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The dynamics of Okun's law: cross-country analysis across economic cycles (1980–2023)

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Abstract

Economic dynamics vary across business cycles, particularly in the relationship between output and unemployment. This study examines Okun's Law across 92 countries from 1980 to 2023, focusing on its validity and stability during expansion, recession, and recovery. The results confirm that Okun's Law broadly holds, but its strength is highly regime- and country-specific. A consistent pattern emerges: the Okun coefficient is steeper during recessions, flatter during expansions, and statistically weaker or insignificant during recoveries, consistent with jobless recoveries. Cross-country evidence further reveals that high-income and OECD economies exhibit robust Okun relationships across regimes, while many low-income economies display weak or non-significant responses due to informality and structural labor market rigidities. Dynamic specifications confirm short-run stickiness in employment, with cumulative effects reinforcing the asymmetric adjustment of unemployment to output. By introducing a three-regime empirical design and incorporating post-pandemic labor market dynamics, this study provides the most comprehensive cross-country assessment of Okun's Law to date. The findings underscore the importance of regime-contingent policy strategies: countercyclical support during recessions, targeted incentives during recoveries, and structural reforms in economies with weak output–employment linkages.

Keywords Okun's law · Business cycles · Unemployment · Recession · Recovery

JEL Classification E24 · E32 · J64

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1 Introduction

The relationship between business cycles and unemployment is a critical topic in macroeconomics. Periods of economic contraction often generate substantial labor market slack, while recoveries do not always guarantee employment rebounds, highlighting the asymmetry and complexity of business cycle dynamics. The persistent variability in unemployment responses across countries and over time emphasizes the need for a refined analysis of the output–unemployment nexus.

Okun's Law, originally formulated by Okun (1962), posits a stable inverse relationship between real output and unemployment. Though widely used as a benchmark for macro-labor dynamics, more recent literature increasingly challenges its universality. Empirical studies show that the strength and stability of Okun's coefficient are context-dependent, varying significantly across time, economic regimes, and institutional environments (Owyang and Sekhposyan 2012; Valadkhani and Smyth 2015; Economou and Psarianos 2016; Oh, 2018; Pizzo 2019; Boda and Povazanova 2021; Boda and Povazanova 2023; Butkus et al. 2023). For instance, following the 2007–09 global financial crisis, the relationship between unemployment and output appeared to weaken, as seen in the U.S., where unemployment declined sluggishly despite moderate GDP growth (Gordon 2010; Meyer and Tasci 2012; Ball et al. 2017; Grant 2018; Nebot et al. 2019; Mussida and Zanin 2023). This phenomenon, often termed as *"jobless recovery,"* poses significant challenges for policymakers. A weakening of Okun's Law suggests that traditional fiscal and monetary measures may be insufficient on their own, necessitating labor market-specific interventions to achieve desired employment outcomes (Obst 2022).

Despite substantial research, key gaps persist in the literature. While some studies have examined Okun's relationship with a focus on recessionary periods (Valadkhani and Smyth 2015; Grant 2018; Nebot et al. 2019; Mussida and Zanin 2023; Sharma and Rai 2024), the behavior of Okun's Law across distinct phases of business cycles—expansion, recession, and recovery—has not been systematically explored, particularly within a diverse set of countries. Existing studies often concentrate on single-country analyses or narrow geographic regions, leaving open questions about the generalizability of findings across developed, emerging, and frontier markets.

To address these gaps, this study conducts a comprehensive analysis of Okun's Law using a global dataset spanning 1980–2023, comprising 92 countries at varying levels of economic development. By employing dynamic panel estimation techniques, the analysis accounts for country-specific heterogeneity and enables robust comparisons across different phases of the business cycle. The study has three key contributions. First, it presents the most extensive cross-country investigation of Okun's Law to date, utilizing a dataset that spans more than four decades and encompasses a diverse range of economies. Second, it systematically examines the relationship between output and unemployment across three distinct phases of the business cycle—recession, recovery, and expansion—within a unified empirical framework, providing new evidence on the temporal and cyclical stability of Okun's relationship. Third, by incorporating post-pandemic data, the study offers timely insights into labor market dynamics in the aftermath of major global economic disruptions, particularly those stemming from the COVID-19 pandemic.

The findings confirm that while Okun's Law remains broadly valid, its magnitude and statistical significance vary considerably across regimes and regions. The coefficient steepens during recessions, indicating heightened labor market sensitivity to negative output shocks; it flattens during expansions, reflecting more modest employment gains during growth periods; and it flattens further during recoveries, often accompanied by reduced significance. These dynamics suggest a decoupling of output and employment in the post-recession phase, consistent with jobless recoveries and structural labor market rigidities. The observed heterogeneity reinforces the importance of regime-contingent and region-specific policy design in addressing unemployment.

The study contributes to the ongoing literature on the variability of Okun's Law by offering robust empirical evidence on its regime-specific behavior and global relevance. The results also have practical implications for policymakers, underscoring the need to account for both cyclical conditions and institutional contexts when designing labor market interventions.

The remainder of the paper is structured as follows: Sect. 2 provides a comprehensive review of the relevant literature. Section 3 outlines the data and methodological approach used in this study. Section 4 presents and interprets the empirical findings, while Sect. 5 concludes.

2 Literature review

2.1 Theoretical literature

Okun's Law is often derived from a Cobb-Douglas production function:

$$Y = Af(K^{\alpha}, L^{1-\alpha}) \tag{1}$$

where output Y depends on physical capital K, total employment L, and total factor productivity A. The parameter α represents the output elasticity of capital, while $1\text{-}\alpha$ is the output elasticity of labor. Assuming constant returns to scale ($\alpha+(1-\alpha)=1$), this specification provides a theoretical link between output and labor input.

Unemployment U is defined as the difference between the total labor force N and actual employment L, i.e., $U=N-L$. Substituting this into the log-linearized production framework yields a modified expression for output:

$$lnY = lnA + \eta\, lnK + \phi\, lnN - \phi\, lnU \tag{2}$$

where η and φ are partial derivatives representing the responsiveness of output to capital and unemployment, respectively.

Assuming that A, K, and N grow steadily over time, and denoting deviations from long-run trends with asterisks, we express the cyclical component of output as:

$$Y_t - Y_t^* = (A_t - A_t^*) + \eta (K_t - K_t^*) + \phi (N_t - N_t^*) - \phi (U_t - U_t^*) + \epsilon_t \quad (3)$$

Since *A*, *K*, and *N* are typically assumed to evolve smoothly, short-run fluctuations in output (*Y-Y**) are primarily driven by changes in unemployment (*U-U**). Simplifying, we obtain the gap version of Okun's Law:

$$Y_t - Y_t^* = -\phi (U_t - U_t^*) + \omega_t \quad (4)$$

where $\varphi > 0$ represents the Okun coefficient, and ω_t captures residual effects such as measurement errors or omitted shocks.

The theoretical underpinning also links output deviations to employment, and in turn to unemployment. First, changes in employment are assumed to respond to output gaps:

$$E_t - E_t^* = \gamma \ (Y_t - Y_t^*) + \epsilon_t \quad (5)$$

Second, changes in unemployment arise from deviations in employment:

$$U_t - U_t^* = \theta \ (E_t - E_t^*) + \mu_t \quad (6)$$

where $\gamma > 0$, $\theta < 0$, and E_t is the natural logarithm of employment. Substituting Eq. (5) into Eq. (6) yields an alternative form of Okun's Law:

$$U_t - U_t^* = \beta \ (Y_t - Y_t^*) + r_t \quad (7)$$

where $\beta = \theta \cdot \gamma$ and $r_t = \mu_t + \theta \cdot \epsilon_t$. Under ideal conditions, this implies $\beta = -1/\phi$, confirming the inverse relationship between unemployment and output. The disturbance term r_t captures factors such as labor participation shifts or productivity shocks.

This version of Okun's Law evaluates how far the economy is from full employment by comparing deviations in output and unemployment from their potential levels. Since these potential levels are unobservable, empirical studies rely on methods to extract cyclical components from raw data. These include classical detrending (e.g., first differencing), and more advanced filters such as the Hodrick–Prescott (HP) filter, Baxter–King filter, and Christiano–Fitzgerald filter.

2.2 Empirical literature

A growing body of empirical literature has documented the instability and asymmetry of Okun's Law across countries, time periods, and phases of the business cycle. While early formulations posited a stable, linear relationship between output and unemployment, more recent analyses challenge this assumption, showing that Okun's coefficient varies systematically depending on macroeconomic conditions, labor market structures, and the cyclical phase of the economy.

Evidence from the United States has been central to this debate. Several studies emphasize the asymmetric behavior of Okun's coefficient across recessions and recoveries. Owyang and Sekhposyan (2012) find that the relationship between unemployment and output fluctuates significantly during recessions, with Okun's coefficient steepening (i.e., increasing in absolute value) as unemployment becomes more responsive to output declines. Valadkhani and Smyth (2015) reach similar conclusions using a Markov-switching model: during recessions, Okun's coefficient steepens, while during recoveries it flattens, indicating that stronger output growth is needed to reduce unemployment. Donayre (2022) further elaborates on this regime-dependence by identifying three distinct unemployment regimes based on endogenously determined thresholds. His findings confirm that unemployment responds most strongly to output losses during deep recessions, less so during mild downturns, and least during expansions. This cyclical asymmetry is shown to be linked to nominal wage rigidities and justifies the use of differentiated policy responses across regimes.

Other U.S.-focused studies explore structural sources of Okun coefficient variation. Gordon (2010) highlights the declining role of productivity in mediating the output–employment nexus, attributing changes in Okun's relationship to factors like offshoring and immigration. Oh (2017) challenges the prevailing view that increased labor market flexibility post-1985 drove the rise in Okun's coefficient. Instead, his findings suggest that changes in the responsiveness of hours per employee during early expansions and the employment rate during late expansions are more influential. Panovska (2017) adds further nuance by showing that changes in employment dynamics, especially increased sensitivity to demand shocks, rather than changes in business cycle persistence or the relative weight of transitory shocks, explain recent deviations from Okun's historical patterns. Together, these studies indicate that Okun's Law continues to hold, but its manifestation depends on the structure and responsiveness of the labor market across different recovery paths.

Cross-country studies confirm that Okun's Law is broadly valid but varies markedly in magnitude and persistence across nations and regimes. Boda and Povazanova (2021), using a flexible four-regime model across 21 OECD countries, show that Okun's coefficient is stronger during contractions than expansions and that the relationship is more pronounced for male unemployment. They also find that nonstandard regimes, where output and unemployment both increases, produce coefficients that defy conventional interpretation. Mussida and Zanin (2023) observe that the Great Recession amplified the absolute value of Okun's coefficient, whereas the COVID-19 pandemic weakened it due to widespread government job retention schemes that temporarily decoupled unemployment from output declines. This decoupling muted the traditional response of unemployment to output shocks, particularly in European economies, where furlough programs preserved employment levels despite falling Mathy (2024) offers a complementary interpretation, arguing that so-called "jobless recoveries" are better understood as slow recoveries that remain consistent with Okun's Law. He emphasizes that with sufficient fiscal and monetary stimulus, as in the post-COVID-19 period, recoveries can become "jobfull," with a steepening of the Okun coefficient—reflecting a stronger responsiveness of employment to output growth. In contrast, when the stimulus is limited, Okun's coefficient tends to flatten, as sluggish output growth fails to generate meaningful labor market improvement. These findings underscore the importance of macroeconomic policy in shaping the cyclical strength of the output–unemployment relationship. Similarly, Nebot et al. (2019) detect nonlinear shifts during the Eurozone crisis in France but find relative stability in other large European economies.

In the European context, several studies investigate the moderating role of labor market institutions (LMIs). Economou and Psarianos (2016) find that Okun's coefficients are weaker and less persistent in countries with higher labor market protection expenditures. These results mirror those of Cazes et al. (2013), who argue that strong LMIs dampen cyclical sensitivity. Obst (2022) supports this interpretation, showing that Okun's coefficient across EU15 countries averages between −0.3 and −0.4, and remains robust across estimation techniques. However, he notes considerable cross-country heterogeneity and emphasizes the importance of dynamic models with mixed lag structures to capture the delayed responses of unemployment to output changes. His findings also indicate that trade union density and temporary employment shares are significant, though underexplored, factors shaping cross-national differences in Okun's responsiveness.

