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Sylvina Porras-Arena y Mauricio Suárez-Cal*

Resumen

La ley de Okun, que analiza la relación entre el desempleo y el crecimiento económico, ha sido objeto de numerosas investigaciones desde la contribución pionera de Arthur Okun (1962), que se basó en tres modelos uniecuacionales: el modelo en diferencias, el de brechas y el de elasticidad ajustado a la tendencia. El coeficiente de Okun, derivado de estos enfoques de ecuación única, resume en un único valor los efectos agregados del crecimiento económico sobre diferentes variables del mercado laboral, pero no permite identificar qué hay detrás de la ley. Este artículo propone un marco alternativo para estudiar la relación entre desempleo y crecimiento mediante la estimación de un sistema de ecuaciones múltiples que capta la dinámica del mercado laboral, identificando los efectos diferenciados del crecimiento económico sobre las distintas variables del mercado laboral. Mediante un ejercicio de simulación, este método muestra los canales específicos a través de los cuales el crecimiento económico afecta al desempleo, lo que aporta información valiosa para el diseño de políticas públicas más eficaces. Aplicamos este nuevo enfoque al estudio del mercado de trabajo de Uruguay, un país que presenta una relación de Okun estadísticamente significativa, aunque relativamente débil en comparación con las economías avanzadas. Los resultados muestran que el crecimiento económico tiene un impacto directo sobre el empleo, la oferta de mano de obra y los salarios, y que, a través de los salarios, ejerce un impacto indirecto sobre el empleo y la oferta de mano de obra. La combinación de todos estos efectos se resume en una reacción débil del desempleo ante los cambios en la actividad económica, lo cual se debe a que la oferta de mano de obra presenta un fuerte comportamiento procíclico, lo que reduce parcialmente la fuerte reacción del empleo ante el crecimiento económico.

Palabras clave

Ley de Okun, desempleo, empleo, oferta laboral, crecimiento económico, ARDL

Clasificación JEL

C32, E24, J21, J23

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Abstract

Okun’s law, which examines the relationship between unemployment and economic growth, has been the subject of extensive research since Arthur Okun’s seminal contribution, which relied on three single-equation models: the differences model, the gap model, and the trend-adjusted elasticity model. The Okun coefficient derived from these single-equation approaches summarizes in a single value the aggregate effects of economic growth on different labor market variables, but does not allow one to identify what's behind the law. This article proposes an alternative framework for studying the unemployment–growth relationship by estimating a multi-equation system that captures the dynamics of the labor market, identifying the differentiated effects of economic growth on different labor market variables. Through a simulation exercise, this method shows the specific channels through which economic growth affects unemployment, thereby providing valuable insights for the design of more effective public policies. We apply this new approach to Uruguay, a country that exhibits a statistically significant Okun relationship, though one that is relatively weak compared with advanced economies. The results show that economic growth has a direct impact on employment, labor supply, and wages, and through wages, it has an indirect impact on employment and labor supply. The combination of all these effects is summarized in a weak reaction of unemployment to changes in economic activity, and this is because in that country, labor supply exhibits strong procyclical behavior, which partially reduces the strong reaction of employment to economic growth.

Keywords

Okun's law, unemployment, employment, labor supply, economic growth, ARDL.

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A New Approach to Studying Unemployment and Economic Growth Relationship

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Abstract

Okun's law, which examines the relationship between unemployment and economic growth, has been the subject of extensive research since Arthur Okun's seminal contribution, which relied on three single-equation models: the differences model, the gap model, and the trend-adjusted elasticity model. The Okun coefficient derived from these single-equation approaches summarizes in a single value the aggregate effects of economic growth on different labor market variables, but does not allow one to identify what's behind the law. This article proposes an alternative framework for studying the unemployment–growth relationship by estimating a multi-equation system that captures the dynamics of the labor market, identifying the differentiated effects of economic growth on different labor market variables. Through a simulation exercise, this method shows the specific channels through which economic growth affects unemployment, thereby providing valuable insights for the design of more effective public policies. We apply this new approach to Uruguay, a country that exhibits a statistically significant Okun relationship, though one that is relatively weak compared with advanced economies. The results show that economic growth has a direct impact on employment, labor supply, and wages, and through wages, it has an indirect impact on employment and labor supply. The combination of all these effects is summarized in a weak reaction of unemployment to changes in economic activity, and this is because in that country, labor supply exhibits strong procyclical behavior, which partially reduces the strong reaction of employment to economic growth.

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1. Introduction

While Okun's law holds for most countries, evidence suggests that the relationship is not statistically significant in some developing economies (Ball et al., 2019). Uruguay, however, presents a different case: the relationship is statistically significant, with an estimated coefficient of about –0.2. This value is close to the average for developing countries but lower than the –0.4 typically observed in advanced economies (Ball et al., 2019). Estimates for Uruguay include –0.27 for 1968–2018 (Merlo & Porras-Arena, 2019), –0.18 to –0.22 for 1986–2017 (Porras-Arena & Martín-Román, 2023b), and –0.2 for 1983–2015 (Ball et al., 2019). These results suggest that for each one-percentage-point increase in annual gross domestic product (GDP) growth above its potential or natural rate, the unemployment rate decreases by roughly 0.20 percentage points. In another study, Tapie et al. (2020) estimated Uruguay's Okun coefficient at approximately -0.06 using quarterly data for the period 1986–2019. This would correspond to an annual coefficient of around -0.22, which aligns closely with the aforementioned estimates. But why is this relationship relatively weak? What are the channels through which economic growth affects unemployment? These are some of the questions this research aims to answer.

