of unemployment" concept emerged and the inflation-unemployment relationship began to be decomposed into short and long run (Işık, 2024: 256). In the 1970s, the "stagflation" period in which unemployment and inflation increased simultaneously questioned the validity of the PC. In this period, especially Monetarist economists began to argue that the PC was valid in the short run but not in the long run (Tabar and Çetin, 2016: 80-81).

New Classical economists believe that people generally make the right decisions in economic matters. Even if they make mistakes, they learn from these mistakes and do not repeat them. According to this view, although there is an inverse relationship between inflation and unemployment in the short run, this relationship weakens in the long run. However, unexpected economic policies can affect unemployment (Ekinci et al., 2023: 88-89).

Different schools of economic thought offer varying perspectives on the long-run implications of the PC. New Keynesian economics posits a vertical long-run PC, suggesting no trade-off between inflation and unemployment. In contrast, Post Keynesian economists propose a convex long-run relationship. Conversely, Rational Expectations theory contends that the PC is invalid in both the short and long run (Buyrukoğlu and Mercan, 2022: 1511).

By the definition of the PC, since it is difficult to tackle inflation and unemployment problems at the same time, countries have been struggling with these two fundamental problems for years and have had to develop their policies. For this purpose, the aim of this study is to analyze the validity of the PC by using annual unemployment and inflation data covering the period 1991-2023 for 38 Organisation for Economic Co-operation and Development (OECD) countries. In this context, in the analysis part of the study, cross-sectional dependence and homogeneity tests were first applied to the variables, and unit root analysis was performed with Cross-sectionally Augmented Dickey-Fuller (CADF) Panel unit root test. The cointegration relationship between unemployment and inflation variables is analyzed with the Panel Fourier cointegration test developed by Olayeni et al. (2021). In the last step, the long-run cointegration coefficient estimates between the variables are performed with the Interactive Fixed Effects (IFE) estimator developed by Bai (2009).

In the economic literature, studies on the existence of the PC, which posits a negative relationship between inflation and unemployment rates, present both supportive and critical results. The results of studies by Hsing (1989), Hindrayanto et al. (2019), Ho and Iyke (2019), Bozma et al. (2020), Lisani et al. (2020), Şengönül and Tekgün (2021), Popescu and Diaconu (2022), and Aginta (2023) support the PC, while the studies by Kırca and Canbay (2020), Uğur (2021), and Bozkaya (2023) do not support the PC in general across the panel.

This study offers significant, original contributions to the literature and stands apart from other works. Firstly, this topic has not been sufficiently focused on in the literature in the context of OECD countries recently. The CADF Panel unit root test used in the study was particularly preferred because it provides stronger results by taking into account the cross-sectional dependence often observed in panel data, while the new generation Panel Fourier cointegration test was chosen for its ability to better capture structural breaks and low-frequency changes. Additionally, the use of a contemporary method such as the Panel Fourier cointegration test brings a new perspective to the PC literature, helping to uncover previously overlooked potential cointegration relationships. This comprehensive and up-to-date econometric approach allows the study to make a significant contribution to the existing literature and to provide clearer and more reliable results regarding the validity of the PC in OECD countries.

The study consists of five main sections. After the introduction, there are national and international empirical studies on the PC, followed by a section explaining the data set and methodology, and then the results obtained from the econometric analysis. The study is concluded with a concluding section and policy recommendations.

2. Literature Review

In this section of the study, empirical studies on the validity of the PC for individual countries and country groups are presented. In this framework, firstly, empirical studies on individual countries analyzing the PC are summarized chronologically in Table 1.