Comparative research from emerging economies further underscores the role of structural labor market features. Porras-Arena and Martín-Román (2023) find that in Latin America, fluctuations in output have a relatively muted effect on unemployment. They argue that weak Okun coefficients reflect structural segmentation and informality, and that cyclical downturns in such settings are more likely to degrade employment quality than increase measured unemployment. Their results challenge the effectiveness of traditional stimulus policies and advocate for targeted sectoral interventions.

Collectively, this literature reveals that Okun's coefficient is not only country-specific but also regime-contingent and shaped by institutional, structural, and behavioral factors. While a general negative relationship between output and unemployment holds, the strength and timing of this relationship depend on the phase of the business cycle, the nature of the labor market, and the broader macroeconomic context. This study contributes to this evolving literature by offering a comprehensive, cross-country analysis of Okun's Law across expansion, recession, and recovery periods using a large global dataset spanning 1980–2023.

3 Data & methodology

3.1 Data & sample

This study leverages a comprehensive dataset covering GDP and unemployment rates for 92 countries from 1980 to 2023. GDP data are primarily obtained from the World Bank's World Development Indicators (WDI) database[1], while unemployment rates are mainly sourced from LSEF Refinitiv (formerly Thomson Reuters Eikon) Datastream. In cases where data for a particular country were missing in one source,

[1] https://databank.worldbank.org/source/world-development-indicators.

the corresponding variable was retrieved from the alternative database to ensure completeness and consistency of the panel.

The sample was initially constructed from all countries available in the World Bank database. Due to data limitations, the final sample comprises 92 countries with sufficient coverage across the study period. This diverse set spans developed, emerging, and developing economies, enabling robust cross-country comparisons. The wide scope is essential for assessing the global validity and heterogeneity of Okun's Law across institutional settings, development levels, and business cycle regimes.

Descriptive statistics are presented at Table 4 in the Appendix.

3.2 Model

This study examines the Okun coefficient across three distinct phases of the business cycle: expansion, recession, and recovery. To ensure conceptual precision and empirical consistency, we adopt a regime classification based on real GDP growth dynamics, while clearly delineating how these regimes differ in both economic interpretation and model specification.

Recessions are defined as years in which real GDP growth falls below zero. This threshold captures periods of contraction, where output declines relative to the previous year. A dummy variable D_t^R is coded as 1 during such years and 0 otherwise.

Recoveries follow an NBER-inspired approach. The recovery phase begins in the first year of positive GDP growth after a recession and continues until the cumulative loss from the previous contraction has been fully offset—that is, until the level of real GDP returns to or surpasses its pre-recession peak. This ensures that the recovery phase captures not just the initial rebound but the entire adjustment period during which the economy regains its earlier output level. A dummy D_t^X variable equals 1 during recovery years and 0 otherwise. This approach avoids conflating a single year of positive growth with a complete recovery and reflects more accurately the transitional dynamics observed in real economies.

Expansions comprise the remaining periods of positive real GDP growth that are not part of a recovery phase. Specifically, they represent years of continued growth beyond the recovery threshold, during which output exceeds the previous cyclical peak. The dummy variable for expansion, D_t^E, is constructed residually such that $D_t^E = 1$ only if both $D_t^R = 0$ and $D_t^X = 0$. This ensures that the three regimes are mutually exclusive and collectively exhaustive.

Using these definitions, the country-specific Okun relationship is modeled as:

$$U_t^{GAP} = \beta_1 Y_t^{GAP} D_t^E + \beta_2 Y_t^{GAP} D_t^R + \beta_3 Y_t^{GAP} D_t^X + \in_t \tag{8}$$

where U_t^{GAP} denotes the cyclical component of the unemployment rate, $D_t^E = (1 - D_t^R)(1 - D_t^X)$, Y_t^{GAP} represents the cyclical component of real output, and $\in_t$ is an idiosyncratic error term. The coefficients β_1, β_2, and β_3 correspond to Okun's law estimates during expansion, recession, and recovery phases, respectively. By interacting the output gap with regime-specific dummies, the model allows for the responsiveness of unemployment to output fluctuations to vary systematically across different stages of the business cycle.

To extract the cyclical components of real output (real GDP) and unemployment rate, we apply the Hodrick-Prescott (HP) filter, using a smoothing parameter ($\lambda = 100$), consistent with the convention for annual data (Ravn and Uhlig 2002). The HP filter isolates deviations from trend (μ_t) by minimizing the following objective function:

$$\min_{\{\mu_t\}_{t=0}^{T}} \left(\sum_{t=0}^{T} (y_t - \mu_t)^2 + \lambda \sum_{t=1}^{T-1} \left((\mu_{t+1} - \mu_t) - (\mu_t - \mu_{t-1}) \right)^2 \right) \quad (9)$$

where y_t denotes the observed time series (GDP or unemployment), and μ_t represents its estimated trend component. The resulting output and unemployment gaps are used as the basis for all estimations throughout the paper.

For robustness, we conduct panel analysis to ensure the reliability of our findings. We assess the consistency and efficiency of generalized least squares (GLS) estimators using three approaches: cross-sectional fixed effects (FE), random effects (RE), and pooled estimation. The pooled model assumes homogeneity across entities and does not account for between-effects, such as unobserved heterogeneity stemming from factors like culture or religion, which may result in heteroskedastic residuals. Conversely, the fixed-effects model addresses this limitation by allowing each entity to have its own intercept, effectively eliminating between-effects and focusing solely on within-entity variation:

$$U_{it}^{GAP} = \alpha_i + \beta_1 Y_{it}^{GAP} \cdot D_{it}^{E} + \beta_2 Y_{it}^{GAP} \cdot D_{it}^{R} + \beta_3 Y_{it}^{GAP} \cdot D_{it}^{X} + \in_{it} \quad (10)$$

The α_i (country fixed effects) controls time-invariant heterogeneity (between-effect) across countries, and ε_{it} is an idiosyncratic error term. The FE model assumes that residuals ($\in_{it}$) are independently and identically distributed ($\in_{it} \sim i.i.d.N\left(0, \sigma_e^2\right)$,) and that covariates ($x_{it}$) are exogenous ($cov\left(\in_{it}, x_{it}\right) = 0$) with $\mathrm{Var}\left(\in_{it}\right) = \sigma_e^2$).

The RE model, in contrast, accounts for time-varying heterogeneity across entities:

$$U_{t}^{GAP} = \alpha_0 + \beta_1 Y_{it}^{GAP} \cdot D_{it}^{E} + \beta_2 Y_{it}^{GAP} \cdot D_{it}^{R} + \beta_3 Y_{it}^{GAP} \cdot D_{it}^{X} + \omega_i + \in_{it} \quad (11)$$

where $\omega_i \sim N\left(0, \sigma^2\right)$ is a random country-specific effect that controls for between-entity errors, while $\in_t$ controls within-entity errors. Thus, $\omega_i + \in_{it}$ is the composite error term. The residuals of the RE model are often shrunken, and thus homoskedastic, and it also offers the possibility of differences between cross-sections. However, due to potential correlation between covariates of covariates and ω_i, the RE model might produce biased estimates.

The trade-off between the heteroskedasticity problem of the FE and the serial correlation problem of the RE depends on the data and sample. To select the best panel model, we use the Redundant Fixed Effects (RFE) test, Breusch-Pagan Lagrange Multiplier (BP LM) test, and, if necessary, the Hausman test (Table 1).

Table 1 Panel Estimation model selection

First Step	Second Step	Decision
H_0 of RFE test is not rejected (NO FIXED-EFFECT) H_0 of BP LM test is not rejected (NO RANDOM-EFFECT)	NA	Poolable
H_0 of RFE test is not rejected (NO FIXED-EFFECT) H_0 of BP LM test is rejected (RANDOM-EFFECT)	NA	Random Effect
H_0 of RFE test is rejected (FIXED-EFFECT) H_0 of BP LM test is not rejected (NO RANDOM-EFFECT)	NA	Fixed Effect
H_0 of RFE test is rejected (FIXED-EFFECT) H_0 of BP LM test is rejected (RANDOM-EFFECT)	H_0 of Hausman test is rejected	Fixed Effect
H_0 of RFE test is rejected (FIXED-EFFECT) H_0 of BP LM test is rejected (RANDOM-EFFECT)	H_0 of Hausman test is not rejected	Random Effect

The null hypothesis for Breush-Pagan LM test is “No Random Effects”. The null hypothesis for Redundant Fixed Effect test is “No Unobserved Heterogeneity (No Fixed Effect)”. The null hypothesis for Hausman Test is “there is no correlation between unique errors and the regressors”

To address concerns regarding the instability of Okun’s Law due to its lack of dynamic components (Meyer and Tasci 2012), we incorporate lagged real output gaps into our panel model to capture delayed employment adjustments. However, modeling the relationship between unemployment and output raises potential concerns about endogeneity, particularly reverse causality, where higher unemployment may negatively impact aggregate demand and output.

Given the potential issues associated with instrument proliferation in dynamic panel GMM estimators, particularly in panels with a large cross-sectional dimension (N) and limited time-series length (T), we adopt a stepwise ordinary least squares (SOLS) approach. SOLS facilitates flexible lag selection, accommodates heterogeneous dynamics across countries, and provides more interpretable estimates within our regime-specific framework. Additionally, by incorporating lagged output gap terms, our SOLS specification mitigates potential simultaneity concerns by exploiting temporal precedence in the relationship between output and unemployment. We further apply heteroskedasticity and autocorrelation consistent (HAC) robust standard errors, specifically using Newey-West corrections, to ensure valid inference in the presence of potential heteroskedasticity and serial correlation.

The specified SOLS model is as follows:

$$U_t^{GAP} = \sum {}_{i=0}^{4} \beta_{\,i} Y_{t-i}^{GAP} + \omega_{\,t} \tag{12}$$

Lag selection is restricted to four years to balance explanatory power against multicollinearity risks. The backward stepwise regression uses partial F-tests and t-tests with pre-specified thresholds. Specifically, we test the following null hypotheses for each lagged coefficient:

$$H_{0i}: \beta_i = 0, \quad where \;\; i = \{1, \; 2,3, 4\}$$

The lowest partial F-test value F_x corresponding to $H_{0i}: \beta_i = 0$ or t-test value t_x is compared with the preselected significance thresholds F_0 and t_0. If $F_x < F_0$ or $t_x < t_0$, the corresponding lag is excluded; otherwise, it remains in the model.

As an additional robustness check, we employ a dynamic ordinary least squares (DOLS) framework. The DOLS specification incorporates both leads and lags of the independent variable, with optimal specifications determined using the Schwarz criterion, allowing for a maximum of four lead-lag combinations. Covariances are estimated using the Bartlett kernel with Newey-West fixed bandwidths, ensuring robust standard errors. Compared to standard panel or stepwise OLS models, the DOLS framework demonstrates superior explanatory power by more comprehensively accounting for temporal dynamics. This approach enables a more accurate capture of variations in the dependent variable and provides further evidence supporting the robustness of our findings.

The combination of SOLS and DOLS methodologies, alongside robust standard errors, ensures that our analysis addresses potential endogeneity concerns and provides reliable estimates of Okun's coefficients across different phases of the business cycle.

4 Results & discussion

This section presents updated estimates of Okun's coefficients across distinct business cycle regimes: full-sample (R0), expansion (R1), recession (R2), and recovery (R3). These regimes are defined using the cyclical component of real GDP obtained via the HP filter, with recovery phases redefined to follow an NBER-style criterion, beginning with the first year of positive output gap following a recession and continuing until the cumulative GDP loss has been offset. Full country-specific estimates, including Wald tests of coefficient equality across regimes, are reported in Appendix Table 5. Figure 1 summarizes the Okun coefficients for the full period (1980–2023), displaying only those that are statistically significant.