Given the wide cross-country variation in Okun coefficients (e.g. Boďa & Považanová, 2023; Porras-Arena & Martín-Román, 2023c;), a growing, albeit still limited, literature has examined the factors driving differences in the responsiveness of unemployment to GDP growth. Some researchers argue that employment protection legislation may hinder the speed at which employment adjusts to GDP fluctuations (e.g. Balakrishnan et al., 2010; Blanchard, 2012; Cazes et al., 2013; Herwartz & Niebuhr, 2011; Sögner & Stiassny, 2002). Such labor market institutions may increase the costs firms incur when hiring or laying off workers, thereby reducing the elasticity of employment with respect to output. Other studies highlight the role of changes in labor productivity or changes in the sectoral composition of output and employment as factors influencing the Okun relationship (e.g. Herwartz & Niebuhr, 2011; Villaverde & Maza, 2009). All these factors primarily affect the employment-GDP growth linkage, which constitutes an indirect channel through which GDP affects unemployment. In addition, cyclical movements in labor supply in response to economic growth may further influence the strength of Okun's relationship.

This context raises several key questions: Through which mechanisms does output growth affect labor market variables in Uruguay, such that the resulting impact on unemployment is relatively muted compared to more advanced economies? Is this attenuation attributable to the employment-GDP growth linkage—specifically, to a weak response of labor demand to GDP changes? Alternatively, could pro-cyclical labor supply behavior be a dominant factor, thereby dampening the responsiveness of unemployment to economic growth? What role do wages play in this process?

A simple estimation of the unemployment–GDP relationship cannot address these questions. A more comprehensive methodological framework is required—one that can disentangle the channels through which economic growth influences unemployment, while also offering an alternative estimation of Okun's law that can be compared with results from traditional single-equation methods.

Applying this new approach to the case of Uruguay is particularly interesting for several reasons: (a) As noted, Uruguay is one of the few developing countries where Okun's coefficient is statistically significant and comparable to the average for developing countries, albeit lower than that observed in more advanced economies. b) The relationship appears relatively stable in Uruguay. Various estimates for different periods yield similar coefficients, and rolling-window analyses support this stability (Porras-Arena & Martín-Román, 2023b). In contrast, other countries exhibit considerable variability in their Okun coefficients over time. c) Uruguay has undergone pronounced economic fluctuations during the study period—including sustained growth during the 1990s, a severe economic crisis in the late 1990s and early 2000s, over a decade of strong expansion, a contraction due to the COVID-19 pandemic, and a subsequent recovery. Despite these fluctuations, unemployment exhibited relatively modest sensitivity to economic activity, suggesting that some of the transmission channels through which growth affects unemployment may counteract the mechanisms typically described by Okun's law. This warrants further investigation.

The remainder of this paper is structured as follows: Section 2 outlines the theoretical framework. Section 3 describes the empirical strategy and data. Sections 4 and 5 present the results and conclusions, respectively.

2. Theoretical Framework

2.1. Indirect Relationship Between Unemployment and GDP

In 1962, Arthur Okun was the first to document a negative relationship between economic growth and unemployment. Since then, the empirical regularity identified by Okun (1962) for the United States has been broadly confirmed across a wide range of countries and time periods. As a result, this short-run macroeconomic relationship became known as *Okun's Law*

Despite this observed regularity, standard economic theory does not posit a direct link between economic growth and unemployment. Rather, the relationship operates indirectly through the effects of economic activity on labor demand and labor supply. Since unemployment is a summary indicator of labor market conditions, the influence of economic growth on unemployment occurs via its impact on these intermediate variables (Porras-Arena & Martín-Román, 2023a, Figure 1).

The link between economic growth and employment is well-established in economic theory and grounded in the theory of labor demand, which asserts that increases in economic activity positively influence employment levels (Hamermesh, 1993). This relationship is mediated by factors such as average labor productivity, average hours worked, and the nature of production technology. These variables, in turn, affect the strength of Okun's Law, as initially noted by Okun (1962).

