BMIJ
ISSN: 2148-2586

bmij (2026) 14 (1):215-231
doi: https://doi.org/10.15295/bmij.v14i1.2695

Research Article

Economic growth and employment in the EU-27: Panel Fourier causality evidence

AB-27'de ekonomik büyüme ve istihdam: Nedensellik kanıtları

Ali Rauf Karataş[1]

Müşerref Arık[2]

Melike Buse Akcan[3]

[1] Asst. Prof. Dr, Karabük University, Karabük, Türkiye,
aliraufkaratas@karabuk.edu.tr

ORCID: 0000-0003-1031-6722

[2] Lecturer, KTO Karatay University, Konya, Türkiye,
muserref.arik@karatay.edu.tr

ORCID: 0000-0002-5334-8743

[3] Dr., Konya, Türkiye,
melikebuseakcan@hotmail.com

ORCID: 0000-0001-5101-1613

Corresponding Author:

Ali Rauf Karataş,

Karabük University, Karabük, Türkiye,

aliraufkaratas@karabuk.edu.tr

Submitted: 1/01/2026

Revised: 30/01/2026

Accepted: 15/02/2026

Online Published: 25/03/2026

Citation: Karataş, A.R., & Arık, M., & Akcan, M.B., Economic growth and employment in the EU-27: Panel Fourier causality evidence, bmij (2026) 14 (1):215-231, doi: https://doi.org/10.15295/bmij.v14i1.2695

Abstract

Jobless growth refers to a process in which economic growth occurs without a simultaneous increase in employment. It has become a concept extensively discussed in economic literature, particularly since the 1990s. This study examines the effects of economic growth on employment and unemployment, using the EU-27 as an example, and tests whether economic growth leads to an increase in employment and/or a decrease in unemployment in the long term. Within this scope, using data from 1991–2024, the causal relationships among economic growth, employment, and unemployment rates were analysed using the Panel Fourier Toda–Yamamoto causality test. This method offers significant advantages over traditional causality tests widely used in the literature, as it accounts for structural breaks and non-linear dynamics in the series. At the panel level, the evidence suggests that growth-driven employment creation is weak and inconsistent, implying that economic expansion does not directly translate into improved labour market outcomes. These results show that the capacity of economic growth to create employment may vary across countries, depending on country-specific structural characteristics, labour market dynamics, and the policy frameworks in place. The study aims to empirically contribute to the jobless growth literature by examining the growth–employment–unemployment relationship from a two-way perspective and highlighting the importance of inclusive, employment-friendly growth strategies for policymakers.

Keywords: Economic Growth, Jobless Growth, Panel Fourier Causality Test

Jel Codes: E24, J21, O47

Öz

İşsiz büyüme, ekonomik büyümenin istihdam artışıyla eşzamanlı gerçekleşmediği bir büyüme sürecini ifade etmekte olup, özellikle 1990'lı yıllardan itibaren iktisat literatüründe yoğun biçimde tartışılan bir kavram hâline gelmiştir. Bu çalışma, AB-27 ülkelerini örnek alarak ekonomik büyümenin istihdam ve işsizlik üzerindeki etkilerini incelemekte olup ekonomik büyümenin AB-27'de uzun vadede istihdamda artışa ve/veya işsizlikte azalmaya yol açıp açmadığını test etmektedir. Bu kapsamda, 1991–2024 dönemine ait veriler kullanılarak ekonomik büyüme, istihdam ve işsizlik oranları arasındaki nedensellik ilişkileri Panel Fourier Toda–Yamamoto nedensellik testi aracılığıyla analiz edilmiştir. Söz konusu yöntem, serilerdeki yapısal kırılmaları ve doğrusal olmayan dinamikleri dikkate alması bakımından literatürde yaygın olarak kullanılan geleneksel nedensellik testlerine kıyasla önemli avantajlar sunmaktadır. Panel düzeyinde, kanıtlar büyüme odaklı istihdam yaratmanın zayıf ve sistematik olmadığını göstermektedir. Bu da ekonomik büyümenin doğrudan işgücü piyasasında iyileşmeye yol açmadığını ima etmektedir. Bu sonuçlar, ekonomik büyümenin istihdam yaratma kapasitesinin ülkeye özgü yapısal özellikler, işgücü piyasası dinamikleri ve uygulanan politika çerçevelerine bağlı olarak değişebileceğini göstermektedir. Çalışma, büyüme–istihdam–işsizlik ilişkisini çift yönlü bakış açısıyla ele alarak işsiz büyüme literatürüne ampirik katkı sağlamayı amaçlamakta; aynı zamanda politika yapıcılar açısından kapsayıcı ve istihdam dostu büyüme stratejilerinin önemine dikkat çekmektedir.

Anahtar Kelimeler: Ekonomik Büyüme, İşsiz Büyüme, Panel Fourier Nedensellik Testi

Jel Kodları: E24, J21, O47

Introduction

Economic growth forms the foundation of macroeconomic studies and is often associated with the keywords 'unemployment' and 'employment'. (Ball et al., 2017; Okun, 1962). However, when assessing the labour market, it is also recognised that the dynamics of employment and labour force participation may not always move in proportion to production growth, as various factors may influence them. This situation brings the importance of the jobless growth debate and policy implications for inclusive development back to the agenda. The relationship between economic growth and employment was first examined in the Keynesian approach (Kaldor, 1957; Keynes, 1937), and the classical Keynesian approach determined that the relationship that exists between economic growth and employment growth is positive (Ball et al., 2017; Kaldor, 1957; Keynes, 1937; Okun, 1962). Following the classical Keynesian approach, the relationship between variables has also been examined using the Neoclassical (Solow, 1956) and New Classical (Lucas, 1988) approaches. Studies based on the relevant theoretical framework have indirectly expressed that relationship through factors such as productivity growth, capital (Lucas, 1988; Romer, 1990), and technological progress. Although it is claimed that increased production will boost labour demand, structural changes such as technological development, automation and efficiency-focused growth may weaken the employment content of growth.

Although employment growth is cited as one of the underlying factors of economic growth in numerous studies in the literature (Abou Hamia, 2016; Kaldor, 1957; Keynes, 1937; Kitov & Kitov, 2011; Lal et al., 2010; Okun, 1962) there are also studies that state economic growth occurs independently of employment (Abraham, 2019; Padhi & Panda, 2021; Salim & Basher, 2024; Tejani, 2016; Yağmur, 2025). This observed difference in the results points to an empirical contradiction in the literature. A superficial assessment of similar growth processes may yield significantly different labour market outcomes across countries and periods. Therefore, verifying the validity of jobless growth has become an important issue. The term jobless growth was first discussed in writing about India and was introduced into the literature in a World Bank report published in the 1990s. It was then systematically examined in the study by Bhattacharya & Sakthivel (2003). This concept first emerged in developing countries but has become increasingly important for developed economies, particularly in the context of structural transformation, digitalisation and changes in labour market institutions.