The results confirm that Okun's Law holds in a majority of countries (78%) under at least one regime, supporting its empirical relevance. However, the law appears absent in countries such as Algeria, Armenia, Azerbaijan, Bosnia, China, Georgia, Iran, Kuwait, Kyrgyzstan, Mongolia, the Philippines, Qatar, Saudi Arabia, Tajikistan, Tanzania, Turkmenistan, and Uzbekistan. The absence or weakness of the Okun relationship in these countries may be attributable to a combination of structural labor market rigidities, limited macroeconomic volatility, or poor data quality[2]. For instance, China, Qatar, and Saudi Arabia exhibit low unemployment volatility and

[2] For many of these countries, empirical studies on Okun's Law remain scarce or inconclusive. Limited prior evidence exists for China (Liu et al. 2018) and Saudi Arabia (Louail and Riache 2019). For others

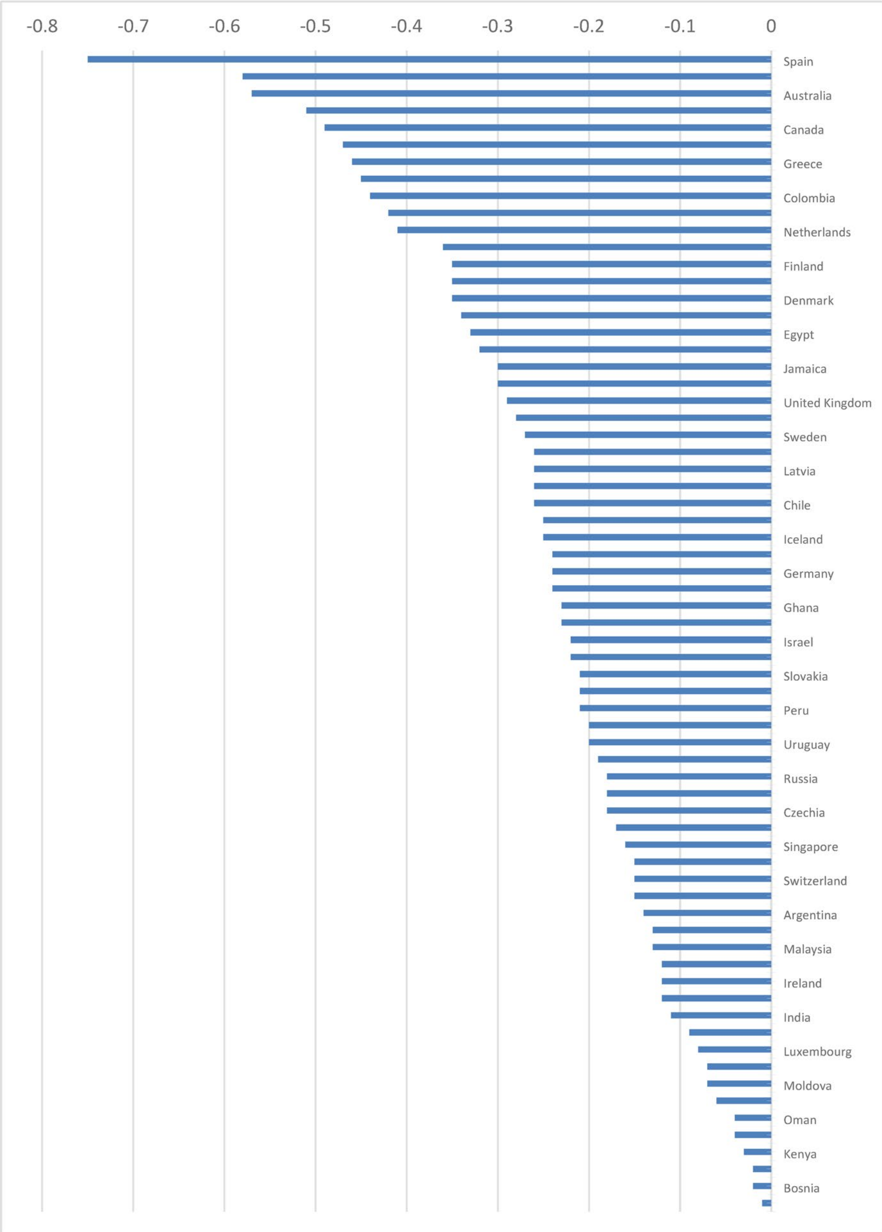

Fig. 1 Okun Coefficient during 1980–2023

state-dominated labor markets, with migrant labor policies that allow employment adjustments without altering national unemployment figures (Wagle 2024). In post-

like Kyrgyzstan, Tajikistan, and Turkmenistan, a lack of high-quality labor market data has hindered robust estimation efforts.

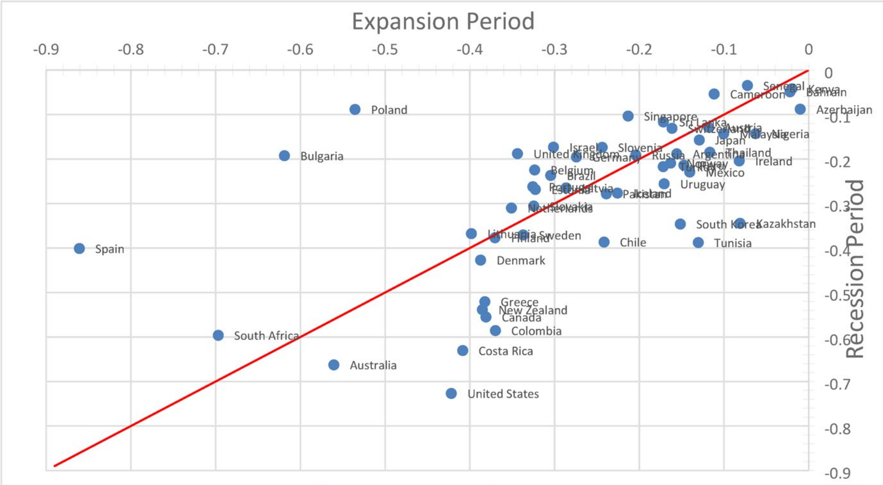

Fig. 2 Okun Coefficient during Expansion and Recession periods

Soviet economies such as Georgia and Uzbekistan, the legacy of central planning, combined with underdeveloped private sectors, limits the responsiveness of unemployment to cyclical output fluctuations. Weak or inconsistent coefficients are also observed in Bangladesh, Iraq, Jordan, Morocco, Nepal, and Senegal, suggesting a broader pattern of dampened cyclical labor adjustments in developing and structurally rigid economies.

Figure 2 provides a scatter plot comparing significant Okun coefficients during expansion and recession periods across countries. The x-axis represents coefficients during expansions, while the y-axis captures those observed during recessions. A 45-degree reference line is included to represent parity in unemployment responsiveness across the two regimes. Most observations lie below this line, indicating that unemployment tends to respond more strongly to output changes during recessions than during expansions. However, this asymmetry is not uniform: several countries, such as Bulgaria, Poland, and Spain, lie above the 45-degree line, suggesting stronger cyclical responses during expansions or more muted effects during recessions. These divergences highlight that not all recessions yield steeper Okun coefficients, and that the characteristics of each downturn, such as its duration, severity, and sectoral composition, also shape labor market sensitivity.

The United States exhibits the expected cyclical behavior: a baseline coefficient of −0.5844, flatter during expansions, steeper during recessions, and statistically weaker in recovery phases. These results are in line with earlier findings by Gordon (2010), Meyer and Tasci (2012), and Grant (2018), all of whom document a weakening Okun relationship post-2007, particularly during recoveries. The observed recession steepening also echoes the estimates from Owyang and Sekhposyan (2012), confirming the U.S. as a benchmark case for asymmetric Okun behavior. Equally, Spain's steep expansion coefficient aligns with Villaverde and Maza (2009) and Mussida and Zanin (2023), who emphasize high labor market sensitivity to output growth in Mediterranean Europe. In contrast, Japan shows relatively flat and consistent coefficients across all regimes, reflecting persistent labor market frictions and institutional inertia (Ball et al. 2019). A similar post-recession flattening of the Okun coefficient is observed in countries such as Australia, Canada, Costa Rica, Denmark, Germany, Mexico, New Zealand, Norway, South Korea, and Switzerland. These patterns may reflect hiring rigidities, increased reliance on part-time or temporary employment, or firms' preference for productivity-led recovery strategies before expanding headcount.

Several countries, including France, Italy, and Luxembourg, exhibit statistically insignificant Okun coefficients during recessions, indicating that output contractions do not systematically result in higher unemployment. This may reflect the role of protective labor regulations, widespread collective bargaining, or the presence of informal labor markets that absorb cyclical shocks outside formal employment metrics. Likewise, in recovery periods, the unemployment–output relationship tends to weaken or become insignificant in a broad set of economies, including Argentina, Austria, Brazil, France, Poland, Portugal, Singapore, South Africa, Turkey, and the United Kingdom. This corroborates the literature on "jobless recoveries," in which output rebounds are not immediately accompanied by employment gains due to delayed hiring, labor hoarding, or firm-level productivity adjustments (Panovska 2017; Elroukh et al. 2020). Together, these asymmetries reinforce the necessity of modeling Okun's Law in a regime-contingent framework rather than assuming time-invariant responsiveness, as further explored in the next section.

4.1 Regime-specific variations

The regime-dependent behavior of Okun's coefficient is confirmed across regimes, though with heterogeneous magnitude and significance. The Wald test results, reported alongside the coefficients in Table 5, formally assess whether the response of unemployment to output gaps significantly differs across expansion, recession, and recovery phases. In many countries (e.g., France, India, Japan, Netherlands, New Zealand, Pakistan, South Korea, Sweden, United States), the null hypothesis of coefficient equality is strongly rejected, justifying the regime-based modeling approach.

4.1.1 Expansion and recession periods (R1 & R2)

The behavior of Okun's coefficient differs markedly between expansions and recessions, although the patterns are not uniform across countries. In many developed economies, unemployment reacts more strongly to output declines during recessions than to output gains during expansions. For instance, in the United States, the coefficient is -0.4219 during expansions but steepens to -0.7268 during recessions. Similar dynamics are observed in Australia, Canada, Denmark, Iceland, Norway, New Zealand, Sweden, and South Korea. This heightened sensitivity during recessions reflects the creation of substantial labor market slack, whereby additional contractions in output result in disproportionately larger increases in unemployment. These findings are consistent with Donayre (2022), who documents steeper coefficients during deep downturns.

By contrast, during expansions, Okun's coefficients are generally flatter, indicating that unemployment declines less rapidly relative to output growth. In countries such as Australia, Canada, Chile, Colombia, Costa Rica, Greece, Malaysia, Mexico, Norway, New Zealand, and South Korea, this asymmetry can be attributed to labor hoarding, hiring rigidities, and firms' preference to increase hours or productivity before expanding headcount (Ball et al. 2017). In economies with high informality, such as Chile, Colombia, Costa Rica, and Mexico, output gains may initially reduce underemployment or draw discouraged workers back into the labor force before affecting official unemployment metrics. Structural mismatches and regional inequalities in labor demand may also dilute the strength of the output–unemployment link.

Nevertheless, several countries, including Brazil, France, Germany, Portugal, Singapore, Spain, Switzerland, and the United Kingdom, display relatively steep and significant coefficients even during expansions. Spain's strong responsiveness is consistent with earlier findings linking its pro-cyclical labor adjustments to the prevalence of temporary employment (Villaverde and Maza 2009; Mussida and Zanin 2023). Germany likewise shows strong expansion-phase responsiveness, reflecting the country's robust industrial sector and historically synchronized output–employment dynamics during normal times (Burda and Hunt 2011). In Singapore and Switzerland, flexible labor market institutions and high exposure to global demand may accelerate employment growth during booms.

The asymmetry between expansions and recessions is, however, not universal. In some economies, including Portugal, Singapore, Spain, South Africa, and the United Kingdom, coefficients actually flatten during recessions, indicating muted responsiveness even in downturns. This suggests that significant declines in output do not always translate proportionally into higher unemployment, possibly due to labor market rigidities, structural unemployment, or protective institutions that limit cyclical adjustment. The COVID-19 crisis further illustrates this divergence. In several countries, including Australia, France, Spain, and the United Kingdom, the Okun coefficient flattened during the downturn due to job-retention schemes that decoupled employment from output (Mussida and Zanin 2023).

Figure 3 illustrates these dynamics using rolling Okun coefficients for selected countries, including Australia, Canada, France, Germany, Japan, Spain, the United Kingdom, and the United States, with a particular focus on recession periods. The grey shaded areas indicate country-specific recessions, while the yellow and pink shaded regions correspond to the Great Recession and the COVID-19 pandemic, respectively. In several cases, such as Japan and the United States during the Great Recession, and Australia, Canada, and Germany during the early 1980s downturn, the Okun coefficient steepened, indicating greater sensitivity of unemployment to output fluctuations. This aligns with the findings of Donayre (2022). However, this pattern is not uniform across all recessions. For instance, Germany in 1993 and 2020, and Japan in 2020, show relatively flat or attenuated coefficients, underscoring the importance of institutional, demographic, and policy-specific factors. Notably, during the COVID-19 crisis, a reversal of typical recession dynamics is visible in Australia, France, Spain, and the United Kingdom, where the Okun coefficient flattens.

