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Research Article/Araştırma Makalesi

Assessing Asymmetry in Okun's Law: A Nonlinear Approach in the Turkish Economy[1]

Okun Yasası'nda Asimetri: Türkiye Ekonomisi için Doğrusal Olmayan Yöntemlerle Analiz

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Abstract

In this paper, the presence of asymmetric behavior in Okun's Law for Turkey during the period 2005-2023 is analysed. The relationship between economic growth and the unemployment rate has been assessed in the context of nonlinear time series models. Nonlinear methods are typically favoured in macroeconomic series analyses as they generate more robust findings. In this paper, nonlienear symmetric KSS cointegration and nonlinear asymmetric Hepsağ cointegration tests were used to test for the existence of a long-run relationship between the variables, and the Hatemi-j test was used to test for nonlinear causality. Our findings demonstrate no evidence of co-integration between the variables. Hatemi-j test results, on the other hand, indicate the presence of a causality relationship from negative growth components to positive unemployment components. Specifically, a decrease in the growth was found to be the only one of all the components that was a statistically significant cause of an increase in the unemployment.

Jel Codes: *C12, E24, F43*
Keywords: *Okun's Law, Asymmetry, Nonlinear Time Series, Turkey*

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Öz

Bu çalışmada, 2005-2023 döneminde Türkiye için Okun Yasası'nda asimetrik davranışın varlığı incelenmiştir. Reel GSYH ile işsizlik oranı arasındaki ilişki doğrusal olmayan zaman serisi modelleri ile analiz edilmiştir. Doğrusal olmayan yöntemler, özellikle makroekonomik serilerin analizinde daha güçlü sonuçlar sunması sebebiyle tercih edilmektedir. Bu çalışmada, değişkenler arasında uzun dönemli bir ilişkinin varlığını test etmek için doğrusal olmayan KSS eşbütünleşme ve doğrusal olmayan asimetrik Hepsağ eşbütünleşme testleri kullanılmıştır. Değişkenler arasındaki nedensellik ilişkisini incelemek amacıyla ise Hatemi-j testinden yararlanılmıştır. Bulgular, değişkenler arasında eşbütünleşme olduğuna dair bir kanıt göstermemektedir. Öte yandan Hatemi-j testi sonuçları, negatif büyüme bileşenlerinden pozitif işsizlik bileşenlerine doğru bir nedensellik ilişkisinin varlığına işaret etmektedir. Buna göre, tüm negatif ve pozitif bileşenlerin karşılıklı nedensellik ilişkilerine bakıldığında yalnızca GSYH değişkenindeki bir azalmanın, işsizlik değişkenindeki bir artışın istatistiksel olarak anlamlı bir nedeni olduğu bulunmuştur.

Jel Kodları: *C12, E24, F43*
Anahtar Kelimeler: *Okun Yasası, Asimetri, Doğrusal Olmayan Zaman Serileri, Türkiye*

1. Introduction

Over the years, theoretical and empirical studies have examined the effect of changes in countries' economic growth rates on the level of the unemployment rate. A large number of studies in the economic literature have clearly shown the relationship between the unemployment rate and economic growth. According to the literature, high economic growth is frequently linked with low unemployment, while low or negative growth is often associated with high unemployment.

Arthur M. Okun (1962) was the first to clearly demonstrate the relationship between economic growth and unemployment in his study "Potential GNP: Its Measurement and Significance". In this study, based on the US economy, Okun provided empirical evidence of the negative relationship between the unemployment rate and the level of output. Okun proposed three alternative approaches to the estimation of the relationship between variables: the first differences approach, the trial gaps approach, and the fitted trend and elasticity approach. In the original paper, Arthur M. Okun assumed that the link between unemployment and output was linear. According to Okun, unemployment responds to a change in output at the same rate during the expansion and contraction phases of the economic cycle (Okun, 1962: 99). Okun's Law has an important role in macroeconomics, both in theory and in empirical terms. Theoretically, Okun's Law links the aggregate supply curve to the Philips curve. The aggregate supply curve can be obtained by relating Okun's law to the Philips curve. It is therefore effective in guiding policy in the goods market and also in the labour market. Empirically, the Okun coefficient calculated has an essential role in forecasting and policy decisions for the economy. Furthermore, the Okun coefficient is used to determine the optimal growth rate in an economy and to calculate the cost of unemployment.

In the original paper, Arthur M. Okun assumed that the link between unemployment and output was linear. According to Okun, unemployment responds to a change in output at the same rate during the expansion and contraction phases of the economic cycle (Okun, 1962: 99). In numerous studies following Okun, it is supposed that the response of the unemployment rate to output during cyclical fluctuations is absolutely the same, assuming that the relationship is symmetric. In recent years, though, Okun's Law has been the subject of discussion in different dimensions, as a result of the findings of empirical studies and arguments that an increase in the growth rate will reduce unemployment rates in both developed and developing economies. Here, the structural differences between countries' sources of growth and labour markets are studied. The reason is that the effect of economic growth on the change in the unemployment rate is determined by various factors, such as the qualitative or quantitative type of growth and the different labour market dynamics in the countries, i.e. the increasing female workforce participation rate, tax policies and the labour productivity (Silvapulle et.al., 2004: 360-62). Accordingly, it has been found that the effect of output on the unemployment rate in contractionary periods of the economy may not be the same as in expansions. The asymmetry in the link between output and unemployment, as expressed in Okun's law, has therefore received more attention. This asymmetry implies that the impact of output growth on unemployment varies, respectively, when the economy is expanding or contracting. This differs from the assumption of symmetry, which implies that output in expansions and contractions have the same absolute effect on unemployment.