Studies in the literature that evaluate jobless growth are often grounded in Okun's Law. (Bhargava et al., 2025; Dönmez & Sugözü, 2022; Peláez-Herreros, 2025). Okun's law assumes an inverse relationship between economic growth and unemployment; situations where this law does not hold indicate jobless growth. When studies examining jobless growth and the validity of Okun's law are assessed, it is seen that there are several demographic and macroeconomic variables among the variables examined in relation to economic growth, and it is seen that the 15(+) employment to population ratio variable examined in this study is not included in the study. Selecting this variable enriches the literature. This is because the employment-to-population ratio (15+) provides a broader and more direct indicator of labour market performance than the unemployment rate alone. The total unemployment rate does not include everyone outside the labour market in terms of scope. When evaluating the reasons for unemployment, factors such as individuals actively stopping their job searches, not applying for jobs due to repeated failures, or being unemployed due to education, family responsibilities, health problems, or early retirement can be observed. Unemployment rates are incomplete because they do not account for those who are not actively seeking work. Therefore, unemployment figures alone do not reveal the true weakness of the labour market. This issue is important in that it reveals that labour markets exhibit diversity beyond the total unemployment rate. The employment-to-population ratio (15+) is more comprehensive because it directly reflects the share of the working-age population that is actually employed, regardless of whether non-employed individuals are classified as unemployed or inactive. This variable directly reflects the portion of the working-age population that is actually employed.

This study adds to what we already know about this subject by evaluating both total unemployment and the 15(+) employment-to-population ratio variable. This ratio is important because it shows how many in the working-age population can actually benefit from economic growth. Including both variables in the study allows growth to be examined from both employment and unemployment perspectives. This scope is significant because it broadens the literature's narrow perspective.

The study's examination of 27 EU countries is another strength. Although countries are members of a specific economic union and are shaped by concepts such as a common market and trade integration, their different labour force structures and levels of economic development are important in determining the relationships among variables and the differences observed. The study covers the period from 1991

to 2024, including events and phenomena with global impact, such as economic and health crises, thereby providing a broad scope for interpreting the findings.

A causality test was applied to examine the relevant variables for 27 European Union countries within the specified time period. The method used to evaluate the relationship between variables is the Panel Fourier Toda-Yamamoto causality test (Nazlioglu et al., 2016; Toda & Yamamoto, 1995), which accounts for structural breaks, a feature that distinguishes it from other methods. The aim is to determine whether there is a causal link between economic growth, employment and unemployment. The study's findings aim to test for the existence of jobless growth.

Based on the relevant objective, following the introduction section of the study, the literature review presents studies that test jobless growth and/or Okun's law, the methods used, the time periods examined, the countries, and the outputs obtained. This section is important because it articulates the contribution of this study. Following a literature review, the method applied in this study is described, and the equation constructed using this method is presented. The findings from analysing the variables using the relevant method are presented in the fourth section of the study. The findings were presented in the fifth section of the study, in light of studies that enrich the literature, and were evaluated by offering policy recommendations.

Literature review

The study examines two different unemployment variables in relation to economic growth. These variables have been determined as the total population ratio (15+) and the total unemployment rate. By examining the relevant variables, the aim is to analyse the correlation between growth and employment in 27 countries. This section of the study aims to evaluate the scope of studies examining the relationship between economic growth and employment variables. Table 1 provides information about the studies included in the literature review.

Table 1 provides information on the main variables, methods and key findings of the selected studies. The information in the table enables a clearer comparison of how economic growth affects job creation and unemployment reduction.

Table 1: Literature Review

Authors	Year	Country	Variables	Method	Result
Akusta	2025	Türkiye	Economic Growth (GDP) Sectoral Growth Unemployment	FMOLS CCR ARDL	The hypothesis is not valid.
Yağmur	2025	EU-27	Economic Growth (GDP) Employment	Panel Data Analysis	Jobless growth varies across countries.
Salim & Basher	2024	Bangladesh	Employment GDP Sectoral Employment	Decomposition Analysis	A trend of jobless growth has emerged.
Arora et al.	2024	India	Sectoral Production Data Inflation Rates Foreign Direct Investment Trade Balance	ARDL	The hypothesis is valid.
Akter	2021	Bangladesh	Economic Growth Employment Unemployment Female Labor Force Participation	Descriptive Analysis	The hypothesis is valid.
Padhi & Panda	2021	India	Sectoral Growth Employment Productivity	Decomposition Analysis	The hypothesis varies by sector.
Das & Ray	2020	South Asian Countries	Economic Growth Employment Globalisation	Panel Data Analysis	The hypothesis is not valid.
Abubakar & Nurudeen	2019	India	Gross National Income (GNI) GDP	Time Series Analysis	The hypothesis is not valid.
Abraham	2019	India	Sectoral Growth Economic Growth Employment Globalisation	Structural Transformation Analysis	The hypothesis is valid.
Meyer & Sanusi	2019	South Africa	Economic Growth Gross Fixed Capital Formation Employment	VECM Johansen Cointegration Test	The hypothesis is valid.
Bölükbaş	2018	Türkiye	Informal Employment Youth Unemployment Economic Growth	VAR Analysis Granger Causality Test	The hypothesis is not valid.
Tejani	2016	India	Sectoral Growth Employment Unemployment	Time Series Analysis	The hypothesis is valid.
Abou Hamia	2016	MENA Countries	Economic Growth Employment Unemployment	Panel Data Analysis ARDL	Jobless growth varies from country to country.
Kitov & Kitov	2011	United States of America United Kingdom France Australia Canada Japan	GDP Per Capita Employment/Population Unemployment Rate	Least Squares Method	The hypothesis is not valid.
Lal et al.	2010	Some Asian Countries	Unemployment Rate Economic Growth	ECM Cointegration Test	Jobless growth varies from country to country.

In the study by Lal et al. (2010), the researchers selected developing Asian countries as their sample. The study examined the period from 1980 to 2006 and conducted the analysis using an error correction model and the Engle-Granger cointegration test. The study examined employment and economic growth variables and determined the validity of Okun's law. The results of the study differ across countries, with Okun's coefficient calculated at -0.03 for Pakistan, -0.08 for Bangladesh, -0.29 for India, -0.12 for Sri Lanka, and -0.56 for China.