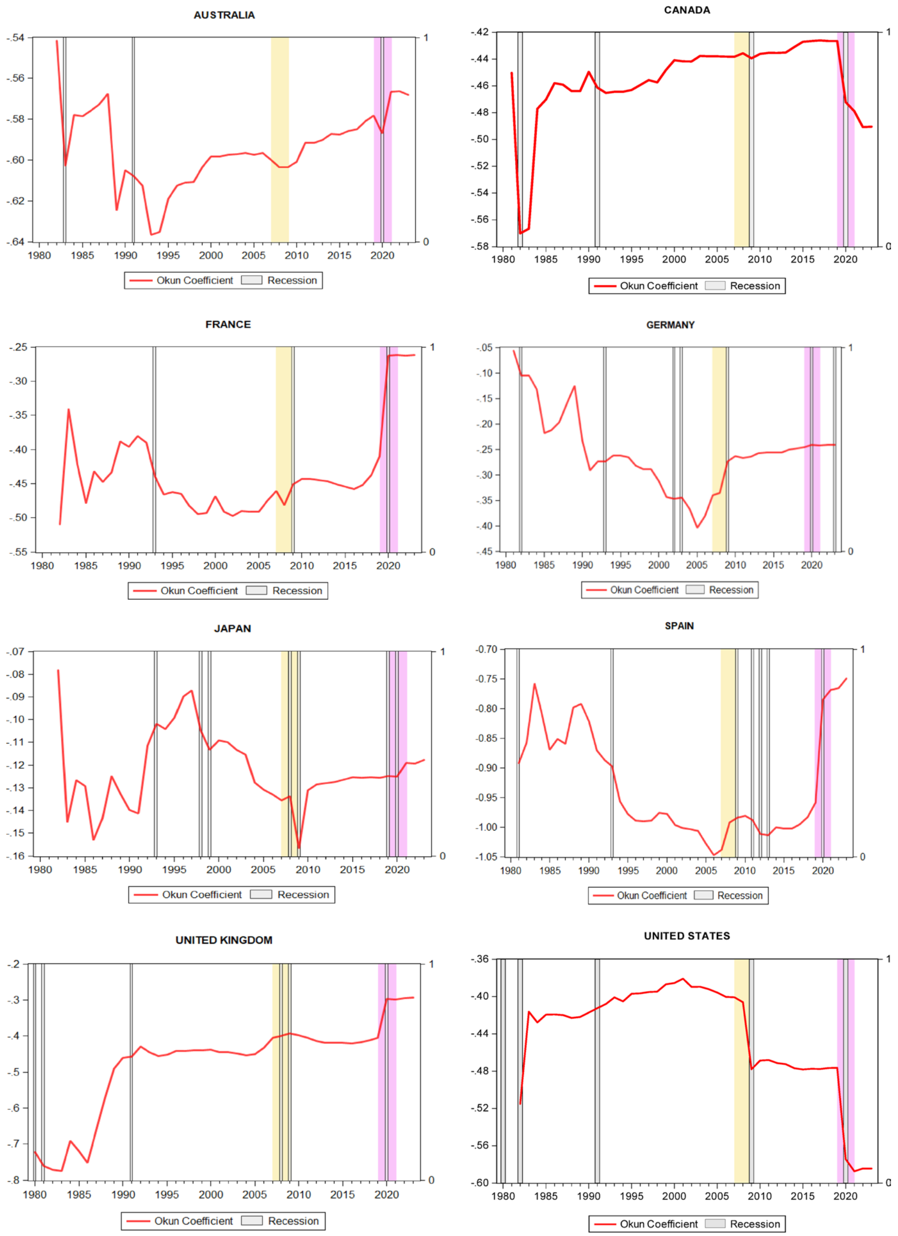

Fig. 3 Rolling Okun Coefficient

This anomaly is likely driven by widespread job-retention schemes, which decoupled employment from output changes, as discussed by Mussida and Zanin (2023).

Overall, expansions and recessions reveal distinct but heterogeneous patterns. While many economies exhibit the expected asymmetry with steeper coefficients during recessions and flatter ones during expansions, a non-trivial number of countries display muted or inconsistent responses. These divergences suggest that both structural characteristics and recession-specific conditions jointly determine the cyclical strength of Okun's Law.

4.1.2 Recovery periods (R3)

The empirical evidence reveals that Okun's Law weakens considerably during recovery phases. In nearly 70% of the 92 countries analyzed, the unemployment–output relationship becomes statistically insignificant or substantially flatter compared to expansion and recession periods. This muted responsiveness is consistent with the well-documented phenomenon of jobless recoveries, in which output begins to improve but labor market gains lag behind (Ball et al. 2017; Mussida and Zanin 2023).

For example, in the United Kingdom, the Okun coefficient during recovery is −0.1337 and not statistically significant, despite more pronounced effects during expansion (–0.3438***) and recession (–0.1879**). In the United States, the recovery-phase coefficient (–0.4259*) is statistically weaker than in recession (–0.7268***), but it remains almost identical in magnitude to the expansion coefficient (–0.4219***), suggesting that output gains during recoveries translate into unemployment reductions at roughly the same rate as during normal expansions. Spain also displays a flatter and insignificant coefficient in recovery (–0.3496), contrasting with its steep and significant coefficient during expansion (–0.8608***). Similar decoupling of output and unemployment is observed in many countries, including Austria, Belgium, Bulgaria, Cameroon, Colombia, Estonia, Iceland, Israel, Norway, Latvia, Poland, Singapore, and Sweden.

Nevertheless, the pattern is not universal. In approximately 30% of the sample (29 out of 92 countries), the recovery coefficient remains statistically significant. In several cases, including Australia, Mexico, Pakistan, Greece, and Malaysia, the coefficient is comparable to that observed during expansions and, in some instances, even steeper than during recessions. These exceptions challenge the notion of a uniformly weak relationship during recoveries and highlight meaningful cross-country heterogeneity in labor market adjustment.

Several mechanisms may account for the generally weak performance of Okun's Law in recovery phases. Firms may initially respond to improved demand through increased hours for existing workers or productivity gains rather than through new hiring. Long-term unemployment and labor market scarring can also delay re-entry, reducing the sensitivity of employment to output. Additionally, policy measures implemented during downturns, such as job retention schemes or wage subsidies, may suppress measured unemployment during recessions and mask the slack that persists during recovery. Conversely, in countries where recovery coefficients remain significant, more flexible labor markets, stronger reemployment incentives, or structural reforms may facilitate faster reductions in unemployment once growth resumes.

These dynamics are particularly salient in annual data, where the lag between output recovery and employment response is often more pronounced. Crucially, the Wald tests reported in Appendix Table 5 reject the null hypothesis of coefficient equality across regimes in many countries, including Japan, France, Nepal, the Netherlands, South Korea, Pakistan, Sweden, Thailand, and the United States. This indicates that Okun's Law operates asymmetrically across different phases of the business cycle. In such cases, the strength and direction of the unemployment-output relationship vary significantly between expansion, recession, and recovery phases, validating the use of regime-specific modeling.

By contrast, in countries where the Wald test fails to reject the null, such as Czechia, Latvia, or Russia, the Okun coefficient remains stable across regimes, suggesting more symmetric labor market adjustment. Overall, the pattern of regime-contingent heterogeneity underscores that the unemployment response to output fluctuations is neither uniform nor time-invariant, particularly in the aftermath of recessions.

Overall, the evidence underscores that the recovery regime is typically the least responsive phase of the business cycle in terms of the unemployment–output link. However, the significant exceptions demonstrate that jobless recoveries are not inevitable and that institutional and structural factors decisively shape the extent to which output rebounds translate into labor market improvements.

4.1.2.1 Robustness: constraining recovery to three years Several countries exhibit unique recovery patterns due to large and prolonged economic contractions, raising the question of whether recovery periods should be capped at a fixed horizon. To explore this, we re-estimated Okun's coefficients by limiting recovery phases to a maximum of three consecutive years following the end of a recession. The exercise offers insights into the robustness of our regime classifications and the sensitivity of results to alternative recovery definitions.

For Russia, the economy contracted by −51.71% between 1990 and 1996, followed by a prolonged recovery lasting until 2006. Under our baseline definition, Okun's coefficient during recovery is significant; however, when the recovery period is capped at three years, the coefficient loses its statistical significance. A similar dynamic is observed for Albania, which experienced a −44.76% contraction during 1990–1992 and recovered by 1999. When the recovery period is truncated to three years, the coefficients become significant in both the expansion (–0.33*) and recovery (–0.34*) phases, while the recession coefficient remains insignificant.

In Chile, which contracted by −16.03% during 1982–1983 and recovered by 1987, the three-year constraint had no notable effect. Similarly, Hungary (–19.02% contraction during 1990–1993, recovery by 2000), Estonia (–44.70% during 1989–1994 and again −19.75% during 2007–2008), and Bulgaria (–29.61% during 1989–1993 and −14.11% in 1997) display little sensitivity to the redefinition. In Czechia, the cumulative decline of −14.25% between 1990 and 1992 was followed by a four-year recovery. When constrained to three years, the expansion-phase Okun coefficient becomes significant (–0.1727*), though the recovery coefficient remains insignificant (–0.1346).

Latvia and Lithuania, both of which experienced economic collapses of nearly 50% in the early 1990s and recovered only after a decade, show stable expansion coefficients under the three-year recovery definition (–0.2651*** and −0.3016***, respectively), while recovery coefficients remain statistically insignificant. In Nigeria, the economy shrank by −31.97% between 1981 and 1984 and took eight years to recover. Limiting the recovery period to three years increases the significance of the expansion-phase coefficient (–0.0971***) and renders the recovery coefficient insignificant.

In Slovakia (–21.30% contraction during 1991–1992), the recovery lasted five years; under the truncated recovery definition, the expansion-phase coefficient steepens (–0.3336***), while recovery becomes flat and insignificant. Uruguay, with a −21.17% contraction during 1982–1984 and a six-year recovery, exhibits similar patterns: the expansion coefficient remains significant, but the recovery phase remains statistically weak.

Several post-Soviet and transition economies are particularly sensitive to this specification. Moldova, which suffered a staggering −84.47% cumulative GDP loss from 1991 to 1996, shows a positive and significant Okun coefficient (0.1037**) during expansion and a weakly negative one (–0.0462**) during recovery when the latter is limited to three years. In Armenia (–62.30% contraction from 1991 to 1993), the expansion coefficient steepens (–0.0907**), but recovery remains insignificant. In contrast, in Azerbaijan (–77.90% during 1991–1995), both expansion and recovery coefficients become statistically insignificant under the new definition.

Cameroon, which experienced a −32.73% decline between 1987 and 1993 with a nine-year recovery, exhibits a collapse in the expansion coefficient and a newly significant recovery coefficient (–0.0482***) under the three-year rule. Georgia, which underwent a −127.68% contraction following the Soviet collapse (1989–1994) and recovered only after 22 years, remains an outlier: Okun's Law fails to hold under any regime, even with the constrained recovery period.

Other countries such as Kazakhstan, Kyrgyzstan, Belarus, Italy, Mongolia, Tajikistan, Turkmenistan, and Uzbekistan show limited sensitivity to this reclassification. For instance, Uzbekistan, with a −20.09% decline during 1991–1995, exhibits a mildly significant expansion-phase coefficient (–0.0698*) under the three-year rule, while other regimes remain insignificant.

Taken together, these special cases underscore the importance of carefully defining recovery periods, particularly in economies that experienced large transitional shocks or persistent post-crisis stagnation. While the overall empirical patterns remain robust, the findings suggest that prolonged recoveries—especially in post-socialist and developing countries—may obscure the cyclical sensitivity of unemployment to output, depending on how recovery is operationalized.

4.2 Regional & panel analysis

Table 2 presents Okun coefficient estimates across global regions and economic regimes, while Fig. 4 provides a visual illustration of these results. A regional approach is essential because labor market dynamics, economic structures, and policy responses vary considerably across development levels, institutional contexts, and degrees of global integration. Aggregated estimates may mask such differences, so disaggregated analysis provides a more nuanced interpretation and policy relevance.

