Cyclical asymmetries and spatial dependence in Okun's Law: global evidence from 163 countries

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Cyclical asymmetries and spatial dependence in Okun's Law: global evidence from 163 countries

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Abstract

This study assesses the empirical validity, heterogeneity, and spatial dependence of Okun's Law in a global setting. Using annual data for 163 countries over the period 1992–2023, we estimate country-specific unemployment–output elasticities under two standard specifications (output-gap and first-difference models) and allow for cyclical asymmetries by distinguishing expansionary and recessionary phases. The results indicate that Okun's coefficient is negative and statistically significant in most countries, although its magnitude is highly heterogeneous and varies systematically across income groups. Controlling for the common 2020 shock (COVID-19) does not meaningfully alter statistical significance for most countries, but it generates economically relevant shifts in the coefficient's magnitude for a non-negligible subset, thus improving cross-country comparability. We also document pronounced asymmetry: elasticities are, on average, stronger during recessions than expansions, particularly among middle- and high-income economies. Moran's I statistics reveal positive and significant spatial autocorrelation in cyclical sensitivities across alternative k-nearest-neighbour weighting matrices, with stronger dependence during recessions. These findings motivate the design of countercyclical labour-market policies tailored to structural heterogeneity and coordinated regionally during downturns.

Keywords: Okun's Law; Economic growth; Unemployment; Spatial dependence; Economic integration.

JEL Codes: C21; C32; E32; J21; R23

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1. Introduction

Okun's Law describes a negative empirical relationship between two fundamental pillars of macroeconomic analysis: the unemployment rate and output growth. Although originally formulated for the United States (Okun, 1962), its applicability has transcended national boundaries and has become a key analytical tool for examining labour-market dynamics in response to business-cycle fluctuations. Nevertheless, its empirical usefulness hinges upon a central question: does this relationship hold broadly and comparably across countries, or does it change systematically in the presence of exceptional shocks, cyclical phases, and regional linkages?

Since Okun's seminal contribution, numerous studies have explored this relationship across diverse institutional and geographical settings. However, a persistent bias remains in the accumulated evidence, which is still largely concentrated in developed economies (Ball et al. (2017; Gil-Alana et al., 2020; Ismihan, 2016; Kaufman, 1988; Moosa, 1997; Porras-Arena & Martín-Román, 2023a; Sögner & Stiassny, 2002).This constitutes a clear limitation for policy design in developing countries, where employment sensitivity to output fluctuations is typically lower (Ball et al., 2019; Pizzo, 2020; Porras-Arena & Martín-Román, 2023b; Sovbetov, 2025), challenging the universal validity of Okun's Law and underscoring the need for context-specific approaches. Expanding comparative evidence at a global scale is therefore essential to identify both general patterns and empirically verifiable regularities.

A growing body of research has increasingly questioned the assumption of a homogeneous unemployment–growth relationship, emphasising that the Okun coefficient varies substantially across countries depending on structural and institutional characteristics and labour-market rigidities. Recent studies reinforce the idea that Okun's Law is intrinsically heterogeneous and that its magnitude depends on the surrounding economic and institutional environment (Porras-Arena & Martín-Román, 2023b). This observation raises a critical and still unresolved question: how sensitive are Okun coefficients to cycle-specific factors and regional contexts? This becomes particularly relevant when recognising that heterogeneity manifests not only in coefficient magnitude, but also in the timing and conditions under which it changes. Extraordinary episodes, methodological differences, and cross-economy interdependence may all influence both the size and international comparability of the estimated effects.

Although the literature often estimates an average elasticity of unemployment with respect to GDP, such an approach implicitly assumes a symmetric response of labour markets to expansions and recessions. This assumption may hide relevant asymmetric mechanisms that shape the effectiveness of countercyclical policies (Pitoňáková et al., 2025). A further limitation lies in the frequent omission of potential spatial dependence, even though labour-market dynamics may be significantly influenced by the economic performance of neighbouring countries—particularly in contexts of deepening international integration (Villaverde & Maza, 2021). Consequently, assessing Okun's Law as an average relationship, without distinguishing cyclical regimes or accounting for regional interdependencies, may lead to incomplete inferences regarding shock transmission and the efficacy of stabilisation policies.

This study contributes to the literature by jointly incorporating two dimensions that have rarely been analysed together: cyclical asymmetries and spatial dependence. To this end, we estimate the Okun coefficient using both output-gap and first-difference specifications Belmonte & Polo (2004) for a broad sample of 163 countries between 1992 and 2023. This wide geographical coverage, spanning both developed and developing economies, enables a systematic and global comparison of cyclical unemployment sensitivities. The analysis does not merely report an average coefficient; rather, it constructs country-specific estimates and contrasts their robustness across alternative specifications, with the aim of distinguishing empirical regularities from methodology-dependent outcomes. Moreover, the COVID-19 shock is explicitly incorporated to assess whether the estimated magnitude of the coefficient changes once this exceptional event is disentangled from regular cyclical dynamics.

Additionally, Moran's I spatial autocorrelation statistics is applied to examine the existence of regional interdependence in the estimated cyclical sensitivities. This perspective makes it possible to investigate whether spatial patterns may be conditioning labour market responses to the business cycle. In doing so, the study addresses two central questions: (i) does unemployment sensitivity to GDP vary across business-cycle phases, and (ii) do spatial patterns exist that reflect regional synchronisation in labour-market responses? Answering these questions provides a more precise and context-sensitive understanding of Okun's Law, with relevant implications for macroeconomic policy design.

Accordingly, this research contributes along three complementary dimensions: (i) providing global evidence on the validity and heterogeneity of Okun's Law, (ii) assessing its robustness in the presence of the COVID-19 shock and alternative methodological choices, and (iii) examining whether cyclical sensitivities exhibit spatial clustering patterns.

The remainder of the paper is structured as follows. Section 2 reviews the related literature and motivates our research questions. Section 3 formalises the research hypotheses. Section 4 describes the empirical methodology. Section 5 presents the data and assesses the time-series properties required for consistent estimation. Section 6 reports and discusses the results, including robustness checks. Section 7 concludes and outlines the policy implications of our findings.

2. Literature Review

For decades, Okun's Law has been regarded as one of the most extensively tested empirical relationships in macroeconomics, positing that economic growth is systematically associated with reductions in unemployment. However, the apparent simplicity of this relationship has been increasingly qualified by a growing body of literature emphasising its sensitivity to structural, institutional, and geographical factors (Altig et al., 2020; Mavrodi et al., 2024; Sovbetov, 2025). In particular, the Okun coefficient has been shown to vary substantially across countries, with its magnitude conditioned by each economy's specific characteristics (Ball et al., 2019; Goto & Bürgi, 2021; Hamada & Kurosaka, 1984; Lee, 2000; Moosa, 1997; Peláez-Herreros, 2025)

Beyond cross-country heterogeneity, a substantial strand of the literature argues that the unemployment–output relationship does not unfold uniformly across business-cycle phases. Following Chamberlin (2011), the unemployment–output nexus may change depending on whether an economy is in an expansionary or recessionary state. This has motivated a deeper exploration of asymmetries in Okun's Law, examining whether unemployment responses to output growth differ according to the sign and intensity of cyclical fluctuations. Recent syntheses converge on the conclusion that Okun's Law tends to be stronger during recessions than expansions, with asymmetries mediated by labour-market rigidities and institutional frameworks (Butkus et al., 2024; Donayre, 2022; Sovbetov, 2025).

Silvapulle et al. (2004) document pronounced cyclical asymmetry for the United States, showing that unemployment reacts more sharply to GDP contractions than expansions. Mnasri et al. (2023), using an asymmetric quadratic error-correction model, identify both sign and magnitude asymmetries: recessionary shocks trigger stronger but short-lived increases in unemployment, whereas expansions produce more gradual yet persistent improvements. Complementary evidence comes from Pereira (2014), who finds that in metropolitan areas of Virginia the growth–unemployment linkage weakens during recoveries, limiting the effectiveness of local stimulus policies. Benos & Stavrakoudis (2022) reach similar conclusions for G7 economies, where the Okun relationship becomes clearly operative primarily during recessionary phases[1].

Within the European context, a generalised pattern of asymmetric responses has been documented across countries and regions. In Italy, Lanzafame (2010) shows that, at sufficiently high growth rates, unemployment may become procyclical, implying a threshold beyond which the traditional Okun relationship reverses. In Spain, Bande & Martín-Román (2018) and Cutanda (2023) find significant short- and long-run differences in the Okun relationship, revealing asymmetry between boom and recession phases that remains robust across filtering and estimation methods. At the Eurozone level, Zwick (2018) validates Okun's Law but finds lower sensitivity during recessions, signalling weak employment-recovery dynamics Mussida & Zanin (2023), covering nine European countries, show that including major shocks such as the Great Recession and the COVID-19 pandemic amplifies asymmetries.

Economies in Central and Eastern Europe also display marked asymmetries. Using Markov-switching models, Cevik et al. (2013), show that unemployment reacts more strongly to contractions in most transition economies. Mihajlović & Fedajev (2021) confirm this for South-Eastern Europe, highlighting that recessionary phases exert more intense labour-market effects and justifying the use of non-linear approaches such as the NARDL model Bod'a & Považanová (2021) find that Okun coefficients increase during recessions and that sensitivity is more pronounced for male unemployment. Comparable evidence emerges for Turkey, where Erdoğan Coşar & Arzu Yavuz (2021) show that men, youth, and highly educated workers are disproportionately affected by recessionary phases. Pitoňáková et al. (2025) corroborate this for Slovakia, concluding that negative

[1] Moreover, recent evidence highlights that asymmetry findings are also contingent upon empirical modelling strategies. Linear versus non-linear specifications, as well as filter selection, exert a crucial influence on coefficient estimates (Boďa & Považanová, 2023; Raifu, 2023; Widarjono, 2020).

output shocks generate stronger unemployment increases than the adjustments observed during expansions.

Studies from Latin America also support the asymmetric hypothesis. In Mexico, Loría (2022) uses a threshold regression model and finds that output contractions rapidly increase unemployment, whereas expansions fail to generate similar reductions. In Sub-Saharan Africa, N'guessan (2006) documents asymmetric industrial employment responses in Côte d'Ivoire, with recessions exerting more pronounced effects. For South Africa, Ngubane et al. (2024) observe stronger unemployment elasticity during contractions, reinforcing the need for institutional reforms that improve responsiveness during expansions. Asian economies show similar patterns, mediated by institutional rigidities. In South Korea, Woo (2023) reports that restrictions on dismissals have muted unemployment spikes during recessions but have also limited improvements during expansions, generating a more rigid and asymmetric labour-market structure.

A key element in recent literature concerns the empirical disruption caused by the COVID-19 pandemic. Several studies show that this episode altered the conventional unemployment–output relationship, either weakening it or temporarily modifying its dynamics. Evidence indicates that the magnitude of this structural break depends strongly on policy responses, particularly employment-retention schemes (Abdul Malik & Khan, 2025; García, 2024; Maza, 2026; Porras-Arena et al., 2024).

While the evidence reviewed thus far confirms the widespread existence of cyclical asymmetries, several authors emphasise that analysing these dynamics without incorporating the geographical dimension may produce biased or incomplete estimates (Duran, 2022). National and regional labour-market dynamics rarely operate in isolation: cross-border interactions—through trade, investment, or industrial similarity—can significantly influence domestic responses to output fluctuations. Villaverde & Maza (2021) highlight the relevance of indirect spatial effects or spillovers among geographically close regions. Duran (2022) shows that in Turkish regions, both the magnitude of the Okun coefficient and the presence of asymmetries are conditioned by spatial dependence, particularly during recessions. Additional evidence demonstrates that cross-border interactions generate indirect effects that shape unemployment–output dynamics, making regional policy coordination more relevant when spatial contagion is strong (Adeosun, 2025; Diop, 2018; Omoshoro-Jones & Bonga-Bonga, 2022).

Elhorst & Emili (2022) show that the level of growth required to achieve unemployment reduction may be substantially higher once indirect regional effects are considered. These findings indicate that sustained labour-market improvements require policy designs that consider not only internal structural characteristics but also reciprocal influences from neighbouring economies.

3. Hypotheses

Against this backdrop, the present research advances a broader analytical framework that transcends the traditional focus on the direct unemployment–output nexus, raising questions about how economic dynamics in a given country or region may be shaped by the performance of neighbouring economies, particularly across differentiated phases of the business cycle.

Accordingly, this study contributes to the empirical debate along three complementary dimensions. First, it evaluates the validity of Okun's Law and its potential asymmetry across business-cycle phases. Second, it examines whether the COVID-19 shock introduced structural breaks that amplified international heterogeneity in the coefficient. Third, it assesses the robustness of the results to alternative estimation and filtering strategies, incorporating spatial spillover effects in order to avoid incomplete inferences.

General:

- **Hypothesis 1:** Okun's Law holds in the majority of countries.
- **Hypothesis 2:** The COVID-19 pandemic generated significant changes in the magnitude of Okun's Law.
- **Hypothesis 3:** The Okun coefficient varies according to the estimation method employed.
- **Hypothesis 4:** There is substantial heterogeneity in the magnitude of the Okun coefficient when analysed by country income group.

Symmetry:

- **Hypothesis 5:** The unemployment–output relationship is asymmetric and depends on the phase of the business cycle.
- **Hypothesis 6:** The relationship is stronger during recessions than during expansions.

Spatial

- **Hypothesis 7:** Estimated cyclical sensitivities exhibit significant spatial dependence across countries.
- **Hypothesis 8:** Spatial dependence is stronger during recessionary phases.

4. Methodology

4.1. Baseline models

Our empirical strategy relies on two widely used specifications in the Okun's Law literature: (i) the gap model (Bande & Martín-Román, 2018) and (ii) the first-difference model (Belmonte & Polo, 2004; Cutanda, 2023; Okun, 1962; Porras-Arena & Martín-Román, 2023b) We begin with the gap specification, which relates deviations of unemployment from its natural level to the output gap, i.e., deviations of actual output from potential output. Formally:

$$(u_t - u_t^*) = \beta_0 + \beta_1(y_t - y_t^*) + \varepsilon_t \quad (1)$$

where u_t denotes the observed unemployment rate in period t, $y_t$the natural logarithm of real output, u_t^* the natural rate of unemployment, and y_t^* the natural logarithm of potential output. The left-hand side measures the unemployment gap, while the right-hand side captures the output gap. The coefficient β_1 is the Okun coefficient and, on theoretical grounds, it is expected to be negative ($\beta_1 < 0$), signalling that a positive output gap is associated with a reduction in the unemployment gap, thereby constituting the central criterion for testing **Hypothesis 1**. Finally, ε_t is the stochastic error term.

To evaluate potential changes around the pandemic episode, we replicate the estimation incorporating a COVID-19 control. Specifically, we add a dummy variable D_t that takes value 1 in 2020 and 0 otherwise:

$$(u_t - u_t^*) = \beta_0 + \beta_1(y_t - y_t^*) + \beta_2 D_t + \varepsilon_t \quad \textbf{(2)}$$

Under this specification, β_1 is interpreted as the cyclical sensitivity of unemployment to output once the 2020 shock is controlled for. Comparisons between equations (1) and (2) allow us to test **Hypothesis 2**; i.e., whether omitting the pandemic year biases the magnitude and/or the statistical significance of the Okun coefficient. Evidence supporting this hypothesis is identified if the inclusion of D_t generates relevant changes in the magnitude and/or statistical significance of the Okun coefficient.