Kitov & Kitov (2011) examined the existence of jobless growth and conducted assessments in six countries. The study used per capita GDP, the unemployment rate, and the inflation rate as indicators of economic growth. The study tested the validity of Okun's law and found that economic growth reduces unemployment. This situation demonstrates that Okun's law is valid, whereas the hypothesis is not. This finding implies that, in the examined countries, economic growth remains employment-absorbing rather than jobless.

Abou Hamia (2016) also assessed jobless growth across 17 MENA countries during 1980-2013. The study applied panel data analysis and demonstrated that Okun's law holds in Algeria, Egypt, Iran, Jordan,

Lebanon, and Türkiye. This situation can be interpreted as signifying that jobless growth does not apply to the six countries in question. For the remaining 11 countries, however, it can be interpreted that the jobless growth hypothesis applies. Taken together, these results confirm that jobless growth dynamics differ across countries even within the same region, highlighting the importance of accounting for heterogeneity in empirical assessments.

Tejani (2016) evaluated the Indian sample in his study and assessed the relationship between sectoral growth and employment during 1978-2010. The study is based on the Kaldor-Verdoorn approach and concludes that jobless growth is valid. The findings indicate that growth is associated with productivity.

Bölükbaş (2018), on the other hand, conducted a study covering the period from January 2010 to September 2017 and tested the existence of jobless growth in Türkiye. The study evaluated the relationships among the economic growth, informal employment, and youth unemployment variables using VAR analysis and the Granger causality test. The study revealed a positive, bidirectional relationship between the two informal employment and economic growth variables, concluding that youth unemployment decreases as the economy grows. This situation indicates that jobless growth is not valid.

Meyer & Sanusi (2019), on the other hand, examined jobless growth in South Africa, analysing economic growth, gross fixed capital formation, and employment variables for the period 1995:Q1-2016:Q4. In the study, the relevant variables were analysed using the VECM model, and a long-term relationship was identified through the Johansen cointegration test. The findings have identified a cointegration relationship. Bidirectional causality has been observed among the examined variables. The results have differed in the long term. The study concluded that jobless growth has been identified.

Abraham (2019), on the other hand, examined the Indian sample in his study and analysed the correlation between GDP and employment, based on sectoral employment data, as well as productivity and demographic factors. Structural transformation analysis was applied in the study, and the examination was conducted in two different periods: 1993-1994 and 2011-2012. In the study, economic growth was measured using per capita value added. In this regard, the finding that the increase in value added observed in the study was due to labour productivity indicates that the most important driver of economic growth is productivity, not the employment rate. When combined with the finding that the relationship between the relevant observation and growth is inverse, this indicates that the jobless growth hypothesis is valid.

Another study examining jobless growth in India that same year was contributed to the literature by Abubakar & Nurudeen (2019). The study examined the variables of gross national income (GNI) and GDP growth rate. The study examined the validity of Okun's law using time-series analysis and determined whether the hypothesis was supported. The results of the study show that the approximately 11% economic growth reduced unemployment by only 0.52%, a very low rate. Therefore, it is difficult to conclude that economic growth reduces unemployment based on the available data.

Das & Ray (2020), on the other hand, examined jobless growth in South Asian countries. The study examines multiple countries and applies panel data analysis. Over the period from 1991 to 2016, the investigation reveals that the relationship between employment and globalisation varies across countries, but the prevailing pattern indicates no relationship between the variables. The study examines globalisation, economic growth, and employment variables, but shows that jobless growth is not significantly valid.

Another researcher examining jobless growth in India conducted a study (Padhi & Panda, 2021) covering the period from 2011-2012 to 2017-2018. The study examined employment rates, population structure, and productivity variables and presented a growth assessment by sector. The article's findings show that growth in the industrial and construction sectors is driven by productivity, whereas jobless growth is prevalent in agriculture and manufacturing.

Akter (2021), on the other hand, examined economic growth, unemployment, employment, and women's labour force participation in Bangladesh. No quantitative analysis was conducted in the study; a descriptive analysis was performed using secondary data, including graphs from the World Bank database. The study concluded that jobless growth exists and that the quality of demographic factors must be strengthened to reduce unemployment.

Salim & Basher (2024), on the other hand, evaluated the relationship between sectoral growth and employment in Bangladesh. The study applied a disaggregated analysis and examined the agriculture, manufacturing, and construction sectors with a focus on gender. The study showed that the link

between economic growth and employment weakened as of 2013. Consequently, it was observed that the economy was approaching a structure of jobless growth.

Arora et al. (2024), on the other hand, conducted their study on a sample from India and evaluated employment by sector. This study differs from previous literature by examining employment flexibility by sector. The study also evaluated sectoral production data, inflation rates, foreign direct investment, and trade openness ratios. In the study, the ARDL bounds test was applied to test jobless growth on a sectoral basis, and the correlation between GDP and employment in the short and long term was evaluated. The findings obtained differ across sectors.

Akusta (2025), on the other hand, tested the validity of the jobless growth hypothesis for the period 2000-2022. The study used an ARDL analysis to determine whether jobless growth differed across sectors. The ARDL bounds test was applied in the study, and the long-term relationship between the variables was assessed using the FMOLS and CCR methods. The study's findings show that growth reduces unemployment across all sectors. This result demonstrates that jobless growth is not valid in Türkiye. The results obtained remain valid both in the short and long term.

In his study, Yağmur (2025) conducted an analysis using the EU-27 countries as the sample. In the study that applied the Panel Fourier Lagrange Multiplier (LM) unit root test, causality between variables was determined using the Panel Fourier Toda–Yamamoto causality test. The study examined the period from 1991 to 2022 and evaluated economic growth and employment variables. The study also evaluated foreign trade variables, including exports and imports. The study's results show that the jobless growth hypothesis holds in most countries. The EU-27 countries where jobless growth is not valid are Bulgaria, the Czech Republic, Finland, Germany, Luxembourg, Portugal, and Romania.

A review of the literature reveals differing assessments of the relationship between economic growth and employment. While most studies rely on unemployment-based indicators within the framework of Okun's law, fewer incorporate broader measures of employment and labour market attachment. This study has conducted an assessment that integrates the employment-population ratio (15+) into the unemployment-growth debate, accounting for structural breaks. The study contributes to the literature by using the Panel Fourier Toda-Yamamoto causality approach and covering a long time period for all EU-27 countries.