The results demonstrate substantial heterogeneity in the strength and significance of the unemployment–output relationship across both regions and regimes. In most regions, the coefficient is negative and statistically significant during expansions and recessions, except in South Asia and low-income countries. The steepest coefficients appear during recessions, consistent with heightened unemployment sensitivity to negative output shocks. During expansions, coefficients are flatter but generally significant, suggesting more moderate labor market gains. Wald tests comparing expansion and recession coefficients (R1 = R2) confirm significantly steeper recession effects in North America, South Asia, and the Euro Area, while in Latin America, Sub-Saharan Africa, high-income countries, and the OECD, the null of equality cannot be rejected. This indicates that although recession coefficients often appear larger in magnitude, the difference from expansions is not statistically significant in all regions.

Recovery periods generally display a more muted unemployment–output relationship, with coefficients typically less consistently significant. This pattern reflects jobless recoveries, where output growth fails to generate proportional employment gains, as observed in the Arab World, Central Europe and the Baltics, the Euro Area, and Sub-Saharan Africa, where recovery coefficients turn insignificant (Panovska 2017; Elroukh et al. 2020). Table 2 also highlights cases where the Okun's relationship remain significant yet is flatter in recoveries than in expansions, such as in Latin America (R1: −0.2141*** vs. R3: −0.1710***), high-income countries (R1: −0.3278*** vs. R3: −0.1444***), and the OECD (R1: −0.3440*** vs. R3: −0.1628***). By contrast, in South Asia (–0.2337***), North America (–0.6047***), and middle-income countries (–0.1292***), recovery coefficients are both significant and steeper than those in expansions, suggesting that labor markets in these regions may respond more strongly once economies exit recession. Such cases may reflect pent-up labor demand, rapid policy-driven rebounds, or greater labor market flexibility that enables firms to expand hiring quickly after downturns.

This regional divergence underscores that jobless recoveries are not universal. While muted or insignificant recovery responses dominate in many regions, other areas demonstrate that recoveries can be phases of heightened labor market sensitivity. The contrast highlights the importance of institutional, structural, and policy environments in shaping cyclical labor market dynamics.

The Wald tests reported in Table 2 also reinforce this interpretation, supporting the regime-dependent nature of Okun's Law. The null hypothesis of coefficient equality across regimes is strongly rejected in most regions, including the Euro Area, South Asia, Central Europe and the Baltics, North America, Latin America, High-Income Countries, the OECD, and the global aggregate, with p-values below the 1% level. East Asia and the Pacific shows significant heterogeneity at the 5% level, while Sub-Saharan Africa and the Arab World display weaker but still suggestive evidence at the 10% level. By contrast, the Middle East & North Africa and Low-Income Countries do not reject equality, suggesting that output–unemployment dynamics in those regions are more uniform across regimes.

Table 2 Regional Okun coefficient across economic cycles

Region	R0	R1	R2	R3	Wald R1 = R2 = R3	Wald R1 = R2	Wald R1 = R3	Wald R2 = R3
Central Europe & Baltics	− 0.2285*** (0.0713)	− 0.3142*** (0.0901)	− 0.2545*** (0.0560)	0.0318 (0.0941)	8.42*** [0.00]	0.45 [0.51]	7.95*** [0.00]	16.84*** [0.00]
East Asia & Pacific	− 0.0788*** (0.0178)	− 0.0612*** (0.0152)	− 0.1211*** (0.0253)	− 0.0947*** (0.0198)	3.32** [0.05]	4.10** [0.05]	1.82 [0.18]	0.68 [0.42]
Euro Area	− 0.2046** (0.0850)	− 0.3873*** (0.0426)	− 0.2320** (0.0924)	0.0525 (0.0399)	50.29*** [0.00]	2.63* [0.10]	96.34*** [0.00]	10.01*** [0.00]
Middle East & North Africa	− 0.1096*** (0.0311)	− 0.0969** (0.0482)	− 0.1400** (0.0651)	− 0.1031** (0.0510)	0.15 [0.86]	0.28 [0.59]	0.01 [0.93]	0.20 [0.65]
North America	− 0.6990*** (0.0892)	− 0.4336*** (0.0813)	− 0.8564*** (0.0779)	− 0.6047*** (0.1147)	12.54*** [0.00]	11.89*** [0.00]	1.29 [0.26]	10.72*** [0.00]
Latin America	− 0.2271*** (0.0299)	− 0.2141*** (0.0824)	− 0.2602*** (0.0176)	− 0.1710*** (0.0222)	10.01*** [0.00]	0.32 [0.57]	0.33 [0.57]	17.83*** [0.00]
South Asia	− 0.1200*** (0.0340)	− 0.0265 (0.0328)	− 0.1585*** (0.0256)	− 0.2337*** (0.0679)	12.79*** [0.00]	9.74*** [0.00]	7.48*** [0.01]	1.07 [0.31]
Sub-Saharan Africa	− 0.0427*** (0.0120)	− 0.0490** (0.0224)	− 0.0567*** (0.0151)	0.0233 (0.0201)	2.90* [0.07]	0.12 [0.73]	3.87** [0.05]	5.80** [0.02]
High Income Countries	− 0.3205*** (0.0269)	− 0.3278*** (0.0507)	− 0.3687*** (0.0273)	− 0.1444*** (0.0348)	9.71*** [0.00]	0.44 [0.51]	11.99*** [0.00]	14.87*** [0.00]
Middle Income Countries	− 0.1162*** (0.0234)	− 0.0715*** (0.0247)	− 0.1680*** (0.0279)	− 0.1292*** (0.0438)	3.38** [0.04]	6.65*** [0.01]	1.31 [0.26]	0.55 [0.46]
Low Income Countries	− 0.0307 (0.0199)	− 0.0427 (0.0355)	− 0.0144*** (0.0026)	− 0.0828 (0.0723)	0.80 [0.46]	0.66 [0.42]	0.23 [0.63]	0.86 [0.36]
Arab World	− 0.1150*** (0.0355)	− 0.1053** (0.0461)	− 0.1698*** (0.0249)	− − 0.0091 (0.0731)	2.80* [0.08]	1.51 [0.23]	1.23 [0.28]	4.30** [0.04]

Table 2 (continued)

Region	R0	R1	R2	R3	Wald R1 = R2 = R3	Wald R1 = R2	Wald R1 = R3	Wald R2 = R3
OECD	− 0.3281*** (0.0276)	− 0.3440*** (0.0640)	− 0.3729*** (0.0316)	− 0.1628*** (0.0314)	9.18*** [0.00]	0.14 [0.71]	8.71*** [0.00]	12.70*** [0.00]
World	− 0.1539*** (0.0159)	− 0.1300*** (0.0240)	− 0.1730*** (0.0194)	− 0.1157*** (0.0123)	10.45*** [0.00]	2.55 [0.12]	0.42 [0.52]	19.43*** [0.00]

Table reports Okun's coefficients under different regimes defined as follows: R0 refers to the zero regime, which covers the entire analysis period (baseline); R1 represents expansion periods; R2 corresponds to recession periods; and R3 indicates recovery periods. HAC-robust standard errors are reported in parentheses. The Wald test evaluates the null hypothesis of coefficient equality across regimes and reports F-statistics with p-values in brackets. Statistical significance follows: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Coefficients are visually illustrated in Fig. 4

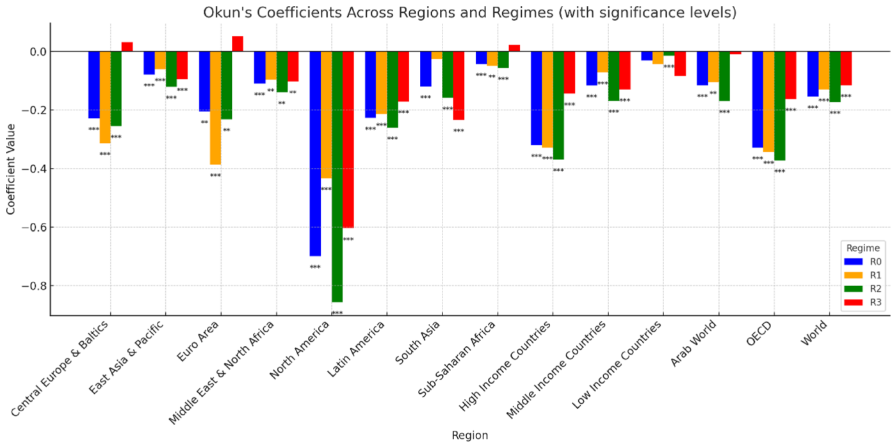

Fig. 4 Regional Okun coefficient across regimes

Overall, the results demonstrate that Okun's Law is regime-dependent, with expansions, recessions, and recoveries differing systematically in their unemployment responsiveness to output. Recoveries, in particular, are not merely delayed expansions but represent distinct phases shaped by rigidities, dual labor markets, and institutional frictions that can either mute or amplify employment responses. This underscores the importance of modeling macro–labor dynamics with explicit attention to cyclical states, as assuming a uniform, single-parameter relationship risks overlooking the structural constraints that govern labor market adjustment during recoveries.

In addition, we also panelize results for robustness. Table 3 provides comprehensive panel-level estimates that reinforce the regime-dependent nature of Okun's Law. Diagnostic tests, including the Redundant Fixed Effects (RFE) and Breusch–Pagan (BP) LM tests, indicate that the random-effects (RE) specification is the most appropriate, while the Swamy-Arora variance decomposition confirms that the data are also poolable. This ensures that the coefficients obtained from dynamic models such as DOLS and SOLS are econometrically robust.

In the one-regime specification, both RE and FE estimators yield a stable and significant Okun coefficient of approximately −0.10, implying that a 1-percentage-point increase in real output reduces the unemployment gap by around 0.10% points. This one-to-ten relationship is consistent across specifications and serves as a benchmark for evaluating nonlinear dynamics across business cycles.

The three-regime specification adds important nuance. The RE model estimates Okun coefficients of -0.09 during expansions, -0.14 during recessions, and −0.07 during recoveries, all significant at the 1% level. These findings confirm that unemployment reacts most strongly during downturns, more moderately during expansions, and least responsively, but still significantly, during recoveries. This regime-contingent structure aligns with country-specific patterns and underscores the asymmetry of labor market responses across economic phases.

Table 3 Panel Okun coefficient

	One Regime State			Two Regime State			Three Regime State			Dynamic State		
	Pooled	Random	Fixed	Pooled	Random	Fixed	Pooled	Random	Fixed	DOLS	SOLS	
PANEL A: Full period (1980–2023)												
ΔY_t	− 0.1079***	− 0.1079***	− 0.1083***	–	–	–	–	–	–	− 0.1027***	ΔY_t	− 0.1073***
	(0.0219)	(0.0219)	(0.0223)							(0.0172)		(0.0052)
ΔY^E	–	–	–	− 0.0549***	− 0.0533***	− 0.0300***	− 0.0908***	− 0.0767***	− 0.0600***	–	ΔY_{t-1}	− 0.0363***
				(0.0158)	(0.0155)	(0.0089)	(0.0147)	(0.0121)	(0.0083)			(0.0046)
ΔY^X	–	–	–	–	–	–	− 0.0674***	− 0.0647***	− 0.0356**	–	ΔY_{t-2}	–
							(0.0213)	(0.0202)	(0.0134)			
ΔY^R	–	–	–	− 0.1585***	− 0.1401***	− 0.1362***	− 0.1483***	− 0.1359***	− 0.1367***	–	ΔY_{t-3}	–
				(0.0284)	(0.0283)	(0.0167)	(0.0288)	(0.0297)	(0.0177)			
C	0.0140**	0.0140**	0.0140***	− 0.1065***	− 0.0850**	− 0.1097***	–	− 0.0339***	− 0.0536***	–	ΔY_{t-4}	–
	(0.0069)	(0.0069)	(0.0001)	(0.0381)	(0.0405)	(0.0218)		(0.0379)	(0.0189)			
R^2	0.1183	0.1184	0.1215	0.1364	0.1348	0.1352	0.1370	0.1366	0.1359	0.1217	0.1425	
Country	92	92	92	92	92	92	92	92	92	92	92	
Obs.	3393	3393	3393	3393	3393	3393	3393	3393	3393	3240	3240	
PANEL B: Without COVID-19 (1980–2019)												
ΔY_t	− 0.1030***	− 0.1030***	− 0.1036***	–	–	–	–	–	–	− 0.1138***	ΔY_t	− 0.1001***
	(0.0239)	(0.0239)	(0.0243)							(0.0184)		(0.0057)
ΔY^E	–	–	–	− 0.0521***	− 0.0513***	− 0.0263***	− 0.0877***	− 0.0773***	− 0.0466***	–	ΔY_{t-1}	− 0.0357***
				(0.0163)	(0.0158)	(0.0088)	(0.0149)	(0.0128)	(0.0066)			(0.0049)
ΔY^X	–	–	–	–	–	–	− 0.0624***	− 0.0617***	− 0.0296**	–	ΔY_{t-2}	–
							(0.0219)	(0.0209)	(0.0136)			
ΔY^R	–	–	–	− 0.1558***	− 0.1430***	− 0.1279***	− 0.1476***	− 0.1393***	− 0.1380***	–	ΔY_{t-3}	–
				(0.0341)	(0.0321)	(0.0229)	(0.0357)	(0.0345)	(0.0259)			
C	0.0148**	0.0148**	0.0149***	− 0.0996***	− 0.0852**	− 0.0988***	–	− 0.0309***	− 0.0529***	–	ΔY_{t-4}	–
	(0.0069)	(0.0069)	(0.0014)	(0.0369)	(0.0385)	(0.0223)		(0.0363)	(0.0159)			
R^2	0.1032	0.1032	0.1062	0.1210	0.1203	0.1340	0.1224	0.1225	0.1195	0.1029	0.1259	

