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The Unemployment and Growth Nexus in Türkiye: A Quantile-on-Quantile Regression Analysis

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Abstract This study investigates the relationship between economic growth and unemployment in Türkiye over the period 2005: Q1-2024:Q4 using the Quantile-on-Quantile Regression (QQR) approach. The existing literature predominantly relies on linear or mean based models and therefore overlooks potential nonlinear and state-dependent dynamics in the unemployment and growth nexus. By incorporating the full joint distribution of both variables, the QQR method enables a more comprehensive assessment of how different unemployment quantiles interact with various growth quantiles. Preliminary tests confirm non-normality, structural breaks, and nonlinear dependence in the data, validating the suitability of a quantile based framework. The empirical results reveal that the relationship between unemployment and growth is strongly asymmetric. In low growth quantiles particularly when unemployment is high unemployment exerts a pronounced negative effect on output, indicating heightened vulnerability during contractionary phases. In middle growth quantiles, the effect becomes statistically insignificant, suggesting relative resilience under more stable conditions. In high growth quantiles, a positive association emerges when unemployment is low, implying that improvements in labor market conditions support economic expansion. However, at medium and high unemployment quantiles, the effects on growth vary considerably, demonstrating that the interaction is not linear across economic states. Overall, the findings emphasize the importance of adopting distribution sensitive and state-contingent labor market policies. The study contributes to the literature by providing a nuanced understanding of the heterogeneous dynamics underlying Okun's relationship in an emerging economy context.

Keywords Okun's law · quantile-on-quantile regression · economic growth · unemployment · nonlinear dynamics

JEL Classification E24 · E32 · C14 · O40

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The Unemployment and Growth Nexus in Türkiye: A Quantile-on-Quantile Regression Analysis

Modern economies are confronted with persistent financial and economic challenges, predominantly stemming from insufficient economic growth and persistent unemployment. The upward trend in unemployment rates constitutes a globally contentious issue, including within advanced economies. As critical indicators of macroeconomic performance, both unemployment and economic growth are closely monitored by policymakers and the public alike, as they serve as proxies for a nation's level of economic development. The interdependence between unemployment and economic growth constitutes a central macroeconomic concern, extensively explored in both empirical and theoretical literature (Weber, 1995; Moosa, 1997; Freeman, 2000; Villaverde & Maza, 2009; Gabrisch & Buscher, 2005; Bartolucci et al., 2018; Sögner & Stiassny, 2000).

The seminal work of Okun (1963) was the first to empirically investigate the inverse relationship between unemployment and economic growth, establishing what is now known as "Okun's Law." Analyzing data for the United States from 1948 to 1960, Okun demonstrated that a 1 percentage point increase in real GDP growth above its potential rate (2.25% at the time) corresponded to a 0.5 percentage point decrease in the unemployment rate. Since its inception, Okun's Law has gained empirical support across various developed countries and regions (Freeman, 2000; Lee, 2000; Villaverde & Maza, 2009; Silvapulle et al., 2004; Ball et al., 2017). In addition, several studies have concentrated on assessing cross country differences by examining the influence of various factors such as labor market policies, financial crises, and pandemics on the unemployment and growth relationship (Grant, 2018; Porras-Arena & Martín-Román, 2019; An et al., 2022). This line of inquiry is particularly relevant because, in developing countries, the relationship between unemployment and growth tends to be less stable than in advanced economies and varies significantly depending on country specific structural conditions.

As a developing economy, Türkiye has experienced persistently high unemployment, particularly in the past two decades. As of September 2025, the national unemployment rate was recorded at 8.6% (CBRT-EVDS), surpassing the average rate of 5.3% for developing countries and the global average of 4.9% (WorldData, 2025). Structural contributors to unemployment in Türkiye include low female labor force participation, a young labor force demographic, rural employment patterns, skills mismatches, internal migration, urbanization pressures, and elevated dismissal costs (Işığıçok, 2011; Apaydın, 2018). These issues are compounded by underemployment, a large informal sector, and a growing unskilled youth population (Koray, 1991).

In addition, Türkiye's labor market has been vulnerable to external shocks such as financial crises, geopolitical tensions, pandemics, and natural disasters (ILO, 2023; IMF, 2024; TUIK, 2025). The COVID-19 pandemic, in particular, resulted in significant labor market disruptions due to government imposed lockdowns and social distancing measures, which imposed heavy financial costs (Ahmad et al., 2023; Pak et al., 2020; Kartal et al., 2023). The COVID-19 crisis has also brought new problems for labor and production markets. During and after the pandemic, unemployment rates increased. This increase resulted in a disruption of the supply-demand chain (Açıkgöz and Günay, 2020). This crisis further exacerbated pre-existing labor market weaknesses. Although Türkiye recorded robust economic growth between 2001 and 2023, this growth was primarily driven by foreign exchange credit expansion and rising private sector debt post 2008 (Demir Şeker et al., 2020). Despite IMF, supported reforms after the 2001 crisis that stimulated growth, unemployment remained persistently high: from a low of 6.5% in 2000, it rose to 10.84% in 2004 and peaked at 15% in early 2009 due to the global financial crisis (CBRT-EVDS). Between 2013 and 2019, while growth rates fluctuated

between 8.48% and 0.89%, unemployment rose from 8.73% to 13.67%, prompting widespread commentary on the phenomenon of "jobless growth" and Türkiye's entrapment in the middle income trap (CBRT-EVDS, Figure 1; Presidency of Strategy and Budget, 2019).

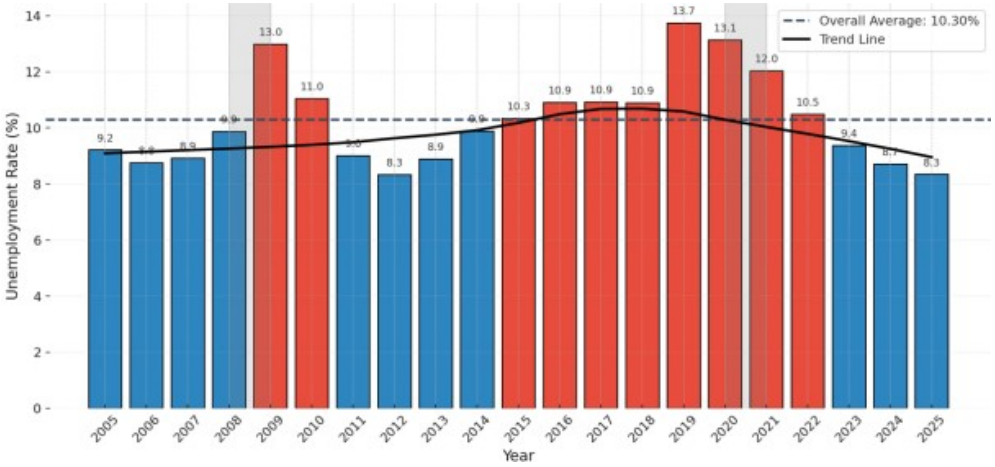
The twin earthquakes on February 6, 2023, had widespread economic repercussions across 11 provinces, significantly disrupting the regional labor market (Demirbaş & Görücü, 2024). Concurrently, the Syrian refugee crisis, which began in 2011, placed additional pressures on the labor market, especially with the influx of individuals under temporary protection status (Korkmaz, 2018). These internal and external shocks collectively illustrate the structural and cyclical factors shaping Türkiye's labor market.