Data and methodology

The variables used as instruments to examine the existence of jobless growth and their relationships with economic growth are presented in Table 2. The data in the table are from the World Bank database and cover the period from 1991 to 2024. The relevant values were examined for 27 EU countries. The dataset is complete for the EU-27 for the period 1991–2024, with no missing data. Data sources and codes, along with variable descriptions and abbreviations, are presented in Table 2.

Table 2: Description of Variables

Variable Code	Definition	Abbr.	Source
NY.GDP.MKTP.KD.ZG	GDP growth (annual %)	GDP	WDI
SL.EMP.TOTL.SP.ZS	Employment to population ratio, 15+, total (%)	EPR	WDI
SL.UEM.TOTL.ZS	Unemployment, total (% of total labour force)	UNEM	WDI

When the variables are examined in order, the variable expressed as GDP growth (annual %) and abbreviated as GDP shows how much the country's gross domestic product has increased from the previous year. The GDP variable shows how much an economy has grown compared to the previous year. It provides output by production method and, at the same time, allows an assessment of how much production capacity has expanded in the relevant country compared to one year ago.

Another variable is the total 15+ employment-to-population ratio (%). This variable shows the percentage of the population aged 15 and over who are employed. This variable examines employability above the relevant age limit, based on the ILO standard that considers 15 years of age as the working age. Compared to unemployment rates, the EPR (15+) indicator directly reflects the proportion of the working-age population that is actually employed, without accounting for the active job-seeking status of unemployed individuals. This allows for a broader measurement of labour market performance.

The unemployment rate (total % of the labour force) is the most frequently used variable in studies on jobless growth. The relevant variable assesses the population's unemployment rate and provides output that accounts for the total labour force.

Studies in the literature on jobless growth and the validity of Okun's law have frequently addressed the unemployment rate and GDP variables, and no study has been found that uses the 15 (+) total employment to population ratio variable. This study evaluates the labour market at three points using the variables examined. Here, in addition to the overall assessment of economic growth and employment, evaluating how many working-age individuals are actually employed and whether this growth translates into employment offers a different perspective. This article contributes to the literature on jobless growth by jointly analysing growth and the unemployment-population ratio alongside the unemployment rate, and by examining job creation and labour market stagnation within an integrated panel causality framework.

Table 3: Descriptive Statistics

	GDP	UNEM	EPR
Mean	2.215118	8.427502	52.94025
Median	2.563840	7.312500	53.21200
Maximum	24.62399	27.68600	66.65600
Minimum	-32.11857	1.100000	37.28900
Std. Dev.	4.413825	4.377867	5.795294
Skewness	-1.495457	1.241826	-0.066630
Kurtosis	11.64414	4.761946	2.372624
Jarque–Bera	3200.249	354.6916	15.73446
Probability	0.000000	0.000000	0.000383

Table 3 presents the descriptive statistics of the three variables examined. The table shows the mean, maximum, minimum, standard deviation, skewness, and kurtosis for the variables for the period 1991-2024. The table shows that economic growth averaged 2.21 during the relevant period, ranging from 24.62 to -32.12. This situation indicates that the economic growth variable showed a high degree of deviation in the EU-27 countries; in other words, an unstable structure was identified. The probability value is 0.000, indicating that the H0 hypothesis is rejected.

The unemployment rate variable (UNEM) shows that the average unemployment rate across EU countries is 8.42%. Among the countries examined, the lowest unemployment rate was 1.10%, while one country had a very high unemployment rate of 27.68%. Unemployment rates also vary from country to country and do not have a stable structure; this assessment can be evaluated in light of the relevant data sets.

The final variable examined in the study is the employment rate for the population aged 15 and over (EPR). The average value for the relevant variable is 52.94%, which is not significantly different from the maximum of 66.65% or the minimum of 37.29%. The calculations show that approximately half of the working-age population is employed across the 27 EU countries. The standard deviation of the relevant variable is considered more stable than that of other variables, indicating limited deviation.

This study applies panel data analysis to test the relationships among the relevant variables and the causal relationships. The study examined the period from 1991 to 2024 and analysed the relationship between variables using the Toda-Yamamoto causality test. The formulas describing the applied tests are expressed in this section of the study.

Before applying the causality test in the study, cross-sectional dependence and homogeneity tests were applied. Among these tests, the LMadj test, which is a cross-sectional dependence test, was introduced to the literature by Pesaran et al. (2008). The test formulation is stated in line (1).

$$\left(\frac{2}{N(N-1)}\right)^{\frac{1}{2}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} [\widehat{p_{ij}^2} \left(\frac{T-K-1\hat{\rho}_{ij}-\hat{\mu}_{ij}}{v_{Tij}}\right)] N(0.1) \quad (1)$$

The study also applied the homogeneity test introduced by Pesaran (2006), which tests whether the series are homogeneously or heterogeneously distributed. The results are presented in Table 4. When evaluating the findings, it is known that accepting the null hypothesis (H_0) indicates that the series are

homogeneous, while accepting the alternative hypothesis (H_1) indicates that the series are heterogeneous. The test equation is expressed in lines (2-3).

$$LM_{adj} = \left(\frac{2}{N(N-1)}\right)^{\frac{1}{2}} \quad (2)$$

$$\hat{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}S-k}{v(T,k)}\right) N(0.1) \quad (3)$$

In the study, the Toda-Yamamoto causality test was applied to determine the causal relationship between the variables. Lag lengths (k) were selected based on information criteria (AIC). The method introduced into the literature by Toda & Yamamoto (1995) was applied with Fourier extension in the studies by Nazlioglu et al. (2016) and Yilanci & Gorus (2020), and the method's equations are given by formulas (4-5). The Fourier approach has been preferred because it accounts for structural changes (breaks) that may occur over time in a series.

$$y_{i,t} = \mu_i + \sum_{j=1}^{k_i+d_{max_i}} A_{11} y_{i,t-j} + \sum_{j=1}^{k_i+d_{max_i}} A_{12} y_{i,t-j} + A_{13}\sin\left(\frac{2\pi t f_i}{T}\right) + A_{14}\cos\left(\frac{2\pi t f_i}{T}\right) + u_{i,t} \quad (4)$$

$$x_{i,t} = \mu_i + \sum_{j=1}^{k_i+d_{max_i}} A_{21} y_{i,t-j} + \sum_{j=1}^{k_i+d_{max_i}} A_{22} y_{i,t-j} + A_{23}\sin\left(\frac{2\pi t f_i}{T}\right) + A_{24}\cos\left(\frac{2\pi t f_i}{T}\right) + u_{i,t} \quad (5)$$

The empirical findings section reports the statistical values calculated using these formulations. In this framework, the study tests the following hypotheses for each causal direction:

H_0: GDP does not Granger-cause EPR

H_0: GDP does not Granger-cause UNEM

H_0: EPR does not Granger-cause GDP

H_0: UNEM does not Granger-cause GDP

Accordingly, rejecting H_0 indicates the presence of a statistically significant causal linkage in the relevant direction.