Table 3 (continued)

	One Regime State			Two Regime State			Three Regime State			Dynamic State	
	Pooled	Random	Fixed	Pooled	Random	Fixed	Pooled	Random	Fixed	DOLS	SOLS
Country	92	92	92	92	92	92	92	92	92	92	92
Obs.	3025	3025	3025	3025	3025	3025	3025	3025	3025	3025	3025

The Okun's coefficients are estimated using panel least squares (Eqs. 11–12), panel dynamic least squares (DOLS, Eq. 13), and panel stepwise least squares (SOLS, Eq. 13) techniques. The results present HAC-robust standard errors in parentheses, with *, **, and *** denoting significance at the 10%, 5%, and 1% levels, respectively. The panel consists of 92 cross-sections over 43 periods, and the numbers in parentheses represent HAC/White cross-section standard errors. DOLS is specified with the "Auto-Schwarz" maximum four leads-lags specification, while long-run coefficient covariances are computed using the sandwich method with a Bartlett kernel and Newey-West fixed bandwidth methodology. SOLS employs a stepwise backwards selection method, testing up to four lags and the intercept with a p-value criterion of 0.10. The analysis period spans from 1980 to 2023. The superscripts "E", "X", and "R" represent estimations for expansion, recovery, and recession periods, respectively. The Redundant Fixed Effects test fails to reject the null hypothesis, while the Breusch-Pagan, Honda, and King-Wu LM tests suggest time random effects. The two-regime specification defines expansion and recession periods based on the sign of the real GDP gap: expansion corresponds to periods with a positive gap, and recession to periods with a negative gap

To address potential over-parameterization and simplify interpretation, we introduce a two-regime specification that excludes recovery periods and groups the data into expansion and recession phases based on GDP gap signs. This specification yields a similar coefficient for recessions (-0.14), reinforcing its robustness, but a notably flatter coefficient for expansions (-0.05), nearly half of that observed in the three-regime case. The intercept also increases, suggesting that omitting recovery periods absorbs some of the transitional dynamics into the constant term. This attenuation during expansions may reflect the mixed behavior of post-recession rebounds, which, when not isolated as a distinct regime, dilute the average responsiveness of unemployment to output growth.

Mussida and Zanin (2023) argue that COVID-19 has flattened Okun's coefficients in a few countries. We also test it at the panel-level, re-estimating all models using data only up to 2019. Panel B of Table 3 presents these pre-pandemic results. The coefficients remain largely stable across all specifications. In the three-regime RE model, Okun coefficients for expansion (-0.0773), recession (-0.1393), and recovery (-0.0617) are very close to their full-sample counterparts. The dynamic models likewise show minimal deviation, with the DOLS long-run estimate remaining at -0.11 and the SOLS cumulative effect at -0.14. This consistency indicates that the inclusion of 2020–2023 data does not materially bias the results at the panel level.

Together, these findings provide strong empirical validation for Okun's Law in both level and dynamic terms. However, the estimates reveal considerable heterogeneity across regimes and regions, particularly during recoveries, where delayed labor market responses and structural rigidities limit the elasticity of unemployment with respect to output. Accounting for these nonlinearities is crucial for accurate modeling and effective policy formulation in macro-labor contexts.

5 Concluding remarks

This study provides a comprehensive analysis of Okun's Law by disaggregating the unemployment–output relationship across distinct economic regimes (expansion, recession, and recovery) using a multi-country panel spanning 1980 to 2023. While Okun's Law broadly holds across most economies, its magnitude and stability are highly contingent on both the business cycle phase and country-specific conditions.

The empirical results show that Okun's Law holds most strongly during recessions, when economic contractions lead to substantial labor market slack. The unemployment gap reacts sharply to output losses, consistent with cyclical job shedding and underutilization of labor. During expansions, the relationship remains statistically significant but is generally more muted, indicating a slower pace of job creation relative to output growth.

The recovery phase, however, diverges notably. Relative to expansions and recessions, the estimated Okun coefficients are less consistently significant in recoveries; where significance persists, they are typically flatter than in expansions. This attenuation indicates that output rebounds are often not matched by commensurate employment gains, consistent with jobless recoveries. The pattern is most pronounced in advanced and transition economies characterized by rigid labor institutions, aging workforces, and ongoing sectoral shifts toward capital- and technology-intensive production.

Several factors may explain this empirical asymmetry. First, firms tend to increase working hours or improve productivity before expanding payrolls, thereby delaying unemployment reductions. Second, skill mismatches, particularly in structurally changing economies, hinder reemployment. Third, policy interventions during recessions, such as wage subsidies and furlough schemes, may temporarily preserve employment relationships, deferring true labor market adjustments. Finally, post-crisis uncertainty and cost pressures can suppress hiring despite output recovery.

Our Wald test results decisively reject the null hypothesis of regime-invariant coefficients in most regional groups, reinforcing the conclusion that the output–unemployment nexus is nonlinear and highly regime-sensitive. While high-income and OECD economies maintain strong Okun relationships across regimes, many low-income countries display weaker or non-significant responses, reflecting structural labor market informality, underemployment, and institutional limitations.

These regional patterns underscore the need for context-specific interpretations of Okun's Law. In high-income countries, the consistent negative relationship points to the importance of policies that reduce labor market rigidities and support job-rich growth, particularly during recoveries. In contrast, low- and middle-income economies require more targeted labor market strategies. The prevalence of informality and structural barriers limits the ability of output growth to generate broad-based employment gains.

These findings carry several important policy implications. For advanced economies, labor market flexibility, skills upgrading, and rehiring incentives can help accelerate employment recovery and prevent long-term scarring. For lower-income economies, formalization efforts, vocational training, and youth employment initiatives are crucial to enhancing the employment elasticity of output.

Moreover, counter-cyclical labor market interventions remain essential. Public works and income support programs can serve as buffers during recessions, while wage subsidies and hiring incentives can stimulate reemployment during recoveries, especially among vulnerable or marginalized groups. Recovery periods should not be treated as passive transitions; they require active policy engagement to rebuild labor demand and ensure inclusive labor market revitalization.

In conclusion, while Okun's Law continues to offer a valuable framework for understanding macro-labor dynamics, its practical relevance depends heavily on economic regimes, institutional structures, and national contexts. Recognizing the cyclical asymmetry and structural conditions that influence unemployment responsiveness is key to formulating effective employment policies. Future research should deepen the analysis by incorporating the roles of automation, labor market dualism, and policy sequencing in shaping the performance of Okun's Law across the global economy.

Appendix

See Tables 4 and 5.

Table 4 Descriptive statistics

	Unemployment Rate					Real GDP growth rate						UNemployment rate					Real GDP growth rate				
	Mean	Max.	Min.	St.Dev.	N	Mean	Max.	Min.	St.Dev.	N		Mean	Max.	Min.	St.Dev.	N	Mean	Max.	Min.	St.Dev.	N
Albania	0.1603	0.3001	0.1030	0.0412	33	0.0301	0.1332	− 0.2800	0.0703	43	Kyrgyzstan	0.0261	0.0463	0.0100	0.0101	33	0.0237	0.132	− 0.2009	0.0725	37
Algeria	0.1781	0.3184	0.0982	0.0762	33	0.0264	0.0650	− 0.0500	0.0241	44	Latvia	0.1169	0.2070	0.0270	0.0467	33	0.0174	0.1283	− 0.3212	0.087	33
Argentina	0.0923	0.1959	0.0230	0.0428	44	0.0183	0.1044	− 0.1089	0.0572	44	Lithuania	0.1050	0.1781	0.0110	0.0463	33	0.0199	0.1108	− 0.2126	0.0752	33
Armenia	0.1006	0.1321	0.0160	0.0281	33	0.0366	0.1400	− 0.4180	0.1073	33	Luxembourg	0.0391	0.0680	0.0148	0.0161	41	0.0357	0.0998	− 0.0324	0.0307	44
Australia	0.0665	0.1088	0.0367	0.0182	44	0.0306	0.0576	− 0.0222	0.0150	44	Malaysia	0.0379	0.0829	0.0048	0.0148	44	0.0552	0.1000	− 0.0736	0.0380	44
Austria	0.0453	0.0646	0.0190	0.0103	44	0.0188	0.0528	− 0.0632	0.0203	44	Mexico	0.0389	0.0710	0.0176	0.0105	36	0.0225	0.0959	− 0.0835	0.0370	44
Azerbaijan	0.0655	0.1178	0.0090	0.0245	33	0.0392	0.3450	− 0.2310	0.1214	33	Moldova	0.0406	0.1114	0.0079	0.0289	33	− 0.0005	0.1393	− 0.3090	0.0982	33
Bahrain	0.0117	0.0177	0.0094	0.0015	33	0.0381	0.1287	− 0.0756	0.0407	44	Mongolia	0.0606	0.0927	0.0391	0.0104	33	0.0459	0.1729	− 0.0926	0.0525	42
Bangladesh	0.0388	0.0583	0.0220	0.0102	33	0.0517	0.0788	0.0082	0.0156	44	Morocco	0.1262	0.2286	0.0891	0.0346	38	0.0387	0.1237	− 0.0718	0.0407	44
Belarus	0.0829	0.2440	0.0060	0.0496	33	0.0235	0.1145	− 0.1170	0.0623	33	Nepal	0.1076	0.1316	0.1054	0.0052	33	0.0432	0.0968	− 0.0298	0.0275	44
Belgium	0.0829	0.1300	0.0536	0.019	44	0.0190	0.0620	− 0.0479	0.0186	44	Netherlands	0.0608	0.1265	0.0212	0.0256	44	0.0210	0.0628	− 0.0387	0.0210	44
Bosnia	0.2315	0.3111	0.1042	0.054	33	0.0605	0.5420	− 0.0935	0.1165	33	New Zealand	0.0581	0.1067	0.0330	0.0190	38	0.0257	0.0639	− 0.0124	0.0187	44
Brazil	0.0804	0.1370	0.0237	0.0307	43	0.0235	0.0920	− 0.0435	0.0331	44	Nigeria	0.0442	0.0706	0.0307	0.0115	38	0.0307	0.1533	− 0.1313	0.0520	44
Bulgaria	0.1052	0.1992	0.0423	0.0426	33	0.0185	0.1094	− 0.1412	0.0513	43	Norway	0.0381	0.0631	0.0170	0.0113	42	0.0236	0.0605	− 0.0194	0.0179	44
Cameroon	0.0542	0.0912	0.0306	0.0217	33	0.0309	0.1708	− 0.0793	0.0443	44	Oman	0.0369	0.0476	0.0146	0.0097	33	0.049	0.1705	− 0.0344	0.0507	44
Canada	0.0812	0.1202	0.0528	0.0175	44	0.0230	0.0590	− 0.0504	0.0224	44	Pakistan	0.0416	0.0783	0.0040	0.0212	44	0.0466	0.1022	− 0.0127	0.0231	44
Chile	0.0865	0.1960	0.0435	0.0301	44	0.0409	0.1133	− 0.1101	0.0427	44	Paraguay	0.0566	0.0939	0.0340	0.0129	44	0.0352	0.1171	− 0.0304	0.0345	44
China	0.0360	0.0561	0.0180	0.0102	44	0.0901	0.1519	0.0224	0.0304	44	Peru	0.0569	0.1179	0.0321	0.0235	44	0.0309	0.1336	− 0.1231	0.0569	44
Colombia	0.1149	0.2052	0.0780	0.0281	44	0.0342	0.1080	− 0.0719	0.0288	44	Philippines	0.0561	0.1119	0.0224	0.0284	44	0.0382	0.0758	− 0.0952	0.0377	44
Costa Rica	0.0739	0.1643	0.0393	0.0288	33	0.0375	0.0920	− 0.0729	0.0312	44	Poland	0.1071	0.2021	0.0274	0.0530	33	0.0370	0.0793	− 0.0702	0.0289	33
Cote d'Ivoire	0.0470	0.0722	0.0190	0.0166	33	0.0264	0.1076	− 0.1096	0.0457	44	Portugal	0.0762	0.1619	0.0381	0.0307	41	0.0199	0.0749	− 0.0820	0.0307	44
Czechia	0.0512	0.0876	0.0070	0.0232	34	0.0173	0.0662	− 0.1161	0.0372	34	Qatar	0.0055	0.0087	0.0010	0.0033	33	0.0592	0.3001	− 0.0687	0.0779	44
Denmark	0.0651	0.1072	0.0368	0.0184	44	0.0185	0.0738	− 0.0497	0.0206	44	Romania	0.0658	0.0826	0.0391	0.0115	33	0.0230	0.1043	− 0.1292	0.0520	33
Egypt	0.0900	0.1315	0.0497	0.0225	44	0.0493	0.1001	0.0113	0.0200	44	Russia	0.0712	0.1326	0.0308	0.0253	32	0.0090	0.1000	− 0.1453	0.0605	34
Estonia	0.0789	0.1671	0.0056	0.0371	35	0.0184	0.1305	− 0.2117	0.0707	35	Saudi Arabia	0.0579	0.0745	0.0435	0.0078	33	0.0212	0.1099	− 0.1611	0.0516	44
Finland	0.0860	0.1701	0.0307	0.0354	44	0.0200	0.0640	− 0.0808	0.0302	44	Senegal	0.0326	0.0676	0.0265	0.0096	33	0.0359	0.0801	− 0.0565	0.0257	44
France	0.0951	0.1259	0.0642	0.0151	44	0.0176	0.0688	− 0.0744	0.0206	44	Serbia	0.1508	0.2400	0.0868	0.0408	33	0.0317	0.0893	− 0.1033	0.0382	33
Georgia	0.1313	0.2071	0.0270	0.0437	33	0.0145	0.1258	− 0.4490	0.1110	44	Singapore	0.0376	0.0684	0.0150	0.0122	44	0.0602	0.1452	− 0.0387	0.0419	44
Germany	0.0672	0.1119	0.0307	0.0228	41	0.016	0.0526	− 0.0555	0.0203	44	Slovakia	0.1245	0.1915	0.0576	0.0397	33	0.0266	0.1082	− 0.1457	0.0477	33