A practical challenge of gap models is that u_t^* and y_t^* are unobserved. In this study, the time-series filter proposed by Hodrick & Prescott (1997) (HP) is employed, as suggested by Marinkov & Geldenhuys (2007) and Moosa (2008). We use the standard frequency-scaling rule to set the smoothing parameter at $\lambda = 100$, which is appropriate for yearly data[2]. From the filtered components we recover the unemployment and output gaps and estimate equations (1)–(2) by Ordinary Least Squares (OLS) with heteroskedasticity-robust standard errors White (1980). The comparison of (1) and (2) determines the baseline we use in the rest of the paper (i.e., whether to include the 2020 dummy or not), based on the stability and international comparability of the parameter β_1. The chosen specification serves as the benchmark for evaluating **Hypothesis 1** and **Hypothesis 2**.

4.2. First-difference model

As a robustness check, we complement the gap specification with the first-difference model, which relates changes in the unemployment rate to contemporaneous output growth. This approach mitigates potential biases arising from measurement errors in the construction of potential output and the natural unemployment rate. Formally, the specification is given by (3):

$$u_t - u_{t-1} = \gamma_0 + \gamma_1 g_{yt} + \gamma_2 D_t + \epsilon_t \quad \textbf{(3)}$$

where $\Delta u_t = u_t - u_{t-1}$ denotes the annual change in the unemployment rate, and g_{yt}represents the real output growth rate in period t. The coefficient γ_0 captures the average drift in unemployment when output growth is zero, while γ_1 measures the sensitivity of unemployment changes to output growth (i.e., the Okun coefficient in first differences) which is theoretically expected to be negative. The parameter γ_2 captures the exceptional impact of the COVID-19 shock on unemployment dynamics. Finally, $\epsilon_t$denotes a white-noise error term.

Equation (3) is estimated using OLS with heteroskedasticity-robust standard errors. This allows the model to provide a consistent benchmark for comparing the results

[2] Given that the standard value λ =1.600 was originally formulated for quarterly data, the scaling rule proposed by Backus & Kehoe (1992) is applied, multiplying this value by the square of the relative frequency of annual data with respect to quarterly data. This yields an adjusted value of λ =100.

of the gap specification (equations 1–2) with those from the first-difference approach. In particular, the systematic contrast between the estimated β_1 coefficients from the gap model and the $\gamma_1$coefficients from the first-difference model enables us to assess the methodological sensitivity of Okun's Law and to document the extent to which estimated cyclical sensitivities vary across countries. Thus, the systematic comparison of the β_1 coefficients obtained in equations (1)—(2) with the γ_1 coefficient from equation (3) provides an empirical basis for testing **Hypothesis 3** (coefficient variation across estimation methods) and **Hypothesis 4** (high heterogeneity by country income groups).

4.3. Model with cyclical asymmetry

To investigate whether the unemployment–output relationship differs across phases of the business cycle, we extend the baseline gap model by decomposing the output gap into its positive and negative components Cutanda (2023) [3]. Let $(y_t - y_t^*)^+$ denote the positive part of the output gap—i.e., $(y_t - y_t^*)^+ = \max\{y_t - y_t^*, 0\}$—capturing periods in which actual output exceeds its potential level (expansions). Conversely, let $(y_t - y_t^*)^-$ denote the negative part—i.e., $(y_t - y_t^*)^- = \min\{y_t - y_t^*, 0\}$—capturing downturns in which output falls below its long-run equilibrium[4]. The dummy variable D_t, equal to 1 for observations corresponding to the year 2020 and 0 otherwise, is included again. The resulting specification is:

$$(u_t - u_t^*) = \theta_0 + \beta^+(y_t - y_t^*)^+ + \beta^-(y_t - y_t^*)^- + \delta D_t + \mu_t \quad (4)$$

where β^+ and β^-measure the unemployment elasticity with respect to positive and negative output gaps, respectively. Both coefficients are theoretically expected to be negative, although their magnitudes may differ. A statistically significant difference between β^+ and β^-provides evidence of cyclical asymmetry, while a larger absolute value of β^-indicates stronger sensitivity during recessions than expansions.

Equation (4) is estimated using OLS with heteroskedasticity-robust standard errors. The decomposition of the output gap allows us to test **Hypothesis 5** (the presence of cyclical asymmetry) and **Hypothesis 6** (greater sensitivity during recessionary phases).

4.4. Spatial dependence analysis

After obtaining country-level Okun coefficients—both for the full cycle and separated by expansionary and recessionary phases—we assess whether these estimates exhibit spatial autocorrelation. Specifically, we compute Moran's I statistic (Moran, 1948) to test whether neighbouring countries display similar magnitudes of cyclical unemployment sensitivity.

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[3] A comparable extension aimed at deepening the analysis of labour supply dynamics across the business cycle can be found in Maridueña-Larrea & Martín-Román (2025)

[4] In practical terms, we use two indicator variables defined according to the sign of the deviation. Specifically, $D_t^+ = 1$ if $(y_t - y_t^*) > 0$ and 0 otherwise; conversely; $D_t^- = 1$ if $(y_t - y_t^*) < 0$ and 0 otherwise. Accordingly, $(y_t - y_t^*)^+ = (y_t - y_t^*) \times D_t^+$ and $(y_t - y_t^*)^- = (y_t - y_t^*) \times D_t^-$, such that each component coincides with the output gap exclusively within its corresponding phase and takes a value of zero in all remaining periods.

Let $X_i$denote the estimated effect for country i (either the overall Okun coefficient or its phase-specific counterpart), $\bar{X}$ its cross-sectional mean, and $SW_{i,j}$ a spatial-weights matrix encoding geographical proximity. Moran's I is defined as:

$$I_{Moran} = \frac{n}{S_0} \times \frac{\sum_{i,j}^{n} SW_{i,j}(X_i - \bar{X})(X_j - \bar{X})}{\sum_{i=1}^{n}(X_i - \bar{X})^2} \quad \textbf{(5)}$$

where n is the number of countries and S_0 is the sum of all weights. Positive and statistically significant values of I_{Moran} indicate spatial clustering—i.e., countries located near each other tend to display similar cyclical sensitivities—whereas values close to zero are consistent with spatial randomness[5].

We consider a set of k-nearest-neighbour weight matrices to probe robustness with respect to the spatial neighbourhood definition. In the baseline configuration, $SW_{i,j}$ is constructed using $k \in \{1,5,10\}$ nearest neighbours for each country; results are compared across these alternatives to ensure that inferences do not hinge on a particular value of k. The analysis is implemented for (i) the overall coefficient (full cycle), and separately for (ii) expansionary and (iii) recessionary phases, allowing us to test **Hypothesis 7** (presence of spatial dependence) and **Hypothesis 8** (stronger dependence in recessions).

5. Data

5.1. Series used

This study employs annual time-series data covering the period from 1991 to 2023, corresponding to the time span for which the World Bank provides consistent information for the selected countries. The estimation of the Okun coefficient—both at the global level and disaggregated across cyclical phases—is constructed using the indicators detailed in Table 1.

Table 1. Variables used to estimate Okun's Law

Indicator	Unit of measurement
GDP	Gross Domestic Product (GDP) at constant 2015 prices (transformed to natural logarithms for cycle extraction and used to compute annual growth rates).
UR	The unemployment rate (UR) refers to the proportion of the Economically Active Population (EAP) that is without employment but available for and actively seeking work.

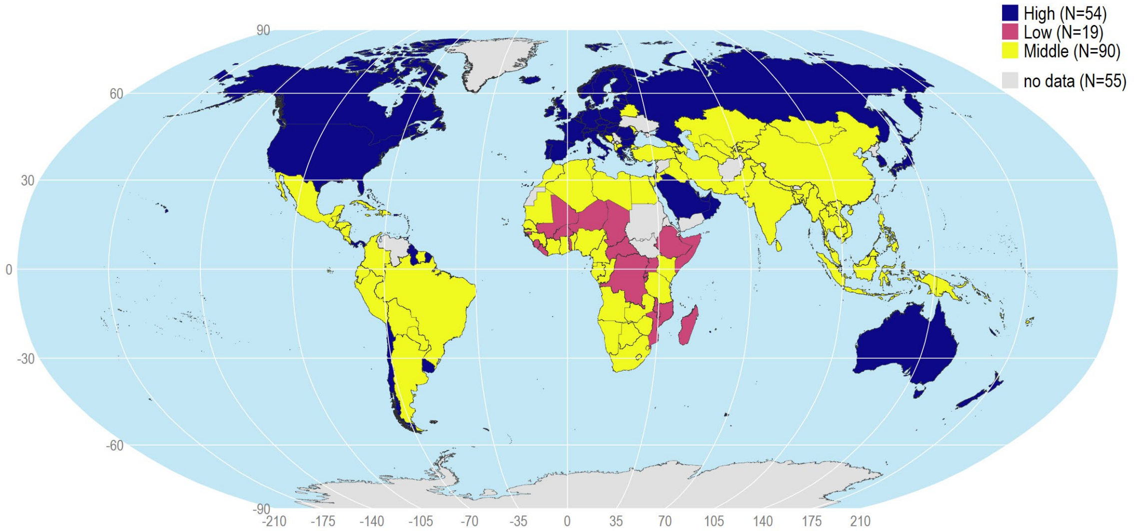
Source: World Bank.

To characterise the cross-sectional landscape at the end of the sample, we report two descriptive figures. Figure 1 shows a country classification by income group for 2023 based on the World Bank's GNI per-capita thresholds. Figure 2 presents the spatial distribution of unemployment rates in 2023. These visuals provide context for the heterogeneity analysed later—both in average cyclical sensitivities and in their dispersion

[5] For a methodologically comparable implementation Maridueña-Larrea & Martín-Román (2024).

across high-, middle-, and low-income country groups—without pre-empting the econometric results.

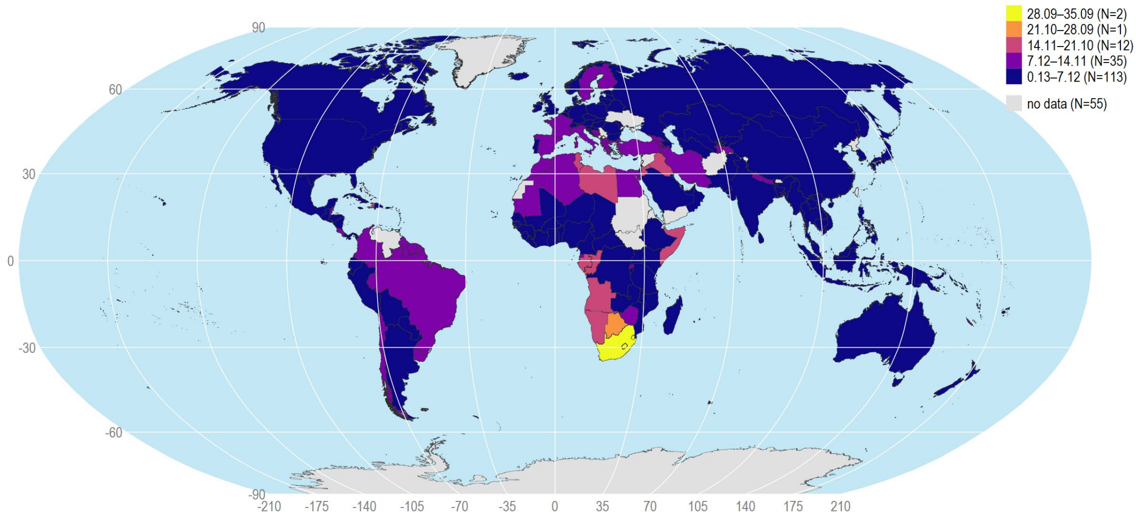
Figure 1. Classification of selected countries by income group (2023)



Source: World Bank. Author's own elaboration.

Notes: The World Bank classifies countries into four categories according to Gross National Income (GNI) per capita, adjusted using the Atlas methodology: high income (above USD 14,005), upper-middle income (between USD 4,516 and USD 14,005), lower-middle income (between USD 1,146 and USD 4,515), and low income (below USD 1,145). For the purposes of this analysis, upper-middle- and lower-middle-income countries are grouped under the category of middle-income economies. High = high income; Low = low income; Middle = middle income; No data = data not available.

Figure 2. Distribution of the unemployment rate (Selected economies; 2023)



Source: World Bank. Author's own elaboration.

Figure 1 (country income groups, 2023) reveals the expected global pattern: high-income economies concentrate in North America, Western Europe, parts of East Asia and Oceania, while middle-income countries dominate Latin America, Eastern Europe, North Africa, and large areas of South and Southeast Asia. Low-income economies remain primarily concentrated in Sub-Saharan Africa. This stratification motivates our income-group comparisons of cyclical sensitivities in later sections.

Figure 2 illustrates the spatial distribution of unemployment rates for the same year (2023), highlighting six intervals. The largest group, comprising countries with the lowest unemployment rates (between 0.13% and 7.12%), is predominantly located in Eastern Europe, Asia, and Oceania. By contrast, the highest unemployment rates (between 21.10% and 35.09%) are concentrated in only three Sub-Saharan African economies: Botswana (23.38%), South Africa (32.20%), and Eswatini (35.09%).

All subsequent transformations (HP filtering for gap variables and first differences for growth rates), along with the testing of time-series properties, are detailed in the following subsections to ensure methodological transparency and international comparability.

5.2. Properties of the series

Prior to model estimation, the integration properties of the series involved were examined in order to avoid spurious results and ensure the statistical validity of the inferences. Given that both the gap model (equation 1) and the first-difference model (equation 2) require stationary series, unit root tests were conducted using the Augmented Dickey–Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) procedures.

For the gap model, cyclical residuals obtained from the series through the HP filter were employed, applying a smoothing parameter adjusted to λ =100. The resulting GDP gap PIB $(y_t - y_t^*)$ and unemployment gap $(u_t - u_t^*)$ were subjected to unit root testing, with stationarity confirmed in both cases. In the first-difference specification, it was likewise verified that the annual change in the unemployment rate $(u_t - u_{t-1})$ and the output growth rate (g_{yt}) are stationary in their transformed form.

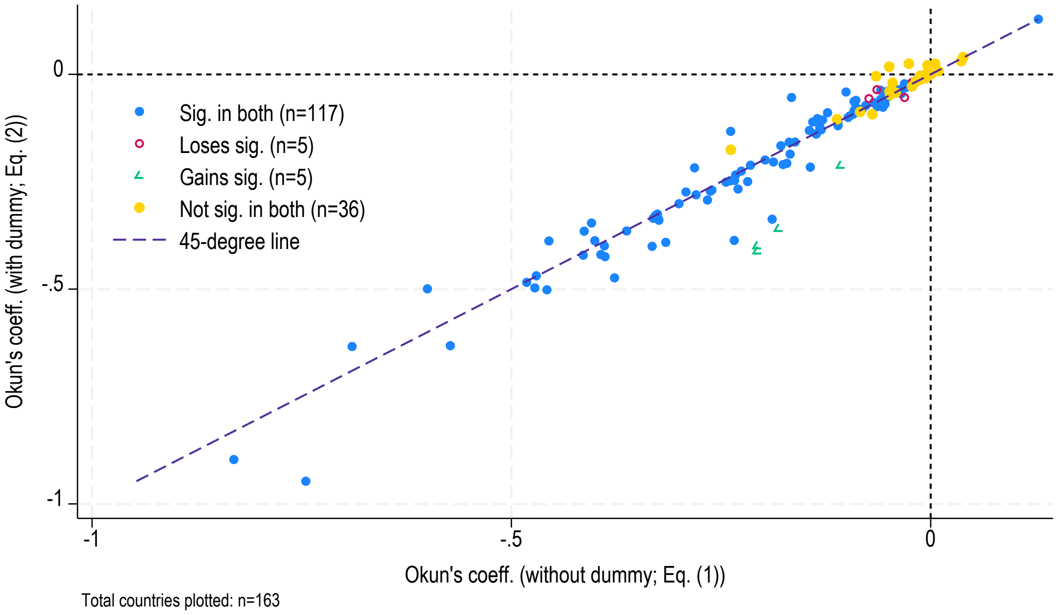
The detailed results of these tests are reported in Appendix A (Table A1), where the test statistics and corresponding significance levels for each variable analysed are presented. This methodological verification ensures that the estimated models are grounded on appropriately transformed series, thereby supporting the robustness and reliability of the empirical findings.