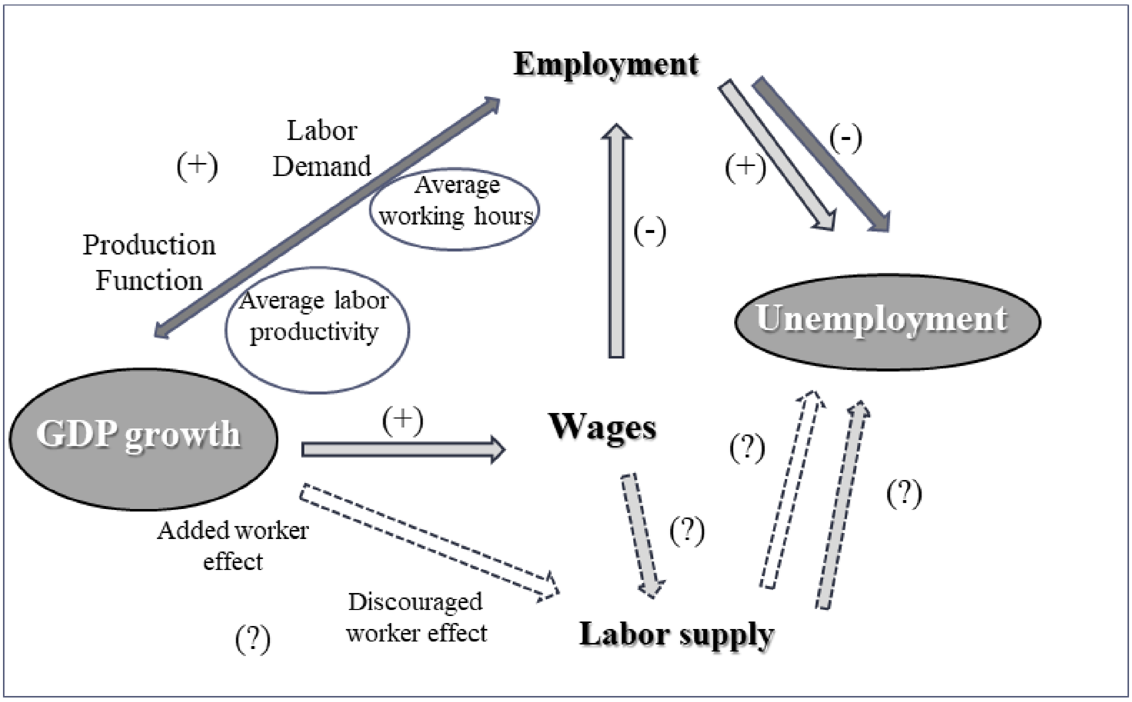

Fig. 1 Indirect Relationship Between Unemployment and Economic Growth
(*Source*: Based on Porras-Arena & Martín-Román (2023a).)

Regarding labor supply, changes in economic activity may also exert significant influence, though the direction of the effect is not theoretically unambiguous due to the presence of competing mechanisms. On one hand, during economic downturns, the loss of household income may prompt previously inactive individuals to enter the labor market in an attempt to compensate for the loss—a phenomenon known as the *added worker effect* (Humphrey, 1940; Woytinsky, 1940). In such cases, labor supply increases during recessions and decreases during expansions, indicating countercyclical behavior. On the other hand, the *discouraged worker effect* occurs when individuals cease searching for employment during economic contractions due to diminished job prospects (Long, 1953; 1958), causing labor supply to decline and behave procyclically. As such, the net effect of economic activity on labor supply depends on which of these effects dominates. Martín-Román (2022) reviews a range of studies that attempt to identify the prevailing mechanism, with findings varying across countries and time periods.

Fluctuations in economic activity can also influence both labor supply and employment through their impact on wages. Regardless of the specific transmission mechanism—whether stemming from rising labor productivity or increased bargaining power during collective negotiations—economic growth is typically associated with upward pressure on wages. According to labor demand theory, however, higher wages tend to reduce employment due to the negative direct price elasticity of labor demand (Hamermesh, 1993), thereby contributing to an increase in unemployment. The response of labor supply to wage changes is theoretically ambiguous: it may increase due to the substitution effect or decrease due to the income effect. Consequently, wage increases induced by economic growth can give rise to a complex interaction of effects. On the one hand, they have a negative effect on employment and consequently cause increases in unemployment, but at the same time, wages can generate increases or decreases in labor supply, creating an a priori uncertain effect on unemployment.

Therefore, the Okun coefficient, typically derived from a single-equation model linking GDP growth and unemployment, implicitly captures the cumulative influence of these diverse mechanisms (Ismihan, 2016). Some effects reinforce the negative relationship, while others weaken it, leading to variation in the magnitude and stability of the coefficient across countries and time periods.

Structural changes in the relationship between labor supply and demand in response to GDP growth can indirectly influence the correlation between output and unemployment, leading to significant variations in Okun's Law over time (Ismihan, 2016). Accordingly, Ismihan argues for the development of a broader analytical framework that captures the multifaceted ways in which economic growth affects unemployment.

Similarly, Sögner and Stiassny (2002), in a cross-country study, document evidence of instability in Okun coefficients and explore whether such variation is attributable to labor supply- or demand-side. However, none of these studies estimate Okun's relationship within a multi-equation framework that explicitly models the dynamics and interactions of key labor market variables.

A more recent contribution by Lim et al. (2021) adopts a labor market flows framework to analyze the behavior of the Okun coefficient in the United States. This approach allows for a more nuanced understanding of why the Okun coefficient may exhibit time-variation, asymmetry, or constancy over different periods. Their model includes not only unemployment but also the dynamics of employment and labor supply, thereby offering a more complete picture of the mechanisms driving the relationship between economic growth and unemployment.

2.2. Formalizing the indirect relationship

Of the three methods proposed by Okun (1962) to estimate the relationship between economic growth and unemployment, the two most commonly used are the difference model and the gap model:

$$\Delta u_t = \alpha_0 + \alpha_1 \Delta y_t + \epsilon_t \quad (1)$$

$$u_t - u_t^* = \beta_0 + \beta_1 (y_t - y_t^*) + \varepsilon_t \quad (2)$$

The difference model (Equation (1)) links changes in GDP (Δy_t) with changes in the unemployment rate (Δu_t), where α_1 is the coefficient of interest. In contrast, the gap model (Equation (2)) captures the relationship between deviations of actual GDP and unemployment from their potential or natural levels, with β_1 as the key parameter.[3] However, as outlined above, both α_1 and β_1 summarize the multiple channels through which GDP growth influences the labor market.

The labor market can be represented in simplified form by the following system of equations:

- **Employment**: $n_t = c_n + \rho_1 w_t + \rho_2 y_t$ (3)
- **Labor supply**: $lf_t = c_{lf} + \tau_1 w_t + \tau_2 y_t + \tau_3 z_t$ (4)
- **Wages**: $w_t = c_w + \gamma_1 y_t$ (5)

[3] Variables marked with an asterisk refer to their natural or potential values.