Although economists' interest in the assumption of asymmetry usually arises from the study of asymmetry in cyclical fluctuations, the idea actually has its origins in Keynes, who argued that the downturn in the business cycle can be sharper than the upturn. According to Keynes, the replacement of an upswing by a downswing (in cycles) is often sudden and violent, whereas the reverse, i.e. the replacement of a downswing by an upswing, is not usually so sharp (Keynes, 1936: 196).

The aim of this paper is to analyse the asymmetry in Okun's Law by nonlinear methods that account for the asymmetric behaviour. It is important to assess the asymmetry due to the probability of the Phillips curve being asymmetric if the relationship representing the Okun law is asymmetric, the probability of estimation errors if the asymmetry is ignored, and to choose the policy according to the asymmetric relationship (Harris and Silvestone, 2001). The plan of the paper is as follows. Section 2 presents the literature review; section 3 is an overview of growth and labor markets in Turkey. The econometric methodology and empirical analysis are given in Section 4. Finally, conclusions are stated.

2. Literature Review

One of the studies analysing the existence of asymmetric behaviour in Okun's Law was carried out by Palley (1993) for the US economy. The study analysed Okun's law with cyclical fluctuations in the US economy for the period 1948q3-1991q1. The analysis showed that unemployment increased more in periods when the business cycle was downward. In his study, Palley explained the asymmetric behaviour in Okun's law by the changes in the employment structure and labour supply. Lee (2000) analysed the post-war period using output and unemployment data for sixteen OECD countries. He analysed the period 1955-1996 using the Hodrick-Prescott filter, Beveridge-Nelson decomposition, Kalman filter to compare first differences and gaps approaches. According to the results of the analysis, with the structural break that appeared in most countries in the 1970s, lower output losses started to be observed with higher unemployment rates. In a study, Harris & Silverstone (2001) examined the relationship between unemployment and output change in seven OECD countries under the assumption of asymmetry. For this they estimated the variables between 1978 and 1999 using the asymmetric error correction model. In line with the authors' previous research[3], they found that ignoring asymmetry for some countries may lead to a rejection of the validity of Okun's law. Silvapulle, Moosa & Silvapulle (2004) tested the gaps approach in Okun's paper by considering the period 1941q1-1999q4 in the US. Using Harvey's structural time series model, they examined the asymmetry assumption and found that the effect of growth on unemployment, which implies the existence of asymmetry, differs in expansion and contraction cycles. Holmes & Silverstone (2006) analysed the asymmetric behaviour in the relationship between cyclical unemployment and growth rates in the period 1963q1-2004q3 in the US using the Markov regime switching model. They conclude that there is an inversed relationship between cyclical unemployment and growth rates in the US during expansions.

[3] For further information, Harris & Silverstone, "Asymmetric Adjustment of Unemployment and Output in New Zealand: Rediscovering Okun's Law", **Working Paper in Economics** 2/00, University of Woikato, 2000.

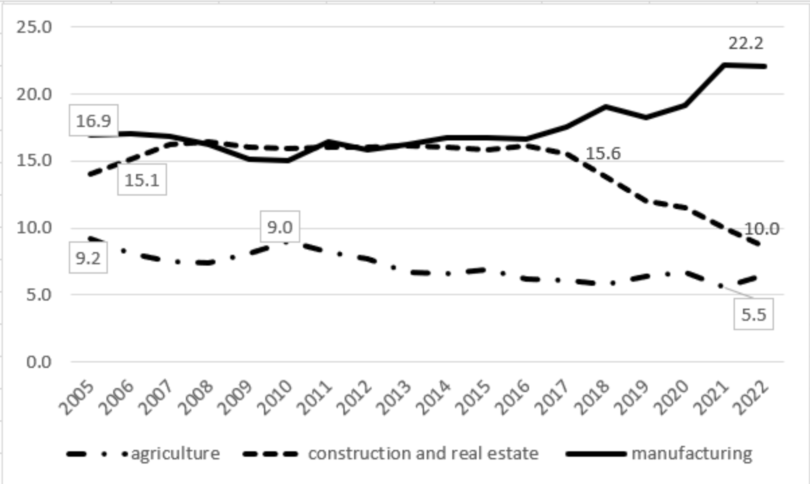
For Turkey, one of the first studies estimating the asymmetry in Okun's law was published by Ceylan & Şahin (2010). In testing the asymmetry, TAR and M-TAR cointegration models was carried out for the data between 1950-2007. They concluded that Okun's law is valid in the long run and that the effect of real output on reducing unemployment in the expansions and the effect of real output on increasing unemployment in the contractions are differentiated. Tarı & Abasız (2010) analysed the relationship between unemployment and growth in the 1968-2008 period and estimated it with two-regime threshold cointegration and threshold error correction models. According to their findings, it is stated that the effect of growth on unemployment is higher in the contractionary regime than in the expansionary regime, that is, the relationship between variables is asymmetric according to regimes. Barışık et al. (2010) comparatively examined the existence of asymmetry in Okun's law in Turkey using linear and nonlinear models with output gap and unemployment gap series. In the estimates using the Markov regime switching model, the Okun coefficient, which is quite weak in the contraction regime, is statistically insignificant for the expansion regime. The study states that the Okun coefficient is significantly differencing in expansion and contraction regimes. Arabacı & Arabacı (2018) studied the non-linear structure in Okun's law by means of the unemployment gap and real GDP gap series. Based on the study, it is stated that the contraction and expansion periods of the economy have an asymmetric effect on unemployment in the period 2001-2012 for Turkey. Boğa (2020) analysed the asymmetric relationship between economic growth and unemployment and estimated the linear and nonlinear structure by taking the period 2000-2019 into view. The findings of the study show that there is no relationship between the variables according to the linear cointegration results, while there is an asymmetric cointegration and asymmetric unidirectional causality. Özer (2022) analysed the long-run relationship between economic growth and unemployment rate for the Turkish economy for the period 2005q1-2021q1 using the Fourier ARLD and the causality relationship using the Fourier Toda-Yamamoto test. The results revealed the existence of a long-run cointegration relationship between the variables and a unidirectional relationship from economic growth to unemployment rate in the short run.