Accordingly, a nuanced investigation into the unemployment and growth nexus in Türkiye is necessary to inform evidence based structural reforms. Although conventional wisdom suggests that robust economic growth reduces unemployment through the business cycle, this relationship is neither universally symmetric nor temporally stable. Evaluating the dynamic, state-dependent relationship between growth and unemployment is therefore critical for assessing the socioeconomic implications of macroeconomic performance.

This study proceeds as follows: Section 2 provides a review of the extant literature; Section 3 outlines the theoretical framework and methodology; Section 4 presents the empirical data and findings; and the final section concludes with policy implications derived from the analysis.

Figure 1

Unemployment rates by year (average; %)



Source: The data have been graphically visualized by the author based on CBRT-EVDS statistics.

Literature

Weber (1995) examined the U.S. economy over the period 1948-1988, dividing the data into three subperiods and analyzing the relationship between the unemployment rate and gross national product (GNP) using time series methodologies. Adopting a dynamic modeling framework, his findings corroborated Okun's Law; however, he estimated an Okun coefficient of approximately −0.25, which was notably lower than in comparable empirical studies. Moosa (1997) conducted a cross country analysis of the unemployment and growth relationship among G7 economies during the period 1960-1995. Employing both Ordinary Least Squares (OLS) and Seemingly Unrelated Regression (SUR) techniques, the study affirmed the validity of Okun's Law in terms of the directionality of the relationship, although the magnitude of the coefficients varied across countries. The highest coefficient was estimated for the United States (-0.49), and the lowest for Japan (-0.09).

Lee (2000), in a study covering 16 OECD member states from 1955 to 1996, investigated the validity of Okun's Law through time series techniques and examined cointegration relationships. The output gap was

measured using four different methods (the Baxter-King filter, Beveridge-Nelson decomposition, Kalman filter, and Okun's first difference approach). His findings suggested that the Okun coefficients for European countries were generally higher in absolute value compared to those of the United States. Sögner and Stiassny (2000) similarly tested both the validity and structural stability of Okun's Law across 15 OECD countries for the 1960-1999 period, using the Kalman filter to estimate the output gap and OLS for model estimation. Their findings indicated that Okun coefficients varied significantly, ranging from −0.12 to −0.82 depending on the country.

Freeman (2000) analyzed ten developed economies (the United States, Canada, Japan, Australia, France, Germany, Italy, the Netherlands, Sweden, and the United Kingdom) between 1958 and 1988 using panel data analysis techniques. While the negative association between unemployment and growth was upheld across countries, the magnitude of the Okun coefficients varied: the smallest (in absolute value) was −1.045 for Italy, while the largest was −3.922 for Japan. Harris and Silverstone (2001), using a sample of seven OECD countries (the United States, Australia, Germany, Canada, Japan, the United Kingdom, and New Zealand) over the 1978-1999 period, initially failed to identify a long run relationship between unemployment and output when ignoring model asymmetry. However, once asymmetries were considered, the existence of a long run relationship was rejected for all countries except Canada, highlighting the asymmetric nature of the Okun relationship.

Virén (2001) challenged the linearity assumption embedded in Okun's Law through a study of 20 OECD countries covering 1960-1997. The findings showed that when actual growth exceeded its long term average, the unemployment rate declined, but the response was nonlinear. Moreover, population shocks were found to increase unemployment, whereas growth shocks had mitigating effects. Moazzami and Dadgostar (2009) applied time series analysis incorporating short and long term error correction models to data from 13 OECD countries covering the period 1988 to 2007. Their findings revealed that a 1% reduction in unemployment was associated with an increase in output ranging from 2.6% to 4.7%, with the responsiveness of employment to growth being strongest in Finland, Norway, Canada, and the United States. Adanu (2007) investigated the unemployment and growth relationship across ten Canadian provinces from 1981 to 2001 using the Hodrick-Prescott (HP) and Quadratic Trend (QT) filters. Both methods supported Okun's Law in directional terms, though coefficient magnitudes differed. For Canada as a whole, the Okun coefficient was −1.58 with the HP filter and −1.32 with the QT filter.

Villaverde and Maza (2009) examined Spain from a regional perspective (1980-2004), applying three filtering techniques (QT, Baxter-King, and HP) to compute the output gap. Using OLS, they found that Okun's Law held at the national level and in most of the 17 regions, though regional variations in coefficient estimates were sensitive to the chosen filtering method. Christopoulos (2004) explored 13 Greek regions over 1971-1993 using panel Fully Modified Ordinary Least Squares (FMOLS). Okun's Law was validated in six regions, and while a negative relationship was evident across the entire panel, it was not statistically significant in all cases. Caporale and Gil-Alana (2014) investigated the interrelationship among youth unemployment, growth, and inflation for 15 European countries during 1980-2015 using time series cointegration techniques. Their analysis provided evidence of a long run equilibrium relationship among the variables. Gabrisch and Buscher (2005) studied eight Central and Eastern European countries (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia) over 1994-2004 using a mix of panel and time series methods. Okun coefficients ranged from −0.05 (OLS) to −0.075 (two-stage fixed effects) (-0.037 with FE, −0.054 with 2SOLS). Grant (2018), focusing on the United States, revealed that the probability of the Okun coefficient maintaining its conventionally accepted value diminished significantly during the Great Recession, only recovering in subsequent years.