- **Unemployment**: $u_t \cong lf_t - n_t$ (6)

Here, n_t, lf_t , w_t and u_t are endogenous variables representing employment, labor supply, real wages, and the unemployment rate, respectively. The exogenous variables are output or GDP (y_t), the working-age population (z_t) and constants c_i , (i=n, lf , w). All variables are in natural logarithms ($x_t = lnX_t$), except for u_t, which is expressed as a rate.

Employment is represented by Equation (3). Within the framework of cost-minimization theory for the production of goods and services under a constant elasticity of substitution (CES) technology (Hamermesh, 1993), firms' demand for labor is negatively related to wages and positively related to economic activity. Accordingly, the elasticity of substitution between capital and labor (ρ_1) is expected to be negative, while the elasticity of employment with respect to output (ρ_2) is expected to be positive.

Labor supply is described by Equation (4). Participation decisions are assumed to depend on real wages (τ_1), economic activity or GDP (τ_2), and the working-age population (τ_3). The signs of τ_1 and τ_2 are ambiguous, as both real wages and economic activity can influence labor supply in either direction. In contrast, τ_3 is expected to be positive, since the working-age population constitutes the pool of potentially active individuals.

Real wages are modeled in Equation (5). For more than half of the period analyzed in this study, wages in Uruguay were determined through collective bargaining within the framework of Wage Councils.[4] These negotiations involve worker representation through unions, employer representation via business chambers, and the government. During periods of economic expansion, workers' bargaining power tends to increase, leading to higher wage settlements (γ_1>0), while the opposite holds during recessions. Thus, economic growth creates favorable conditions for increases in real wages.

The final Equation (6) expresses the unemployment rate as a residual variable, derived from the difference between labor supply and employment, with both variables in logarithmic form. When this equation is expressed in first differences, we obtain

$$u_t - u_{t-1} \cong (lf_t - n_t) - (lf_{t-1} - n_{t-1})$$

$$\Delta u_t \cong (lf_t - lf_{t-1}) - (n_t - n_{t-1}) \qquad (7)$$

[4] In 2005, Uruguay's first left-wing coalition government reinstated the Wage Councils—tripartite bodies composed of labor unions, employer associations, and government representatives—organized by industry to negotiate wage increases and other aspects of labor relations.

Defining the growth rate of a variable X_t as $g_{xt} = x_t - x_{t-1}$, where $x_t = lnX_t$, the change in the unemployment rate approximately equals the difference between the growth rates of labor supply and employment:

$$\Delta u_t \cong g_{lft} - g_{nt} \tag{8}$$

Using Equation (3) and noting that $g_{nt} = n_t - n_{t-1}$, we derive:

$$g_{nt} = (c_n + \rho_1 w_t + \rho_2 y_t + \epsilon_{nt}) - (c_n + \rho_1 w_{t-1} + \rho_2 y_{t-1} + \epsilon_{nt-1}) \tag{9}$$

Assuming $\epsilon_{nt} = \epsilon_{nt-1}$, this simplifies to:

$$g_{nt} = \rho_1(w_t - w_{t-1}) + \rho_2(y_t - y_{t-1})$$

$$g_{nt} = \rho_1 g_{wt} + \rho_2 g_{yt} \tag{10}$$

This suggests that the employment growth rate is a weighted sum of the growth rates of real wages and GDP. By applying similar reasoning to Equations (4) and (5), we derive expressions for the growth rates of labor supply and real wages:

$$g_{lft} = \tau_1 g_{wt} + \tau_2 g_{yt} + \tau_3 g_{zt} \tag{11}$$

$$g_{wt} = \gamma_1 g_{yt} \tag{12}$$

Substituting Equation (12) into Equations (10) and (11) and simplifying results in:

$$g_{nt} = (\rho_2 + \rho_1\gamma_1) g_{yt} \tag{13}$$

$$g_{lft} = (\tau_1\gamma_1 + \tau_2) g_{yt} + \tau_3 g_{zt} \tag{14}$$

Substituting Equations (13) and (14) into Equation (8) gives:

$$\Delta u_t \cong \theta_1 g_{yt} + \theta_2 g_{zt} \tag{15}$$

where:

$$\theta_1 = \tau_2 - \rho_2 + \tau_1\gamma_1 - \rho_1\gamma_1 \tag{16}$$

$$\theta_2 = \tau_3 \tag{17}$$

Equation (15) links changes in the unemployment rate to GDP growth, similar to the relationship described by Okun's law in Equation (1).[5] However, Equation (16) highlights that this relationship is not straightforward, as the parameter θ_1 embodies the multiple channels through which output influences unemployment. Specifically, it captures both the direct effects of GDP on labor supply (τ_2) and employment (ρ_2), as well as the indirect effects mediated through real wages, which subsequently affect labor supply ($\tau_1\gamma_1$) and employment ($\rho_1\gamma_1$).

By estimating each parameter within a multi-equation system (Equations (3) to (5)) that models labor market behavior, we can identify the transmission mechanisms through which economic activity affects unemployment. This approach provides an alternative method for estimating Okun's law and offers insights into the structural factors underlying Uruguay's relatively low Okun coefficient compared to those observed in more advanced economies.

3. Empirical Strategy

The empirical strategy involves multiple stages. First, each labor market equation (employment equation, labor supply equation and wage equation) is estimated individually, and cointegration analysis is conducted for the variables in each equation. If cointegration is confirmed, the equation is re-estimated, retaining only the statistically significant variables. Subsequently, the coefficients are re-estimated using both Ordinary Least Squares (OLS) and Three-Stage Least Squares (3SLS), based on the system comprising the four labor market equations (Equations (3) to (6)). The system is then solved to generate estimates of the endogenous variables, which are compared with their observed values. Finally, a simulation exercise is conducted using the estimated system to assess the impact of a change in GDP on unemployment.