3. Economic Growth and Labour Markets in Turkey

Since the early 2000s, the Turkish economy has experienced a significant structural transformation. In November 2000 and February 2001, the economy faced crises that caused severe damage to the banking, financial, and real sectors. To restore macroeconomic balances, the Transition to Strong Economy Program was implemented after the February 2001 crisis. In addition to regulating the banking and financial sectors, this program aimed to ensure stability of growth. The Turkish economy experienced a period of continuous growth during the first few years of the program. However, the quantitative increase in growth was insufficient in terms of quality, as it did not increase employment at the expected level.

The Turkish economy has experienced significant changes in the composition of economic activities over the last two decades. Chart 3.2 shows the shares of agriculture, manufacturing industry, construction and real estate activities in GDP. It is observed that the share of agricultural activities has halved in the last two decades. Despite Turkey's advantageous geographical and climatic conditions, there are several reasons for the decline in agricultural activity. This decline can be attributed to several factors, including the dispersed nature of agricultural land, the lack of sustainable agricultural practices, and the low yield and quality of agricultural products. In addition to these issues, the decline in agricultural activities can be linked to the ageing of the agricultural population, the level of education of producers, the acceleration of rural-urban migration, the high rate of informality and the high rate of unpaid family work.

Figure 1: Share of Economic Sectors in GDP (2005-2022)

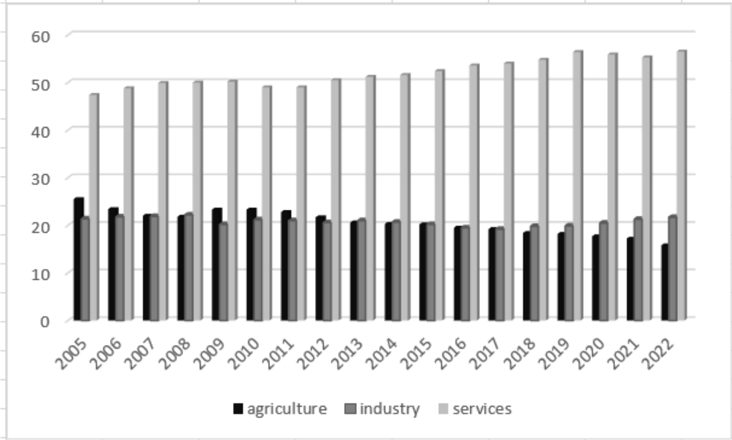


Note: Data obtained from TurkStat.

In 2005, the manufacturing industry accounted for 16.9% of GDP, while this share declined by 2008-2010. It is widely acknowledged that the European crisis had a significant impact on the economies of many countries during this period. From 2010 onwards, the manufacturing industry consistently accounted for 16-18% of GDP. Due to the COVID-19 pandemic, there was a contraction in global production, resulting in a decrease in the industry's share in 2019. However, it is worth mentioning the increase in construction activity in the country's economy in the early 2000s. At times, it held an equivalent share to manufacturing, and between 2008 and 2011 it reached a higher share than manufacturing.

Upon analysing the sectoral distribution of employment in Turkey (Figure 2), it is evident that the employment rate of the industry has been poor over the last 20 years, the agricultural employment has gradually decreased. On the other hand, the services sector has experienced growth during this period. The share of the services sector has been above 50 per cent, especially in the last decade. It is noted that the decrease in agricultural employment is accompanied by a similar increase in services employment (Orhangazi, 2020). According to the economic literature, countries with an industrial share of 30-40% experience a gradual decline in the share of industry and an increase in the share of services. This shift from industry to services reflects the deindustrialisation process in such countries. In Turkey, however, the share of industry in GDP has declined to less than 30%, while the services sector has correspondingly increased. This may indicate a premature deindustrialisation process, as noted by Rodrik (2016).