Table 4 (continued)

	Unemployment Rate					Real GDP growth rate						UNemployment rate					Real GDP growth rate				
	Mean	Max.	Min.	St.Dev.	N	Mean	Max.	Min.	St.Dev.	N		Mean	Max.	Min.	St.Dev.	N	Mean	Max.	Min.	St.Dev.	N
Ghana	0.0552	0.1046	0.0217	0.0222	33	0.0446	0.1405	− 0.0692	0.0351	44	Slovenia	0.0669	0.1010	0.0365	0.0166	33	0.0220	0.0839	− 0.0890	0.0394	33
Greece	0.1229	0.2769	0.0342	0.0604	43	0.0101	0.0865	− 0.0988	0.0396	44	South Africa	0.2669	0.3615	0.2155	0.0377	33	0.0207	0.0662	− 0.0617	0.0253	44
Hungary	0.0729	0.1210	0.0170	0.0277	34	0.0160	0.0706	− 0.1189	0.035	44	South Korea	0.0343	0.0696	0.0205	0.0098	44	0.0572	0.1338	− 0.0513	0.0403	44
Iceland	0.0404	0.0756	0.0187	0.0157	33	0.0300	0.0899	− 0.0766	0.0373	44	Spain	0.1702	0.2609	0.0823	0.0480	44	0.0218	0.0668	− 0.1094	0.0299	44
India	0.0757	0.0870	0.0417	0.0102	33	0.0597	0.0969	− 0.0578	0.0264	44	Sri Lanka	0.0747	0.1466	0.0388	0.0330	33	0.0426	0.0867	− 0.0735	0.0323	44
Indonesia	0.0439	0.0806	0.0166	0.0178	44	0.0496	0.0988	− 0.1313	0.0343	44	Sweden	0.0620	0.1036	0.0146	0.0248	44	0.0206	0.0594	− 0.0426	0.0217	44
Iran	0.1104	0.1368	0.0909	0.0119	33	0.0249	0.2317	− 0.2160	0.0696	44	Switzerland	0.0315	0.0501	0.0020	0.0157	44	0.0183	0.0539	− 0.0230	0.0175	44
Iraq	0.1001	0.1617	0.0797	0.0269	33	0.0625	0.5782	− 0.6405	0.1942	44	Tajikistan	0.1005	0.1650	0.0190	0.0371	33	0.0265	0.1390	− 0.2900	0.0980	38
Ireland	0.1035	0.1806	0.0368	0.0488	44	0.0516	0.2462	− 0.0553	0.0528	44	Tanzania	0.0301	0.0388	0.0213	0.0048	33	0.0463	0.0767	− 0.0098	0.0236	44
Israel	0.0818	0.1408	0.0337	0.0335	44	0.0415	0.0934	− 0.0146	0.0244	44	Thailand	0.0168	0.0577	0.0025	0.0118	44	0.0464	0.1329	− 0.0763	0.0408	44
Italy	0.0976	0.1268	0.0608	0.0167	44	0.0122	0.0893	− 0.0887	0.0266	44	Tunisia	0.1522	0.1833	0.1237	0.0147	35	0.0335	0.0795	− 0.0901	0.0310	44
Jamaica	0.1477	0.3551	0.0302	0.0827	44	0.0130	0.0942	− 0.0992	0.0336	44	Turkey	0.0995	0.1403	0.0650	0.0187	44	0.0463	0.1144	− 0.0575	0.0422	44
Japan	0.0338	0.0539	0.0200	0.0103	44	0.0172	0.0666	− 0.0569	0.0235	44	Turkmenistan	0.0606	0.1270	0.0140	0.0328	33	0.0568	0.3538	− 0.1730	0.0936	36
Jordan	0.1535	0.2131	0.1190	0.0268	33	0.0393	0.1718	− 0.1073	0.0441	44	United Kingdom	0.0715	0.1151	0.0366	0.0243	44	0.0204	0.0858	− 0.1030	0.0288	44
Kazakhstan	0.0701	0.1346	0.0090	0.0347	33	0.0295	0.1350	− 0.126	0.0648	33	United States	0.0611	0.0970	0.0364	0.0171	44	0.0263	0.0724	− 0.0258	0.0195	44
Kenya	0.0329	0.0581	0.0265	0.0102	33	0.0383	0.0806	− 0.0080	0.0225	44	Uruguay	0.0962	0.1666	0.0631	0.0254	44	0.0225	0.0881	− 0.1027	0.0473	44
Kuwait	0.0162	0.0354	0.0069	0.0078	33	0.0303	0.8281	− 0.4101	0.1735	44	Uzbekistan	0.0677	0.1330	0.0190	0.0297	33	0.0450	0.0947	− 0.1120	0.0429	36

Table 5 Country-specific Okun coefficient across economic cycles

Country	R0	R1	R2	R3	Wald	Country	R0	R1	R2	R3	Wald
Albania	− 0.4542**	− 0.0855	− 0.1017	− 0.4834***	6.82***	Kyrgyzstan	− 0.0055	− 0.0107	− 0.0053	− 0.0053	0.03
	(0.2244)	(0.1113)	(0.4165)	(0.0941)			(0.0037)	(0.0145)	(0.0043)	(0.0037)	
Algeria	− 0.1122	− 0.0704	− 0.2548***	0.5783	0.81	Latvia	− 0.2628**	− 0.2864***	− 0.2648***	− 0.2370	0.04
	(0.1022)	(0.1807)	(0.0478)	(0.8976)			(0.1147)	(0.0330)	(0.1425)	(0.1704)	
Argentina	− 0.1387**	− 0.1558***	− 0.1882**	0.0030	2.84*	Lithuania	− 0.3466***	− 0.3982***	− 0.3676***	− 0.2543	0.33
	(0.0582)	(0.0503)	(0.0805)	(0.1086)			(0.0703)	(0.0679)	(0.0862)	(0.1571)	
Armenia	0.0024	− 0.0592**	0.0147	− 0.0225	3.05**	Luxembourg	− 0.0843***	− 0.0895***	− 0.0686	0.0906	1.03
	(0.0165)	(0.0285)	(0.0159)	(0.0288)			(0.0213)	(0.0194)	(0.1065)	(0.1434)	
Australia	− 0.5681***	− 0.5605***	− 0.6626***	− 0.4877***	2.44*	Malaysia	− 0.1312***	− 0.1005***	− 0.1431***	− 0.1978**	5.46***
	(0.0419)	(0.0634)	(0.0433)	(0.1071)			(0.0427)	(0.0349)	(0.0575)	(0.0945)	
Austria	− 0.1484***	− 0.1184*	− 0.1286***	− 0.0544	0.22	Mexico	− 0.2077***	− 0.1405**	− 0.2292***	− 0.2884***	2.65*
	(0.0313)	(0.0762)	(0.0417)	(0.1196)			(0.0432)	(0.0416)	(0.0945)	(0.0475)	
Azerbaijan	− 0.0239	− 0.0101*	− 0.0879***	0.0509	5.21***	Moldova	− 0.0662***	− 0.0047	− 0.0760***	− 0.0305	3.28**
	(0.0225)	(0.0053)	(0.0303)	(0.0548)			(0.0157)	(0.0459)	(0.0153)	(0.0217)	
Bahrain	− 0.0359***	− 0.0222***	− 0.0488***	− 0.0849**	2.96*	Mongolia	− 0.0301	− 0.1403***	0.0736	− 0.0903*	3.55**
	(0.0125)	(0.0065)	(0.0135)	(0.0338)			(0.0625)	(0.0398)	(0.0974)	(0.0500)	
Bangladesh	− 0.1629*	NA	NA	NA	NA	Morocco	− 0.1396*	0.0682	− 0.1616	− 0.1806	1.08
	(0.0839)						(0.0719)	(0.1542)	(0.1181)	(0.1119)	
Belarus	− 0.2996***	0.0149	− 0.3024***	− 0.4484***	7.88***	Nepal	− 0.1404*	− 0.0361	− 0.3823***	− 0.9875***	29.07***
	(0.1136)	(0.0144)	(0.0956)	(0.1673)			(0.0851)	(0.0263)	(0.0415)	(0.2905)	
Belgium	− 0.3389**	− 0.3235***	− 0.2245*	0.1927	5.09***	Netherlands	− 0.4123**	− 0.3509***	− 0.3100*	− 0.3384**	36.97***
	(0.1437)	(0.1087)	(0.1219)	(0.1261)			(0.1080)	(0.0721)	(0.1887)	(0.1572)	
Bosnia	− 0.0218	− 0.0167	− 0.0651	− 0.0053	0.33	New Zealand	− 0.4167***	− 0.3852***	− 0.5386***	− 0.4131***	10.87***
	(0.0176)	(0.0148)	(0.0611)	(0.1991)			(0.0332)	(0.0434)	(0.0227)	(0.0168)	
Brazil	− 0.2629***	− 0.3046***	− 0.2368***	− 0.2146	3.90**	Nigeria	− 0.0927***	− 0.0628*	− 0.1429**	− 0.1118**	3.99**
	(0.0639)	(0.0649)	(0.0745)	(0.1393)			(0.0208)	(0.0371)	(0.0717)	(0.0551)	
Bulgaria	− 0.1993***	− 0.6188***	− 0.1924***	− 0.1552	4.31**	Norway	− 0.1947***	− 0.1631***	− 0.2091***	− 0.3189	0.31
	(0.0734)	(0.1176)	(0.0709)	(0.1261)			(0.0422)	(0.0642)	(0.021)	(0.2622)	
Cameroon	− 0.0592***	− 0.1117**	− 0.0538***	− 0.0071	2.25*	Oman	− 0.0414**	− 0.0075	− 0.1056**	− 0.0689	1.83
	(0.0186)	(0.0487)	(0.0048)	(0.0251)			(0.0207)	(0.0143)	(0.0477)	(0.0637)	