Table 1: Summary of the Empirical Literature on the PC

Author(s)	Sample	Method	Findings
Özçelik and Uslu (2017)	Türkiye, 2007:1-2014:12	Johansen cointegration, Vector Autoregressive (VAR) analysis and Granger causality test	PC is not valid.
Karahan and Uslu (2018)	Türkiye, 1996-2016	ARDL method and Kalman Filter model	In the long run, the PC is valid.
Maden (2018)	Türkiye, 1980-2016	Engle-Granger cointegration test and Error Correction Model (ECM)	PC is valid.
Ümit and Karataş (2018)	Türkiye, 2000:Q1-2013:Q4	VAR method, Toda-Yamamoto causality test and Impulse-Response analysis	PC is valid in the first two periods.
Dereli (2019)	Türkiye, 1988-2017	ARDL	PC is valid.
Şahin (2019)	Türkiye, 2005:M1-2018:M4	Johansen cointegration test and Granger causality test based on Vector Error Correction Model (VECM)	It shows that there is a bidirectional causality relationship between the variables.
Akiş (2020)	Türkiye, 2005:M1-2020:M2	Johansen cointegration test and Granger causality test based on VECM	In the long run, the PC is valid.
Bokhari (2020)	Kingdom of Saudi Arabia, 1988-2017	Johansen cointegration test and VECM	In the long run, the PC is valid.
Kayacan and Birecikli (2020)	Türkiye, 1998:Q1-2016:Q2	Harvey (2011) Unobservable Component Models	PC is not valid.
Naqibullah et al. (2020)	Malaysia, 1991-2018	ARDL and Granger causality tests	In the long run, the PC is valid.
Yıldırım and Sarı (2021)	Türkiye, 2005:1-2020:8	Fourier Shin cointegration test and DOLS	PC is not valid.
Yıldız (2021)	Türkiye, 2006:1-2020:11	Fourier cointegration and Single Fourier-Frequency Toda-Yamamoto causality tests	PC is not valid.
Ekinci et al. (2023)	Türkiye, 1995-2021	ARDL and VAR Granger causality tests	In the short run, the PC is valid.
Şeker (2023)	Türkiye, 2014:1-2023:7	Nonlinear Autoregressive Distributed Lag (NARDL)	In the long run, the PC is valid.
Işık (2024)	United States of America (USA), 2007:8-2009:6 and 2020:3-2022:5	Toda-Yamamoto and Granger causality tests	PC is not valid.
İlhan (2024)	Türkiye, 2006:1-2023:9	Markov regime-switching model	PC is not valid in both low and high inflation regimes used in the sample.
Tunçsiper and Yamaçlı (2024)	Türkiye, 2010:5-2022:9	Johansen cointegration test, ECM and artificial neural network regression method	PC is valid in the long run, but not in the short run according to the ECM.

Since country groups are analyzed in this study, empirical panel studies on country groups analyzing the validity of the PC are discussed separately. In this context, firstly, the studies that find that the PC is not valid, then the studies that analyze the causality relationship between inflation and unemployment variables, and finally the empirical studies that find that the PC is valid are included.

Esu and Atan (2017) use the Fixed Effects Panel Data Analysis method to investigate the validity of the PC for Sub-Saharan African countries between 1991 and 2015 and find that the PC is not valid for these countries. Alev et al. (2022) examined the validity of the PC using data covering the period 1991-2021 for Türkiye and G7 countries with Emirmahmutoğlu and Köse (2011) panel causality test and found that the PC is not valid across the panel. Kırca and Canbay (2020) examined the relationship between inflation and unemployment using data covering the period 1991-2019 for the Fragile Five countries with Kónya (2006) Panel causality test and found that the PC is not valid. Similarly, Uğur (2021) analyzed the relationship between inflation and unemployment using data covering the period 1993-2018 for BRICS-T countries with the Kónya (2006) panel causality test and found that the PC is not valid in these countries.

Özkök and Polat (2017) examined the causality relationship between inflation and unemployment using data covering the period 1998:Q1-2016:Q1 for G7 countries with Johansen-Fisher panel cointegration and Dumitrescu-Hurlin (2012) causality tests and found a bidirectional causality relationship between the variables. Sasongko et al. (2019) examined the causality relationship between the inflation rate and the open unemployment rate using data covering the period 2013-2017 for the Indonesian economy (33 provinces) using Panel Data Model and Panel Granger causality test and found a unidirectional causality relationship from the inflation rate to the open unemployment rate.