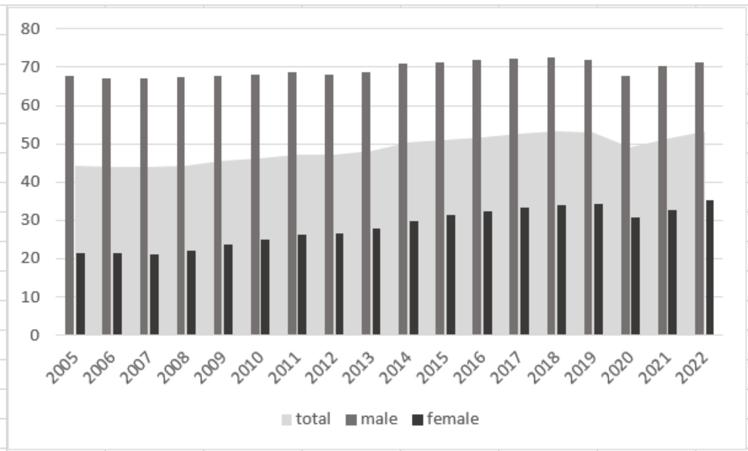
Figure 2: Employment Rate by Sectors (2005-2022)



Note: Data obtained from TurkStat.

Based on TurkStat data, the labour force participation rate has increased over the years, but it was negatively impacted by the pandemic between 2019 and 2021. In 2005, the total labour force participation rate was 44.1%, which increased by approximately 10 percent to 53.1% in 2022.

Figure 3: Labour Force Participation Rate (2005-2022)



Note: Data obtained from TurkStat.

As seen in the Figure 3- the participation rate by gender, although there is an overall increase in the years outside the pandemic, the share of female participation in the total participation rate is rather low. This may be since women are often considered secondary employees in the home, and they have the responsibility of childcare and elderly care mainly. The rise in female unemployment in Turkey is mainly attributed to the shift in the labour force from agriculture to industry and services sectors, rural-urban migration, and the challenges faced by housewives and female agricultural workers in finding new employment opportunities in urban areas.

Since Turkey has a demographic structure with a high youth population, the increase in labour supply often remains behind the employment rate. This has caused the labour force participation rate to stay at a low level due to the relatively low capacity of the economy to create employment. In recent years, the employment structure in Turkey has been concentrated in the services sector rather than the highly productive industrial sector. This has an important role to play in the participation rate.

4. Methodology and Empirical Findings

The econometric methodology is detailed in this section of the paper. Firstly, the significance of non-linearity in time series models is discussed alongside a discussion of techniques to test linearity. Secondly, non-linear unit root and cointegration testing procedures are explored. The asymmetric causality test is then briefly introduced.

Time series analysis of macroeconomic data highlights notable breaks due to economic crises, cyclical fluctuations or changes in economic policy. The significance of these structural breaks, in explaining estimation failures in analyses performed with linear models, has been clearly demonstrated. When forecasting with econometric analysis, the model used should be based on assumptions that provide an accurate forecast and explain these changes in the pattern of the series. Nonlinear models, threshold models, smooth transition models, and regime switching models, have been increasingly employed instead of linear time series models in the studies carried out in this context.

Linearity Tests

Recently, there has been significant focus on the subject of non-linear time series modelling. Non-linear models are frequently more precise at describing actual data behaviour compared to their linear equivalents. The latest literature on time series analysis has shown that economic variables, are better characterised by non-linear time series models than by linear time series models, particularly in the case of macroeconomic and financial variables. Efficiently predicting such variables depends on modelling them appropriately, making it vital to detect non-linearity where it exists.

The linearity test proposed by Harvey & Leybourne (2007), a method for testing the null hypothesis of linearity in a time series against the alternative of non-linearity. Their approach varies from other linearity tests in that, under the linear null hypothesis, the order of integration of the data is not uniquely determined. It may be generated from a linear I(0) or I(1) process. Following Harvey and Leybourne (2007), the regression model in terms of the observed *yt* is as:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-1}^2 + \beta_3 y_{t-1}^3 + \beta_4 \Delta y_{t-1} + \beta_5 (\Delta y_{t-1})^2 + \beta_6 (\Delta y_{t-1})^3 + \varepsilon_t$$

A null hypothesis of linearity, which does not specify whether *yt* is linear I(0) or I(1); and the alternative hypothesis of nonlinearity, which again does not specify whether the non-linearity is of an I(0) or I(1) are stated as:

$$H_0: \beta_2 = \beta_3 = \beta_5 = \beta_6 = 0$$

$$H_1: at\ least\ one\ of\ \beta_2, \beta_3, \beta_5, \beta_6 \neq 0$$

One further linearity test proposed by Harvey et al. (2008) is applicable in cases where there is uncertainty as to whether the series contains a unit root or not. The test depends on an approach which asymptotically selects the W_0 statistic when the data are stationary and the W_1 statistic when the data have a unit root:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-1}^2 + \beta_3 y_{t-1}^3 + \sum_{j=1}^{p} \beta_{4,j} \Delta y_{t-j} + \varepsilon_t$$

$$H_0: \beta_2 = \beta_3 = 0 \ \rightarrow W_0$$

$$\Delta y_t = \Delta y_{t-1} + \lambda_2 (\Delta y_{t-1})^2 + \lambda_3 (\Delta y_{t-1})^3 + \sum_{j=1}^{p} \lambda_{4,j} \Delta y_{t-j} + \varepsilon_t$$

$$H_0: \lambda_2 = \lambda_3 = 0 \ \rightarrow W_1$$

Nonlinear Unit Root Tests

The stationarity of the series should be determined first, since time series is used in the research. Moreover, the order of integration of the variables needs to be identified in order to examine a possible long-run relationship between variables. To ensure accurate analysis, it is crucial to determine whether a series is linear or not prior to selecting the appropriate method. This is due to the fact that nonlinear unit root tests tend to produce more robust results compared to linear tests. Moreover, the use of linear procedures in the analysis of nonlinear series may lead to misleading results.