Yerdelen Tatoğlu (2017) investigated the relationship between unemployment and economic growth across 23 European countries for the period 2008-2016, employing multidimensional panel data models. The findings confirmed the validity of Okun's Law both for individual countries and for the panel as a whole. Similarly, Soylu et al. (2018) tested Okun's Law in nine Eastern European economies between 1992 and 2014 using panel data techniques and found a statistically significant negative relationship, indicating that economic growth contributes to a reduction in unemployment.

Several empirical studies have also focused specifically on Türkiye using time series approaches. Bildirici et al. (2012), analyzing the period from 1980 to 2010, evaluated the effects of economic crises on unemployment using extensive data from the Turkish Statistical Institute's labor force surveys. Their findings highlighted that economic crises during this period produced hysteresis effects, leading to persistent increases in unemployment.

Ceylan and Şahin (2010), employing Threshold Autoregressive (TAR) and Momentum-TAR (M-TAR) models, analyzed the unemployment and growth nexus in Türkiye for the period 1950-2007. Their results demonstrated the long run validity of Okun's Law, with notable asymmetries in the relationship. Similarly, Akay et al. (2016) employed a Markov Regime Switching Model for the period 1969-2014 and found that the relationship between unemployment and economic growth was statistically significant in both the short and long run, with the effect being more pronounced during periods of economic contraction than expansion. Arı (2016) examined the relationship between economic growth and unemployment in Türkiye using the Bayer and Hanck cointegration test and the Hacker-Hatemi-J causality test for the 1980-2014 period. The results indicated no long run relationship or causality between the two variables, reinforcing the argument that growth in Türkiye has not been employment generating. Similarly, Öztürk and Sezen (2018), analyzing the 2005-2017 period using Engle & Granger cointegration and Granger causality tests, found a long run unidirectional relationship running from economic growth to unemployment. Takım (2010), focusing solely on causality, reported a bidirectional relationship between economic growth and unemployment for the period 1975-2008.

Zeren and Savrul (2017) examined the interrelationships among urbanization, economic growth, and unemployment to identify factors affecting female labor force participation in Türkiye from 1991 to 2014. Using the Granger and Yoon asymmetric cointegration test, the study found long term asymmetric relationships among these variables, with economic growth, unemployment, and urbanization significantly influencing female employment. Boğa (2020) also employed a version of the asymmetric cointegration test (Hatemi-J and Irandoust, 2012) to explore the relationship between growth and unemployment. The results provided evidence of an asymmetric long term association: positive shocks to growth decreased unemployment, while negative shocks increased it. Bayrak (2019) investigated the unemployment and growth nexus using both narrow and broad definitions of unemployment over the 2005-2017 period. The study employed the Toda-Yamamoto causality test and found a unidirectional causality from growth to general unemployment, and a bidirectional causality between growth and broadly defined unemployment.

Engin and Konuk (2020) assessed the long run effects of international migration on unemployment and economic growth in Türkiye from 1995 to 2019 using Johansen cointegration techniques. Their findings revealed that increases in migration were associated with both rising unemployment and enhanced economic growth. Similarly, Erkişi and Çetin (2023), analyzing the 2000-2022 period, estimated two long run models using FMOLS, DOLS, and CCR estimators. Model I showed that migration initially reduced unemployment, but after 2013 amid increased refugee inflows migration simultaneously fueled growth and elevated unemployment. Model II emphasized that regular migration fosters economic development and

reduces unemployment, whereas irregular migration boosts growth through informal employment while exacerbating unemployment.

Demez and Polat (2021) analyzed the triadic relationship among growth, inflation, and unemployment in EAGLE countries over the 1997-2019 period using the Konya panel causality test. Their findings revealed a range of causal pathways: from growth to inflation in India, Brazil, and the Philippines; from inflation to growth in Russia, Malaysia, and China; from unemployment to growth and from growth to unemployment in Malaysia; and from unemployment to growth in Russia and Türkiye.

Yıldırım and Vıcıl (2023), applying a Self Exciting Threshold Autoregressive (SETAR) model to Turkish data from 2001 to 2023, provided evidence of a threshold effect in the unemployment and growth relationship, indicating nonlinearity and potential regime shifts. Akusta (2025) investigated the presence of jobless growth at the sectoral level in Türkiye over the 2000-2022 period. Using FMOLS and CCR estimators, the findings indicated that economic growth contributed to reductions in unemployment across all sectors, thereby rejecting the hypothesis of jobless growth. Karahasan (2025) applied spatial econometric methods to examine regional labor market dynamics in Türkiye. The analysis demonstrated significant regional polarization despite national level growth, with the emergence of distinct convergence clubs. This polarization was especially pronounced among women and revealed a spatial segregation affecting both underdeveloped southeastern provinces and some urbanized western regions.

While the existing empirical literature frequently investigates the relationship between unemployment and economic growth in Türkiye over various periods, the focus of most studies has been limited to cointegration, causality, or the identification of specific threshold effects. In particular, the majority of these studies emphasize how increases or decreases in economic growth or in the output gap affect unemployment. However, the critical question of which levels of economic growth or output gaps exert a more decisive impact on labor market outcomes remains largely underexplored. Moreover, assuming that the effects of changes in output or growth are symmetrical or linear across different levels of unemployment or economic activity constitutes a significant methodological limitation. In this regard, the primary contribution of the present study lies in its application of the Quantile-on-Quantile Regression (QQR) approach, which examines the relationship between unemployment and economic growth across the full joint distribution of the two variables. This methodology allows for a more granular analysis by evaluating how unemployment reacts to economic growth at different quantile levels and vice versa. In doing so, the study provides policy relevant insights that go beyond conventional linear models by capturing the heterogeneity in response patterns. The empirical framework adopted herein seeks to generate more accurate and structurally realistic recommendations for addressing the unemployment and growth nexus in Türkiye, particularly in light of its complex labor market dynamics.

The relationship between unemployment and economic growth has been extensively documented and continues to attract scholarly attention across a broad spectrum of countries and time periods. Advances in econometric and statistical techniques have made it possible to revisit this relationship from more nuanced perspectives. This study employs the Quantile-on-Quantile Regression (QQR) method developed by Sim and Zhou (2015), which facilitates the examination of the unemployment growth relationship by analyzing how the quantiles of one variable respond to the quantiles of the other. The QQR framework addresses the limitations of both conventional quantile regression and mean based models by enabling a layered and distribution sensitive assessment of the interaction between unemployment and economic growth. Through this approach, the study offers new empirical evidence on the nature of this relationship in the Turkish context, highlighting its complex, asymmetric, and level dependent characteristics.