6. Results

6.1. Baseline model

Figure 3 compares the Okun coefficients obtained from the gap model in equation (1) with those from the specification that includes the 2020 dummy in equation (2). The distribution of points around the 45-degree line shows a strong overall alignment in the sign of the coefficient ($\beta < 0$), indicating that controlling for the pandemic year does not materially alter the core relationship. In practice, 116 countries display the expected negative and statistically significant coefficient in both specifications, 36 are non-significant in both, and only 10 experience transitions: 5 gain and 5 lose significance after incorporating the dummy. This pattern supports **Hypothesis 1**, as the unemployment–output relationship is statistically significant and correctly signed in 74% of the sample.

Figure 3. Okun's coefficient: gap model with and without the COVID-19 dummy



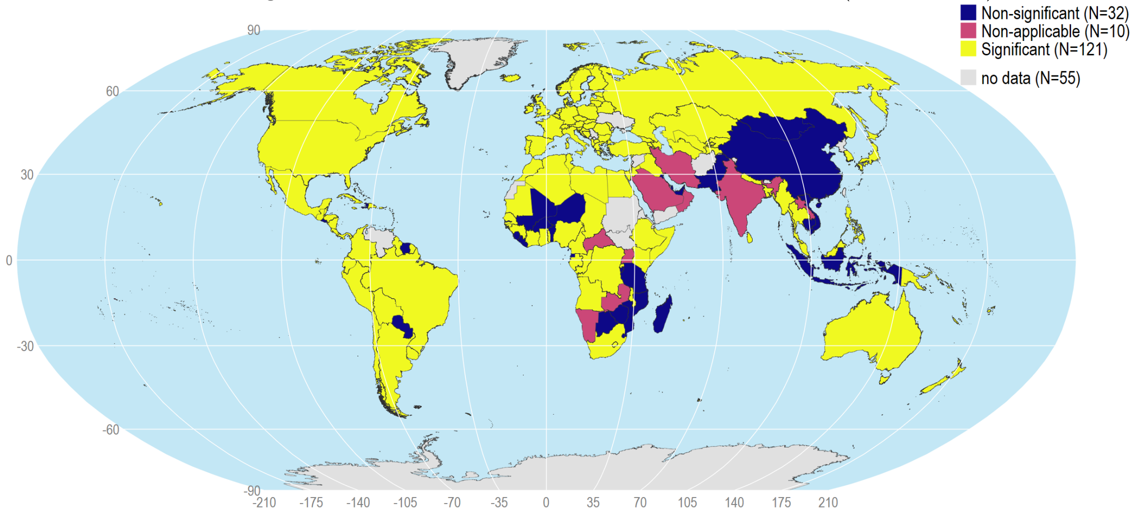
Although sign and significance are broadly stable across specifications, the magnitude of the Okun coefficient varies. The median absolute change is small (around 0.01), and about 60% of countries show very minor adjustments (below 0.01), indicating robustness for a large share of the sample. Yet a non-negligible subset exhibits larger shifts: roughly 15% record variations greater than 0.05, which justifies comparing the two equations as a sensitivity check to the 2020 shock. This supports **Hypothesis 2**: while effects are heterogeneous, adding the 2020 dummy induces quantitatively relevant changes—and in some cases alters significance—implying that failure to control for COVID-19 can bias the estimated magnitude. Notable shifts include Italy (from −0.21 to −0.41), France (from −0.21 to −0.40), Belgium (from −0.18 to −0.36), and South Africa (from −0.11 to −0.21), which gain significance with the dummy. Among countries significant in both specifications, magnitudes become more negative in Spain (from −0.75 to −0.95), the United Kingdom (from −0.23 to −0.39), and the Bahamas (from −0.19 to −0.34).

A closer inspection of Figure 3 adds nuance. Countries below the 45-degree line are those where the Okun coefficient becomes more negative once the dummy is introduced (i.e., larger in absolute value), whereas observations above the diagonal indicate an attenuation of the coefficient after controlling for 2020. The pattern is fairly balanced: 63 countries display a more negative coefficient with the dummy, compared with 58 showing a less negative one. This reinforces the view that controlling for COVID-19 yields heterogeneous, rather than uniform, adjustments across countries.

Therefore, although the statistical significance of the Okun coefficient is largely unchanged for most countries, introducing a 2020 dummy both captures a common, exceptional shock and reveals meaningful cross-country variation in coefficient magnitudes. To enhance international comparability and avoid attributing COVID-19-related fluctuations to regular cyclical dynamics, all subsequent analyses are conducted **including** the 2020 control.

Under this specification, Model 2 results are mapped in Figure 4. Broadly, the inverse unemployment–output relationship holds for 121 countries, indicating that Okun's Law is widespread once the pandemic episode is isolated. At the same time, 32 countries display non-significant coefficients, suggesting a weak or poorly defined response of unemployment to cyclical output fluctuations. In 10 cases the coefficient either lacks the expected sign or statistical significance; these observations are therefore treated as non-informative for supporting the hypothesised negative relationship.

Figure 4. Okun Coefficient cyclical estimation (equation 2)



Source: World Bank. Author's own elaboration.

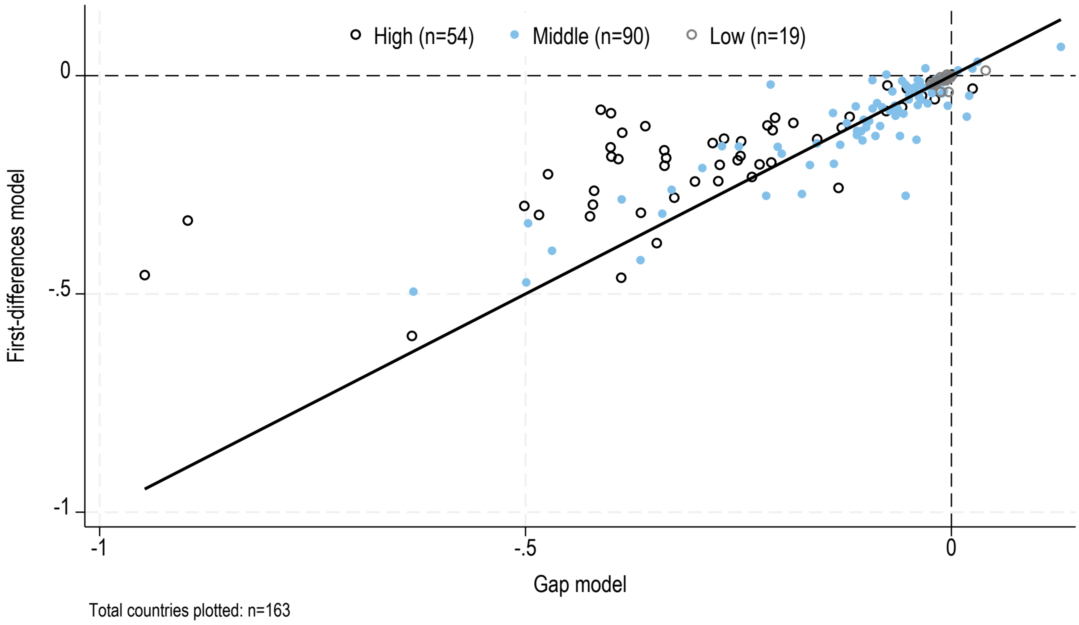
Notes: Non-significant= negative coefficient that is not statistically significant, Non-applicable= positive coefficient, Significant= negative and statistically significant, no data= data no available.

To further assess robustness, Figure 5 compares Okun coefficients from the gap model (X-axis; equation (2)) with those from the first-difference model (Y-axis; equation (3)), classifying observations by income group[6]. The 45-degree line serves as a benchmark for equality across methods. Most points lie above the diagonal, indicating that the gap specification typically yields larger magnitudes in absolute value than the first-difference approach. This suggests that isolating structural cyclical components in the gap model captures stronger unemployment sensitivity to output fluctuations. These methodological differences support **Hypothesis 3**, insofar as the estimated coefficient depends on the specification employed.

Additionally, high-income economies cluster at higher absolute Okun coefficients—especially under the gap model—indicating a more elastic labour-market response to cyclical conditions (e.g., Spain at −0.95, Poland at −0.90, United States at −0.63). Middle-income countries display lower magnitudes on average but substantial dispersion, with cases such as Albania (−0.63), Costa Rica (−0.50), and Algeria (−0.50) exceeding the group mean (−0.13). Low-income economies, by contrast, exhibit coefficients close to zero (around −0.01 on average), suggesting a muted unemployment response to output fluctuations. This stratification is consistent with **Hypothesis 4**, indicating systematic differences across income groups.

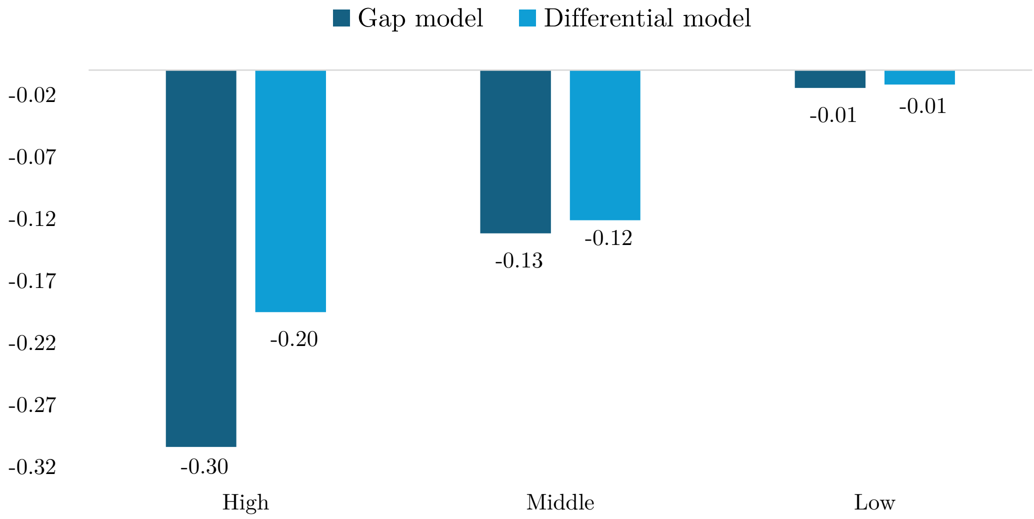
[6] The estimations can be found in Appendix B, Table B1.

Figure 5. Okun coefficients by country income group



In sum, Okun's Law holds for most countries, but the magnitude of the coefficient varies widely. This heterogeneity aligns closely with income groups: as summarised in Figure 6, high-income economies exhibit substantially larger average coefficients in absolute terms (e.g., about −0.30 in the gap model), middle-income countries display roughly half that sensitivity (around −0.13), and low-income countries show values near zero. Building on this foundation, Figures 5 and 6 enable a more granular characterisation of (i) cross-group heterogeneity in magnitudes and (ii) methodological sensitivity to the specification employed.

Figure 6. Average Okun coefficient by country income group.



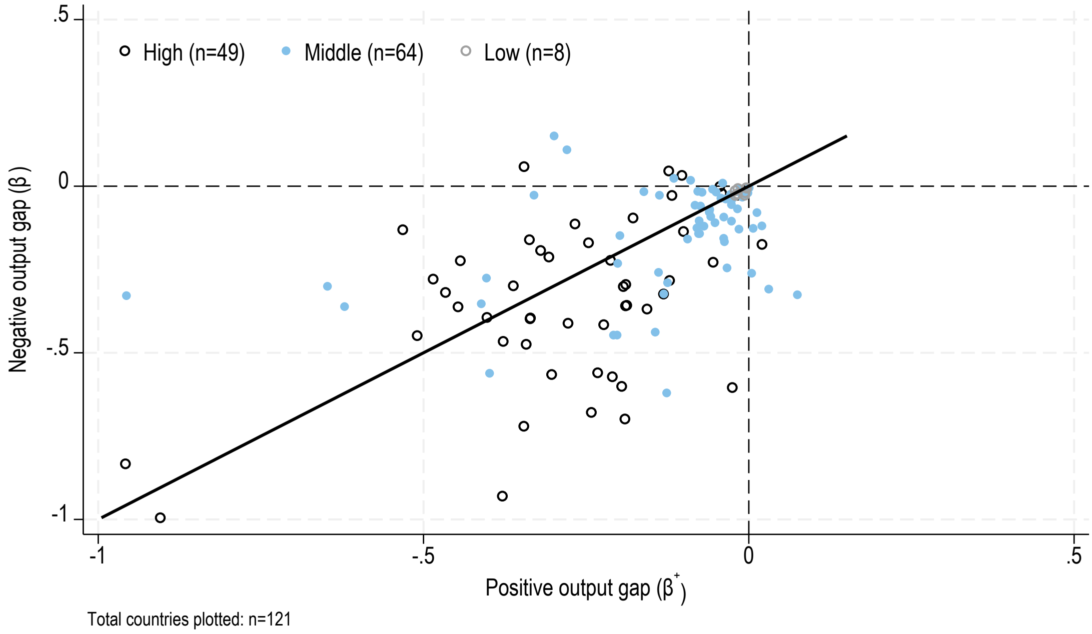
6.2. Cyclical Asymmetries

Figure 7 summarises the results from equation (4), which allows for potential asymmetries in the unemployment–output relationship by distinguishing between periods of economic expansion and contraction[7]. This distinction is implemented by decomposing the output gap $(y_t - y_t^*)$ into its positive and negative components, enabling the estimation of a coefficient β^+ for periods of positive gaps (output above potential) and a coefficient $\beta^-$for negative gaps (output below long-run equilibrium).

The results indicate that most observations lie below the 45-degree line, showing that the absolute value of β^-typically exceeds that of β^+. Thus, unemployment responds more strongly to output contractions than to expansions, consistent with the presence of cyclical asymmetry and with a steeper adjustment of unemployment during downturns. This pattern aligns with **Hypotheses 5 and 6**, confirming that cyclical unemployment sensitivity is generally more pronounced in recessionary phases.

The figure also shows that this asymmetry appears across all income groups, though it is more pronounced among middle- and high-income economies. Several advanced countries display particularly steep recessionary sensitivities, including Spain (−1.00), the United States (−0.93), and Greece (−0.72). By contrast, low-income economies tend to cluster around much smaller values for both coefficients, reflecting weaker cyclical unemployment responses and the more limited depth of their formal labour markets.