Bildirici and Sonüstün (2018) analyzed the relationship between inflation and unemployment with the ARDL method using data covering the period 1960-2016 for Japan, Türkiye and the USA economy and 1970-2016 for the French economy and found that the PC is valid in the long run in the countries included in the analysis. Hindrayanto et al. (2019) examined the validity of the PC for the Eurozone and its five largest economies (Germany, France, Italy, Spain and the Netherlands) using data covering the period 1985:Q1-2017:Q4 with the unobservable components model and found that the PC is valid in the Eurozone, Germany, France and the Netherlands. Ho and Iyke (2019) tested the validity of the PC with the Pooled Mean Group estimator using data covering the period 1999:1-2017:2 for 11 Eurozone countries and found that the PC is valid in the short and long run. Korkmaz and Abdullazade (2020), using data covering the period 2009-2017 for Australia, Brazil, Canada, France, Germany, Italy, the Russian Federation, Türkiye and the United Kingdom, examined whether there is a relationship between inflation and unemployment rates with the Granger causality test and found that the PC is valid. İspir and Atılgan (2022) examined the validity of the PC for G8 countries between 1993 and 2020 with the Kónya (2006) Panel causality test and found that the PC is valid in G8 countries. Yayar and Tekgün (2022) examined the relationship between unemployment and inflation for the D8 countries between 1996 and 2020 with the Dynamic panel data regression analysis method and found that the PC is valid in the D8 countries. Aginta (2023) tested the validity of the PC for the Indonesian economy (both at provincial and national level) between 2012-2019 with the Dynamic panel analysis method and concluded that the PC is valid in Indonesia. Bozkaya (2023) examined the causality relationship between inflation and unemployment for BRICS countries between 1997-2018 with the Kónya (2006) causality test and the results of the analysis show that the PC is valid only in Russia.

These studies show that the validity of the PC may vary depending on the geographical region, period and econometric method used. It is seen that the Panel Fourier cointegration test introduced to the literature by Olayeni et al. (2021) is not used in the studies. In this respect, this study differs from other studies.

3. Data and Methodology

This paper investigates the validity of the PC in 38 OECD countries using annual data from the World Bank for the period 1991-2023. The analysis starts by assessing cross-sectional dependence and homogeneity, then the CADF panel unit root test is applied to determine the stationarity of the data. Then, the Panel Fourier cointegration test developed by Olayeni et al. (2021) is used to examine the long-run relationship between unemployment and inflation.

Finally, Panel IFE estimator is used for the long-run cointegration coefficient estimates between the variables.

To test the validity of the PC, the inflation rate (INF) is set as the dependent variable and the unemployment rate (UNEMP) as the independent variable. The model equation with all variables can be expressed as a simple linear regression model as follows:

$$INF_{it}= \alpha_{it} + \beta_1 UNEMP_{it} + \varepsilon_{it} \tag{1}$$

In the model, α_{it} represents country-specific fixed effects, β is the slope coefficient, ε_{it} is the error term, t=1991,...,2023 is the time period, i=1,2,3,...,38 is the number of countries, $UNEMP_{it}$ is the unemployment rate and INF_{it} is the inflation rate variable.

3.1. Cross-Section Dependence and Homogeneity Tests

To assess the presence of cross-sectional dependence in panel data analysis, the Breusch-Pagan LM test, developed by Breusch and Pagan (1980), is a widely used statistical method:

$$CD_{LM1} = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \quad (2)$$

The $\hat{\rho}_{ij}^2$ in Equation 2 represents the sample estimate of the pairwise correlations between the variables in the panel data. By testing the assumption that error terms have constant variance, this test helps to assess the validity of the model and to choose the appropriate estimation method.

Pesaran (2004) introduced another test that can be used for large values of *N* and *T*. The test statistic used for the Pesaran (2004) test follows an asymptotically standard normal distribution:

$$CD_{LM2} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T\hat{\rho}_{ij}^2 - 1)\,, N(0{,}1) \quad (3)$$

Where *N* is the number of cross-sectional units and *T* is the time dimension of the panel data. Pesaran (2004) test statistics, called CD_{LM2}, are expressed as a scaled version of CD_{LM1} test statistics (Pesaran, 2004: 5):

Pesaran et al. (2008) addressed the limitations of the traditional LM test for detecting cross-sectional dependence in panel data by developing the LM_{adj} test.

This improved test, which corrects for bias in the original LM test by utilizing the exact mean and variance, exhibits greater sensitivity to cross-sectional independence among error terms.

$$LM_{adj} = \sqrt{\left(\frac{2}{N(N-1)}\right)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \frac{(T-k)\hat{\rho}_{ij}^2 - \mu_{Tij}}{\sqrt{\upsilon_{Tij}}}\,, N(0{,}1) \quad (4)$$

Here k, μ_{Tij} and υ_{Tij} represent the number of regressors, mean and variance, respectively (Altıntaş and Mercan, 2015: 359).