In this research, the nonlinear unit root tests Leybourne, Newbold & Voguas (1998) (henceforth LNV), which allows for one breakpoint in the series; Harvey & Mills (2002) test which allows for two breakpoints, were used. Leybourne, Newbold & Voguas (1998) introduced the LNV unit root test under the assumption that the changes in economic series occur slowly and smoothly rather than sharply. Therefore, LNV unit root test proposes three alternative models by defining structural changes with a logistic smooth transition function instead of a dummy variable (Leybourne et. al., 1998).

Model A : $$y_t = \alpha_1 + \alpha_2 S_t(\gamma, \tau) + v_t$$

Model B : $$y_t = \alpha_1 + \beta_1 t + \alpha_2 S_t(\gamma, \tau) + v_t$$

Model C : $$y_t = \alpha_1 + \beta_1 t + \alpha_2 S_t(\gamma, \tau) + \beta_2 t S_t(\gamma, \tau) + v_t$$

The logistic smooth transition function is denoted by $S_t(\gamma, \tau)$ in the models. Model A indicates a break in the constant term, Model B indicates a break in the presence of a deterministic trend and Model C indicates a break in the presence of both a constant and a deterministic trend (Leybourne et.al., 1998).

Harvey & Mills (2002) test expands on the one smooth transition unit root test suggested by LNV, with the two smooth transitions. Therefore, as in the LNV test, it is defined by Model A, Model B and Model C specifications.

Model A: $$y_t = \alpha_1 + \alpha_2 S_{1t}(\gamma_1, \tau_1) + \alpha_3 S_{2t}(\gamma_2, \tau_2) + v_t$$

Model B: $$y_t = \alpha_1 + \beta_1 t + \alpha_2 S_{1t}(\gamma_1, \tau_1) + \alpha_3 S_{2t}(\gamma_2, \tau_2) + v_t$$

Model C: $y_t = \alpha_1 + \beta_1 t + \alpha_2 S_{1t}(\gamma_1, \tau_1) + \beta_2 t S_{1t}(\gamma_1, \tau_1) + \alpha_3 S_{2t}(\gamma_2, \tau_2) + \beta_3 t S_{2t}(\gamma_2, \tau_2) + v_t$

Model A indicates two breaks in the constant term, model B indicates two breaks in the presence of a deterministic trend and model C indicates two breaks in the presence of both a constant and a deterministic trend (Harvey & Mills, 2002).

Nonlinear Cointegration Tests

Co-integration tests are used for testing the long-run relations between variables. Using linear cointegration tests to analyse this relationship, which follows a non-linear process, can lead to results that tend to indicate the non-existence of a cointegrated relationship. According to prior studies, nonlinear cointegration tests are more reliable than linear ones. Hence, nonlinear Kapetanios, Shin & Snell (KSS) and Hepsağ cointegration tests were used in the study.

In 2006, Kapetanios, Shin & Snell developed an extended version of the Engle-Granger cointegration test that incorporates a nonlinear process. In the initial phase of the KSS, the long-term model is estimated by ECM and the residuals of the model are obtained. In the second phase, considering that the residual series may be non-linear, the ESTAR error correction model is applied (Kapetanios et.al., 2006). The basic model of the KSS test is as follows:

$$\Delta y_t = \phi u_{t-1} + \gamma u_{t-1}\left(1 - e^{-\theta(u_{t-1}^2)}\right) + \psi' \Delta x_t + \sum_{i=1}^{p} \omega'_i \Delta z_{t-i} + \varepsilon_t$$

$$\Delta x_t = \sum_{i=1}^{p} \Gamma'_i \Delta z_{t-i} + \eta_t$$

$$\hat{u}_t = \hat{y}_t - \beta^{?x_t}$$

Kapetanios et al. stated that the co-integration cannot be tested directly in the model they used in their study, since γ, the parameter of the ESTAR error correction model, is not defined in the null hypothesis. Accordingly, four different test statistics were developed, namely, F_{NEC}, F_{NEC}^*, t_{NEC} and t_{NEG}. In this paper, F_{NEC} and F_{NEC}^*, which exhibit relatively high robustness among these statistics, are used (Kapetanios et.al., 2006).