Methodology

The first part of this section outlines the importance of unit root and stationarity in time series econometrics and introduces the specific tests utilized in the empirical analysis. The second part presents the theoretical structure and practical applicability of the Quantile-on-Quantile Regression (QQR) technique adopted to analyze the relationship between unemployment and economic growth.

Unit root and stationarity tests

In time series econometrics, stationarity, defined as the constancy of a series' mean, variance, and autocovariance over time, is a critical prerequisite for avoiding spurious regression results. Therefore, testing for stationarity represents a fundamental step in empirical modeling (Granger & Newbold, 1974; Gujarati, 2021). Among the earliest and most widely used procedures is the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979, 1981), which examines the presence of a unit root under three model specifications: none, with intercept, and with intercept and trend. If the test statistic's slope parameter is negative and statistically significant, the null hypothesis of a unit root is rejected, implying stationarity. The calculated test statistics are evaluated against critical values provided by MacKinnon (1996).

To address potential issues such as autocorrelation and heteroskedasticity in the residuals that may distort the reliability of the ADF test, Phillips and Perron (1988) proposed an alternative procedure known as the PP test. This test offers the same null hypothesis and critical values as the ADF but improves robustness by adjusting for serial correlation in the errors.

In contrast to the ADF and PP tests, the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test (1992) reverses the null hypothesis: it assumes that the series is stationary, testing it against the alternative of a unit root. This Lagrange Multiplier (LM) based test computes the statistic from the variance of the residual sum and employs a Bartlett kernel for estimation. This approach allows for direct inference about stationarity and helps to identify cases where classical unit root tests might lead to misclassification.

Although these conventional tests are widely used, they do not account for structural breaks, which are frequently observed in macroeconomic time series. Ignoring such breaks can reduce the power of unit root tests and lead to erroneous conclusions (Nelson & Plosser, 1982; Zivot & Andrews, 1992; Lee & Strazicich, 2003; Im et al., 2003, 2005). To remedy this, Lee and Strazicich (2003) introduced a structural break test based on the LM approach, which allows for up to two endogenous breakpoints in both the intercept and trend. The null hypothesis asserts the presence of a unit root with structural breaks; rejection implies stationarity despite those breaks. Similarly, Narayan and Popp (2010) developed an ADF type unit root test that endogenously determines two breakpoints in either the intercept or both the intercept and trend. This method is particularly useful in small samples, as it minimizes the risk of overrejecting the null hypothesis. Monte Carlo simulations conducted by the authors confirm the test's consistency and power properties.

Quantile-on-Quantile (QQ) regression

The quantile regression technique, initially developed by Koenker and Bassett (1978), enables the analysis of how the independent variable influences different quantiles of the dependent variable unlike ordinary least squares (OLS), which is confined to mean effects (Altaylar & Dursun, 2021). As such, quantile regression provides a more comprehensive view of the distributional characteristics of the dependent variable. The Quantile-on-Quantile Regression (QQR) approach, proposed by Sim and Zhou (2015), extends this framework by estimating the impact of various quantiles of an independent variable on each quantile of the dependent variable. In this way, QQR enables the estimation of slope coefficients that vary across both dimensions τ

(quantile of the dependent variable) and θ (quantile of the independent variable) thus allowing for a more flexible modeling of dependence structures.

The rationale for employing the QQR methodology in this study is threefold:

i. Descriptive statistics (such as the Jarque-Bera (JB) and Shapiro-Wilk (SW) tests for normality) along with visual tools like histograms and quantile-quantile (Q-Q) plots, suggest that Türkiye's unemployment and economic growth data deviate from normality and exhibit asymmetric and nonlinear characteristics. QQR is particularly well suited for capturing such features (Sohag et al., 2021; Suki et al., 2020).
ii. In contrast to OLS and traditional quantile regression, QQR incorporates nonparametric elements that mitigate the shortcomings of both approaches (Sohag et al., 2022; Meo & Abd Karim, 2022).
iii. QQR is designed specifically for bivariate analysis, minimizing risks associated with model misspecification. As such, it allows the estimation of how the unemployment rate and real economic growth in Türkiye interact over the full distribution of each variable. Formally, the τ-th quantile of real economic growth (GDP_t) is expressed as a function of the unemployment rate (UN_t):

$$UN_t = \beta^{\tau} GDP_t + u_t^{\tau} \tag{1}$$

Here, there are two unknowns depending on the relationship between the UN and GDP: The first β^{τ} is a term with an unknown value. The second is the error term u_t^{τ} residual series. To linearize the unknown functional relationship in Equation (1), a first-order Taylor expansion is conducted around the θ-th quantile of the unemployment distribution. This yields the following local linear approximation:

$$\beta^{\tau} GDP_t \approx \beta^{\tau} GDP^{\theta} + \beta^{t}\big(GDP^{\theta}\big)\big(GDP_t - GDP^{\theta}\big) \tag{2}$$

where, $\beta^{\tau} GDP^{\theta}$ and $\beta^{t}\big(GDP^{\theta}\big)$ are slope parameters that vary jointly across the quantiles τ and θ, capturing the heterogeneity in the effect of unemployment on economic growth across the distribution. Substituting this into the original equation results in:

$$\beta^{\tau} GDP_t \approx \beta_0(\tau,\theta) + \beta_1(\tau,\theta)\big(GDP_t - GDP^{\theta}\big) \tag{3}$$

To arrive at the final form of the equation, Equation 3 is substituted into Equation 1:

$$\mathrm{UN}_t = \underbrace{\beta_0(\tau,\theta) + \beta_1(\tau,\theta)\big(GDP_t - GDP^{\theta}\big)} + u_t^{\tau} \tag{4}$$

where, $\underbrace{\beta_0(\tau,\theta) + \beta_1(\tau,\theta)\big(GDP_t - GDP^{\theta}\big)}$, τ denotes the conditional quantile of the unemployment rate (UN). This formulation captures how unemployment in Türkiye responds to variations in economic growth across the entire joint distribution of both variables. Unlike standard quantile regression, the coefficients in the QQR framework are indexed by both τ (the quantile of the dependent variable) and θ (the quantile of the independent variable), allowing for a two-dimensional response structure. To analyze the reverse relationship namely, how economic growth responds to changes in unemployment the same procedure is applied by treating GDP as the dependent variable and UN as the explanatory variable, resulting in the corresponding equations.

$$\mathrm{GDP}_t = \underbrace{\beta_0(\tau,\theta) + \beta_1(\tau,\theta)\big(UN_t - UN^{\theta}\big)} + u_t^{\tau} \tag{5}$$

It is worth noting that, in nonparametric estimation contexts like QQR, the selection of bandwidth is critical: while a wider bandwidth reduces variance, it increases estimation bias.