The main hypotheses for cross-sectional dependence are as follows:

H_0: There is no cross-section dependency.

H_1: There is cross-section dependency.

If the probability values of the test statistics exceed the significance levels, the null hypothesis of no cross-sectional dependence cannot be rejected. However, when the probability values fall below the significance levels, the null hypothesis is rejected, indicating the presence of cross-sectional dependence in the series (Demir, 2019: 87).

The test suggested by Pesaran and Yamagata (2008) is used to determine whether the structure between the series is homogeneous:

$$\tilde{\Delta}= \sqrt{N}\left(\frac{N^{-1}\tilde{S}-k}{\sqrt{2k}}\right) \quad (5)$$

$$\tilde{\Delta}_{adj}= \sqrt{N}\left(\frac{N^{-1}\tilde{S}-\mathrm{E}(\tilde{z}_{iT})}{\sqrt{Var(\tilde{z}_{iT})}}\right) \quad (6)$$

In the preceding equations, N denotes the number of cross-sections, k denotes the number of explanatory variables, $\tilde{S}$ and $\tilde{z}_{iT}$ denote the adjusted Swamy test statistic and independent random variables with bounded mean and variation, respectively (Pesaran and Yamagata, 2008).

The hypotheses are formulated as follows: H_0: $\beta_i = \beta$, ∀i Slope coefficients are homogeneous; H_1: $\beta i \neq \beta_j$ Slope coefficients are not homogeneous.

3.2. CADF Panel Unit Root Test

The CIPS statistic, developed by Pesaran (2007), is calculated as the mean of individual CADF test statistics for each country within the panel to assess the presence of a unit root in the overall panel (Pesaran, 2007: 280-281).

The calculated CIPS statistic is compared with the table values in Pesaran's (2007) study. First, the CADF unit root test statistic is calculated for all cross-sectional units and then the CIPS unit root test statistic values are calculated for all units in the panel by taking the arithmetic mean of these test statistics (Yalçınkaya, 2016: 152).

The CADF test statistic is estimated as follows:

$$y_{it} = (1-\phi_i)\mu_i + \phi_i\, y_{i,t-1} + u_{it}, \quad i = 1, \dots, N;\ t = 1, \dots, T \quad (7)$$

Where y_{it} denotes the observation for the i'th cross-sectional unit at time t. u_{it} has a one-factor structure.

$$u_{it} = \gamma_i f_t + \varepsilon_{it} \quad (8)$$

f_t and ε_{it} in Equation 8 represent the unobserved common effect and individual-specific error, respectively.

Equations (7) and (8) can be written as follows:

$$\Delta y_{it} = \alpha_i + \beta_i\, y_{i,t-1} + \gamma_i f_t + \varepsilon_{it} \quad (9)$$

In addition, the unit root test statistics for each cross-section are averaged to obtain the CIPS, which is the unit root test statistic for the panel as a whole. The CIPS statistic is constructed as in Equation 10:

Moreover, the CIPS test proposed by Pesaran (2007) involves calculating the arithmetic mean of the individual CADF test statistics for each country in the panel to determine the presence of a unit root at the panel level.

$$CIPS = N^{-1} \sum_{i=1}^{N} CADF_i \quad (10)$$

After calculating CADF and CIPS values, the hypotheses of the test are established as follows: H_0: The series contains unit root; H_1: The series does not contain unit root.

Compared to the critical values presented in Pesaran (2007), a larger absolute value of the CIPS statistic indicates that the series in the panel do not contain unit roots. In this case, the unit root hypothesis H_0 is rejected and the alternative hypothesis is accepted.

3.3. Panel Fourier Cointegration Test and Panel IFE Method

Due to its robustness to nonlinearity, cross-sectional dependence, and structural breaks of unknown forms and numbers, the Panel Fourier cointegration test developed by Olayeni et al. (2021) offers significant advantages over other cointegration testing methods. Since it has superiority over other test methods, it is preferred in this study. The relationship between $X_{i,t}$ and $Z_{i,t}$ is as follows:

$$X_{i,t} = \beta_{0,i} + \beta_{1,i} Z_{i,t} + v_{i,t} \text{ and} \quad (11)$$

$$v_{i,t} = \rho_i v_{i,t-1} + \varepsilon_{i,t} \quad (12)$$

To implement the resampling routine, Olayeni et al. (2021) follow these steps: Equation 11 is estimated by OLS and $\hat{v}_{i,t}$ residuals are obtained. Using the residuals in equation 11, equation 12 is estimated by OLS. With $\hat{\rho}_i$, we obtain the estimated residuals $\hat{\Phi}_{i,t}$ given by $\hat{\Phi}_{i,t} = \hat{v}_{i,t} - \hat{\rho}_i \hat{v}_{i,t-1}$. Residual-based stationarity is bootstrapped from $\{\hat{\Phi}_{i,t}\}$ with replacement and pseudo residuals $\{\ddot{\Phi}_{i,t}\}$ are calculated. Under the assumption of no cointegration relationship, we calculate the pseudo residual $\ddot{v}_{i,t}$ by summing $\ddot{\Phi}_{i,t}$.

$\ddot{X}_{i,t} = \hat{\beta}_{0,i} + \hat{\beta}_{1,i} \ddot{Z}_{i,t} + \ddot{v}_{i,t}$ to obtain the pseudo series on $\ddot{X}_{i,t}$. Here $\hat{\beta}_{0,i}$ and $\hat{\beta}_{1,i}$ denote the parameter estimates in equation 11. Equation 11 is estimated using $\{\ddot{X}_{i,t}, Z_{i,t}\}$ data. Using equation 12 and $\{v^{\cdots}_{i,t}\}$, $\ddot{\rho}_i$ is estimated. This process is repeated 3-7 B times, with B typically recommended to be set at 399 or 999. To address potential nonlinearity and structural breaks, equation 12 is modified to the form of equation 13. To mitigate the impact of structural breaks, residuals are initially calculated, thereby partially isolating the effects of sudden shifts in the data.

$$\tilde{v}_{i,t} = \hat{v}_{i,t} - \hat{\alpha}_i - \hat{X}_i sin\left(\frac{2\pi kt}{T}\right) - \hat{\varphi}_i cos\left(\frac{2\pi kt}{T}\right) \quad (13)$$

Where k, $\hat{X}$ and $\hat{\varphi}_i$ are the approximation frequency, amplitude and displacement parameters, respectively (Olayeni et al., 2021: 482-483).

After determining the cointegration relationship between the variables in the panel countries, the long-run cointegration coefficient estimates were performed with the Panel IFE method introduced to the literature by Bai (2009). Panel IFE estimator is a powerful econometric method used to estimate cointegration relationships in panel data analysis.

Panel IFE is basically formulated as follows:

$$Y_i = X_i\beta + F\lambda_i + \varepsilon_i \tag{14}$$

In the equation, Y_i is the value of the dependent variable at unit time, X_i is the vector of observable regressors ($k \times 1$), λ_i is the vector of individual factor loadings ($r \times 1$) that are constant over time, F is the vector of unobservable factors ($r \times 1$) that are the same for all individuals, and ε_i is the idiosyncratic error component.

The Panel IFE estimator can provide more consistent and reliable results than traditional panel cointegration estimators, especially in the presence of problems such as cross-sectional dependence, heterogeneity and endogeneity. With these features, the Panel IFE estimator is especially preferred in this study since it is widely used in panel data analyses where long-run relationships are analyzed and complex econometric problems exist.

4. Empirical Findings

This section presents the main findings of the study. First, the results of cross-sectional dependence, homogeneity and CADF panel unit root tests for unemployment and inflation variables are presented. Then, the results of the Panel Fourier cointegration test for the cointegration relationship between the variables and the Panel IFE estimation results for the long-run cointegration coefficient estimates are presented and interpreted.

Table 2: Results of Cross-Sectional Dependence Tests

	Cross-Sectional Dependence LM 1		**Cross-Sectional Dependence LM 2**		**Cross-Sectional Dependence LM 3**		**Cross-Sectional Dependence LM Adjusted**	
Variables	**Test Statistics**	**Prob. Value**	**Test Statistics**	**Prob. Value**	**Test Statistics**	**Prob. Value**	**Test Statistics**	**Prob. Value**
INF	3520.195***	0.000	75.132***	0.000	9.455***	0.000	24.871***	0.000
UNEMP	2984.633***	0.000	60.849***	0.000	-1.845**	0.032	41.064***	0.000

Note: ** and *** Critical values indicate 5% and 1% significance level, respectively.