Figure 7. Okun coefficient classified by cyclical state of the economies



Complementary evidence in Table 2 details statistical significance by cyclical phase. Among the 121 countries with a negative and significant Okun coefficient, 44 economies (36%) exhibit significance in both expansionary (β^+) and recessionary (β^-) regimes, predominantly high-income (24 cases) and middle-income (18), with only two low-income countries (Guinea-Bissau and Somalia).

Second, 36 countries (30%) exhibit a statistically significant Okun coefficient only during expansionary phases (β^+). This pattern indicates that, in these economies, higher

[7] Model estimates for all countries included in the analysis can be found in Appendix B, Table B1.

output is associated with a significant reduction in unemployment, but without a statistically clear response during recessions. Middle-income economies dominate this group (20 cases), followed by high-income countries (16). No low-income country is observed in this category.

In turn, 31 economies (26%) display a significant inverse effect exclusively during recessionary phases (β^-). This implies that unemployment reacts strongly to output contractions but does not necessarily improve during expansions. This group includes 19 middle-income countries, 8 high-income economies, and 4 low-income countries. Finally, 10 countries (8%) do not exhibit a statistically significant Okun coefficient in either phase of the cycle. This group comprises 7 middle-income economies and 3 low-income countries.

Table 2. Statistical significance of cyclical unemployment responses (Country classification by income group: negative and statistically significant Okun coefficient)

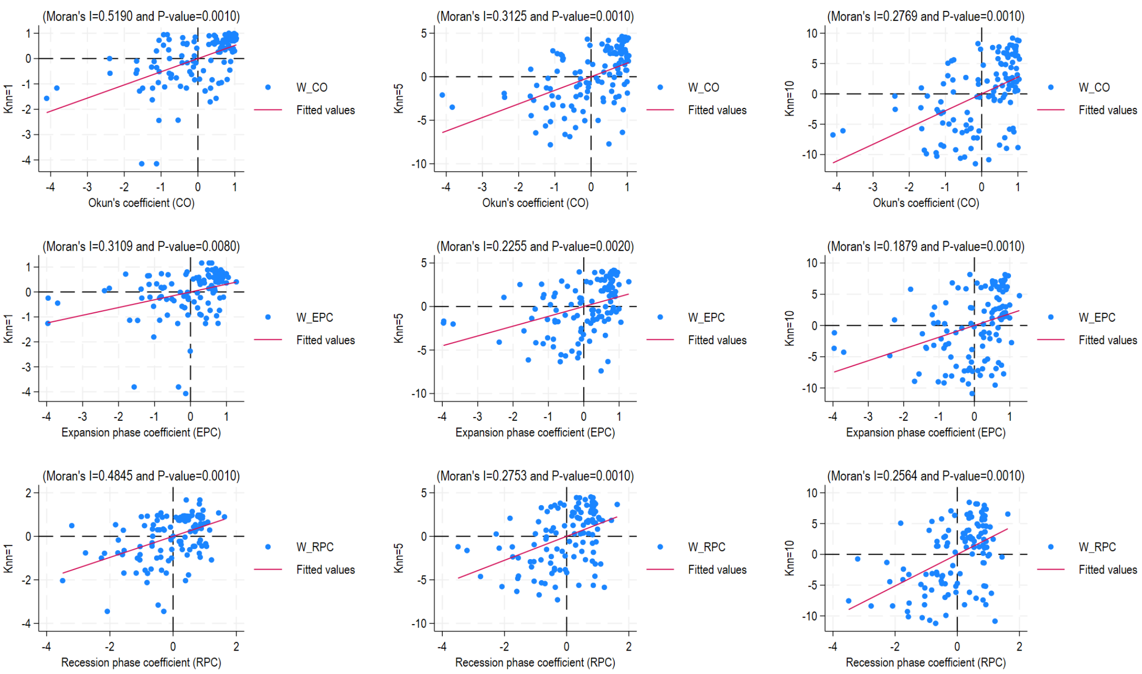
Income group	Significant across the cyclical phases	Total
High	**Significant and inverse effect in both cyclical phases (β^+, β^-)**	
	Bahrain, Russian Federation, Slovenia, Estonia, Chile; Netherlands, Iceland, Latvia, Republic of Korea, United Kingdom, Japan, Lithuania, Denmark, Czech Republic, Switzerland, New Zealand, Cyprus, Greece, United States, Slovak Republic, Canada, Finland, Spain, Poland	24
	Significant and inverse effect only in positive gaps (β^+)	
	Malta, Guyana, Romania, Luxembourg, Trinidad and Tobago, Panama, Austria, Barbados, Belgium, Germany, Norway, Bahamas, Bulgaria, Italy, France, Australia	16
	Significant and inverse effect only in negative gaps (β^-)	
	Singapore, Brunei Darussalam, Uruguay, Ireland, Sweden, Israel, Hungary, Portugal	8
	Non-significant effect in both cyclical phases	
	Croatia	1
Middle	**Significant and inverse effect in both cyclical phases (β^+, β^-)**	
	Fiji, Libya, Mauritania, Thailand, Côte d'Ivoire, Ecuador, Mauritius, Morocco, Malaysia, Saint Vincent and the Grenadines, Nicaragua, Mexico, Kazakhstan, Belarus, Arab Republic of Egypt, St Lucia, Brazil, Costa Rica	18
	Significant and inverse effect only in positive gaps (β^+)	
	Comoros, Georgia, Azerbaijan, Bosnia and Herzegovina, Philippines, Republic of Moldova, Cameroon, Myanmar, Guinea, Cuba, Nepal, Dominican Republic, Uzbekistan, South Africa, North Macedonia, Jamaica, Ghana, Honduras, Algeria, Albania	20
	Significant and inverse effect only in negative gaps (β^-)	
	Kyrgyzstan, Papua New Guinea, Iraq, Solomon Islands, Angola, Tajikistan, Republic of the Congo, Kenya, Turkmenistan, Vanuatu, Gabon, Lesotho, Guatemala, Türkiye, Jordan, Belize, Bangladesh, Tunisia, Colombia	19
	Non-significant effect in both cyclical phases	
	Peru, Bolivia, Nigeria, Armenia, Sri Lanka, Senegal, Argentina	7
Low	**Significant and inverse effect in both cyclical phases (β^+, β^-)**	
	Guinea-Bissau, Somalia.	2

Income group	Significant across the cyclical phases	Total
	Significant and inverse effect only in positive gaps (β^{+})	0
	-	
	Significant and inverse effect only in negative gaps (β^{-})	4
	Chad, Democratic Republic of the Congo, Togo, Malawi	
	Non-significant effect in both cyclical phases	2
	Rwanda; Ethiopia	
	Grand total	**121**

6.3. Spatial dependence

To test for spatial dependence in cyclical unemployment sensitivities, we compute Moran's I for the country-specific Okun coefficients. The variable of interest includes the overall coefficient (CO), and the phase-specific coefficients for expansions (EPC) and recessions (RPC). Three alternative geographical neighbourhood structures were modelled using k-nearest-neighbour weight matrices with $k = 1, 5, 10$.

Figure 8. Spatial dependence analysis



The results in Figure 8 show positive and statistically significant spatial autocorrelation across all three spatial configurations. For the overall coefficient (CO), Moran's I remains significant, ranging from 0.2769 to 0.5190, indicating that geographically proximate countries tend to exhibit similar cyclical unemployment sensitivities. This confirms **Hypothesis 7**, as the unemployment–output relationship displays clear spatial clustering at the global scale.

This pattern persists when phases are analysed separately. Recessionary phases (RPC) exhibit the highest spatial autocorrelation ($I = 0.4845$ with one neighbour, $I =$

0.2753 with five, and $I = 0.2564$ with ten) suggesting that adverse shocks to output are spatially synchronised, with neighbouring countries showing similarly strong unemployment responses to negative gaps. In short, reactions to recessions are not independent but regionally clustered. The systematically larger I in RPC relative to EPC supports **Hypothesis 8**, indicating that spatial interdependence intensifies during contractions.

For expansionary phases (EPC), Moran's I is lower but remains statistically significant across neighbourhood definitions (from 0.1879 to 0.3109). Thus, nearby countries also share similar employment improvements during booms. The comparatively weaker autocorrelation likely reflects greater institutional and structural heterogeneity in how economies translate growth into job creation, relative to the more uniform propagation observed in recessions.

Overall, the evidence supports **Hypotheses 7 and 8**: cyclical unemployment sensitivities exhibit significant spatial dependence—for the full cycle and by phase—with a stronger clustering during recessions. These results underscore the need to explicitly model the spatial dimension when analysing Okun's Law; otherwise, estimates risk being biased or misspecified in contexts of pronounced regional interdependence.

7. Conclusions and policy implications

This study examined the validity and heterogeneity of Okun's Law from a global and comparative perspective, jointly incorporating three dimensions rarely explored together: 1) the persistence and cross-country variability of the coefficient, 2) its sensitivity to adverse shocks and methodological choices, and 3) the potential spatial dependence of these sensitivities. Using several complementary methods on a large—and, to our knowledge, unprecedented—sample of 163 countries from 1992 to 2023, the analysis provides a systematic assessment of robustness and yields relevant insights for designing public policies aimed at strengthening labor markets worldwide.

The empirical strategy confirmed **Hypothesis 1**, as the inverse relationship between unemployment and economic activity holds in most countries. Regarding **Hypothesis 2**, the results show that controlling for adverse shocks such as COVID-19 generally does not affect the statistical significance of the coefficient, though it does alter its magnitude for a subset of economies. The comparison between the gap model and the first-difference model supports **Hypothesis 3**, revealing clear variations in the coefficient across specifications. Finally, **Hypothesis 4** is validated by the substantial dispersion of the coefficient across income groups: high-income economies display larger sensitivities in absolute terms, while low-income countries tend to cluster around values near zero.

Regarding business cycle phases, the results support **Hypothesis 5**, showing that unemployment responses vary with the cyclical state of the economy, and they confirm **Hypothesis 6** by indicating that unemployment sensitivity is, on average, greater during recessions than expansions. This pattern aligns with the idea that labor markets adjust more quickly and sharply during contractions, while employment recovers more gradually in expansionary periods—a distinction essential for interpreting labor market dynamics beyond average effects.

The spatial analysis supports **Hypothesis 7**, identifying positive and statistically significant spatial autocorrelation in the estimated Okun sensitivities, indicating that they are not randomly distributed but instead cluster among neighboring countries. The evidence also supports **Hypothesis 8**, as spatial dependence is stronger during recessions than expansions, consistent with greater regional synchronization in the transmission—or co-occurrence—of contractionary employment shocks.

From a policy perspective, the findings suggest three main implications. First, the heterogeneity observed across income groups and methodological specifications discourages the adoption of "universal" policy rules based on a single average coefficient, reinforcing the need for country-group-specific diagnostics and calibrations. Second, the evidence of cyclical asymmetry indicates that employment-oriented stabilisation strategies should be designed recognising that labour market costs during recessions tend to be disproportionately larger than employment gains during expansions; consequently, the prevention and mitigation of recessionary episodes become central for policymakers. Third, the presence of spatial dependence suggests that national policy frameworks may benefit from regional coordination mechanisms, particularly in contractionary contexts where spatial synchronisation appears to intensify.

This study contributes to the literature by providing global and comparable evidence that integrates methodological robustness, income-level heterogeneity, cyclical asymmetries, and spatial structure into the analysis of Okun's Law. Future research could further investigate the mechanisms driving spatial dependence and explore how labor market institutions and productive structures jointly shape the magnitude, asymmetry, and spatial distribution of the coefficient.

Appendix A

Table A1. Unit root test

Country	Equation (1)						Equation (2)					
	$u_t - u_t^*$			$y_t - y_t^*$			$u_t - u_{t-1}$			g_{yt}		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
Albania (ALB)	4.91***	4.67***	0.13	-4.41***	-4.36***	0.12	-11.16***	-9.31***	0.15	-3.30***	-3.44***	0.28
Germany (DEU)	-2.64**	-2.85***	0.07	-4.32***	-4.21***	0.05	-3.19***	-3.07***	0.34	-4.61***	-4.62***	0.11
Angola (AGO)	-2.49**	-2.60**	0.06	-3.86***	-4.12***	0.18	-3.48***	-3.38***	0.21	-2.74***	-2.66***	0.18
Saudi Arabia (SAU)	-2.65**	-2.62**	0.05	-3.52***	-3.47***	0.07	-4.23***	-4.22***	0.11	-3.05***	-3.00***	0.14
Algeria (DZA)	-2.88***	-2.94***	0.13	-3.39***	-3.56***	0.1	-4.33***	-4.31***	0.15	-2.10**	-1.93*	0.14
Argentina (ARG)	-3.26***	-3.34***	0.08	-2.81***	-2.91***	0.06	-4.24***	-4.19***	0.21	-4.27***	-4.23***	0.17
Armenia (ARM)	-2.94***	-3.09***	0.05	-2.25**	-2.22**	0.26	-4.17***	-4.16***	0.31	-4.98***	-4.74***	0.19
Australia (AUS)	-3.65***	-3.42***	0.12	-3.43***	-3.21***	0.15	-4.79***	-4.78***	0.13	-0.84	-0.51	0.40
Austria (AUT)	-4.43***	-4.35***	0.04	-4.47***	-4.37***	0.07	-7.02***	-7.41***	0.11	-3.81***	-3.79***	0.3
Azerbaijan (AZE)	-3.11***	-3.28***	0.12	-2.46**	-2.90***	0.17	-3.12***	-2.99***	0.33	-2.01**	-2.10**	0.19
Bahamas (BHS)	-3.51***	-3.49***	0.06	-4.17***	-3.96***	0.09	-6.32***	-6.29***	0.09	-5.40***	-5.40***	0.12
Bahrain (BHR)	-3.68***	-3.37***	0.05	-3.44***	-3.49***	0.07	-5.59***	-5.67***	0.07	-2.41**	-2.19**	0.34
Bangladesh (BGD)	-4.27***	-4.09***	0.07	-3.48***	-3.45***	0.07	-5.84***	-6.11***	0.17	-0.54	-0.28*	0.65
Barbados (BRB)	-2.70***	-2.77***	0.07	-3.20***	-2.96***	0.08	-3.44***	-3.43***	0.21	-4.51***	-4.46***	0.09
Belarus (BLR)	-3.20***	-3.41***	0.1	-2.71***	-3.02***	0.16	-3.73***	-3.65***	0.21	-2.36**	-2.28**	0.17
Belize (BLZ)	-2.90***	-2.96***	0.05	-3.30***	-3.29***	0.06	-4.16***	-4.09***	0.08	-4.36***	-4.40***	0.23
Benin (BEN)	-3.26***	-3.22***	0.06	-3.22***	-3.06***	0.09	-5.37***	-5.38***	0.12	-0.92	-0.36	0.29
Bolivia (BOL)	-4.20***	-3.99***	0.05	-2.91***	-2.97***	0.07	-6.65***	-7.11***	0.07	-2.33**	-2.12**	0.11
Bosnia and Herzegovina (BIH)	-2.72***	-2.80***	0.05	-2.16**	-2.46**	0.08	-3.09***	-2.99***	0.57**	-2.11**	-2.27**	0.29
Botswana (BWA)	-2.76***	-2.98***	0.08	-4.95***	-4.92***	0.05	-3.43***	-3.32***	0.1	-4.71***	-4.82***	0.1
Brazil (BRA)	-2.06**	-2.29**	0.06	-2.50**	-2.70***	0.07	-3.85***	-3.76***	0.12	-2.79***	-2.74***	0.22
Brunei Darussalam (BRN)	-3.18***	-3.30***	0.05	-3.53***	-3.51***	0.08	-6.25***	-6.21***	0.17	-5.71***	-5.72***	0.12
Bulgaria (BGR)	-2.30**	-2.62**	0.05	-2.81***	-2.92***	0.07	-3.99***	-4.00***	0.1	-4.82***	-4.95***	0.22
Burkina Faso (BFA)	-3.51***	-3.34***	0.05	-3.34***	-3.36***	0.12	-4.01***	-3.88***	0.2	-1.51	-1.22	0.12
Burundi (BDI)	-2.45**	-2.63**	0.06	-3.00***	-3.09***	0.09	-3.33***	-3.27***	0.12	-2.82***	-2.82***	0.36*
Belgium (BEL)	-3.30***	-3.43***	0.06	-4.68***	-4.63***	0.1	-4.49***	-4.41***	0.14	-3.77***	-3.85***	0.15
Cape Verde (CPV)	-3.57***	-3.45***	0.06	-3.91***	-3.72***	0.06	-5.81***	-5.95***	0.06	-2.88***	-2.72***	0.58**
Cambodia (KHM)	-4.27***	-4.26***	0.05	-4.13***	-4.13***	0.09	-7.62***	-7.72***	0.12	-3.72***	-3.83***	0.18
Cameroon (CMR)	-1.95*	-2.45**	0.07	-3.30***	-3.73***	0.15	-2.15**	-2.24**	0.22	-1.6	-1.44	0.24
Canada (CAN)	-4.29***	-4.12***	0.07	-3.89***	-3.78***	0.08	-5.80***	-6.05***	0.08	-2.85***	-2.74***	0.35
Chad (TCD)	-3.96***	-3.67***	0.05	-3.28***	-3.45***	0.09	-5.73***	-5.94***	0.07	-3.39***	-3.47***	0.17
Chile (CHL)	-4.25***	-4.24***	0.07	-3.69***	-3.67***	0.08	-6.86***	-6.86***	0.12	-3.14***	-3.07***	0.59**
China (CHN)	-3.81***	-3.80***	0.05	-1.80*	-2.26**	0.09	-5.22***	-5.28***	0.33	-1.43	-1.64*	0.60**
Cyprus (CYP)	-1.94*	-2.40**	0.06	-2.32**	-2.51**	0.07	-2.89***	-2.94***	0.11	-3.08***	-3.05***	0.16
Colombia (COL)	-2.88***	-2.91***	0.06	-3.08***	-3.18***	0.07	-4.56***	-4.49***	0.09	-3.06***	-2.99***	0.07
Comoros (COM)	-3.88***	-3.64***	0.06	-3.79***	-3.77***	0.05	-5.56***	-5.81***	0.07	-3.76***	-3.86***	0.06