Variables and empirical findings

This study investigates the interaction between economic growth and unemployment in Türkiye over the period 2005:Q1 to 2024:Q4. The dataset was obtained from the Electronic Data Delivery System (EVDS) of the Central Bank of the Republic of Türkiye (CBRT). Real economic growth is measured by the seasonally

adjusted, chained volume index of gross domestic product (GDP) calculated via the expenditure approach, expressed as the percentage change relative to the previous year end. The unemployment variable represents the seasonally adjusted unemployment rate for individuals aged 15 and older, drawn from core labor force indicators. Table 1 presents the abbreviations, measurement units, and transformation methods applied to the variables.

Table 1
Variables

Definiton of variables	Abbrevation	Unit	Transformation	Database
Economic growth	GDP	Thousand TRY	Natural logarithm of GDP	TCMB-EVDS
Unemployment rate	UN	Rate	Natural logarithm of UN	TCMB-EVDS

To eliminate scale discrepancies between the variables, both GDP and unemployment rates were transformed using natural logarithms. Accordingly, the analysis is conducted using fully elastic functional forms. The closed forms of the models are represented in Equations (6) and (7), respectively:

$$UN_t = f(GDP_t) \tag{6}$$

$$GDP_t = f(UN_t) \tag{7}$$

In these equations, t is the time dimension. In Equation (6), the impact of economic growth on the unemployment rate is examined, whereas Equation (7) analyzes the effect of unemployment on economic growth. Although the models are grounded in the framework of Okun's Law, this study departs from the conventional linear specification by exploring potential asymmetries using a quantile based approach. In this context, the Okun coefficient is treated not as a fixed parameter but as a variable coefficient contingent on different quantiles of both growth and unemployment

Table 2 presents summary statistics for Türkiye's economic growth and unemployment over the sample period. The average unemployment rate during the period is 10.37%, with a median value of 10.08%, indicating a relatively symmetric distribution. The minimum and maximum unemployment rates were recorded at 8.1% (2012: Q2) and 14.03% (2019: Q3), respectively. Conversely, growth figures display a more negative skew. The lowest growth rate, -20.19%, occurred in 2020: Q2 during the COVID-19 pandemic, while the highest growth rate, 10.51%, was revealed in 2011: Q3. The Jarque-Bera (JB) and Shapiro-Wilk (SW) test statistics results reject the null hypothesis of normality for both the unemployment and GDP series at conventional significance levels. These findings provide strong evidence that neither series is normally distributed. Thereby justifying the use of nonparametric techniques such as QQR.

Table 2
Variables

Variables	Mean	Std. Deviation	Median	Minimum	Maximum	JB statistic	SW statistic
UN	10.37	1.64	10.08	8.10	14.03	7.63**	0.93***
GDP	-2.90	8.82	-1.94	-20.19	10.51	5.90*	0.83***

Note: i.***, **, and * demonstrate 10%, 5%, and 1% significance levels, respectively. ii. Jarque-Bera (JB) and Shapiro-Wilk (SW) statistics test for normality.

Table 3 displays the Spearman rank-order correlation coefficient between the unemployment rate and economic growth, revealing a moderately negative relationship of approximately -0.16. While this confirms the expected inverse association between the two variables, it does not capture the heterogeneity or

potential nonlinearity in the relationship issues that are addressed through regression analysis in the following sections.

Table 3

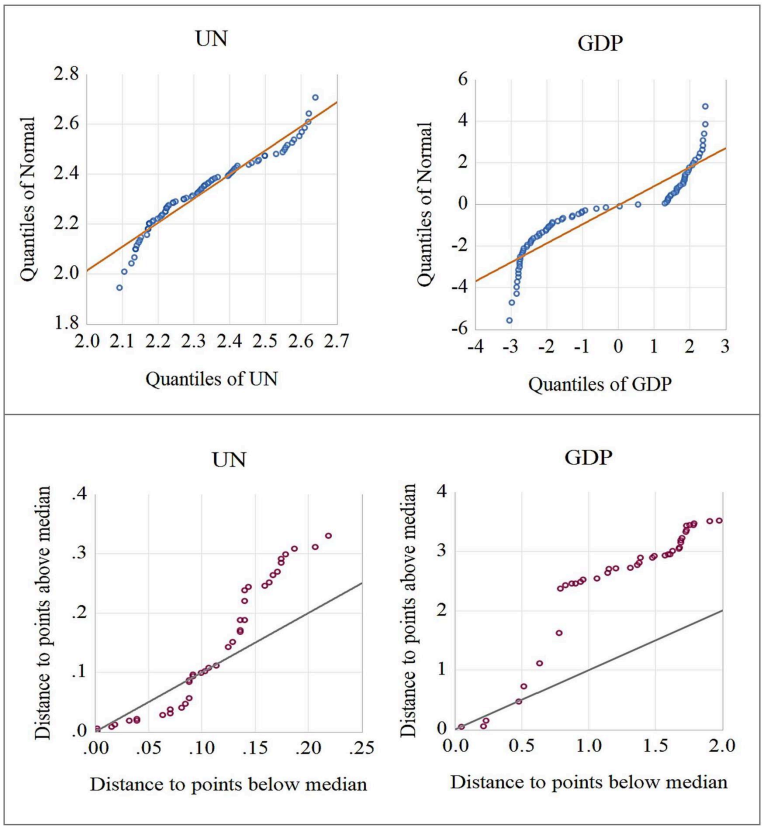
Correlation coefficient (Spearman rank order)

Variables	UN
GDP	−0.1577

Figure 2 illustrates quantile-quantile (Q-Q) plots for both the unemployment and economic growth series, presented in both empirical and symmetric formats. The empirical Q-Q plot visually compares the distribution of the series against a normal distribution, while the symmetric Q-Q plot assesses the data's symmetry around the median. In both cases, the horizontal axis represents the average distance of observations below the median, whereas the vertical axis represents the distance of those above the median. The reference line denotes a perfectly symmetric distribution. Deviations from this line indicate asymmetries in the lower and upper tails of the distribution. Both the UN and GDP series exhibit substantial deviations from the reference line, confirming the presence of distributional asymmetry. These graphical results, consistent with the JB and SW statistics, reinforce the conclusion that mean based estimation techniques may be inadequate for modeling the relationship between unemployment and growth.