F_{NEC} test regression:

$$\Delta y_t = \delta_1 \hat{u}_{t-1} + \delta_2 \hat{u}_{t-1}^2 + \delta_3 \hat{u}_{t-1}^3 + \psi' \Delta x_t + \sum_{i=1}^{p} \omega'_i \Delta z_{t-i} + \varepsilon_t$$

$$H_0: \delta_1 = \delta_2 = \delta_3 = 0$$

F_{NEC}^* test regression:

$$\Delta y_t = \delta_1 \hat{u}_{t-1} + \delta_3 \hat{u}_{t-1}^3 + \psi' \Delta x_t + \sum_{i=1}^{p} \omega'_i \Delta z_{t-i} + \varepsilon_t$$

$$H_0: \delta_1 = \delta_3 = 0$$

An additional cointegration test employed in the study is the nonlinear cointegration test proposed by Hepsağ. Hepsağ (2021) introduced a novel nonlinear asymmetric cointegration test that extends the KSS cointegration test. The Hepsağ cointegration test specifies an asymmetric ESTAR (AESTAR) error correction model for the residuals obtained in the long run, which differs from the KSS cointegration test. The null hypothesis of the Hepsağ test states that there is no cointegration relationship between the variables, as does the KSS test. The alternative hypothesis however tests for the presence of either ESTAR or AESTAR cointegration. The Hepsağ (2021) cointegration test differs from earlier cointegration test as it assumes that positive and negative shocks that occur in the short-run do not have the same effect on the process of achieving equilibrium in the long-run, meaningly, there is an asymmetric effect (Hepsağ, 2021). The main model of the Hepsağ cointegration test is as follows:

$$\Delta y_t = G_t(\theta_1, u_{t-1})\{S_t(\theta_2, u_{t-1})\gamma_1 + (1 - S_t(\theta_2, u_{t-1}))\gamma_2\}u_{t-1} + \psi' \Delta x_t + \sum_{i=1}^{p} \omega'_i \Delta z_{t-i} + \varepsilon_t$$

$$\Delta x_t = \sum_{i=1}^{p} \Gamma'_i \Delta z_{t-i} + \eta_t$$

Hepsağ stated that the co-integrated relationship cannot be directly tested because the parameters $(\theta_2, \gamma_1, and\ \gamma_2)$ of the asymmetric ESTAR (AESTAR) error correction model are not defined in the null hypothesis. Therefore, he introduced two test statistics, namely F_{ANEG} and F_{ANEC} (Hepsağ, 2022: 112).

F_{ANEC} test regression:

$$\Delta y_t = \phi_1 \hat{u}_{t-1}^3 + \phi_2 \hat{u}_{t-1}^4 + \psi' \Delta x_t + \sum_{i=1}^{p} \omega'_i \Delta z_{t-i} + v_t$$

$$H_0: \phi_1 = \phi_2 = 0$$

F_{ANEG} test regression:

$$\Delta \hat{u}_t = \phi_1 \hat{u}_{t-1}^3 + \phi_2 \hat{u}_{t-1}^4 + \sum_{i=1}^{p} \lambda_i \Delta \hat{u}_{t-i} + \xi_t$$

$$H_0: \phi_1 = \phi_2 = 0$$

Depending on whether the alternative hypothesis is accepted, the Hepsağ test enables symmetric cointegration to be tested against asymmetric cointegration.

Asymmetric Casuality Test

Causality tests are commonly used to test the short-run relationship between variables. In order to examine the causality between the variables, the Hatemi-J (2012) asymmetric causality test was used in this study. The Hatemi-J test was chosen for its capacity to display an asymmetrical causal relationship. It assumes that the impacts of positive and negative shocks on variables may differ. Hatemi-J (2012) suggests the following process to test the causality relationship between variables:

$$y_{1t} = y_{1t-1} + \mathcal{E}_{1t} = y_{1,0} + \sum_{i=1}^{t} \mathcal{E}_1 \text{ and } y_{2t} = y_{2t-1} + \mathcal{E}_{2t} = y_{2,0} + \sum_{i=1}^{t} \mathcal{E}_{2i}$$

The equations can be rewritten using the series above, provided by separating positive and negative shocks as; $\varepsilon_{1i}^{+} = maks(\varepsilon_{1i}, 0)$, $\varepsilon_{1i}^{-} = min(\varepsilon_{1i}, 0)$, $\varepsilon_{2i}^{+} = maks(\varepsilon_{2i}, 0)$, $\varepsilon_{2i}^{-} = min(\varepsilon_{2i}, 0)$; and also as $\varepsilon_{1i} = \varepsilon_{1i}^{+} + \varepsilon_{1i}^{-}$; $\varepsilon_{2i} = \varepsilon_{2i}^{+} + \varepsilon_{2i}^{-}$, respectively:

$$y_{1t} = y_{1t-1} + \mathcal{E}_{1t} = y_{1,0} + \sum_{i=1}^{t} \mathcal{E}_{1i}^{+} + \sum_{i=1}^{t} \mathcal{E}_{1i}^{-}$$

$$y_{2t} = y_{2t-1} + \mathcal{E}_{2t} = y_{2,0} + \sum_{i=1}^{t} \mathcal{E}_{2i}^{+} + \sum_{i=1}^{t} \mathcal{E}_{2i}^{-}$$

The cumulative expression of positive and negative shocks for each variable can be presented as follows:

$$y_{1t}^{+} = \sum_{i=1}^{t} \mathcal{E}_{1i}^{+} \text{ , } y_{1t}^{-} = \sum_{i=1}^{t} \mathcal{E}_{1i}^{-} \, ve \; y_{2t}^{+} = \sum_{i=1}^{t} \mathcal{E}_{2i}^{+} \text{ , } y_{2t}^{-} = \sum_{i=1}^{t} \mathcal{E}_{2i}^{-}$$