Empirical findings

The empirical findings section of the study presents the statistical results of the tests applied. The section first presents the results of the cross-sectional dependence test, one of the preliminary tests. The cross-sectional dependence test used in the study is the LMadj test, which is among the most up-to-date methods and was introduced by Pesaran et al. (2008).

Table 4: Cross-Section Dependency Test (LM_{adj})

Variables	Test Stat.	Prob.
Economic Growth	3.798	0.000
Unemployment	39.373	0.000
Employment to population ratio, (15+)	55.705	0.000

Note: The assessment was made with the constraint values of Pesaran et al. (2008) taken into account.

When the test results were examined, it was observed that the probability values for the variables representing economic growth (GDP), unemployment (UNEM), and the share of the working population aged 15 and over in the total population (EPR) were all 0.000. A lower probability value indicates rejection of the null hypothesis and is interpreted as evidence of cross-sectional dependence. The same situation applies to the variables Unemployment (total (% of total labour force)) and Employment to population ratio (15+), with a probability value of 0.000 for both. Based on this, horizontal section dependence was detected in all three variables.

The finding that horizontal dependence exists among the 27 EU countries examined in the study and comprising the panel indicates that these countries are not entirely independent of one another and that a shock or crisis in one country affects another. This situation can be attributed to the fact that the countries within the union have a common market structure, form an economic union with high levels of trade, and have experienced common crises such as the 2008 economic crisis and the COVID-19 pandemic.

Table 5: Homogeneity Test

Variables	Stat.	Prob.
Delta Tilde	-1.816	0.965
Delta Tilde$_{adj}$	-1.902	0.971

Note: H0: Coefficients are homogeneous. H1: Coefficients are not homogeneous (Pesaran, 2006).

Another test evaluated the homogeneity structure of the series containing the variables, and the results are presented in Table 5. When the results were examined, the variable delta t and delta t adj values were calculated as 0.965 and 0.971, respectively. The obtained probability values exceed the constraint values and indicate that the coefficients in the series are homogeneous.

When combined with the output showing cross-country dependence, homogeneity reveals that the impact of economic growth on employment and unemployment generally follows a similar pattern across the 27 EU countries. Based on this, when Tables 4 and 5 are evaluated together, it can be interpreted that countries influence each other within the framework of the relevant variables and also respond similarly to economic growth, unemployment, and employment variables.

The Toda-Yamamoto causality test was applied to determine causality in the study. The test results not only examine the causal relationships between employment and unemployment variables and economic growth, but also provide a two-way assessment by evaluating the causal relationships from economic growth to employment and unemployment. The test results are shown in Table 6.

Table 6: Toda Yamamoto Causality Test (UNEM□GDP)

Countries	Lag	Frequency	Wald Stat.	10%	5%	1%	P-val.
Austria	3	1	2.70	8.78	9.73	13.37	0.45
Belgium	2	1	20.60	9.34	12.10	18.28	0.00***
Bulgaria	2	3	0.95	9.54	9.57	11.60	0.80
Croatia	3	1	2.23	7.40	9.68	13.79	0.60
Cyprus	3	2	3.71	5.04	8.78	11.27	0.35
Czechia	2	1	2.79	5.77	6.27	7.35	0.30
Denmark	3	1	1.40	10.49	10.66	20.85	0.60
Estonia	3	3	8.32	8.27	8.56	8.97	0.10*
Finland	3	1	13.30	6.02	6.88	10.20	0.00***
France	1	1	0.69	3.00	3.08	3.67	0.40
Germany	2	1	0.56	5.43	5.83	6.00	0.90
Greece	2	1	1.16	3.60	4.52	6.49	0.40
Hungary	2	2	4.95	5.14	6.94	8.21	0.15
Ireland	2	2	1.04	3.19	5.51	10.00	0.55
Italy	1	2	0.13	2.14	5.30	5.44	0.80
Latvia	2	1	4.27	3.12	5.20	6.97	0.10*
Lithuania	3	1	2.76	5.96	15.58	30.01	0.40
Luxembourg	2	3	1.38	3.62	3.80	4.47	0.70
Malta	1	1	0.04	4.95	6.98	7.61	0.85
Netherlands	3	1	3.22	4.01	6.89	7.79	0.35
Poland	3	3	4.89	6.10	6.85	25.11	0.20
Portugal	3	1	8.61	5.97	7.59	16.26	0.05**
Romania	2	1	11.43	7.14	8.17	11.49	0.05**
Slovak Republic	3	1	5.50	6.95	7.31	11.35	0.20
Slovenia	2	1	0.48	5.79	6.24	9.75	0.75
Spain	1	2	0.00	0.74	1.96	3.52	1.00
Sweden	3	2	4.36	7.56	9.72	10.15	0.25
Asymptotic P-value							0.000***

The first section of the table assesses the causal relationship between unemployment and economic growth across 27 EU countries, presenting results at both the panel and country levels. The analysis results show that the panel results for the 27 EU countries are 0.000, indicating a causal relationship between the variables. The results obtained indicate that it is highly significant for the panel. This situation shows that unemployment is the cause of economic growth in 27 countries.

When evaluated on a country-by-country basis, a strong causal relationship between the variables was found in Belgium and Finland; any disruption or change in the labour markets of the relevant countries is likely to have a direct impact on the GDP variable. A similar situation is observed for Portugal and Romania, where a 5% level of significance was determined. Estonia and Latvia are seen as countries with a causal relationship, but one that is relatively weaker compared to others. For the 21 EU countries other than those mentioned, no causality can be established.