Equations (3) through (5) are estimated using the Autoregressive Distributed Lag (ARDL) modeling framework, incorporating the cointegration approach developed by Pesaran and Shin (1999), and Pesaran et al. (1996, 2001). At this stage, the presence of cointegration among the variables in each equation is tested. When cointegration is confirmed, the models are re-estimated using the optimal lag structure selected for each variable.

[5] Additionally, the model includes a term ($\theta_2 g_{zt}$), to account for the effect of working-age population growth on unemployment—an effect that, in the estimation of Equation (1), would likely be absorbed by the residuals.

The error correction representation of an ARDL(q,q) model with one endogenous and one exogenous variable is specified as:

$$\Delta Y_t = \delta_0 + \varphi_0 Y_{(t-1)} + \varphi_1 X_{(t-1)} + \sum_{i=1}^{i=q} \delta_i \Delta Y_{(t-i)} + \sum_{i=0}^{i=q} \theta_i \Delta X_{(t-i)} + \varepsilon_t \quad (18)$$

where Y_t denotes the dependent variable and X_t represents the exogenous variable, both at time t.

Cointegration was tested using the *Bounds test*, which applies standard F and t-statistics. The *F-test* assesses the joint significance of the lagged level variables ($\varphi_0 = \varphi_1 = 0$), while the *t-test* examines the individual significance of the lagged endogenous variable ($\varphi_0 = 0$), using the critical values provided by Pesaran and Shin (2001). These tests were conducted under the assumption of homoscedastic, non-autocorrelated, and normally distributed residuals

When lagged dependent variables are included among the regressors, the total (or long-run) effect of *X* on *Y*, based on Equation (18), is given by:

$$\text{Total effect of } X \text{ on } Y = \frac{\varphi_1}{\varphi_0} \quad (19)$$

Once the dynamics of each labor market equation are specified—that is, once the models explaining labor demand, labor supply, and wages are defined—all coefficients are re-estimated using a system of simultaneous equations. This system, which includes Equation (6), allows for the interaction among labor market variables. Due to the potential shortcomings of Ordinary Least Squares (OLS)—in particular, endogeneity and correlation between explanatory variables and the residuals arising from the inclusion of lagged dependent variables—the system was ultimately estimated using Three-Stage Least Squares (3SLS). The instruments used included lags of the explanatory variables.

If the labor market is accurately captured by the estimated system of equations, then the projected values of the endogenous variables—employment (n_t), labor supply (lf_t), wages (w_t), and unemployment (u_t) —obtained from the dynamic solution of the system should closely match their observed historical trajectories. This comparison provides a measure of the overall fit of the multi-equation model.

Finally, if this modeling approach is to be considered a valid alternative to the traditional estimation of Okun's Law, the implied effect of GDP changes on the unemployment rate, as derived from the system, should be consistent with that estimated from the conventional specification (Equations (1) and (2)). Given that the primary objective of this study is to investigate the transmission channels through which GDP fluctuations affect unemployment, a simulation exercise was conducted using the parameters estimated from the system. Specifically, a 1% increase in GDP was simulated, and its indirect impact on unemployment was analyzed through the resulting changes in employment, labor supply, and wages. As noted, the final impact on the unemployment rate from this simulation is expected to be of similar magnitude to the Okun coefficient obtained from the single-equation model that includes only GDP growth and the first difference of the unemployment rate as variables.

4. Results

4.1. Coefficient Estimation

First, it is confirmed that the variables included in the models are first-order integrated (Table A1 in the Appendix). Next, Table A2 in the appendix presents the results of the cointegration analysis for the variables in each equation. As shown, the models exhibit well-behaved residuals, and in all cases, the null hypothesis of no cointegration is rejected, indicating the presence of long-run relationships among the variables. For the employment and labor supply equations, the *Bounds test* yields statistically significant results in models that include up to one lag of the variables. Specifically, both the *F*- and *t-statistics* exceed the critical values provided by Pesaran et al. (2001). In contrast, for the wage equation, the hypothesis of cointegration cannot be rejected regardless of the number of lags included, further supporting the presence of long-run relationships.

Following confirmation of cointegration, each equation was re-estimated in levels, retaining only the statistically significant lags of the relevant variables. Subsequently, the system of equations was jointly estimated using the specifications derived from the individual models.

When working with quarterly data, it is common for lagged dependent variables to partially explain the behavior of the corresponding variable at time t, due to the inherent inertia observed in labor market dynamics—such as employment, labor supply, and wages—throughout the year. For Uruguay, this phenomenon was previously analyzed by Leites and Porras-Arena (2016). Accordingly, the system was estimated using the Three-Stage Least Squares (3SLS) method, employing lagged variables as instruments. This approach mitigates potential endogeneity issues that arise from including lagged dependent variables as regressors (see Table 1).