According to the results of the cross-sectional dependence test applied to inflation and unemployment data in Table 2, the results of all four tests are significant, leading to the conclusion that inflation and unemployment variables are cross-sectionally dependent in OECD countries.

Table 3: Slope Homogeneity Test Results

Slope Homogeneity Test	Test Statistics	Probability Value
Delta Tilde	-2.408	0.992
Delta Tilde Adjusted	-2.525	0.994

Table 4: CADF Panel Unit Root Test Results

	INF		UNEMP	
	Constant	**Constant and Trend**	**Constant**	**Constant and Trend**
Austria	-4.171	-4.334	-2.731	-3.086
Australia	-4.183	-4.187	-2.360	-2.363
Belgium	-3.403	-3.707	-2.984	-3.107
Canada	-3.374	-3.317	-3.778	-3.895
Chile	-4.742	-4.648	-3.649	-3.766
Colombia	-4.504	-4.415	-3.083	-2.968
Costa Rica	-4.593	-4.505	-3.491	-3.358
Czechia	-4.591	-4.629	-3.837	-3.649
Denmark	-3.020	-2.880	-5.057	-5.147
Estonia	-4.570	-4.549	-4.909	-5.107
Finland	-3.551	-3.471	-4.845	-5.637
France	-3.319	-3.461	-3.744	-3.969
Germany	-4.263	-4.177	-2.888	-3.050
Greece	-4.279	-4.260	-2.916	-3.179
Hungary	-4.064	-4.018	-2.960	-3.056
Iceland	-4.475	-4.643	-2.890	-3.549
Ireland	-4.201	-4.331	-2.870	-3.330
Israel	-4.165	-4.488	-3.535	-4.187
Italy	-3.852	-4.024	-4.504	-4.752
Japan	-3.816	-3.981	-5.440	-5.622
Korea Republic	-3.773	-3.868	-4.549	-4.451
Latvia	-3.759	-3.867	-4.225	-4.127
Lithuania	-3.536	-3.691	-3.159	-3.097
Luxembourg	-3.751	-3.965	-2.630	-2.581
Mexico	-3.836	-3.933	-2.863	-2.809
Netherlands	-3.759	-4.252	-3.470	-3.468
New Zealand	-4.116	-4.363	-4.010	-4.032
Norway	-3.303	-3.259	-5.130	-5.033
Poland	-3.899	-3.811	-4.852	-4.849
Portugal	-3.917	-3.832	-5.319	-5.580
Slovak Republic	-5.201	-5.203	-5.775	-5.756
Slovenia	-3.412	-3.721	-5.338	-5.231
Spain	-3.546	-3.844	-6.216	-6.094
Sweden	-3.749	-4.227	-6.671	-6.531
Switzerland	-5.969	-6.081	-4.395	-4.430
Türkiye	-3.671	-3.647	-4.053	-4.328
United States	-3.826	-3.949	-3.619	-4.517
United Kingdom	-4.951	-5.027	-3.112	-3.799
CIPS Stat.	-4.171***	-4.334***	-2.731***	-3.086***

Notes: *** , ** and * Critical values indicate 1%, 5% and 10% significance level, respectively. For the model with constant, 1%, 5% and 10% critical values are -2.23, -2.11 and -2.05, respectively. 1%, 5% and 10% critical values for the model with constant and trend are -2.72, -2.60 and -2.55, respectively (Pesaran, 2007: 280-281).

Homogeneity test was conducted to investigate the homogeneity of the slope coefficients and the probability values were found to be insignificant (Table 3). Therefore, the null hypothesis that the slope coefficients are heterogeneous is not accepted and it is concluded that the slope coefficients are homogeneous.