Country	Equation (1)						Equation (2)					
	$u_t - u_t^*$			$y_t - y_t^*$			$u_t - u_{t-1}$			g_{yt}		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
Democratic Republic of the Congo (COD)	-2.94***	-2.84***	0.07	-2.75***	-3.01***	0.14	-4.39***	-4.32***	0.12	-1.68*	-1.63*	0.69**
Republic of the Congo (COG)	-3.67***	-3.35***	0.06	-2.97***	-3.02***	0.08	-5.57***	-5.72***	0.08	-4.04***	-4.10***	0.19
Republic of Korea (KOR)	-3.42***	-3.30***	0.05	-4.83***	-4.84***	0.06	-4.97***	-4.96***	0.09	-2.46**	-2.23**	0.72**
Costa Rica (CRI)	-2.89***	-2.73***	0.04	-3.81***	-3.64***	0.08	-4.13***	-4.01***	0.06	-2.38**	-2.21**	0.35*
Croatia (HRV)	-1.74*	-2.41**	0.05	-2.73***	-2.77***	0.13	-2.24**	-2.52**	0.13	-3.99***	-4.03***	0.1
Cuba (CUB)	-2.04**	-2.40**	0.09	-3.33***	-3.58***	0.22	-2.55**	-2.62**	0.2	-3.07***	-3.03***	0.18
Côte d'Ivoire (CIV)	-2.73***	-2.94***	0.07	-2.23**	-2.46**	0.07	-4.14***	-4.18***	0.09	-2.21**	-2.08**	0.32
Denmark (DNK)	-3.16***	-3.19***	0.06	-3.29***	-3.27***	0.08	-4.83***	-4.83***	0.13	-3.36***	-3.39***	0.15
Ecuador (ECU)	-4.10***	-3.87***	0.06	-3.36***	-3.29***	0.07	-5.79***	-6.27***	0.07	-3.42***	-3.39***	0.11
Arab Republic of Egypt (EGY)	-2.52**	-2.87***	0.05	-2.09**	-2.63**	0.05	-4.33***	-4.41***	0.11	-0.94	-0.86	0.07
El Salvador (SLV)	-4.84***	-4.84***	0.06	-4.83***	-4.79***	0.13	-7.49***	-7.83***	0.11	-4.39***	-4.41***	0.2
United Arab Emirates (ARE)	-3.83***	-3.81***	0.06	-3.05***	-3.12***	0.05	-6.82***	-6.86***	0.12	-2.71***	-2.62**	0.22
Slovenia (SVN)	-2.17**	-2.47**	0.06	-2.72***	-2.79***	0.08	-3.25***	-3.23***	0.12	-3.44***	-3.57***	0.1
Spain (ESP)	-2.01**	-2.46**	0.08	-3.02***	-3.07***	0.08	-2.79***	-2.77***	0.09	-3.68***	-3.70***	0.16
United States (USA)	-3.23***	-3.22***	0.05	-3.17***	-3.19***	0.07	-5.19***	-5.18***	0.08	-2.25**	-2.02**	0.29
Estonia (EST)	-2.89***	-2.95***	0.05	-2.39**	-2.50**	0.15	-4.12***	-3.98***	0.19	-4.05***	-4.07***	0.11
Eswatini (SWZ)	-1.83*	-2.24**	0.07	-3.63***	-3.63***	0.06	-2.60**	-2.69***	0.15	-2.20**	-1.94*	0.23
Ethiopia (ETH)	-3.08***	-3.02***	0.07	-3.34***	-3.43***	0.09	-4.41***	-4.36***	0.19	-2.10**	-2.02**	0.36*
Russian Federation (RUS)	-2.65**	-2.77***	0.06	-2.57**	-2.77***	0.17	-3.55***	-3.49***	0.24	-3.45***	-3.40***	0.25
Fiji (FJI)	-3.20***	-3.15***	0.05	-3.29***	-3.12***	0.05	-5.18***	-5.17***	0.06	-4.09***	-3.95***	0.06
Philippines (PHL)	-4.01***	-3.88***	0.05	-3.49***	-3.43***	0.06	-5.67***	-5.77***	0.18	-2.29**	-2.09**	0.2
Finland (FIN)	-2.81***	-3.12***	0.19	-2.99***	-2.99***	0.12	-4.56***	-4.87***	0.17	-3.14***	-3.17***	0.31
France (FRA)	-2.71***	-2.92***	0.1	-4.80***	-4.76***	0.09	-4.32***	-4.30***	0.14	-4.60***	-4.70***	0.25
Gabon (GAB)	-2.44**	-2.66***	0.05	-2.78***	-2.91***	0.06	-3.99***	-4.01***	0.08	-3.68***	-3.80***	0.11
The Gambia (GMB)	-1.65*	-2.21**	0.06	-3.81***	-3.74***	0.06	-2.59**	-2.55**	0.12	-3.48***	-3.50***	0.12
Georgia (GEO)	-2.85***	-2.90***	0.06	-2.44**	-2.72***	0.31	-5.18***	-5.20***	0.40*	-4.93***	-4.64***	0.34
Ghana (GHA)	-2.79***	-2.78***	0.07	-2.37**	-2.54**	0.08	-3.72***	-3.57***	0.23	-1.36	-1.11	0.16
Greece (GRC)	-1.53	-2.19**	0.06	-1.85*	-2.20**	0.08	-1.99**	-2.28**	0.15	-3.14***	-3.17***	0.16
Guatemala (GTM)	-6.26***	-6.23***	0.07	-4.35***	-4.24***	0.05	-10.87***	-11.25***	0.13	-1.91*	-1.58	0.16
Guinea (GIN)	-3.76***	-3.47***	0.05	-3.01***	-2.98***	0.08	-4.80***	-4.83***	0.06	-1.25	-0.79	0.39
Equatorial Guinea (GNQ)	-3.45***	-3.19***	0.07	-3.33***	-3.35***	0.11	-4.38***	-4.27***	0.12	-2.98***	-2.88***	0.63**
Guinea-Bissau (GNB)	-5.07***	-5.07***	0.05	-5.86***	-6.15***	0.05	-7.07***	-8.10***	0.23	-5.68***	-5.73***	0.19
Guyana (GUY)	-3.34***	-3.14***	0.07	-0.86	-1.89*	0.07	-5.44***	-5.47***	0.11	-1.94*	-1.86*	0.39*
Haiti (HTI)	-1.68*	-2.13**	0.07	-3.64***	-3.78***	0.12	-2.52**	-2.52**	0.15	-4.99***	-4.99***	0.15
Honduras (HND)	-4.34***	-4.16***	0.06	-4.45***	-4.40***	0.05	-6.98***	-7.24***	0.08	-3.67***	-3.71***	0.12
Hungary (HUN)	-1.96**	-2.32**	0.07	-2.45**	-2.59**	0.08	-3.73***	-3.77***	0.09	-3.33***	-3.37***	0.09
India (IND)	-3.59***	-3.43***	0.07	-3.57***	-3.48***	0.05	-5.51***	-5.53***	0.39*	-1.53	-1.13	0.07
Indonesia (IDN)	-3.25***	-3.30***	0.07	-2.80***	-2.94***	0.07	-4.99***	-5.08***	0.44*	-2.35**	-2.16**	0.07
Iraq (IRQ)	-2.73***	-2.74***	0.07	-3.59***	-3.56***	0.07	-3.78***	-3.81***	0.39*	-4.83***	-4.82***	0.47**

Country	Equation (1)						Equation (2)					
	$u_t - u_t^*$			$y_t - y_t^*$			$u_t - u_{t-1}$			g_{yt}		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
Ireland (IRL)	-1.81*	-2.27**	0.07	-2.50**	-2.59**	0.08	-2.72***	-2.78***	0.12	-2.51**	-2.41**	0.09
Iran (IRN)	-3.19***	-3.14***	0.05	-3.26***	-3.30***	0.09	-4.63***	-4.56***	0.12	-3.08***	-3.04***	0.12
Iceland (ISL)	-2.69***	-2.80***	0.06	-2.56**	-2.72***	0.07	-4.34***	-4.28***	0.07	-2.66***	-2.66***	0.06
Solomon Islands (SLB)	-2.18**	-2.47**	0.07	-1.94*	-2.37**	0.08	-3.52***	-3.55***	0.13	-3.08***	-3.08***	0.08
Israel (ISR)	-2.93***	-3.18***	0.07	-3.56***	-3.48***	0.08	-3.88***	-3.93***	0.07	-2.39**	-2.19**	0.21
Italy (ITA)	-1.97**	-2.32**	0.07	-4.06***	-3.92***	0.09	-3.38***	-3.46***	0.1	-5.41***	-5.41***	0.18
Jamaica (JAM)	-2.92***	-2.93***	0.07	-3.49***	-3.60***	0.06	-4.44***	-4.38***	0.25	-4.64***	-4.57***	0.15
Japan (JPN)	-2.54**	-2.74***	0.05	-3.62***	-3.55***	0.04	-3.40***	-3.33***	0.39*	-5.09***	-5.09***	0.09
Jordan (JOR)	-2.62**	-2.68***	0.06	-1.79*	-2.16**	0.08	-4.04***	-3.96***	0.38*	-3.02***	-2.97***	0.44*
Kazakhstan (KAZ)	-2.75***	-2.89***	0.08	-2.67***	-2.94***	0.13	-3.06***	-3.04***	0.25	-1.56	-1.44	0.24
Kenya (KEN)	-1.94*	-2.48**	0.06	-3.71***	-3.63***	0.09	-2.03**	-2.26**	0.29	-1.66*	-1.31	0.59**
Kyrgyzstan (KGZ)	-3.16***	-2.99***	0.05	-3.29***	-3.57***	0.16	-3.79***	-3.74***	0.08	-2.93***	-2.77***	0.35*
Kuwait (KWT)	-4.07***	-3.86***	0.05	-2.11**	-2.29**	0.18	-5.69***	-5.81***	0.1	-11.16***	-10.42***	0.43*
Lesotho (LSO)	-3.19***	-2.92***	0.05	-2.71***	-2.79***	0.07	-4.72***	-4.65***	0.07	-3.18***	-3.13***	0.44*
Latvia (LVA)	-3.06***	-3.35***	0.09	-2.05**	-2.27**	0.17	-3.73***	-3.59***	0.19	-5.07***	-4.84***	0.14
Liberia (LBR)	-3.11***	-2.92***	0.06	-2.33**	-2.82***	0.09	-4.87***	-4.83***	0.12	-3.52***	-3.52***	0.07
Libya (LBY)	-3.25***	-3.10***	0.08	-5.51***	-5.51***	0.06	-4.36***	-4.17***	0.19	-8.68***	-11.10***	0.08
Lithuania (LTU)	-3.54***	-3.80***	0.07	-2.67***	-2.96***	0.18	-4.55***	-4.54***	0.18	-3.51***	-3.50***	0.22
Luxembourg (LUX)	-3.88***	-3.81***	0.05	-3.15***	-3.14***	0.07	-6.27***	-6.38***	0.15	-2.49**	-2.35**	0.34
North Macedonia (MKD)	-2.70***	-2.92***	0.05	-3.39***	-3.63***	0.17	-3.14***	-3.08***	0.51**	-3.16***	-3.11***	0.31
Madagascar (MDG)	-2.87***	-2.91***	0.05	-4.32***	-4.25***	0.05	-3.72***	-3.60***	0.13	-4.79***	-4.92***	0.06
Malaysia (MYS)	-3.64***	-3.45***	0.06	-3.65***	-3.63***	0.07	-5.23***	-5.32***	0.11	-2.66***	-2.45**	0.32
Malawi (MWI)	-4.16***	-3.97***	0.05	-3.56***	-3.59***	0.07	-6.48***	-6.96***	0.06	-4.31***	-4.57***	0.12
Maldives (MDV)	-1.59	-2.03**	0.09	-5.59***	-5.82***	0.05	-2.23**	-2.20**	0.31	-5.63***	-5.64***	0.09
Malta (MLT)	-3.78***	-3.74***	0.06	-3.62***	-3.65***	0.07	-5.15***	-5.16***	0.37*	-3.12***	-3.12***	0.13
Mali (MLI)	-3.81***	-3.67***	0.05	-3.58***	-3.61***	0.12	-6.25***	-6.29***	0.14	-2.75***	-2.72***	0.11
Morocco (MAR)	-4.06***	-3.97***	0.1	-7.99***	-7.72***	0.22	-6.04***	-6.02***	0.12	-4.78***	-5.11***	0.18
Mauritius (MUS)	-3.87***	-3.57***	0.05	-3.79***	-3.59***	0.05	-5.24***	-5.28***	0.1	-2.87***	-2.74***	0.28
Mauritania (MRT)	-3.11***	-3.03***	0.05	-3.09***	-3.16***	0.04	-4.78***	-4.72***	0.09	-3.48***	-3.51***	0.09
Mongolia (MNG)	-4.64***	-4.72***	0.05	-2.75***	-2.77***	0.14	-8.88***	-9.07***	0.07	-2.02**	-1.99**	0.29
Mozambique (MOZ)	-3.44***	-3.23***	0.06	-3.28***	-3.27***	0.18	-5.24***	-5.24***	0.11	-2.06**	-1.99**	0.3
Myanmar (MMR)	-4.55***	-4.46***	0.06	-2.05**	-2.32**	0.09	-5.89***	-6.15***	0.24	-1.53	-1.36	0.42
Mexico (MEX)	-3.00***	-3.09***	0.06	-3.80***	-3.67***	0.05	-4.58***	-4.51***	0.1	-4.39***	-4.41***	0.19
Namibia (NAM)	-3.05***	-3.04***	0.04	-3.04***	-3.17***	0.07	-4.45***	-4.36***	0.1	-2.97***	-2.97***	0.19
Nepal (NPL)	-4.46***	-4.26***	0.05	-4.44***	-4.32***	0.06	-6.17***	-6.85***	0.07	-2.09**	-1.74*	0.1
Nicaragua (NIC)	-2.79***	-2.91***	0.04	-2.80***	-2.88***	0.06	-4.24***	-4.16***	0.04	-2.28**	-2.12**	0.06
Nigeria (NGA)	-1.45	-2.06**	0.05	-2.76***	-2.94***	0.11	-2.67***	-2.66***	0.13	-1.82*	-1.65*	0.18
Norway (NOR)	-3.29***	-3.24***	0.06	-3.05***	-3.04***	0.06	-5.32***	-5.33***	0.1	-2.13**	-1.91*	0.53**
New Zealand (NZL)	-2.73***	-2.91***	0.06	-2.55**	-2.90***	0.05	-3.40***	-3.36***	0.18	-1.71*	-1.5	0.23