Table 1 Results of the Estimation of the Multi-Equational Labor Market System in Uruguay (Three-Stage Least Squares, 1994.Q1-2023.Q4)

Employment (n_t)			Labor supply (lf_t)			Wages (w_t)		
Variable	coeff.	p-value	Variable	coeff.	p-value	Variable	coeff.	p-value
$n_{(t-1)}$	0.80	0.00	$lf_{(t-1)}$	0.79	0.00	$w_{(t-1)}$	0.94	0.00
y_t	0.11	0.00	y_t	0.06	0.00	y_t	0.07	0.01
$w_{(t-4)}$	-0.06	0.00	$w_{(t-4)}$	-0.03	0.00	$y_{(t-1)}$	-0.15	0.00
c	2.57	0.00	z_t	0.12	0.02	$y_{(t-2)}$	0.11	0.00
			c	1.04	0.07	c	0.12	0.00

Elasticities: Total effect					
Emp.-GDP	0.57	Lf-GDP	0.30	W-GDP	0.59
Emp.-W	-0.29	Lf-W	-0.16		
		Lf-Z	0.59		

System Resid. Normality Tests:	Jarque Bera =	2.4851	prob.	0.870
System Residual Portmanteau Tests for Autocorrelations:			no autocorrelation	

Notes: Logarithmic variables: n = employment, lf = labor supply, w = wages, y = GDP, and z = working-age population. To address potential endogeneity due to correlation with contemporaneous residuals, instruments included lags (h) of the dependent variable (h > 1) and lags of the other explanatory variables. The following dummy variables were included to control for outliers and specific events: Employment equation, 1997.Q1, 2000.Q2, 2002.Q3 and 2020.Q2; labor supply equation, 1997.Q1, 1998.Q1, 2000.Q2, 2001.Q1 and 2020.Q2; wage equation, 2002.Q2, 2002.Q3, 2002.Q4, 2003.Q1 and 2009.Q1 Additionally, seasonal dummy variables were incorporated to account for recurring patterns in the data. The total effect of a given explanatory variable is calculated as the sum of its estimated coefficients (including lags), divided by one minus the sum of the coefficients of the lagged dependent variable.

The employment equation indicates that employment responds significantly to changes in both GDP and wages, with coefficient signs consistent with standard labor demand theory. Specifically, the estimated employment-GDP elasticity is 0.57, while the employment-wage elasticity is -0.29. These results imply that a 1% increase in economic activity leads to a 0.57% increase in labor demand, whereas a 1% increase in wages results in a 0.29% decline in employment. These elasticity estimates align closely with previous findings in the literature. Notably, the employment-GDP elasticity is almost identical to the estimate reported by Amarante (2000), who found a coefficient of 0.53 for the period 1982–1997. It is also near the lower bound of the confidence interval (0.59–0.77) reported by Porras-Arena and Melognio (2012), whose point estimate was 0.68 for the period 1986–2005. These results suggest that employment in Uruguay is considerably responsive to fluctuations in economic activity. As Hamermesh (1993) notes, this elasticity typically falls below one. With the exception of Japan—where labor demand appears nearly inelastic with an estimated elasticity of 0.03—estimates for other countries range from 0.2 to 0.71. It is worth noting that the studies reviewed by Hamermesh (1993) are primarily based on developed economies.

Turning to the labor supply equation, the relationship with GDP is positive, indicating procyclical behavior, with an estimated elasticity of 0.30. This suggests that in Uruguay, the "discouraged worker" effect dominates labor supply decisions—that is, individuals are more likely to enter the labor market as economic conditions improve. In contrast, the elasticity of labor supply with respect to wages is negative, at -0.16, indicating that the income effect outweighs the substitution effect. As expected, labor supply responds positively to changes in the working-age population, with an estimated elasticity of 0.59.

Finally, in the wage equation, GDP appears as a statistically significant determinant, with a wage-GDP elasticity of 0.59. This finding suggests that, although wages in Uruguay were primarily adjusted through collective bargaining for most of the analyzed period, periods of economic growth are associated with upward movements in real wages. Economic expansion strengthens workers' bargaining power during negotiations, while recessions have the opposite effect, weakening that leverage and restraining wage growth.

4.2. The Dynamic Multi-Equation Model and Simulation Exercise

Once the parameters of each equation were estimated within the multi-equation framework, the system was solved dynamically to evaluate its overall ability to represent the labor market and, more specifically, its effectiveness in projecting the trajectory of the unemployment rate. The purpose of this exercise was to assess how the model would have performed if it had been implemented at the start of the period (1994) to forecast the evolution of labor market variables over the subsequent 29 years, using the actual historical values of the exogenous variables as inputs. The results indicate that, while the model exhibits notable deviations from the actual values of some variables, it generally captures the underlying trends observed in the data (EViews 13 User's Guide II).[6]

The dynamically solved multi-equation system produces trajectories for each variable that align closely with observed patterns over time. Most importantly, it generates a reasonably accurate projection of fluctuations in the unemployment rate throughout the analysis period (see Figure 2).

Based on these findings, we conclude that the system provides a relatively good fit, successfully capturing the dynamic relationships among labor market variables and their interactions over time.

The multi-equation system was subsequently employed to estimate Okun's law as an alternative to the traditional single-equation approach, using a simulation-based exercise. The objective was to assess the impact of GDP fluctuations on unemployment—consistent with the Okun framework—while also identifying the transmission channels through which changes in GDP influence unemployment.

[6] Chapter 51. Models. pages 1080-1081.

To this end, we simulated a 1% increase in GDP at time *t* using the estimated multi-equation model. This GDP shock directly affects both employment and labor supply, while also influencing wages. The resulting wage adjustments, in turn, generate additional effects on employment and labor supply, ultimately transmitting to the unemployment rate through these interconnected channels.