To conclude, in the Hatemi-J asymmetric causality test, positive cumulative shocks are defined as $y_t^{+} = (y_{1t}^{+}, y_{2t}^{+})$; negative cumulative shocks are defined as $y_{1t}^{-} = (y_{1t}^{-}, y_{2t}^{-})$ and the causality between the components is tested with the following model:

$$y_{1i}^{+} = \alpha + A_1 y_{t-1}^{+} + \ldots + A_p y_{p-1}^{+} + u_t^{+}$$

The Hatemi-J test compares the WALD test statistic with critical values derived from the bootstrap method. It tests the null hypothesis, which indicates that there is no causal relationship, against the alternative hypothesis, which indicates that there is a causality relationship.

Empirical Findings

In this paper, in order to analyse the presence of asymmetry in Okun's law for the Turkish economy, industrial production index and unemployment rate for the period 2005q1-2023q3 were used. Industrial production index data is used as a proxy variable instead of the GDP variable. Both unemployment rate variable (u) and industrial production index variable (y) are obtained from Turkish Statistical Institute. Due to the revisions carried out by TURKSTAT on the unemployment data, the starting year of the analysis is set as 2005, since it would be completely misleading to use and compare the revised periods and other periods together in time series analyses. The relationship between two variables has been assessed in the context of nonlinear time series models.

It is often the case that macroeconomic series embody a stochastic trend (unit root), indicating their non-stationary behaviour. Moreover, identifying the structure of the non-stationarity in the series is crucial for further analysis. To determine the appropriate unit root tests for the series used in the paper, the linearity assumption was first tested using Harvey & Leybourne

(2007) and Harvey et al. (2008). The null hypothesis of linearity is rejected if the test statistic exceeds the critical value for both tests.

Table 1: Linearity Tests

Series	Tests	Test Statistics	Values (0.05)
y	Harvey & Leybourne (2007)	51.27*	9.48
	Harvey et. al. (2008)	11.68*	5.99
u	Harvey & Leybourne (2007)	13.75*	9.48
	Harvey et.al. (2008)	6.44*	5.99

Note: * represents the rejection of the null hypothesis at 5% significance level. The Harvey & Leybourne (2007) test statistics has $x^2_{(4)}$ distribution. The Harvey et al. (2008) test has $x^2_{(2)}$ distribution.

The findings (Table 1) reveal the rejection of the null hypothesis at a 5% significance level. Therefore, it can be deduced that both series contain a non-linear structure. Given that the series exhibit non-linear behaviour, their stationarity is examined via non-linear unit root tests. Nonlinear unit root tests are more powerful than ADF tests and ADF tests are biased toward non-rejection of the null. Thus, the unit root test of Leybourne, Newbold & Voguas (1998) and the unit root test of Harvey & Mills (2002) are used to test the stationarity. Schwert's (1989) approach was employed to detect the maximum lag-length in the tests. The findings from the unit root tests have been summarised in Table 2.

Table 2: Nonlinear Unit Root Tests

Series	Tests	Lags	Break Point	Test Statistics	Values (0.05)
	LNV				
y	Model A	1	---	-3.097	-4.232
	Model C	1	2008q3	-3.211	-5.011
u	Model A	1	2016q2	-2.865	-4.232
	Model C	1	2018q3	-3.418	-5.011
	Harvey-Mills				
y	Model A	1	--- / 2007q4	-2.511	-5.37
	Model C	1	2008q3 / 2019q1	-4.537	-6.55
u	Model A	1	2011q1 / 2011q2	-3.653	-5.37
	Model C	1	2008q4 / 2014q2	-4.893	-6.55

Note: Critical values for the LNV test are available from Leybourne, Newbold & Voguas (1998) with a sample size of N=100.

The presence of a unit root in the series under the null hypothesis was examined through the LNV and Harvey-Mills' unit root tests. The alternative hypothesis suggests stationarity with a smooth break for LNV; and two smooth breaks for Harvey-Mills. As can be seen from Table 2, null hypothesis cannot be rejected, meaningly the series follows a unit root process.

Since nonlinear unit root tests can only be applied to the level series, the stationarity of the difference series of the variables should be estimated by linear unit root tests. Thus, Table 3 shows the results of both the level and difference series of variables as by ADF and PP unit root tests.

Table 3: Linear Unit Root Tests

Series	Tests		Values (0.05)
	ADF	PP	
y	-3.230	-3.055	-3.471
u	-2.625	-3.297	-3.471
Δy	-10.459*	-10.406*	-1.945
Δu	-2.846*	-11.290*	-1.945

Note: * represents the rejection of the null hypothesis at 5% significance level.

Following the ADF and PP tests on series, the null hypothesis indicating unit root existence cannot be rejected for the level series. However, it is rejected for the difference series, indicating both series are difference stationary (I(I)).