Country	Equation (1)						Equation (2)					
	$u_t - u_t^*$			$y_t - y_t^*$			$u_t - u_{t-1}$			g_{yt}		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
Niger (NER)	-3.47***	-3.43***	0.05	-6.43***	-6.77***	0.13	-5.64***	-5.70***	0.09	-2.81***	-2.69***	0.66**
Oman (OMN)	-4.22***	-4.22***	0.06	-2.57**	-2.63**	0.08	-7.60***	-7.50***	0.12	-2.82***	-2.70***	0.13
Pakistan (PAK)	-4.65***	-4.57***	0.05	-2.59**	-2.77***	0.05	-6.61***	-6.58***	0.2	-2.19**	-2.09**	0.1
Panama (PAN)	-4.05***	-3.85***	0.06	-3.65***	-3.52***	0.08	-6.30***	-6.57***	0.07	-3.32***	-3.30***	0.11
Papua New Guinea (PNG)	-2.78***	-2.84***	0.06	-2.80***	-3.10***	0.12	-4.95***	-4.93***	0.09	-3.44***	-3.37***	0.09
Paraguay (PRY)	-5.30***	-5.29***	0.06	-2.65***	-2.86***	0.07	-8.74***	-9.54***	0.07	-2.80***	-2.75***	0.1
Netherlands (NLD)	-2.43**	-2.88***	0.05	-3.24***	-3.23***	0.07	-3.70***	-3.81***	0.09	-2.96***	-2.89***	0.22
Peru (PER)	-5.75***	-5.99***	0.07	-3.56***	-3.63***	0.07	-7.48***	-9.07***	0.14	-3.33***	-3.40***	0.18
Poland (POL)	-1.84*	-2.49**	0.04	-3.09***	-3.09***	0.05	-2.29**	-2.56**	0.1	-1.80*	-1.5	0.22
Portugal (PRT)	-1.98**	-2.50**	0.06	-3.05***	-3.11***	0.08	-2.82***	-2.89***	0.15	-3.80***	-3.81***	0.14
Qatar (QAT)	-2.87***	-2.85***	0.05	-2.58**	-2.83***	0.09	-3.36***	-3.21***	0.11	-2.45**	-2.37**	0.26
United Kingdom (GBR)	-2.05**	-2.30**	0.08	-4.01***	-3.94***	0.06	-3.77***	-3.84***	0.08	-4.36***	-4.44***	0.24
Central African Republic (CAF)	-3.53***	-3.18***	0.09	-3.25***	-3.27***	0.05	-4.34***	-4.22***	0.14	-5.54***	-5.54***	0.06
Czech Republic (CZE)	-2.70***	-2.79***	0.05	-2.69***	-2.80***	0.05	-3.58***	-3.44***	0.32	-3.08***	-3.05***	0.08
Lao People's Democratic Republic (LAO)	-1.26	-1.90*	0.07	-0.98	-1.72*	0.08	-2.88***	-2.92***	0.1	-0.76	-0.67	0.24
Dominican Republic (DOM)	-3.83***	-3.85***	0.05	-3.77***	-3.71***	0.06	-7.44***	-7.50***	0.06	-2.90***	-2.81***	0.17
Slovak Republic (SVK)	-2.30**	-2.63**	0.04	-2.84***	-2.91***	0.08	-3.57***	-3.56***	0.17	-3.00***	-3.11***	0.13
Republic of Moldova (MDA)	-3.00***	-3.01***	0.09	-3.53***	-3.60***	0.21	-5.02***	-5.05***	0.25	-6.05***	-5.92***	0.42*
Romania (ROU)	-2.95***	-3.02***	0.04	-2.55**	-2.71***	0.07	-5.55***	-5.55***	0.06	-3.50***	-3.60***	0.16
Rwanda (RWA)	-4.13***	-3.85***	0.05	-4.86***	-4.86***	0.1	-4.31***	-3.81***	0.07	-4.93***	-5.01***	0.15
Samoa (WSM)	-2.46**	-2.53**	0.07	-3.36***	-3.30***	0.07	-4.33***	-4.37***	0.31	-3.27***	-3.27***	0.29
Saint Vincent and the Grenadines (VCT)	-2.52**	-2.62**	0.05	-2.42**	-2.61**	0.05	-3.54***	-3.42***	0.09	-2.80***	-2.75***	0.2
Saint Lucia (LCA)	-3.35***	-3.19***	0.05	-4.11***	-3.87***	0.06	-5.38***	-5.36***	0.16	-5.27***	-5.34***	0.08
São Tomé and Príncipe (STP)	-2.44**	-2.52**	0.08	-1.94*	-2.31**	0.07	-3.58***	-3.54***	0.27	-1.72*	-1.49	0.17
Senegal (SEN)	-2.65***	-2.85***	0.05	-2.70***	-2.90***	0.07	-4.56***	-4.57***	0.08	-1.47	-1.07	0.33
Sierra Leone (SLE)	-2.52**	-2.62**	0.06	-3.40***	-3.36***	0.12	-4.14***	-4.09***	0.17	-4.68***	-4.72***	0.3
Singapore (SGP)	-4.58***	-4.50***	0.06	-3.69***	-3.74***	0.07	-6.43***	-7.16***	0.24	-2.62**	-2.41**	0.41*
Somalia (SOM)	-3.08***	-3.09***	0.06	-2.93***	-3.07***	0.12	-5.13***	-5.12***	0.06	-2.95***	-2.93***	0.27
Sri Lanka (LKA)	-3.18***	-3.19***	0.05	-1.54	-1.87*	0.08	-3.59***	-3.67***	0.58**	-2.05**	-1.78*	0.36*
South Africa (ZAF)	-4.17***	-4.02***	0.06	-3.47***	-3.40***	0.14	-4.67***	-4.68***	0.39*	-2.80***	-2.77***	0.29
Sweden (SWE)	-2.87***	-3.08***	0.1	-3.93***	-3.90***	0.12	-3.92***	-3.85***	0.13	-3.28***	-3.25***	0.12
Switzerland (CHE)	-3.39***	-3.40***	0.07	-3.98***	-3.90***	0.08	-4.44***	-4.35***	0.19	-3.12***	-3.11***	0.14
Suriname (SUR)	-3.55***	-3.65***	0.05	-3.68***	-3.63***	0.14	-4.94***	-4.95***	0.18	-3.47***	-3.42***	0.24
Thailand (THA)	-3.78***	-3.75***	0.08	-2.72***	-2.94***	0.06	-7.07***	-7.29***	0.07	-2.87***	-2.74***	0.25
Tanzania (TZA)	-2.94***	-2.96***	0.05	-2.30**	-2.69***	0.15	-4.05***	-3.92***	0.05	-0.36	-0.15	0.34
Tajikistan (TJK)	-2.34**	-2.56**	0.06	-2.08**	-2.59**	0.17	-3.33***	-3.25***	0.08	-2.94***	-2.93***	0.48**
Timor-Leste (TLS)	-2.32**	-2.51**	0.06	-3.88***	-3.58***	0.06	-3.94***	-3.97***	0.27	-4.91***	-4.86***	0.1
Togo (TGO)	-2.52**	-2.63**	0.05	-3.29***	-3.42***	0.07	-3.86***	-3.72***	0.07	-3.59***	-3.70***	0.17
Trinidad and Tobago (TTO)	-4.01***	-3.98***	0.22	-3.07***	-3.22***	0.09	-3.50***	-3.64***	0.44*	-2.77***	-2.73***	0.57**

Country	Equation (1)						Equation (2)					
	$u_t - u_t^*$			$y_t - y_t^*$			$u_t - u_{t-1}$			g_{yt}		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
Turkmenistan (TKM)	-2.14**	-2.36**	0.08	-3.16***	-3.23***	0.16	-2.11**	-2.15**	0.25	-2.91***	-2.90***	0.46*
Turkey (TUR)	-2.93***	-2.89***	0.05	-3.46***	-3.43***	0.04	-4.72***	-4.64***	0.1	-3.12***	-3.10***	0.1
Tunisia (TUN)	-3.37***	-3.29***	0.05	-4.33***	-4.28***	0.07	-5.37***	-5.41***	0.08	-3.21***	-3.18***	0.65**
Uganda (UGA)	-3.15***	-3.19***	0.04	-2.83***	-2.92***	0.07	-5.26***	-5.26***	0.04	-1.08	-0.71	0.38
Uruguay (URY)	-2.37**	-2.53**	0.07	-2.06**	-2.37**	0.07	-3.55***	-3.47***	0.1	-3.21***	-3.20***	0.1
Uzbekistan (UZB)	-2.40**	-2.62**	0.1	-2.30**	-2.65***	0.28	-3.23***	-3.20***	0.28	-1.68*	-1.70*	0.52**
Vanuatu (VUT)	-2.41**	-2.59**	0.06	-2.76***	-2.92***	0.05	-4.17***	-4.20***	0.1	-3.46***	-3.50***	0.1
Vietnam (VNM)	-4.50***	-4.41***	0.07	-2.64**	-2.82***	0.05	-7.29***	-7.86***	0.08	-1.05*	-1.05*	0.48**
Zambia (ZMB)	-2.75***	-2.75***	0.05	-3.17***	-3.12***	0.14	-3.65***	-3.51***	0.08	-2.24**	-1.99**	0.23
Zimbabwe (ZWE)	-2.47**	-2.62**	0.06	-2.08**	-2.35**	0.06	-2.44**	-2.49**	0.17	-3.37***	-3.44***	0.13

Notes: The ADF and PP tests rely on the critical values reported by Mackinnon (1994). The KPSS test is based on the corresponding KPSS critical values. The null hypothesis (H_0) differs across tests: for the ADF and PP tests, H_0 states that the series contains a unit root (i.e., it is non-stationary), whereas for the KPSS test, H_0 assumes stationarity. The symbols *, **, and *** denote rejection of the null hypothesis at the 10%, 5%, and 1% significance levels, respectively. Figures without an asterisk fail to reject the null hypothesis at conventional significance levels. The ADF and PP tests were conducted without including either a constant or a deterministic trend, while the KPSS specification included at least a constant term.

Appendix B

Table B1: Model result for the first-difference and gaps specifications

				First differences	Gap model		
Country	**Code**	**Region**	**Income group**	α_1 (equation 3)	β_1 (equation 2)	β^+ (equation 4)	β^- (equation 4)
Bahrain	BHR	Middle East and North Africa	High	-0.029**	-0.022***	-0.018***	-0.027**
Guyana	GUY	Latin America and the Caribbean	High	-0.014	-0.024**	-0.044***	-0.001
Malta	MLT	Middle East and North Africa	High	-0.046*	-0.035**	-0.042*	-0.021
Romania	ROU	Europe and Central Asia	High	-0.029	-0.052**	-0.103***	0.033
Trinidad and Tobago	TTO	Latin America and the Caribbean	High	-0.072**	-0.058***	-0.123***	0.046
Brunei Darussalam	BRN	East Asia and the Pacific	High	-0.022	-0.075**	0.02	-0.175*
Luxembourg	LUX	Europe and Central Asia	High	-0.081**	-0.076**	-0.118*	-0.028
Singapore	SGP	East Asia and the Pacific	High	-0.094***	-0.119***	-0.1	-0.136**
Russian Federation	RUS	Europe and Central Asia	High	-0.119***	-0.129***	-0.055*	-0.228***
Panama	PAN	Latin America and the Caribbean	High	-0.257***	-0.133***	-0.178*	-0.095
Norway	NOR	Europe and Central Asia	High	-0.145***	-0.158**	-0.345***	0.059
Japan	JPN	East Asia and the Pacific	High	-0.108***	-0.186***	-0.267***	-0.113***
Croatia	HRV	Europe and Central Asia	High	-0.096**	-0.207**	-0.131	-0.324
Barbados	BRB	Latin America and the Caribbean	High	-0.125***	-0.210***	-0.246**	-0.17
Uruguay	URY	Latin America and the Caribbean	High	-0.199***	-0.211***	-0.122	-0.283***
Austria	AUT	Europe and Central Asia	High	-0.114**	-0.216***	-0.213**	-0.223
Estonia	EST	Europe and Central Asia	High	-0.203**	-0.225***	-0.189**	-0.295**
Iceland	ISL	Europe and Central Asia	High	-0.232***	-0.234***	-0.193***	-0.301***
Slovenia	SVN	Europe and Central Asia	High	-0.150***	-0.247***	-0.188***	-0.357***
Germany	DEU	Europe and Central Asia	High	-0.184***	-0.248**	-0.337**	-0.161
Hungary	HUN	Europe and Central Asia	High	-0.194***	-0.251***	-0.025	-0.604***
Switzerland	CHE	Europe and Central Asia	High	-0.144***	-0.267***	-0.320***	-0.193***
Czech Republic	CZE	Europe and Central Asia	High	-0.204***	-0.272***	-0.307***	-0.212**
Chile	CHL	Latin America and the Caribbean	High	-0.242***	-0.274***	-0.189*	-0.359**
Ireland	IRL	Europe and Central Asia	High	-0.154**	-0.280***	-0.156	-0.369***
Latvia	LVA	Europe and Central Asia	High	-0.242**	-0.301***	-0.210***	-0.572***
Lithuania	LTU	Europe and Central Asia	High	-0.279**	-0.325***	-0.278***	-0.411***
Republic of Korea	KOR	East Asia and the Pacific	High	-0.188**	-0.335***	-0.223***	-0.416***
Bahamas	BHS	Latin America and the Caribbean	High	-0.171***	-0.337***	-0.362**	-0.299
Bulgaria	BGR	Europe and Central Asia	High	-0.206***	-0.337***	-0.443***	-0.224
Australia	AUS	East Asia and the Pacific	High	-0.384***	-0.346***	-0.532***	-0.131
Belgium	BEL	Europe and Central Asia	High	-0.116	-0.359***	-0.336*	-0.398
New Zealand	NZL	East Asia and the Pacific	High	-0.314***	-0.365***	-0.336***	-0.395***
Saudi Arabia	SAU	Middle East and North Africa	High	-0.03	0.025	0.113	-0.028
United Kingdom	GBR	Europe and Central Asia	High	-0.131**	-0.386***	-0.232***	-0.560***
United Arab Emirates	ARE	Middle East and North Africa	High	-0.054	-0.02	0.017	-0.064**
Canada	CAN	North America	High	-0.463***	-0.388***	-0.466***	-0.319***