Figure 2

Q-Q Plots for UN and GDP Series



Source: Author's own elaboration.

Empirical findings

Unit root test results

Identifying the presence of a unit root in a time series is essential for avoiding spurious regression outcomes. Accordingly, this study employs both traditional and structural break unit root tests to assess the stationarity properties of the GDP and unemployment (UN) series, aiming to ensure the robustness of the econometric analysis. Table 4 presents the results of the conventional unit root and stationarity tests. For the GDP series, the null hypothesis of a unit root is rejected at the 1% significance level under both the Augmented Dickey & Fuller (ADF) and Phillips & Perron (PP) tests, indicating that the series is stationary in levels. Similarly, the KPSS test does not reject the null hypothesis of stationarity, confirming the robustness of the result across all three tests. In contrast, the results for the unemployment series are mixed. The ADF and PP tests fail to reject the null hypothesis of a unit root at conventional significance levels, whereas the KPSS test does not reject the null of stationarity. However, the ADF and PP tests do reject the null hypothesis of a unit root when applied to the first differenced unemployment series. This divergence across tests raises concerns about the robustness of inferences drawn from traditional approaches.

Table 4

Summary of traditional unit root tests results

	ADF Test		PP Test		KPSS Test	
Variables	τ statistic Intercept	τ statistic Intercept & trend	Adj. τ statistic Intercept	Adj. τ statistic Intercept & trend	LM istatistiği Intercept	LM statistic Int. & trend
GDP	−4.0291***	−4.0988***	−9.4574***	−9.7132***	0.1356	0.0861
UN	−2.3211	−2.2253	−1.9113	−1.7411	0.2525	0.0896
dUN	−4.9718***	−4.9911***	−5.0761***	−5.0311***	0.1220	0.0677

Note : i.***, **, and * demonstrate 10%, 5%, and 1% significance levels , respectively . ii." d " first difference operator.

Given the conflicting results and the inability of standard tests to account for potential structural breaks, the Lee-Strazicich (LS) and Narayan-Popp (NP) tests are employed to provide robust results. These tests explicitly allow for the presence of two endogenous structural breaks in both the level and trend of the series. The results, presented in Table 5, reveal that the null hypothesis of a unit root with structural breaks is rejected for the unemployment series at various significance levels.

This implies that the unemployment series is stationary when structural breaks are taken into account.

Table 5

Summary of SB unit root tests results

	LS Test		NP Test	
Variables	τ statistic Intercept	τ statisticIntercept & trend	τ statistic Intercept	τ statistic Intercept & trend
UN	−3.1399	−4.4064** (2010:Q2; 2018:Q2)	−3.399* (2016:Q3 & 2017:Q1)	−3.798

Note: i.***, **, and * demonstrate 10%, 5%, and 1% significance levels , respectively . ii. Pharantheses show break dates. iii. SB: structural breaks.

Following the unit root and stationarity tests, the BDS (Brock-Dechert-Scheinkman) test is applied to determine whether the relationship between economic growth and unemployment is better characterized by a linear or nonlinear structure. The test results, reported in Table 6, provide strong evidence in favor of nonlinearity for both the GDP and unemployment (UN) series.

Specifically, for the GDP series, the BDS statistics are statistically significant at the 1% level for embedding dimensions m = 3 to m = 6, while the statistic for m = 2 is not significant. For the UN series, all BDS statistics are highly significant across all dimensions, reinforcing the conclusion that the underlying data generating processes do not conform to linear dynamics.

These findings, together with previous evidence of non-normality, asymmetry, and nonlinearity, demonstrate that the relationship between unemployment and economic growth is inherently nonlinear. As such, conventional mean based or linear models are insufficient for capturing the full scope of the interaction between these variables. Accordingly, the Quantile-on-Quantile Regression (QQR) technique developed by Sim and Zhou (2015) is employed. Specifically, the analysis focuses on Model I, which examines how different quantiles of the unemployment rate affect various quantiles of economic growth. This approach enables a more nuanced understanding of the dynamic and asymmetric nature of the unemployment growth nexus.

Table 6

BDS test results

Variables	BDS stat. M=2	BDS stat. M=3	BDS stat. M=4	BDS stat. M=5	BDS stat. M=6
GDP	0.0016	0.0433***	0.0405***	0.0873***	0.1203***
	(0.7331)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
UN	0.1483***	0.2376***	0.2849***	0.3036***	0.3044***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Note : i.*** demonstrates 1% significance level . ii. Pharantheses show p- values.

Figure 3 (Author's own elaboration) displays four distinct 3D surface plots based on Model I, illustrating how different quantiles of economic growth (GDP) affect corresponding quantiles of unemployment (UN). The horizontal axis represents quantiles of GDP, the vertical axis denotes quantiles of UN, and the third dimension reflected through surface height and color gradients captures the estimated response intensity.

The surface exhibits a generally monotonic downward slope, indicating a negative relationship between GDP and unemployment. This downward trend becomes noticeably steeper beginning around the middle quantiles of GDP (approximately 0.4 to 0.5), after which a gradual decline in unemployment is observed across nearly all its quantiles. The slope intensifies further beyond the 0.6 GDP quantile and reaches its steepest point in the higher quantiles particularly after the 0.8 level where the upper quantiles of unemployment exhibit a marked and accelerated decrease. This pattern is further supported by the color transition from red to green and eventually to blue, which visually emphasizes the strong negative association between higher levels of GDP and unemployment.

By contrast, in the lower quantiles of GDP, the surface remains relatively flat, implying that lower growth levels do not significantly alter unemployment outcomes across quantiles. This indicates that the effects are more concentrated and heterogeneous at higher GDP levels, with a broader variance in unemployment responses. Overall, the graphical results underscore the asymmetric nature of the relationship and validate the suitability of the QQR approach in capturing such nonlinear dynamics.

Figure 4 (Author's own elaboration) presents the surface plots derived from Model II (equation 7), which examines the impact of various quantiles of unemployment (UN) on different quantiles of economic growth (GDP). In these 3D visualizations, the horizontal axis corresponds to the quantiles of UN, while the vertical axis represents the quantiles of GDP. The third dimension reflects the estimated coefficients, providing insight into the intensity and direction of the unemployment effect across the joint distribution.