To investigate the presence of a long-term nonlinear relationship between variables, the KSS (2006) and Hepsağ (2021) cointegration tests are used. As with the earlier cointegration tests, these two tests are subject to the restriction that the series should be stationary at first difference. The KSS cointegration test indicates that the null hypothesis is that there is no nonlinear cointegration; the alternative hypothesis tests for the existence of a cointegrated relationship. According to the Hepsağ (2021) cointegration test, the null hypothesis asserts that there is no nonlinear cointegration, however the alternative hypothesis indicates the existence of symmetric or asymmetric cointegration.

Table 4: Nonlinear Cointegration Tests

Tests	**Lags**	**Test Statistics**	**Values (0.05)**
KSS			
F_{NEC}	1	4.896	13.73
F^*_{NEC}	1	5.858	12.17
Hepsağ			
F_{ANEG}	1	4.707	6.325
F_{ANEC}	1	5.347	5.972

Note: Critical values are available in the KSS (2006) and Hepsağ (2021).

As can be seen from Table 4, all of the test statistisc are smaller than the critical values. Null hypothesis stating that there is no long-run equilibrium could not be rejected at 5% significance level. Therefore, based on four statistics, it is concluded that there is no cointegration between the unemployment rate and industrial production index. In other terms, this means that there is no long-term relationship between the variables in the period given.

The Hatemi-J (2012) test for asymmetric causality was employed to analyse the causality relationship between variables. The Hatemi-J test was chosen because it differs from earlier causality tests in the literature by identifying asymmetric causal relationships taking into account that positive and negative shocks of the variables may have varying effects. The null hypothesis states that there is no causality between, while the alternative hypothesis states that a causality relationship exists.

Table 5: Hatemi-J Asymmetric Casuality Test

Casuality	t-statistics	Values (0.05)
$y^{+} \rightarrow u^{+}$	2.086	4.356
$y^{+} \rightarrow u^{-}$	8.345	18.450
$y^{-} \rightarrow u^{-}$	9.677	27.144
$y^{-} \rightarrow u^{+}$	31.941*	15.696
$u^{+} \rightarrow y^{+}$	0.109	4.370
$u^{+} \rightarrow y^{-}$	34.664	36.232
$u^{-} \rightarrow y^{-}$	23.552	23.641
$u^{-} \rightarrow y^{+}$	10.826	29.958

Note: * represents the rejection of the null hypothesis at 5% significance level. Critical values were calculated by the bootstrap method.

The findings of the Hatemi-J causality test, which analysed eight causality relationships and directions by identifying negative (u^{-} and y^{-}) and positive components (u^{+} and y^{+}) of the series, are presented in Table 5. According to the Hatemi-J Test, a causality relationship is only identified between the negative component of the industrial production index variable and the positive component of the unemployment rate variable, at a significance level of 5%. For all other components, the null hypothesis that there is no causality relationship cannot be rejected. According to the results, the link between growth and unemployment known in the economic literature has not been achieved for Turkey. The assumption that an increase in economic growth will increase employment and thus reduce unemployment has not been realised. This situation points to the concept of jobless growth for Turkey. While no causality has been found for economic growth to reduce unemployment, the causality found for contraction to increase unemployment shows the asymmetric behaviour of Okun's law in Turkey.

5. Concluding Remarks

This paper analyses the Turkish economy for the period from 2002 to 2022 by means of economic growth and the unemployment rate based on non-linear methods. The presence of asymmetric behaviour in Okun's law is tested using industrial production index and unemployment rate series. This paper differs from other studies in the literature in its focus on symmetric cointegration, asymmetric cointegration and asymmetric causality tests.

The initial analysis tested the assumption of linearity in the series, revealing that both exhibit non-linear behaviour. On this basis, the variables were tested with non-linear unit root tests. The paper estimated the long-run nonlinear relationship among the variables through the use of non-linear cointegration tests developed by Kapetanios, Shin & Snell (2006) and Hepsağ (2021). The results revealed no evidence of any cointegrated relationship within the variables. Following this, the Hatemi-J asymmetric causality test, which decomposes the variables into their components to analyze short-term causality, was applied. The sole causal relationship observed was between the negative components of growth and the positive components of the unemployment rate. Specifically, a decrease in the growth variable was found to be the only one of all the components that was a statistically significant cause of an increase in the unemployment variable.

In general, the results show that there is no long-run relationship between the unemployment rate and growth in Turkey between 2005 and 2023. Nevertheless, over the short-run, the relationship between the variables shows an asymmetric behaviour in different periods of the economy. The causality results suggest that there is no effect on unemployment in the expansion phase of the economy, but there is a relationship that increases unemployment in the contraction phase. The rise in unemployment is a predictable outcome during an economic downturn. Nonetheless, the absence of any decrease in unemployment during periods of increasing economic growth points to an asymmetry. This refers to the jobless growth process within the Turkish economy. The reasons can be explained in terms of the sectoral composition of the economy, the economic policies pursued, productivity growth, labour market developments and the hysteria effect.

In order to overcome the low job creation performance, several regulatory measures and employment-oriented policies should be implemented in the short-run. It is crucial to review the composition of growth and implement policies aimed at raising productivity. In this respect, priority should be given to policies that enable the labour force leaving the agricultural sector, which is a factor feeding the unemployment growth process, to be employed in different sectors. Training educated staff who are qualified to meet the needs of employers in the labour markets will help both to eliminate the matching problems in the labour markets in terms of labour supply and demand and to ensure that the employed labour force contributes to the quality of the production process.

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