				First differences	Gap model		
Country	Code	Region	Income group	α_1 (equation 3)	β_1 (equation 2)	β^+ (equation 4)	β^- (equation 4)
Kuwait	KWT	Middle East and North Africa	High	-0.002	-0.001	0.002	-0.002
Oman	OMN	Middle East and North Africa	High	0.003	0.001	0.001	0.001
Qatar	QAT	Middle East and North Africa	High	-0.001	-0.003	0.007	-0.011***
Netherlands	NLD	Europe and Central Asia	High	-0.191***	-0.391***	-0.190*	-0.699***
Slovak Republic	SVK	Europe and Central Asia	High	-0.185**	-0.399***	-0.402***	-0.394**
France	FRA	Europe and Central Asia	High	-0.086	-0.400***	-0.485**	-0.279
Israel	ISR	Middle East and North Africa	High	-0.164*	-0.400***	-0.195	-0.601***
Italy	ITA	Europe and Central Asia	High	-0.078	-0.412***	-0.447***	-0.362
Cyprus	CYP	Europe and Central Asia	High	-0.264***	-0.419***	-0.342***	-0.474***
Sweden	SWE	Europe and Central Asia	High	-0.295***	-0.421***	-0.377	-0.466**
Denmark	DNK	Europe and Central Asia	High	-0.322***	-0.424***	-0.303***	-0.565***
Portugal	PRT	Europe and Central Asia	High	-0.226**	-0.474***	-0.242	-0.679***
Finland	FIN	Europe and Central Asia	High	-0.319***	-0.484***	-0.510**	-0.448***
Greece	GRC	Europe and Central Asia	High	-0.298***	-0.501***	-0.346***	-0.720***
United States	USA	North America	High	-0.596***	-0.633***	-0.379***	-0.930***
Poland	POL	Europe and Central Asia	High	-0.332**	-0.896***	-0.958**	-0.833**
Spain	ESP	Europe and Central Asia	High	-0.457**	-0.947***	-0.905***	-0.995***
Burkina Faso	BFA	Sub-Saharan Africa	Low	-0.011	-0.006	0.017	-0.026*
Burundi	BDI	Sub-Saharan Africa	Low	-0.007	-0.003	-0.005	-0.001
The Gambia	GMB	Sub-Saharan Africa	Low	-0.037	-0.013	-0.044	0.029
Liberia	LBR	Sub-Saharan Africa	Low	-0.002	-0.001	0	-0.002
Madagascar	MDG	Sub-Saharan Africa	Low	-0.037**	-0.003	0.065	-0.074**
Mali	MLI	Sub-Saharan Africa	Low	-0.008	-0.005	0.009	-0.019
Mozambique	MOZ	Sub-Saharan Africa	Low	-0.010**	-0.01	-0.005	-0.017
Níger	NER	Sub-Saharan Africa	Low	0.002	-0.005	-0.021	0.006
Central African Republic	CAF	Sub-Saharan Africa	Low	0	0	-0.001	0.001
Sierra Leone	SLE	Sub-Saharan Africa	Low	-0.004*	-0.001	0.013	-0.026**
Uganda	UGA	Sub-Saharan Africa	Low	0.012	0.04	0.140*	-0.076
Chad	TCD	Sub-Saharan Africa	Low	-0.003	-0.004***	-0.003	-0.006**
Rwanda	RWA	Sub-Saharan Africa	Low	-0.003	-0.005**	-0.004	-0.005
Ethiopia	ETH	Sub-Saharan Africa	Low	-0.008	-0.011**	-0.017	-0.007
Democratic Republic of the Congo	COD	Sub-Saharan Africa	Low	-0.004	-0.013**	-0.006	-0.019*
Guinea-Bissau	GNB	Sub-Saharan Africa	Low	-0.014**	-0.018***	-0.021***	-0.014**
Malawi	MWI	Sub-Saharan Africa	Low	-0.022***	-0.019***	-0.006	-0.027***
Togo	TGO	Sub-Saharan Africa	Low	-0.019***	-0.021***	-0.018	-0.023*
Somalia	SOM	Sub-Saharan Africa	Low	-0.019***	-0.024***	-0.021***	-0.028***
Kyrgyzstan	KGZ	Europe and Central Asia	Middle	-0.005**	-0.002*	0.001	-0.005***
Libya	LBY	Middle East and North Africa	Middle	-0.007***	-0.010***	-0.013**	-0.007**
Iraq	IRQ	Middle East and North Africa	Middle	-0.016**	-0.011**	-0.001	-0.020***
Fiji	FJI	East Asia and the Pacific	Middle	-0.012***	-0.013***	-0.010*	-0.015***

				First differences	Gap model		
Country	Code	Region	Income group	α_1 (equation 3)	β_1 (equation 2)	β^+ (equation 4)	β^- (equation 4)
Papua New Guinea	PNG	East Asia and the Pacific	Middle	-0.016***	-0.013***	-0.013	-0.013*
Solomon Islands	SLB	East Asia and the Pacific	Middle	-0.021***	-0.017***	-0.012	-0.022***
Angola	AGO	Sub-Saharan Africa	Middle	-0.016***	-0.021***	-0.01	-0.033***
Georgia	GEO	Europe and Central Asia	Middle	-0.040**	-0.023*	-0.040***	0.009
Comoros	COM	Sub-Saharan Africa	Middle	-0.025**	-0.026***	-0.028**	-0.024
Bosnia and Herzegovina	BIH	Europe and Central Asia	Middle	0.017	-0.030**	-0.056*	-0.009
Mauritania	MRT	Sub-Saharan Africa	Middle	-0.028***	-0.032***	-0.026***	-0.041***
Kenya	KEN	Sub-Saharan Africa	Middle	-0.013	-0.037**	0.013	-0.079**
Nigeria	NGA	Sub-Saharan Africa	Middle	-0.022**	-0.037***	-0.035	-0.038
Republic of the Congo	COG	Sub-Saharan Africa	Middle	-0.043**	-0.038***	-0.017	-0.068**
Azerbaijan	AZE	Europe and Central Asia	Middle	-0.049***	-0.038***	-0.050***	-0.018
Tajikistan	TJK	Europe and Central Asia	Middle	-0.01	-0.039**	-0.043	-0.036*
Peru	PER	Latin America and the Caribbean	Middle	-0.147***	-0.041**	-0.027	-0.055
Guinea	GIN	Sub-Saharan Africa	Middle	-0.029***	-0.045***	-0.078***	-0.015
Cuba	CUB	Latin America and the Caribbean	Middle	-0.031***	-0.048***	-0.089***	0.018
Benin	BEN	Sub-Saharan Africa	Middle	-0.063*	-0.087	0.061	-0.219*
Botswana	BWA	Sub-Saharan Africa	Middle	-0.01	-0.093	-0.429***	0.188**
Cape Verde	CPV	Sub-Saharan Africa	Middle	-0.055**	-0.036	0.048	-0.141***
Cameroon	CMR	Sub-Saharan Africa	Middle	-0.045**	-0.050***	-0.072**	-0.018
Gabon	GAB	Sub-Saharan Africa	Middle	-0.054**	-0.050***	0.007	-0.126***
Eswatini	SWZ	Sub-Saharan Africa	Middle	-0.271	-0.175	0.155	-0.506*
Armenia	ARM	Europe and Central Asia	Middle	-0.029	-0.051*	-0.038	-0.093
Bolivia	BOL	Latin America and the Caribbean	Middle	-0.275***	-0.054*	-0.027	-0.105
Vanuatu	VUT	East Asia and the Pacific	Middle	-0.012	-0.058**	0.02	-0.119***
Equatorial Guinea	GNQ	Sub-Saharan Africa	Middle	0	-0.001	-0.001	-0.001
Nepal	NPL	South Asia	Middle	-0.138*	-0.060*	-0.115***	0.024
Lesotho	LSO	Sub-Saharan Africa	Middle	-0.077***	-0.063**	-0.015	-0.129*
Sri Lanka	LKA	South Asia	Middle	-0.092**	-0.066**	-0.06	-0.07
Myanmar	MMR	East Asia and the Pacific	Middle	-0.069**	-0.066***	-0.074**	-0.06
Namibia	NAM	Sub-Saharan Africa	Middle	-0.046	0.021	0.093	-0.066
Republic of Moldova	MDA	Europe and Central Asia	Middle	-0.074***	-0.068***	-0.061***	-0.078
São Tomé and Príncipe	STP	Sub-Saharan Africa	Middle	-0.064	-0.028	0.162*	-0.194
Philippines	PHL	East Asia and the Pacific	Middle	-0.036***	-0.069***	-0.058***	-0.091
Malaysia	MYS	East Asia and the Pacific	Middle	-0.080***	-0.073***	-0.083***	-0.057*
Tanzania	TZA	Sub-Saharan Africa	Middle	-0.006	-0.016	-0.019	-0.012
Zambia	ZMB	Sub-Saharan Africa	Middle	0.016	0.025	0.316*	-0.402**
Zimbabwe	ZWE	Sub-Saharan Africa	Middle	-0.003	-0.005	0.009	-0.015
Dominican Republic	DOM	Latin America and the Caribbean	Middle	0.003	-0.076**	-0.137*	-0.027
Turkmenistan	TKM	Europe and Central Asia	Middle	-0.072**	-0.081**	-0.052	-0.110***
Guatemala	GTM	Latin America and the Caribbean	Middle	-0.115***	-0.084***	-0.039	-0.156**

				First differences	Gap model		
Country	Code	Region	Income group	α_1 (equation 3)	β_1 (equation 2)	β^+ (equation 4)	β^- (equation 4)
Ecuador	ECU	Latin America and the Caribbean	Middle	-0.138***	-0.089***	-0.076*	-0.104*
Côte d'Ivoire	CIV	Sub-Saharan Africa	Middle	-0.075**	-0.093***	-0.069**	-0.120*
Thailand	THA	East Asia and the Pacific	Middle	-0.104**	-0.097***	-0.037**	-0.167***
El Salvador	SLV	Latin America and the Caribbean	Middle	-0.069	-0.004	-0.039	0.019
Jamaica	JAM	Latin America and the Caribbean	Middle	-0.118***	-0.100***	-0.280***	0.109
Haiti	HTI	Latin America and the Caribbean	Middle	-0.033	-0.048	0.004	-0.085**
Morocco	MAR	Middle East and North Africa	Middle	-0.101***	-0.103***	-0.080*	-0.125*
Mauritius	MUS	Sub-Saharan Africa	Middle	-0.127***	-0.106***	-0.076***	-0.142***
Bangladesh	BGD	South Asia	Middle	-0.127**	-0.111*	0.075	-0.326***
Paraguay	PRY	Latin America and the Caribbean	Middle	-0.148**	-0.104	0.058	-0.293*
Uzbekistan	UZB	Europe and Central Asia	Middle	-0.136***	-0.111***	-0.161***	-0.016
Senegal	SEN	Sub-Saharan Africa	Middle	-0.07	-0.112**	-0.077	-0.142
Saint Vincent and the Grenadines	VCT	Latin America and the Caribbean	Middle	-0.109***	-0.123***	-0.094***	-0.159***
Suriname	SUR	Latin America and the Caribbean	Middle	-0.067*	-0.04	0.13	-0.238***
Jordan	JOR	Middle East and North Africa	Middle	-0.158**	-0.131**	0.004	-0.261**
India	IND	South Asia	Middle	-0.094***	0.018	0.081*	-0.081*
Maldives	MDV	South Asia	Middle	-0.021**	-0.054	-0.068	-0.039
Ghana	GHA	Sub-Saharan Africa	Middle	-0.202***	-0.138**	-0.299***	0.151
Pakistan	PAK	South Asia	Middle	-0.087*	-0.056	-0.017	-0.106
Belize	BLZ	Latin America and the Caribbean	Middle	-0.085***	-0.139***	0.031	-0.309***
Cambodia	KHM	East Asia and the Pacific	Middle	-0.005**	-0.003	0	-0.006
China	CHN	East Asia and the Pacific	Middle	-0.009	-0.018	0.057**	-0.074***
Turkey	TUR	Europe and Central Asia	Middle	-0.155***	-0.158***	-0.033	-0.245**
Argentina	ARG	Latin America and the Caribbean	Middle	-0.205***	-0.166***	-0.198	-0.148
Indonesia	IDN	East Asia and the Pacific	Middle	-0.041**	-0.011	-0.017	-0.001
Kazakhstan	KAZ	Europe and Central Asia	Middle	-0.179***	-0.199***	-0.139**	-0.259***
Nicaragua	NIC	Latin America and the Caribbean	Middle	-0.163***	-0.204***	-0.125*	-0.290***
Mongolia	MNG	East Asia and the Pacific	Middle	-0.027	-0.043	-0.043	-0.042
South Africa	ZAF	Sub-Saharan Africa	Middle	-0.02	-0.212***	-0.202**	-0.232
Honduras	HND	Latin America and the Caribbean	Middle	-0.275***	-0.217***	-0.330***	-0.027
Samoa	WSM	East Asia and the Pacific	Middle	0.012	0.008	0.036	-0.014
Mexico	MEX	Latin America and the Caribbean	Middle	-0.162***	-0.250***	-0.131**	-0.323***
Timor-Leste	TLS	East Asia and the Pacific	Middle	0	-0.005	-0.011	-0.002
Tunisia	TUN	Middle East and North Africa	Middle	-0.162	-0.269**	-0.144	-0.438*
Vietnam	VNM	East Asia and the Pacific	Middle	-0.036	-0.009	0.061	-0.126
North Macedonia	MKD	Europe and Central Asia	Middle	-0.212***	-0.292**	-0.202**	-0.447
Belarus	BLR	Europe and Central Asia	Middle	-0.261***	-0.328***	-0.208***	-0.447***
Saint Lucia	LCA	Latin America and the Caribbean	Middle	-0.316***	-0.339***	-0.403**	-0.276***
Colombia	COL	Latin America and the Caribbean	Middle	-0.423***	-0.365***	-0.126	-0.620*
Brazil	BRA	Latin America and the Caribbean	Middle	-0.283***	-0.387***	-0.411***	-0.353**

				First differences	Gap model		
Country	Code	Region	Income group	α_1 (equation 3)	β_1 (equation 2)	β^+ (equation 4)	β^- (equation 4)
Arab Republic of Egypt	EGY	Middle East and North Africa	Middle	-0.401***	-0.469***	-0.398***	-0.561***
Algeria	DZA	Middle East and North Africa	Middle	-0.338***	-0.497***	-0.648**	-0.3
Costa Rica	CRI	Latin America and the Caribbean	Middle	-0.474***	-0.499***	-0.621***	-0.361**
Iran	IRN	Middle East and North Africa	Middle	0.032	0.031	0.061	0
Albania	ALB	Europe and Central Asia	Middle	-0.495*	-0.632**	-0.957***	-0.328
Lao People's Democratic Republic	LAO	East Asia and the Pacific	Middle	0.066**	0.129***	0.177***	0.076

Notes: ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Coefficients without asterisks are not statistically significant. The results were obtained using heteroskedasticity-robust standard errors (White, 1980).