Table 6: Continue (EPR□GDP)

Countries	Lag	Frequency	Wald Stat.	10%	5%	1%	P-val.
Austria	3	1	2.06	4.57	5.75	12.23	0.45
Belgium	2	1	0.12	2.69	4.78	6.35	0.90
Bulgaria	2	3	0.72	5.79	6.23	17.19	0.80
Croatia	3	1	0.36	7.21	7.30	7.77	0.85
Cyprus	3	2	1.96	8.02	8.62	11.36	0.65
Czechia	2	1	0.64	3.38	3.60	5.58	0.85
Denmark	3	1	3.06	5.15	5.88	8.13	0.35
Estonia	3	3	2.00	6.94	12.43	14.66	0.50
Finland	3	1	8.74	6.81	10.02	12.89	0.10*
France	1	1	1.08	2.91	3.64	6.95	0.40
Germany	2	1	1.42	3.31	3.66	4.26	0.55
Greece	2	1	1.14	7.10	8.78	9.76	0.60
Hungary	2	2	2.58	4.52	8.17	8.24	0.30
Ireland	2	2	0.14	2.87	4.61	5.13	0.90
Italy	1	2	0.67	2.69	6.91	10.16	0.50
Latvia	2	1	11.79	5.29	5.49	8.09	0.00***
Lithuania	3	1	1.33	4.16	6.28	10.50	0.55
Luxembourg	2	3	0.26	3.20	5.35	6.95	0.95
Malta	1	1	0.02	3.93	4.44	6.11	0.95
Netherlands	3	1	2.13	6.69	7.98	18.27	0.45
Poland	3	3	6.02	8.25	8.38	9.84	0.25
Portugal	3	1	7.90	6.93	7.66	8.88	0.05**
Romania	2	1	7.12	3.13	3.38	3.68	0.00***
Slovak Republic	3	1	2.37	5.60	6.77	6.85	0.55
Slovenia	2	1	0.25	7.75	8.85	13.53	0.90
Spain	1	2	0.82	1.70	3.40	7.37	0.25
Sweden	3	2	6.27	8.29	8.33	14.59	0.20
Asymptotic P-value							0.000***

Another relationship tests the causal relationship between employment among the working-age population and economic growth. The relevant assessment has answered the question of whether changes in the employment-to-population ratio for individuals aged 15 and over have a causal effect on economic growth. The results at the panel level are meaningful, and it is assessed that employment is a cause of economic growth.

Romania and Latvia show a high causal relationship, tested at the 0.01 level. In addition to the relevant countries, causality was detected at the 0.05 level in Portugal and at the 0.10 level in Finland. The study's findings indicate that causality was not established in 23 of 27 EU countries. Factors such as productivity increases, capital-intensive production or technological developments can be cited as reasons for economic growth in the relevant countries. The validity of the relevant factors may vary from country to country. However, it is evident that in most EU countries, economic growth is occurring independently of employment.

Table 6: Continue (GDP UNEM)

Countries	Lag	Frequency	Wald Stat.	10%	5%	1%	P-val.
Austria	3	1	12.78	5.36	5.68	6.46	0.00***
Belgium	2	1	4.21	4.73	5.95	8.17	0.15
Bulgaria	2	3	5.10	3.86	3.95	11.65	0.05**
Croatia	3	1	1.55	7.74	8.17	8.89	0.60
Cyprus	3	2	3.17	4.31	6.40	8.85	0.35
Czechia	2	1	4.21	3.83	4.17	8.32	0.05**
Denmark	3	1	4.87	5.70	9.71	12.39	0.20
Estonia	3	3	7.45	5.30	5.52	8.25	0.05**
Finland	3	1	7.85	7.10	15.18	25.91	0.10*
France	1	1	4.05	5.33	5.40	11.84	0.20
Germany	2	1	1.62	2.85	4.03	6.80	0.40
Greece	2	1	6.01	6.91	7.15	7.74	0.15
Hungary	2	2	0.44	4.61	4.71	6.50	0.70
Ireland	2	2	1.45	9.03	9.07	34.72	0.50
Italy	1	2	1.62	2.35	5.26	8.41	0.20
Latvia	2	1	9.83	2.65	3.41	6.85	0.00***
Lithuania	3	1	7.62	6.45	8.87	10.07	0.10*
Luxembourg	2	3	1.50	4.20	4.41	5.62	0.60
Malta	1	1	0.10	4.06	5.22	5.82	0.85
Netherlands	3	1	13.07	6.14	8.08	15.97	0.05**
Poland	3	3	6.60	5.90	7.20	7.95	0.10*
Portugal	3	1	1.78	6.89	17.59	26.50	0.60
Romania	2	1	1.76	4.16	5.31	6.02	0.60
Slovak Republic	3	1	6.62	4.27	7.11	8.36	0.10*
Slovenia	2	1	1.84	4.42	6.49	7.86	0.50
Spain	1	2	0.18	2.69	4.24	4.37	0.45
Sweden	3	2	2.77	7.66	8.51	23.36	0.50
Asymptotic P-value							0.000000***

When evaluating the relevant assessment from the perspective of economic growth, the first step is to examine whether GDP causes unemployment. As in other variations, a causal relationship has been identified at the panel level, with Austria and Latvia showing the highest level of causality (0.01). Significance at the 0.05 level was detected for Bulgaria, the Czech Republic, Estonia, and the Netherlands. Significance at the 0.10 level was found for Finland, Lithuania, Poland, and Slovakia. The results obtained indicate that causality was not established in 17 countries.

Table 6: Continue (GDP□EPR)

Countries	Lag	Frequency	Wald Stat.	10%	5%	1%	P-val.
Austria	3	1	5.7512471	3.6660625	3.9082137	8.7509747	0.05**
Belgium	2	1	6.0594376	4.6617034	5.4086401	9.919477	0.05**
Bulgaria	2	3	1.9258251	5.3021158	7.0930974	8.8019997	0.45
Croatia	3	1	0.44373235	6.2694931	6.4215991	10.001343	1.00
Cyprus	3	2	3.9477554	7.5313492	10.028356	16.160828	0.25
Czechia	2	1	4.1339344	4.7619421	5.6323073	6.7012855	0.15
Denmark	3	1	6.0225471	6.7119475	9.3660322	10.593767	0.15
Estonia	3	3	7.1666399	6.7966538	8.2905026	17.614362	0.10
Finland	3	1	8.8491439	5.2694446	6.8052842	16.870622	0.05**
France	1	1	0.75878824	3.0381446	3.1495394	7.0909249	0.45
Germany	2	1	0.58648151	5.3997962	7.4851264	7.5158319	0.90
Greece	2	1	6.351648	3.9458607	5.4930082	5.7846134	0.00***
Hungary	2	2	6.6608498	8.5412595	9.385681	10.309815	0.35
Ireland	2	2	2.8933888	3.8567108	5.6361075	7.6036275	0.15
Italy	1	2	1.4513106	2.8586159	3.5143998	4.3138439	0.15
Latvia	2	1	16.88359	4.6646721	5.3475672	7.0416885	0.00***
Lithuania	3	1	7.8416143	6.2088808	7.4300715	10.217524	0.05**
Luxembourg	2	3	7.0573508	6.2311083	6.4904869	7.4616304	0.05**
Malta	1	1	0.25109391	3.3021869	5.1291804	6.2978918	0.65
Netherlands	3	1	11.755564	11.493778	11.826764	17.909645	0.10*
Poland	3	3	7.1780696	9.9193185	10.056914	15.403777	0.15
Portugal	3	1	1.6431466	4.6252102	6.1679309	7.9092041	0.70
Romania	2	1	0.30119919	3.3242011	5.519795	7.8566617	0.80
Slovak Republic	3	1	2.6562998	8.498422	9.283714	13.486346	0.40
Slovenia	2	1	1.2568304	4.8755541	6.2344444	8.2424502	0.65
Spain	1	2	1.4708288	1.8037529	1.9870382	7.706066	0.15
Sweden	3	2	2.4410696	6.5627639	8.3191811	23.388949	0.50
Asymptotic P-value							0.000000***