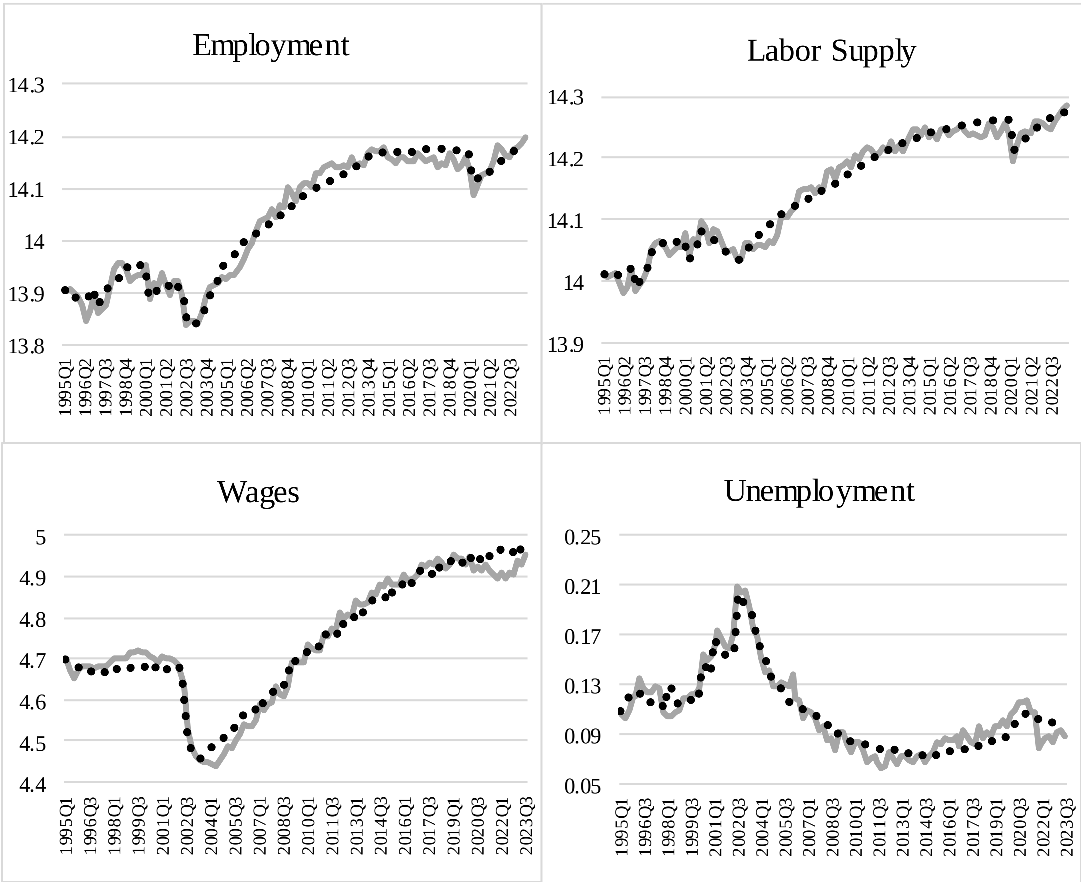

Fig. 2 - Estimated and Observed Values of Labor Market Variables in Uruguay.
Notes: Solid lines represent the observed values of the variables, while dashed lines correspond to the values estimated by the multi-equation model. Employment, labor supply, and wage variables are expressed in logarithms, while the unemployment rate is presented in percentage points.

As shown in Figure 3, a 1% increase in GDP produce an immediate increase in employment (+0.113%) and on labor supply (+0.06%). Consequently, the unemployment rate decreases due to increased job creation but simultaneously faces upward pressure as more individuals enter the labor market. The net effect is a decline in the unemployment rate of approximately 0.05 percentage points, which is in line with Okun's law estimates for Uruguay reported by Tapie et al. (2020) using quarterly data.

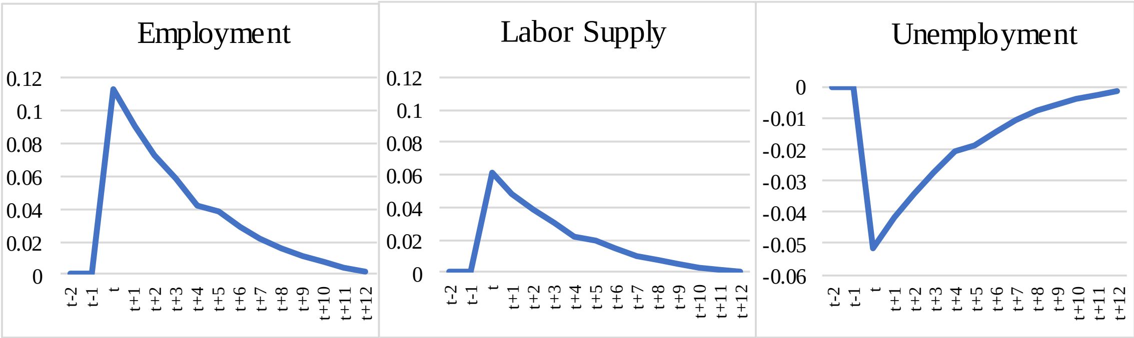

Fig.3 Effects of a 1% GDP Growth at time t on Employment, Labor Supply, and Unemployment.

Furthermore, due to inertia in employment and labor supply—and the lagged effects of GDP on these variables via wages—the impact does not dissipate immediately but persists over several quarters. Figure 4 illustrates the cumulative effect of the simulated GDP shock. The total impact on employment is approximately +0.5%, on labor supply +0.26%, and on the unemployment rate -0.24 percentage points. These findings are consistent with the Okun coefficient estimates discussed in the introduction and support the conclusion that the multi-equation system provides a valid and informative alternative for estimating Okun's law. Importantly, this approach also elucidates the mechanisms through which GDP changes affect labor market outcomes.