References

Abdul Malik, A., & Khan, A. U. I. (2025). COVID-19 and the Okun's law: the case of Ghana1. *Cogent Economics and Finance*, *13*(1). https://doi.org/10.1080/23322039.2025.2460074

Adeosun, O. A. (2025). Inclusive economic growth in Africa: insights from inclusiveness matrix, social mobility curve, and spatial approach. *Social Responsibility Journal*, 1–29. https://doi.org/10.1108/SRJ-02-2025-0135

Altig, D., Fitzgerald, T., & Rupert, P. (2020). Okun's law revisited: Should we worry about low unemployment? *Handbook of Monetary Policy*, 135–142. https://doi.org/10.4324/9780429270949-7

Backus, D. K., & Kehoe, P. J. (1992). International Evidence on the Historical Properties of Business Cycles. *American Economic Review*, *82*(4).

Ball, L., Furceri, D., Leigh, D., & Loungani, P. (2019). Does One Law Fit All? Cross-Country Evidence on Okun's Law. *Open Economies Review*, *30*(5), 841–874. https://doi.org/10.1007/s11079-019-09549-3

Ball, L., Leigh, D., & Loungani, P. (2017). Okun's Law: Fit at 50? *Journal of Money, Credit and Banking*, *49*(7), 1413–1441. https://doi.org/10.1111/jmcb.12420

Bande, R., & Martín-Román, A. (2018). Regional differences in the okun's relationship: New evidence for Spain (1980-2015) | Diferencias regionales en la relación de Okun: Nueva evidencia para España (1980-2015). *Investigaciones Regionales*, *2018*(41), 137–165.

Belmonte, A., & Polo, C. (2004). *Formulaciones de la ley de Okun y resultados para España*. Estudios en homenaje a Luis Ángel Rojo. Políticas, mercados e instituciones económicas: 1, 263-294.

Benos, N., & Stavrakoudis, A. (2022). Okun's law: Copula-based evidence from G7 countries. *Quarterly Review of Economics and Finance*, *84*, 478–491. https://doi.org/10.1016/j.qref.2020.10.004

Bod'a, M., & Považanová, M. (2021). Output-unemployment asymmetry in Okun coefficients for OECD countries. *Economic Analysis and Policy*, *69*, 307–323. https://doi.org/10.1016/j.eap.2020.12.004

Boďa, M., & Považanová, M. (2023). How credible are Okun coefficients? The gap version of Okun's law for G7 economies. *Economic Change and Restructuring*, *56*(3), 1467–1514. https://doi.org/10.1007/S10644-022-09438-9

Butkus, M., Dargenyte-Kacileviciene, L., Matuzeviciute, K., Rupliene, D., & Seputiene, J. (2024). Are there more than three regimes in the output-unemployment relationship? A panel quantile regression estimates of Okun's gap model in EU countries. *Eastern Journal of European Studies*, *15*(1), 201–218. https://doi.org/10.47743/EJES-2024-0109

Cevik, E. I., Dibooglu, S., & Barişik, S. (2013). Asymmetry in the unemployment-output relationship over the business cycle: Evidence from transition economies. *Comparative Economic Studies*, *55*(4), 557–581. https://doi.org/10.1057/ces.2013.7

Chamberlin, G. (2011). Okun's Law revisited. *Economic and Labour Market Review*, *5*(2), 104–132. https://doi.org/10.1057/ELMR.2011.21/METRICS

Cutanda, A. (2023). Stability and Asymmetry in Okun's Law: Evidence from Spanish Regional Data. *Panoeconomicus*, *70*(2), 219–238. https://doi.org/10.2298/PAN191203012C

Diop, S. (2018). Convergence and spillover effects in Africa: A spatial panel data approach. *Journal of African Economies*, *27*(3), 274–284. https://doi.org/10.1093/JAE/EJX027

Donayre, L. (2022). On the behavior of Okun's law across business cycles. *Economic Modelling*, *112*. https://doi.org/10.1016/J.ECONMOD.2022.105858

Duran, H. E. (2022). Validity of Okun's Law in a Spatially Dependent and Cyclical Asymmetric Context. *Panoeconomicus*, *69*(3), 447–480. https://doi.org/10.2298/PAN190529003D

Elhorst, J. P., & Emili, S. (2022). A spatial econometric multivariate model of Okun's law. *Regional Science and Urban Economics*, *93*. https://doi.org/10.1016/j.regsciurbeco.2021.103756

Erdoğan Coşar, E., & Arzu Yavuz, A. (2021). Okun's law under the demographic dynamics of the Turkish labor market. *Central Bank Review*, *21*(2), 59–69. https://doi.org/10.1016/j.cbrev.2021.03.002

García, A. V. (2024). A review of the effectiveness of short-time work programmes: The Spanish case from a comparative perspective. *Economic and Labour Relations Review*, *35*(4), 1000–1030. https://doi.org/10.1017/ELR.2024.60

Gil-Alana, L. A., Skare, M., & Buric, S. B. (2020). Testing Okun's law. Theoretical and empirical considerations using fractional integration. *Applied Economics*, *52*(5), 459–474. https://doi.org/10.1080/00036846.2019.1646407

Goto, E., & Bürgi, C. (2021). Sectoral Okun's law and cross-country cyclical differences. *Economic Modelling*, *94*, 91–103. https://doi.org/10.1016/J.ECONMOD.2020.08.016

Hamada, K., & Kurosaka, Y. (1984). The relationship between production and unemployment in Japan. *European Economic Review*, *25*(1). https://doi.org/10.1016/0014-2921(84)90073-4

Hodrick, R. J., & Prescott, E. C. (1997). Postwar U.S. Business Cycles: An Empirical Investigation. *Journal of Money, Credit and Banking*, *29*(1). https://doi.org/10.2307/2953682

Ismihan, M. (2016). A useful framework for linking labor and goods markets: Okun's law and its stability revisited. *Review of Keynesian Economics*, *4*(2), 175–192. https://doi.org/10.4337/roke.2016.02.03

Kaufman, R. T. (1988). An international comparison of Okun's laws. *Journal of Comparative Economics*, *12*(2). https://doi.org/10.1016/0147-5967(88)90002-9

Lanzafame, M. (2010). The endogeneity of the natural rate of growth in the regions of Italy. *International Review of Applied Economics*, *24*(5), 533–552. https://doi.org/10.1080/02692170903426039

Lee, J. (2000). The robustness of Okun's law: Evidence from OECD countries. *Journal of Macroeconomics*, *22*(2), 331–356. https://doi.org/10.1016/S0164-0704(00)00135-X

Loría, E. (2022). OKUN'S LAW IN MEXICO, AN ASYMMETRIC RELATIONSHIP, 2005.01-2021.10 | LA LEY DE OKUN EN MÉXICO, UNA RELACIÓN ASIMÉTRICA, 2005.01-2021.10. *Investigacion Economica*, *81*(321), 156–173. https://doi.org/10.22201/fe.01851667p.2022.321.82062

Mackinnon, J. G. (1994). Approximate asymptotic distribution functions for unit-root and cointegration tests. *Journal of Business and Economic Statistics*, *12*(2), 167–176. https://doi.org/10.1080/07350015.1994.10510005

Maridueña-Larrea, Á., & Martín-Román, Á. (2024). Spatial Dependence in the Cyclical Sensitivity of Labour Supply: An Analysis at the Regional Level in Ecuador. *Economies*, *12*(12). https://doi.org/10.3390/economies12120353

Maridueña-Larrea, Á., & Martín-Román, Á. (2025). Female Labor Supply in Latin America and the Business Cycle: Instability and Asymmetry1. *Review of Development Economics*. https://doi.org/10.1111/RODE.13231

Marinkov, M., & Geldenhuys, J. P. (2007). CYCLICAL UNEMPLOYMENT AND CYCLICAL OUTPUT: AN ESTIMATION OF OKUN'S COEFFICIENT FOR SOUTH AFRICA. *South African Journal of Economics*, *75*(3), 373–390. https://doi.org/10.1111/J.1813-6982.2007.00134.X

Mavrodi, A. G., Kolias, G., & Karamanis, K. (2024). An empirical analysis of Okun's law at a regional level: evidence from the NUTS 2 European regions. *Applied Economics*, *56*(56), 7600–7620. https://doi.org/10.1080/00036846.2023.2288043

Maza, A. (2026). Exploring Okun's Law during COVID-19: did divergent US state responses shape economic shifts? *Annals of Regional Science*, *75*(1), 33-. https://doi.org/10.1007/S00168-026-01472-Z/TABLES/9

Mihajlović, V., & Fedajev, A. (2021). Okun's law (A)symmetry in see countries: Evidence from nonlinear ARDL model. *Romanian Journal of Economic Forecasting*, *24*(3), 140–157.

Mnasri, A., Mrabet, Z., & Alsamara, M. (2023). A new quadratic asymmetric error correction model: does size matter? *Empirical Economics*, *65*(1), 33–64. https://doi.org/10.1007/s00181-022-02323-4

Moosa, I. A. (1997). A Cross-Country Comparison of Okun's Coefficient. *Journal of Comparative Economics*, *24*(3), 335–356. https://doi.org/10.1006/jcec.1997.1433

Moosa, I. A. (2008). Economic Growth and Unemployment In Arab Countries: Is Okun's Law Valid ? *Journal of Development and Economic Policies*, *10*(2).

Moran, P. A. P. (1948). The Interpretation of Statistical Maps. *Journal of the Royal Statistical Society Series B: Statistical Methodology*, *10*(2), 243–251. https://doi.org/10.1111/J.2517-6161.1948.TB00012.X

Mussida, C., & Zanin, L. (2023). Asymmetry and (in-)stability of Okun's coefficients in nine European countries. *Journal of Economic Asymmetries*, *28*. https://doi.org/10.1016/j.jeca.2023.e00313

Ngubane, M. Z., Mndebele, S., & Ilesanmi, K. D. (2024). Is the current economic performance compatible with the projected NDP unemployment target? *Cogent Economics and Finance*, *12*(1). https://doi.org/10.1080/23322039.2024.2350699

N'guessan, C. F. J. (2006). Testing for asymmetry in the relationship between employment and output: Empirical evidence from the industrial sector of Côte d'Ivoire (1970-1996). *Nigerian Journal of Economic and Social Studies*, *48*(3), 297–312.

Okun, A. M. (1962). Potential GNP: Its Measurement and Significance. *Proceedings of the Business and Economic Statistics Section*, 98–104. https://milescorak.com/wp-content/uploads/2016/01/okun-potential-gnp-its-measurement-and-significance-p0190.pdf

Omoshoro-Jones, O. S., & Bonga-Bonga, L. (2022). Intra-regional spillovers from Nigeria and South Africa to the rest of Africa: New evidence from a FAVAR model. *World Economy*, *45*(1), 251–275. https://doi.org/10.1111/TWEC.13140

Peláez-Herreros, Ó. (2025). INTRINSIC DIFFERENCES IN OKUN COEFFICIENTS OF OECD COUNTRIES, 1995-2019. *Revista de Economia Mundial*, *2025*(69), 145–171. https://doi.org/10.33776/REM.VI69.8208

Pereira, R. M. (2014). Okun's law, asymmetries and regional spillovers: Evidence from Virginia metropolitan statistical areas and the District of Columbia. *Annals of Regional Science*, *52*(2), 583–595. https://doi.org/10.1007/s00168-014-0600-x

Pitoňáková, R., Kucharčík, R., & Kabát, L. (2025). Is the response of the Slovak labor market asymmetric to output changes? *Journal of Economic Asymmetries*, *31*. https://doi.org/10.1016/j.jeca.2025.e00403

Pizzo, A. (2020). *Literature review of empirical studies on Okun's law in Latin America and the Caribbean*. Employment Working Paper No. 252. Geneva: ILO.

Porras-Arena, M. S., & Martín-Román, Á. L. (2023a). The correlation between unemployment and economic growth in Latin America – Okun's law estimates by country. *International Labour Review*, *162*(2), 171–198. https://doi.org/10.1111/ILR.12398

Porras-Arena, M. S., & Martín-Román, Á. L. (2023b). The heterogeneity of Okun's law: A metaregression analysis. *Economic Modelling*, *128*, 106490. https://doi.org/10.1016/j.econmod.2023.106490

Porras-Arena, M. S., Martín-Román, Á. L., Dueñas Fernández, D., & Llorente Heras, R. (2024). Okun's Law: The effects of the COVID-19 pandemic and the temporary layoffs procedures (ERTEs) on Spanish regions. *Investigaciones Regionales*, *2024*(59), 105–125. https://doi.org/10.38191/IIRR-JORR.24.013

Raifu, I. A. (2023). Testing Okun's law at sectoral level: evidence from Nigeria. *International Journal of Development Issues*, *22*(1), 1–20. https://doi.org/10.1108/IJDI-04-2022-0070

Silvapulle, P., Moosa, I. A., & Silvapulle, M. J. (2004). Asymmetry in Okun's law. *Canadian Journal of Economics*, *37*(2), 353–374. https://doi.org/10.1111/j.0008-4085.2004.00006.x

Sögner, L., & Stiassny, A. (2002). An analysis on the structural stability of Okun's law-A cross-country study. *Applied Economics*, *34*(14), 1775–1787. https://doi.org/10.1080/00036840210124180

Sovbetov, I. (2025). The dynamics of Okun's law: cross-country analysis across economic cycles (1980–2023). *Empirica*, *52*(4), 687–720. https://doi.org/10.1007/S10663-025-09662-2

Villaverde, J., & Maza, A. (2021). The role of spillovers in okun's law: Empirical evidence from spain. *Panoeconomicus*, *68*(4). https://doi.org/10.2298/PAN180619006V

White, H. (1980). A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica*, *48*(4), 817. https://doi.org/10.2307/1912934

Widarjono, A. (2020). Asymmetric okun's law in an emerging market: Asean-3 case. *Economics and Sociology*, *13*(3), 203–217. https://doi.org/10.14254/2071-789X.2020/13-3/12

Woo, J. (2023). Revisiting Okun's law in South Korea: Asymmetries, crises, and structural changes. *Journal of Economic Asymmetries*, *27*. https://doi.org/10.1016/j.jeca.2023.e00292

Zwick, H. S. (2018). Instability and asymmetric behaviors of okun coefficients in the eurozone: A Markov-switching autoregressive model. *E Journal of International and Comparative Labour Studies*, *7*(3), 24–44.