When examining causality from economic growth to the 15 (+) working-age population ratio, significance was also detected at the panel level. When evaluated by country, a strong causal relationship was observed in Greece and Latvia. Countries with a significance level of 0.05 were Austria, Belgium, Finland, Lithuania, and Luxembourg, while a causal relationship was observed in the Netherlands at a significance level of 0.10. The number of countries where causality could not be determined was 18. The findings indicate that economic growth has no significant effect on the employment rate in most EU countries. This finding provides information about the prevalence of jobless growth.

Conclusions

Study background and contribution

This study was designed to examine the existence of jobless growth by evaluating the relationship between economic growth, employment, and unemployment variables. A review of the literature reveals variations in how jobless growth is examined in relation to employment and unemployment variables. Studies (Abraham, 2019; Abubakar & Nurudeen, 2019; Arora et al., 2024; Padhi & Panda, 2021; Tejani, 2016) examining the concept of jobless growth often focus on developing countries, with India being the most frequently studied country. These studies show that economic growth's capacity to create jobs has weakened, and that growth has mostly been achieved through non-employment factors

(productivity-led growth, globalisation effects, demographic changes, sectoral transformation, country-specific structural differences).

Studies examining jobless growth in the literature have been widely conducted to test the validity of Okun's law, and the findings vary across countries (Abou Hamia, 2016; Kitov & Kitov, 2011; Lal et al., 2010). In this study, the concept of economic growth was evaluated on a country-by-country basis for the EU-27 countries, while studies in the literature present evaluations on a sectoral basis (Abou Hamia, 2016; Abraham, 2019; Akusta, 2025; Padhi & Panda, 2021; Salim & Basher, 2024; Tejani, 2016) are frequently preferred. Sectoral outputs are commonly associated with productivity (Abraham, 2019; Padhi & Panda, 2021; Tejani, 2016) and thus serve as a driving force for improving workforce quality.

Existing studies in the literature have often focused on the relationship between employment and economic growth, and no study has been found that examines the employment-to-population ratio (EPR) variable for those aged 15 and over in an integrated manner with growth and unemployment within a panel causality framework. Additionally, the application of a modern method, Panel Fourier Toda-Yamamoto causality analysis, has increased the reliability of the findings.

Empirical framework and interpretation

Based on this, the study tested the validity of the jobless growth hypothesis across 27 European Union countries from 1991 to 2024. The study has conducted a comprehensive assessment, examining the causal relationship at both the panel and country levels. The study analysed the economic growth variable, the unemployment rate, and the employment-to-population ratio among those aged 15 and over.

The study examined 27 countries using a cross-sectional dependence test and found that their labour markets are not independent but are interconnected. The reasons for this situation include shared shocks and crises. The homogeneity test also indicated that the coefficients were similar. This situation suggests that the series is homogeneous.

Key findings and policy implications

The Toda-Yamamoto causality test tests whether a causal relationship exists between variables. The most significant finding is that the jobless growth hypothesis holds across the EU-27 panel. The analysis results show a two-way causal relationship between unemployment and economic growth, and between employment and economic growth, across all countries. Most panel-level causality models are not statistically significant for EU countries, which is an important finding. However, country-level analyses show that in both cases, causality from unemployment and employment rates of 15 (+) to economic growth emerges in only a small number of countries. Causal relationships between growth and unemployment, and between unemployment and employment, are also important at the panel level. Still, when calculated individually, they are not statistically significant in most EU countries. Another important finding is that economic growth in many EU-27 member states has not been supported by a commensurate increase in employment, indicating limited employment absorption despite expansion. The results show that in many EU-27 member states, growth has not been supported by a commensurate increase in employment, and that the relationship between expansion and the functioning of the labour market may be limited. In short, the findings reveal that the jobless growth hypothesis holds across the EU-27 panel, but the structure varies across countries. The findings reveal that, in general terms, there is panel-level jobless growth across the EU-27, but that both its prevalence and significance vary considerably between countries. Among the reasons for this difference are technology-driven growth (e.g., automation), labour-market rigidities, a shift towards less labour-intensive production, and demographic changes.

In light of the study results and their evaluation, it has been determined that there are multiple reasons for economic growth, and it is believed that appropriate growth policies should be shaped not only to increase production volume but also to increase employment. The literature emphasises the relationship between productivity and employment, and the link between employment, the labour force, and growth must be strengthened through labour force policies. In economic performance assessments, considering the employment variable, which reflects the share of the working-age population aged 15 and over in employment, alongside growth and unemployment indicators, will enhance the effectiveness of policy analysis.

Work outcomes should be planned in line with the current situation and the employment-creation capacity of EU countries. Here, labour market structures and the employment capacity of growth are seen as the two fundamental criteria. In countries where economic growth is insufficient to create adequate employment, increasing labour market flexibility and reducing structural barriers to

employment can support job creation.Where technological development is among the fundamental reasons for growth across countries, investing in sectoral retraining and skills development programmes may be the right policy. Such policy regulation may help to align labour supply with changing labour demand. Implementing gender-based policy regulations may also demonstrate characteristics that support job creation.

This study examined 27 EU countries using panel data analysis. The study did not consider sectoral-level analyses or pre- and post-crisis sub-period comparisons. Future studies could conduct a comprehensive assessment that also considers elements such as productivity, digitalisation, and labour market flexibility within the scope outlined.

Peer-review:

Externally peer-reviewed

Conflict of interests:

The authors have no conflict of interest to declare.

Grant Support:

The authors declared that this study has received no financial support.