Table 5 (continued)

Country	R0	R1	R2	R3	Wald	Country	R0	R1	R2	R3	Wald
Canada	− 0.4905*** (0.0451)	− 0.3810*** (0.0652)	− 0.5550*** (0.0304)	− 0.4046*** (0.1143)	3.75**	Pakistan	− 0.2765*** (0.0739)	− 0.2389** (0.0985)	− 0.2781*** (0.0442)	− 0.5801*** (0.0000)	28.63***
Chile	− 0.2604*** (0.0395)	− 0.2416*** (0.0457)	− 0.3866*** (0.0608)	− 0.1864 (0.1167)	2.46*	Paraguay	− 0.1790*** (0.0560)	− 0.1223 (0.1284)	− 0.2225*** (0.0615)	− 0.1287 (0.0889)	0.77
China	− 0.0148 (0.0197)	NA	NA	NA	NA	Peru	− 0.2056*** (0.0418)	− 0.1474*** (0.0411)	− 0.2138*** (0.0341)	− 0.2229 (0.1333)	0.85
Colombia	− 0.4359*** (0.0578)	− 0.3698*** (0.1082)	− 0.5855*** (0.0477)	− 0.1972 (0.1447)	2.77*	Philippines	− 0.0341 (0.0341)	0.0482 (0.1202)	− 0.0601 (0.0465)	0.0150 (0.0973)	0.48
Costa Rica	− 0.5119*** (0.0778)	− 0.4084*** (0.1069)	− 0.6304*** (0.0577)	− 0.3973*** (0.0408)	5.20***	Poland	− 0.3553** (0.1566)	− 0.5355*** (0.1464)	− 0.0885*** (0.0000)	0.0720 (0.1514)	6.07***
Cote d'Ivoire	− 0.0691** (0.0352)	− 0.0914 (0.0899)	− 0.0564*** (0.0185)	− 0.0369 (0.0594)	0.09	Portugal	− 0.2548*** (0.0837)	− 0.3257*** (0.0722)	− 0.2621** (0.1065)	− 0.1345 (0.1798)	0.46
Czechia	− 0.1787*** (0.0437)	− 0.1541 (0.0984)	− 0.1903*** (0.0487)	− 0.1574 (0.0967)	0.08	Qatar	0.0004 (0.0017)	0.0007 (0.0021)	− 0.0035 (0.0031)	0.0001 (0.0003)	0.69
Denmark	− 0.3459*** (0.0811)	− 0.3873*** (0.0567)	− 0.4271*** (0.0901)	− 0.1614 (0.1792)	2.23*	Romania	− 0.0401 (0.0331)	− 0.0268 (0.0617)	− 0.0677* (0.0415)	0.0018 (0.0583)	0.50
Egypt	-0.3299*** (0.0839)	NA	NA	NA	NA	Russia	− 0.1807*** (0.0235)	− 0.2042*** (0.0503)	− 0.1910*** (0.0163)	− 0.1515* (0.0830)	0.16
Estonia	− 0.2414** (0.0942)	− 0.3227* (0.1927)	− 0.2683*** (0.0605)	− 0.1123 (0.1165)	0.80	Saudi Arabia	− 0.0571 (0.0456)	− 0.0290 (0.0452)	− 0.1140 (0.0738)	− 0.0134 (0.0551)	1.03
Finland	− 0.3497*** (0.0713)	− 0.3703*** (0.0544)	− 0.3769*** (0.1048)	− 0.1283** (0.0604)	6.96***	Senegal	− 0.0658* (0.0337)	− 0.0724* (0.0399)	− 0.0347*** (0.0000)	− 0.0229 (0.0000)	34.81***
France	− 0.2614*** (0.1215)	− 0.3464*** (0.0512)	− 0.0827 (0.0971)	− 0.0170 (0.0123)	27.97***	Serbia	− 0.0478 (0.0988)	− 0.2184 (0.2601)	− 0.0075 (0.0569)	0.0559 (0.3904)	0.41
Georgia	− 0.0285 (0.0285)	0.0438 (0.1295)	− 0.0408* (0.0210)	0.0033 (0.0683)	1.94	Singapore	− 0.1610*** (0.0391)	− 0.2132*** (0.0369)	− 0.1033*** (0.0350)	− 0.1549 (0.1711)	2.35*
Germany	− 0.2418*** (0.0669)	− 0.2743*** (0.0717)	− 0.1953*** (0.0469)	− 0.1093** (0.0427)	2.49*	Slovakia	− 0.2126*** (0.0783)	− 0.3246*** (0.0943)	− 0.3056*** (0.0899)	− 0.0445 (0.1113)	2.71*
Ghana	− 0.2263*** (0.0842)	NA	NA	NA	NA	Slovenia	− 0.1538*** (0.0298)	− 0.2438*** (0.0546)	− 0.1736*** (0.0341)	− 0.0340 (0.0507)	4.96***

Table 5 (continued)

Country	R0	R1	R2	R3	Wald	Country	R0	R1	R2	R3	Wald
Greece	− 0.4622*** (0.0803)	− 0.3823*** (0.0435)	− 0.5206*** (0.1353)	− 0.5441** (0.1944)	0.63	South Africa	− 0.4667*** (0.1680)	− 0.6969*** (0.2093)	− 0.5962*** (0.0287)	− 0.5638 (0.4769)	8.74***
Hungary	− 0.3231*** (0.1149)	0.0669 (0.0576)	− 0.3893*** (0.1148)	− 0.2305 (0.1766)	6.17***	South Korea	− 0.2446*** (0.0634)	− 0.1516** (0.0670)	− 0.3461*** (0.0246)	− 0.1399*** (0.0091)	39.49***
Iceland	− 0.2518*** (0.0316)	− 0.2258*** (0.0509)	− 0.2765*** (0.0549)	-0.0854 (0.1158)	1.53	Spain	− 0.7495*** (0.1739)	− 0.8608*** (0.1044)	− 0.4010** (0.1909)	− 0.3496 (0.2422)	2.51*
India	− 0.1070*** (0.0378)	− 0.0169 (0.0207)	− 0.1847*** (0.0000)	− 0.1000*** (0.0000)	12.71***	Sri Lanka	− 0.1324*** (0.0219)	− 0.1716*** (0.0552)	− 0.1166*** (0.0145)	− 0.1099* (0.0563)	0.51
Indonesia	− 0.0229** (0.0121)	− 0.0211 (0.0143)	− 0.0498 (0.0516)	− 0.0228 (0.0241)	0.16	Sweden	− 0.2736*** (0.0743)	− 0.3371*** (0.1066)	− 0.3705*** (0.0961)	0.0386 (0.0326)	18.93***
Iran	0.0302 (0.0508)	− 0.1248* (0.0658)	0.0719* (0.0376)	0.1772*** (0.0386)	3.99**	Switzerland	− 0.1511** (0.0375)	− 0.1614*** (0.0595)	− 0.1309*** (0.0474)	− 0.0990*** (0.0365)	2.32*
Iraq	− 0.0070** (0.0028)	− 0.0086** (0.0035)	− 0.0067* (0.0040)	− 0.0027 (0.0083)	1.05	Tajikistan	− 0.0255 (0.0401)	− 0.0208 (0.0613)	− 0.0226 (0.0549)	− 0.0831 (0.0613)	0.01
Ireland	− 0.1188** (0.0580)	− 0.0821* (0.0484)	− − 0.2042* (0.1114)	− 0.0280 (0.1340)	0.92	Tanzania	− 0.0108 (0.0345)	NA	NA	NA	NA
Israel	− 0.2187*** (0.0836)	− 0.3013*** (0.0904)	− 0.1732*** (0.0541)	0.0918 (0.0944)	8.66***	Thailand	− 0.1241*** (0.0209)	− 0.1168*** (0.0308)	− 0.1847*** (0.0176)	− 0.1112*** (0.0110)	10.12***
Italy	− 0.1774 (0.1125)	− 0.2887** (0.1206)	− 0.0857 (0.1513)	− 0.2337** (0.0939)	0.92	Tunisia	− 0.2253** (0.0995)	− 0.1304*** (0.0505)	− 0.3877* (0.2017)	− 0.3122 (0.3426)	1.21
Jamaica	− 0.3003** (0.1198)	− 0.1262 (0.2261)	− 0.2832** (0.1202)	− 0.5273 (0.3396)	0.48	Turkey	− 0.1727*** (0.0441)	-0.1718*** (0.0552)	− 0.2170*** (0.0282)	− 0.1563 (0.1309)	0.33
Japan	− 0.1177*** (0.0182)	-0.1292*** (0.0405)	− 0.1572*** (0.0190)	0.0189 (0.0237)	13.85***	Turkmenistan	− 0.0106 (0.0297)	0.0086 (0.0259)	− 0.0338 (0.0479)	0.0269 (0.0197)	0.58
Jordan	− 0.0941* (0.0494)	− 0.1591 (0.1155)	− 0.6065*** (0.0000)	− 0.0364*** (0.0024)	29.04***	United Kingdom	− 0.2931*** (0.0467)	− 0.3438*** (0.0521)	− 0.1879** (0.0794)	− 0.1337 (0.1210)	2.44*
Kazakhstan	− 0.2179** (0.1006)	-0.0811*** (0.0181)	− 0.3445** (0.1671)	− 0.2147*** (0.0681)	5.67***	United States	− 0.5844*** (0.0972)	− 0.4219*** (0.0404)	− 0.7268*** (0.1163)	− 0.4259* (0.2464)	5.97***

Table 5 (continued)

Country	R0	R1	R2	R3	Wald	Country	R0	R1	R2	R3	Wald
Kenya	− 0.0325***	− 0.0199**	− 0.0420***	− 0.0778***	2.48*	Uruguay	− 0.1984***	− 0.1707**	− 0.2556***	− 0.0800	1.19
	(0.0086)	(0.0081)	(0.0063)	(0.0238)			(0.0555)	(0.0745)	(0.0505)	(0.0505)	
Kuwait	− 0.0016	− 0.0012	− 0.0149	− 0.0010	0.14	Uzbekistan	− 0.0121	− 0.0602	− 0.0283	0.1664	1.77
	(0.0022)	(0.0024)	(0.0277)	(0.0015)			(0.0320)	(0.0508)	(0.0398)	(0.1079)	

The values in the table represent Okun's coefficients estimated using Eqs. (7) and (10) through the Least Squares (LS) method, with HAC-robust standard errors provided in parentheses. Statistical significance is indicated by *, **, and *** for significance at the 10%, 5%, and 1% levels, respectively. The regimes are defined as follows: R0 refers to the zero regime, which covers the entire analysis period (baseline), R1 represents expansion periods, R2 corresponds to recession periods, and R3 indicates recovery periods. "NA" denotes that a specific regime is unavailable due to the absence of negative output growth during the analysis period. The Wald tests the H_0: R(1) = R(2) = R(3)

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Data availability The study is based on annual data spanning 44 years (1980–2023) across 92 countries. The dataset was retrieved from the World Bank's *World Development Indicators (WDI)* database, accessible at https://databank.worldbank.org/source/world-development-indicators. All econometric analyses were performed using EViews software. The EViews data file, along with replicable analysis outcomes, has been submitted as a supplementary file accompanying this article.

Declarations

Competing interests I declare that this manuscript is original, has not been published before, and is not currently under consideration for publication elsewhere. As the sole author, I confirm that the manuscript has been thoroughly reviewed and approved. I take full responsibility for the accuracy of the statements and information provided in the manuscript. Furthermore, I understand that I am solely responsible for all aspects of the editorial process, including responding to reviewers' comments, submitting revisions, and providing final approval of the proofs.

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