Table 5: Panel Fourier Cointegration Test Results

	GLS					PP				
	Test Statistics	**%1 CV.**	**%5 CV.**	**%10 CV.**	**k**	**Test Statistics**	**%1 CV.**	**%5 CV.**	**%10 CV.**	**k**
Austria	-5.385***	-2.179	-1.554	0.308	0.1	-5.366***	-2.364	-1.668	0.587	0.1
Australia	-5.295***	-2.579	-1.759	-0.169	1.9	-5.275***	-2.750	-1.765	0.387	1.9
Belgium	-4.163***	-2.414	-1.698	-0.958	0.1	-4.885***	-2.853	-2.200	-0.897	0.1
Canada	-5.666***	-2.700	-1.869	-0.164	1.9	-4.811***	-2.987	-1.930	0.294	1.9
Chile	-5.925***	-2.903	-1.541	0.510	1.9	-6.610***	-3.179	-1.773	1.840	1.9
Colombia	-5.701***	-2.719	-1.449	1.156	0.1	-9.490***	-3.035	-1.958	1.743	0.1
Costa Rica	-3.326***	-2.809	-1.959	-0.520	1	-4.253***	-2.684	-1.999	-0.650	1
Czechia	-2.879**	-2.881	-1.552	-0.588	0.1	-4.916***	-2.978	-2.064	-0.642	0.1
Denmark	-5.230***	-2.614	-1.019	1.280	1.9	-5.210***	-2.527	-1.188	2.213	1.9
Estonia	-4.372***	-2.267	-1.568	-0.154	0.8	-4.152***	-2.887	-1.830	-0.406	0.8
Finland	-5.191***	-2.719	-1.652	-0.546	0.1	-5.122***	-2.731	-1.791	-0.470	0.1
France	-4.451***	-2.535	-1.590	-0.340	0.1	-4.355***	-2.762	-1.799	-0.324	0.1
Germany	-4.905***	-2.831	-1.945	-0.848	1.7	-4.799***	-3.296	-2.370	-0.087	1.7
Greece	-4.775***	-2.804	-1.431	0.619	1.5	-8.395***	-2.989	-1.723	1.084	1.5
Hungary	-4.061***	-2.772	-1.687	-0.330	1	-6.890***	-2.955	-1.876	-0.722	1
Iceland	-4.947***	-2.366	-1.254	1.257	1.7	-6.269***	-2.691	-1.716	0.828	1.7
Ireland	-5.028***	-2.445	-1.135	0.417	1	-5.262***	-2.891	-1.446	0.250	1
Israel	-3.147***	-2.713	-1.777	-0.614	0.1	-5.880***	-3.588	-2.184	-0.743	0.1
Italy	-4.642***	-2.419	-1.220	1.011	0.1	-6.166***	-2.917	-1.469	1.626	0.1
Japan	-4.388***	-2.697	-1.659	0.283	0.1	-2.654***	-2.886	-2.118	-0.533	0.1
Korea, Rep.	-5.327***	-2.325	-1.397	0.344	0.1	-9.865***	-2.904	-1.699	1.317	0.1
Latvia	-4.413***	-2.831	-1.751	-0.032	1.9	-4.406***	-2.757	-1.951	-0.177	1.9
Lithuania	-3.661***	-2.420	-1.748	-0.737	0.1	-3.708***	-2.767	-1.868	-0.571	0.1
Luxembourg	-6.176***	-3.663	-2.337	-0.233	1.9	-7.422***	-3.691	-2.488	-0.080	1.9
Mexico	-2.783***	-2.170	-1.143	1.080	0.1	-3.854***	-2.324	-1.369	1.305	0.1
Netherlands	-4.977***	-2.175	-1.186	0.409	0.1	-4.991***	-2.378	-1.574	0.639	0.1
New Zealand	-5.061***	-2.567	-1.699	-0.300	1.9	-5.282***	-2.613	-1.732	-0.288	1.9
Norway	-4.991***	-2.676	-1.550	0.542	0.1	-5.037***	-2.754	-1.617	1.495	0.1
Poland	-5.300***	-2.844	-1.931	-0.832	0.1	-5.427***	-3.108	-2.131	-1.103	0.1
Portugal	-4.417***	-2.180	-1.292	1.047	1.9	-4.578***	-2.539	-1.483	1.124	1.9
Slovak Rep.	-2.148**	-2.613	-1.705	-0.420	0.1	-4.417***	-3.397	-2.219	-1.063	0.1
Slovenia	-4.454***	-2.359	-1.372	-0.297	1.7	-3.103***	-2.750	-1.685	-0.489	1.7
Spain	-3.019***	-2.040	-1.130	0.844	0.1	-4.768***	-2.487	-1.537	2.068	0.1
Sweden	-4.953***	-2.129	-1.388	0.561	0.1	-4.857***	-2.457	-1.493	0.358	0.1
Switzerland	-4.209***	-2.678	-1.828	0.883	1.9	-5.180***	-2.968	-2.225	-0.186	1.9
Türkiye	-4.850***	-2.680	-1.887	0.326	0.1	-5.436***	-3.101	-2.170	0.494	0.1
United States	-5.048***	-2.303	-1.396	0.550	1.8	-3.323***	-2.822	-1.736	1.237	1.8
United Kingdom	-1.967**	-2.368	-1.534	-0.065	0.1	-5.011***	-2.470	-1.530	-0.520	0.1
Mean	-4.506***	**Prob.**	0.002			**Mean**	-5.301***	**Prob.**	0.001	
Max	-6.176***	**Prob.**	0.000			**Max**	-9.865***	**Prob.**	0.000	
Median	-4.850***	**Prob.**	0.000			**Median**	-5.037***	**Prob.**	0.002	