Author Contributions:

Idea/Concept/Design: **A.R.K**., Data Collection and/or Processing: **M.A**., Analysis and/or Interpretation: **M.B**.**A.,** Literature Review: **M.A**., Writing the Article: **A.R.K., M.B.A**., Critical Review: **A.R.K., M.A.**, Approval: **A.R.K., M.A., M.B.A.**

References

Abou Hamia, M. A. (2016). Jobless growth: Empirical evidences from the Middle East and North Africa region. *Journal for Labour Market Research*, *49*(3), 239–251. https://doi.org/10.1007/s12651-016-0207-z

Abraham, V. (2019). Jobless growth through the lens of structural transformation. *Indian Growth and Development Review*, *12*(2), 182–201. https://doi.org/10.1108/IGDR-07-2018-0077

Abubakar, J., & Nurudeen, I. (2019). Economic Growth in India, Is It a Jobless Growth? An Empirical Examination Using Okun's Law. *The Indian Journal of Labour Economics*, *62*(2), 307–317. https://doi.org/10.1007/s41027-019-00165-w

Akter, M. (2021). Jobless Growth: Evidence from Bangladesh. *International Journal of Multidisciplinary Informative Research and Review*, *1*(5), 220–231. https://doi.org/10.5281/ZENODO.5555696

Akusta, E. (2025). *Is Jobless Growth Valid in Türkiye? A Sectoral Analysis of the Relationship between Unemployment and Economic Growth* (SSRN Scholarly Paper No. 5833102). Social Science Research Network. https://doi.org/10.17541/optimum.1640550

Arora, H., Pradhan, K. C., & Sharma, R. (2024). Missing Linkages and Jobless Growth in India: An Econometric Analysis. *Economic Papers: A Journal of Applied Economics and Policy*, *43*(3), 257–286. https://doi.org/10.1111/1759-3441.12410

Ball, L., Leigh, D., & Loungani, P. (2017). Okun's Law: Fit at 50? *Journal of Money, Credit and Banking*, *49*(7), 1413–1441.

Bhargava, N., Alam, Q., & Sharma, V. (2025). Analysing dynamics between unemployment and economic growth: An empirical evidence from India using Okun's law. *SN Business & Economics*, *6*(1), 10. https://doi.org/10.1007/s43546-025-00987-5

Bhattacharya, B. B., & Sakthivel, S. (2003). *Economic reforms and jobless growth in India in the 1990s*. *46*, 845–866.

Bölükbaş, M. (2018). Kayıt Dışı İstihdam ve Genç İşsizlik Ekonomik Büyüme ile İlişkili Olabilir Mi? Türkiye İçin Ekonometrik Bir Analiz. *Sosyal Güvenlik Dergisi*, *8*(2), 75–90. https://doi.org/10.32331/sgd.492902

Das, R. C., & Ray, K. (2020). Does Globalisation Influence Employment? Empirical Investigation on Individual as well as Panel of South Asian Countries. *Review of Market Integration*, *12*(1–2), 7–34. https://doi.org/10.1177/0974929220969222

Dönmez, B., & Sugözü, İ. H. (2022). The relationship between unemployment and economic growth under okun's law: A spatial econometric analysis on eu countries. *Reforma*, *1*(93), 35–44.

Kaldor, N. (1957). A Model of Economic Growth. *The Economic Journal*, *67*(268), 591–624. https://doi.org/10.2307/2227704

Keynes, J. M. (1937). The general teory of eployment. *The Quarterly Journal of Economics*, *51*(2), Article 2. https://doi.org/10.2307/1882087

Kitov, I., & Kitov, O. (2011). Employment, Unemployment and Real Economic Growth. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1894209

Lal, I., Muhammad, S. D., Jalil, M. A., & Hussain, A. (2010). *Test of Okun's Law in Some Asian Countries Co-Integration Approach* (SSRN Scholarly Paper No. 1562602). Social Science Research Network. https://doi.org/10.2139/ssrn.1562602

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, *22*(1), Article 1. https://doi.org/10.1016/0304-3932(88)90168-7

Meyer, D. F., & Sanusi, K. A. (2019). A Causality Analysis of the Relationships Between Gross Fixed Capital Formation, Economic Growth and Employment in South Africa. *Studia Universitatis Babes-Bolyai Oeconomica*, *64*(1), 33–44. https://doi.org/10.2478/subboec-2019-0003

Nazlioglu, S., Gormus, N. A., & Soytas, U. (2016). Oil prices and real estate investment trusts (REITs): Gradual-shift causality and volatility transmission analysis. *Energy Economics*, *60*, 168–175.

Okun, A. M. (1962). Potential GNP: It's Measurement and Significance. *Cowless Foundation.* https://link.springer.com/referenceworkentry/10.1057/978-1-349-95121-5_2346-1

Padhi, B., & Panda, S. (2021). Employment and economic growth dynamics in Odisha, India. *Journal of Public Affairs*, *21*(2), e2168. https://doi.org/10.1002/pa.2168

Peláez-Herreros, Ó. (2025). Unboxing Okun's Relation Between Economic Growth and Unemployment Rate: Evidence from the United States, 1948–2024. *Economies*, *13*(3). https://doi.org/10.3390/economies13030059

Pesaran, M. H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica*, *74*(4), Article 4.

Pesaran, M. H., Ullah, A., & Yamagata, T. (2008). A bias-adjusted LM test of error cross-section independence. *The Econometrics Journal*, *11*(1), Article 1. https://doi.org/10.1111/j.1368-423X.2007.00227.x

Romer, P. M. (1990). Capital, labor, and productivity. *Brookings Papers on Economic Activity. Microeconomics*, *1990*, 337. https://doi.org/10.2307/2534785

Salim, A. I., & Basher, S. A. (2024). Jobless growth: Evidence from Bangladesh. *Journal of Social and Economic Development*, *26*(2), 641–662. https://doi.org/10.1007/s40847-023-00286-5

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, *70*(1), 65. https://doi.org/10.2307/1884513

Tejani, S. (2016). Jobless growth in India: An investigation. *Cambridge Journal of Economics*, *40*(3), 843–870. https://doi.org/10.1093/cje/bev025

Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics*, *66*(1), Article 1. https://doi.org/10.1016/0304-4076(94)01616-8

Yağmur, İ. (2025). Jobless Growth in the European Union: Panel Fourier Toda-Yamamoto Causality Test. *İşletme Araştırmaları Dergisi*, *17*(2), 1648–1665. https://doi.org/10.20491/isarder.2025.2057

Yilanci, V., & Gorus, M. S. (2020). Does economic globalisation have predictive power for ecological footprint in MENA counties? A panel causality test with a Fourier function. *Environmental Science and Pollution Research*, *27*(32), 40552–40562. https://doi.org/10.1007/s11356-020-10092-9