The slope of the surface begins to shift noticeably starting from the 0.2 unemployment quantile and becomes steeper around the 0.4-0.5 range. Once unemployment exceeds these levels, a systematic and

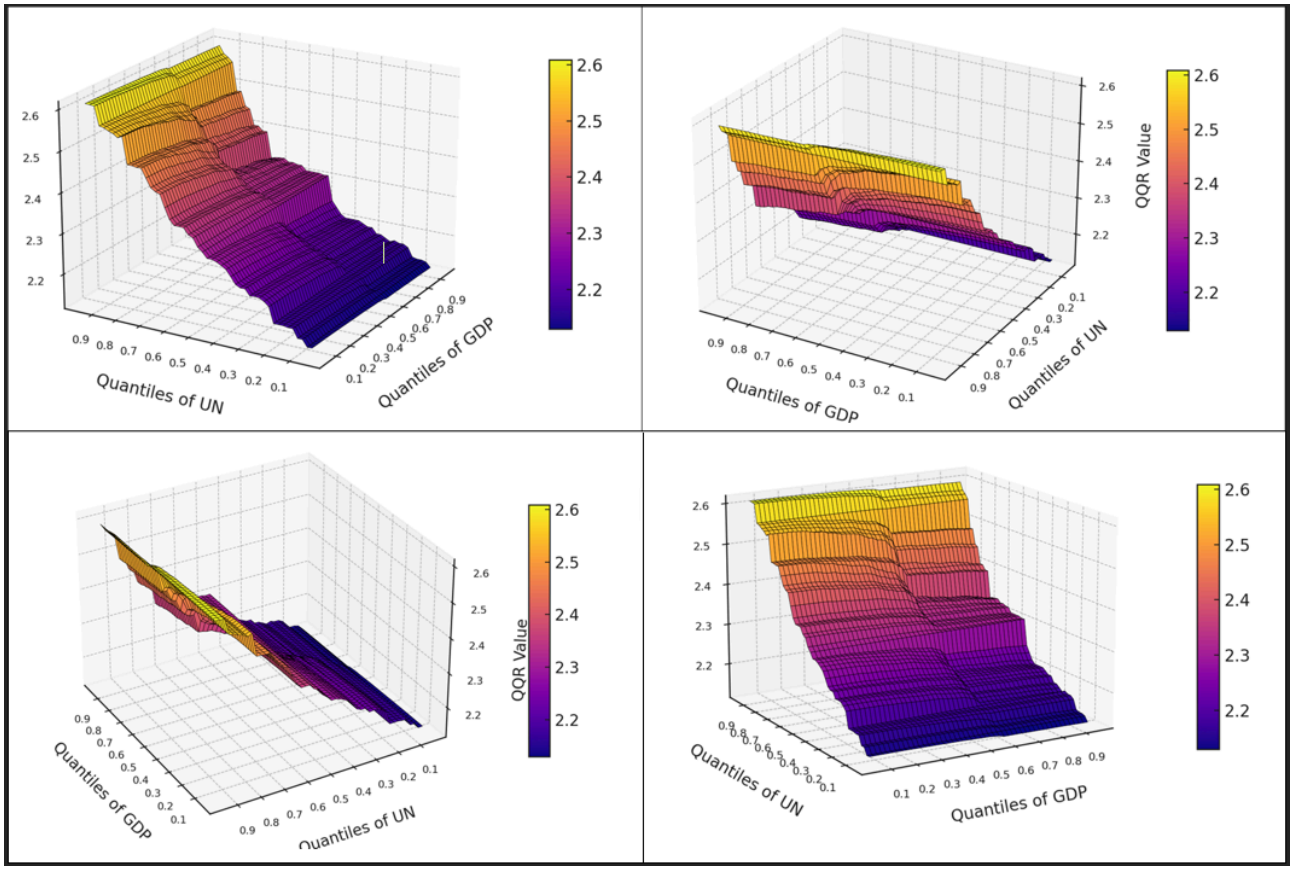
consistent decline in GDP is observed across nearly all of its quantiles. Beyond the 0.6 quantile of unemployment, the downward slope intensifies markedly. This downward slope intensifies further, indicating that increases in unemployment at higher quantiles exert a significantly stronger negative impact on GDP. The most significant contraction in GDP is observed in the upper quantiles of the growth distribution when unemployment is also in its higher quantiles specifically beyond the 0.8 threshold. This suggests that when both variables are situated in the upper ends of their respective distributions, the adverse interaction becomes markedly stronger.

In contrast, the surface remains relatively flat in the lower GDP quantiles across much of the unemployment distribution, indicating a weaker or negligible relationship in those regimes. These surface visualizations underscore the asymmetric and nonlinear nature of the unemployment-growth relationship. The surface visualizations thus confirm the asymmetric nature of the relationship: the negative effect of unemployment on economic growth is much more pronounced in certain quantile combinations, particularly in high-unemployment and high-growth regimes.

The colour distribution is also important. The spectrum, starting from dark red, shifts to yellow and green in the middle, and then to blue, demonstrating how the impact on GDP varies with higher unemployment levels. While there is no sudden jump in colour transitions, the slope change is continuous. The overall slope direction is uniform and asymmetric (flat in the lower quantiles and steep in the upper quantiles). These findings also validate the use of the QQR technique and demonstrate that the relationship between unemployment and economic growth is more complex and conditional than that predicted by fixed-parameter models can predict.

Figure 3

The QQR results of GDP efect on UN (Model I)