Note: ** and *** Critical values indicate 5% and 1% significance level, respectively.

One of the second-generation panel unit root tests, the CADF Panel unit root test, has been applied to the unemployment and inflation variables. According to the CIPS statistical test results of this test, it is concluded that inflation and unemployment variables do not contain unit roots in the whole panel (Table 4). Panel Fourier cointegration analysis for inflation and unemployment variables that are stationary at the same level is given in Table 5.

When the Fourier cointegration test results of the panel data analysis for OECD countries with a total of 33 years between 1991 and 2023 are analyzed, it is understood from the probability values that a long-run cointegration relationship is detected between the variables according to the panel mean values in Table 5. When evaluated on a country basis; according to the GLS test statistic values, it is found that Czechia, Slovak Republic and United Kingdom are significant at 5% level and all other countries are significant at 1% level, while according to the PP test statistic values, all countries are significant at 1% level. Therefore, according to the GLS or PP values, significant cointegration probability values were found across countries. In this case, it has been determined that there is a cointegration relationship between unemployment and inflation variables in all OECD countries while constructing the panel data analysis.

After determining the cointegration relationship between the variables, the study continued with the Panel IFE estimator to estimate the cointegration coefficients in the long run.

Table 6: Panel IFE Test Results

Variable	Coefficient	Standard Error	t-Statistic	Probability Value
UNEMP	-0.0162703	0.0018144	-8.97	0.000

According to the results of Panel IFE coefficient estimation, there is an econometrically significant and negative relationship between inflation and unemployment (Table 6). Therefore, it is concluded that unemployment has a negative effect on inflation. It is concluded that a one-unit increase in the unemployment rate causes a decrease of approximately 0.016 units in the inflation rate. The results of the analysis support the studies of Bildirici and Sonüstün (2018), Karahan and Uslu (2018), Maden et al. (2018), Dereli (2019), Ho and Iyke (2019), Akiş (2020), Bokhari (2020), Korkmaz and Abdullazade (2020), Naqibullah et al. (2020), İspir and Atılgan (2022), Yayar and Tekgün (2022), Aginta (2023) and Şeker (2023).

5. Conclusion and Policy Recommendations

The PC describes the inverse relationship between inflation and unemployment. In the panel data analysis of 38 OECD countries used in the study, it was concluded that unemployment has a negative effect on inflation and that every 1% increase in unemployment causes a 0.016% decrease in inflation. After reaching the conclusion that the PC is valid, it has become clear that the unemployment policies to be implemented by OECD countries are more important. The unemployment policies to be implemented by OECD countries directly affect inflation rates. Therefore, it is important for these countries to consider inflation dynamics while determining the unemployment policies to be implemented. From another perspective, if the results are interpreted, policies aimed at reducing unemployment will cause inflation to rise in these countries. Conversely, if policies that could lead to an increase in unemployment are implemented in these countries, it will result in a decrease in inflation. Thus, reforms such as increasing labor market flexibility and strengthening competition in product markets in OECD countries can help reduce both inflation and unemployment. In addition, global shocks in recent years have had a significant impact on inflation and unemployment by disrupting the supply and demand balance. Pandemics and wars caused supply-side shocks by disrupting production chains and increased inflationary pressures by raising energy and food prices. These shocks also affected labor markets, causing fluctuations in unemployment rates. The fact that the PC is still valid suggests that the effects of these global shocks are temporary and that economies will return to equilibrium in the long run. However, policymakers need to be more cautious and flexible in this period.

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