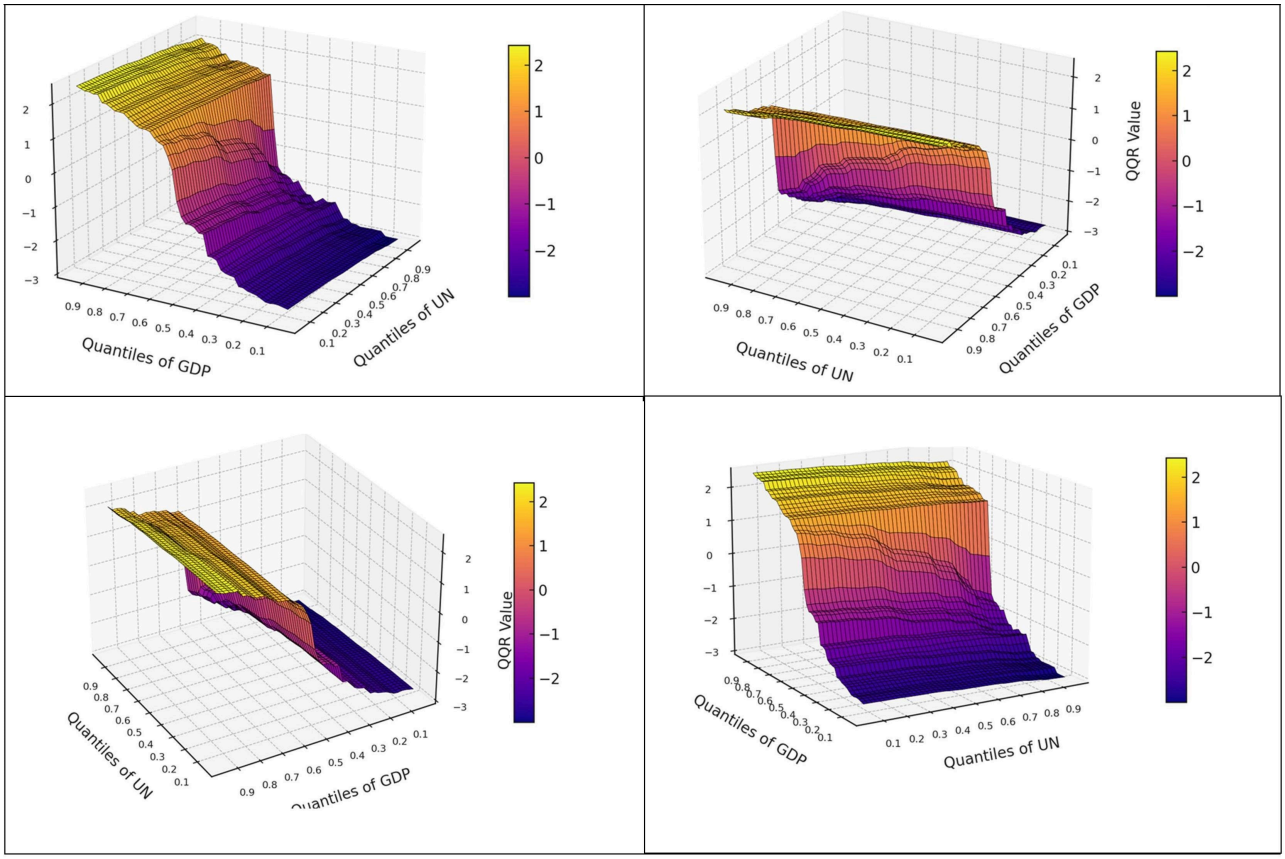


Source: Author's own elaboration.

In the lower quantiles of GDP, the surface remains relatively flat across much of the unemployment distribution, indicating a weaker or negligible relationship in these regimes. The surface visualizations thus confirm the asymmetric nature of the relationship: the negative effect of unemployment on economic growth is much more pronounced in certain quantile combinations, particularly in high-unemployment and high-growth regimes. These results once again demonstrate the necessity of nonlinear and distribution-sensitive estimation methods such as QQR.

Figure 4

The QQR results of UN efect on GDP



Source: Author's own elaboration.

Conclusion

This study investigates the relationship between economic growth and unemployment in Türkiye from 2005:Q1 to 2024:Q4 using the Quantile-on-Quantile Regression (QQR) method. The QQR approach allows for a comprehensive analysis of how different quantiles of unemployment affect different quantiles of growth and vice versa, capturing potential asymmetries and nonlinearities that are not identifiable through traditional mean based or standard quantile regression models.

Preliminary tests indicated that the data series are non-normally distributed and exhibit nonlinearity and structural breaks, thereby justifying the use of a distribution-sensitive method such as QQR. The results reveal a robust but asymmetric and nonlinear relationship between economic growth and unemployment, broadly consistent with the tenets of Okun's Law.

A detailed quantile based analysis shows significant variation across economic states. In low growth quantiles, particularly when unemployment rates are high, the effect of unemployment on GDP is negative and relatively strong, indicating that labor market disruptions substantially constrain economic activity

during downturns or crisis periods. In middle growth quantiles, reflecting more stable economic conditions, the effect of rising unemployment on growth is statistically insignificant, suggesting that under normal circumstances, the Turkish economy exhibits relative resilience to labor market shocks. In high growth quantiles, a positive relationship is observed between growth and unemployment when unemployment is low, implying that labor market improvements reinforce economic momentum in expansionary phases. Furthermore, in quantiles associated with medium to high unemployment levels, the direction and strength of the effect on GDP appear more heterogeneous. While the effects are weak or mixed at medium unemployment levels, the impact on growth becomes negative in certain high-unemployment scenarios. This finding highlights an important asymmetry: although elevated unemployment can suppress growth, this effect is not uniformly linear across all economic conditions.

In light of these findings, the quantile-on-quantile results indicate that the unemployment and growth relationship in Türkiye is highly regime-dependent rather than uniform across the distribution. The differentiated patterns observed across low, medium, and high growth regimes suggest that policy responses should be aligned with the prevailing economic conditions. In periods characterized by low growth and high unemployment, where the adverse effects are most pronounced, targeted and time-bound employment support instruments such as temporary wage subsidies, automatic stabilizers through short-time work schemes, and employment-preserving payroll tax incentives constitute feasible and effective countercyclical tools. In intermediate regimes, where the impact weakens and structural frictions become more salient, policies should prioritize skill-matching programs, vocational training, incentives for youth and female labor force participation, as well as measures aimed at reducing informality. Conversely, during high-growth regimes where the transmission from output to employment becomes more heterogeneous, productivity-enhancing interventions, improved access to finance for SMEs, and regionally balanced investment incentives can help ensure that growth translates into sustainable employment creation. Overall, the evidence underscores that a one-size-fits-all approach is insufficient; instead, an adaptable, regime-contingent policy framework is more likely to support a resilient and employment-inclusive growth trajectory in Türkiye.

Overall, the findings emphasize that the unemployment-growth nexus in an emerging economy is not static but state-dependent. The asymmetric responses observed across quantiles reflect structural rigidities, skill mismatches, and adjustment costs that constrain labor market flexibility. From an economic policy standpoint, these results imply that uniform, average-based countercyclical measures may be insufficient. Instead, employment policies should be state-contingent-targeting rigidities and supporting labor absorption during downturns while enhancing adaptability and productivity during expansions. In this sense, the study extends the traditional framework of Okun's Law by reframing it as a dynamic, nonlinear model of cyclical labor market dynamics under structural and institutional constraints.

Ethics Committee Approval: My study used only secondary data. No surveys, experiments, observations, or data collection processes requiring direct human participation were conducted. Therefore, ethics committee approval is not required within the framework of relevant legislation and ethical rules.
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