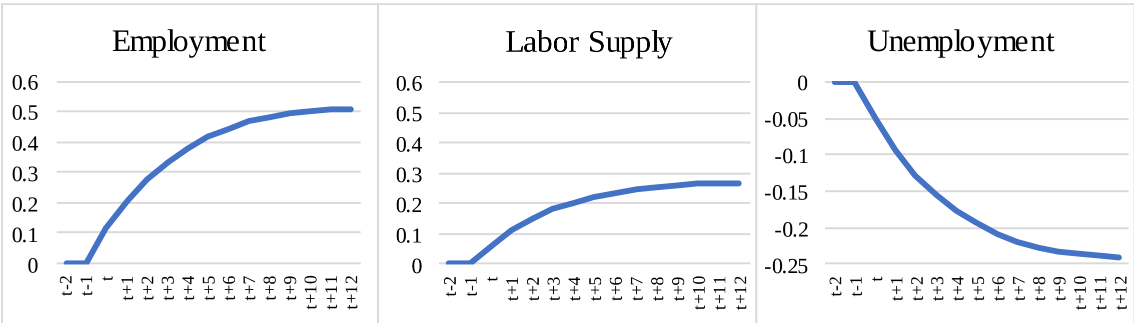

Fig. 4 Cumulative Effects of a 1% GDP Growth at time t on Employment, Labor Supply and Unemployment.

The results suggest that while employment responds positively and relatively strongly to GDP growth, the response of the unemployment rate is more muted. This weaker response is largely due to the procyclical behavior of labor supply, reflecting a dominant "discouraged worker" effect in labor supply decisions. Additionally, as GDP growth exerts upward pressure on wages, there are lagged effects on both employment and labor supply: higher wages eventually reduce employment (due to increased labor costs), which raises unemployment, while at the same time discouraging labor market participation, which lowers unemployment. The net effect of these opposing forces is a modest overall reduction in unemployment.

5. Conclusions

Okun's law, which explores the relationship between unemployment and economic growth, has been extensively studied since Arthur Okun's seminal work (1962), primarily through single-equation models such as the difference model, the gap model, and the trend-adjusted elasticity model. This article proposes an alternative approach to analyzing this relationship by estimating a multi-equation system that captures the dynamics of the labor market. The rationale for this method is that the Okun coefficient derived from a single-equation model aggregates various effects of economic growth on distinct labor market variables—namely, employment, labor supply, and wages. By employing a simulation exercise, the multi-equation framework allows for the identification of the transmission channels through which GDP growth affects unemployment, while also yielding results that are broadly consistent with those produced by traditional single-equation estimates of Okun's law.

While Okun's law is an empirically observed regularity in the Uruguayan economy, estimates of the Okun coefficient suggest that unemployment in Uruguay responds relatively weakly to economic growth compared to patterns typically found in advanced economies. The methodological approach proposed in this paper offers a novel way to investigate this relationship by identifying the channels through which fluctuations in GDP affect the unemployment rate, thereby shedding light on the factors underlying this relatively weak relationship.

The results indicate that the employment elasticity with respect to GDP in Uruguay is relatively high—approximately 0.57—placing it near the upper bound of the range observed in developed countries (0.2–0.71), as reported by Hamermesh (1993). This finding suggests that economic activity significantly influences employment in Uruguay, and thus, the weakness of Okun's law in the country is not attributable to labor demand-side dynamics.

In contrast, labor supply exhibits clear procyclical behavior, with a GDP elasticity of approximately 0.30. That is, a 1% increase in GDP leads to a 0.3% increase in labor supply, reflecting the predominance of the "discouraged worker" effect in participation decisions. Economic expansions tend to draw previously inactive individuals into the labor market, while contractions have the opposite effect.

Moreover, both employment and labor supply respond indirectly to changes in GDP through the impact of GDP growth on wages, which exhibit a positive elasticity of 0.59. Through this wage channel, a

1% increase in GDP leads to a 0.17% decrease in employment (= 0.59 × -0.29) and a 0.09% decrease in labor supply (= 0.59 × -0.16).

Taking both direct and indirect effects into account, the total impact of GDP on employment is 0.40 percentage points (0.57 from the direct GDP effect minus 0.17 from the wage-induced effect). Similarly, the net impact on labor supply is an increase of 0.21 percentage points (0.30 from the direct GDP effect minus 0.09 from the wage channel). As a result, a 1% increase in GDP leads to an overall reduction in the unemployment rate of approximately 0.2 percentage points. This estimate aligns closely with previous findings in the literature, reinforcing the validity of this multi-equation modeling approach as a robust alternative for estimating Okun's law.

The relatively weak Okun coefficient in Uruguay, therefore, appears to be driven primarily by the procyclical nature of labor supply. If labor supply were not procyclical—or if its elasticity with respect to GDP were lower—the impact of economic growth on unemployment would be more pronounced. For instance, during periods of economic expansion, job creation shifts individuals from unemployment to employment. However, these same conditions may also encourage individuals previously classified as inactive to re-enter the labor force in search of work, thereby increasing the number of individuals categorized as unemployed, at least temporarily.

These findings carry important implications for economic policy. Much of the existing literature attributes weak unemployment responses to labor demand factors such as labor market rigidities, sectoral composition of output, or differences in labor productivity. Consequently, policy recommendations often focus on labor market deregulation or structural reform. However, this study shows that the Uruguayan labor market exhibits relatively strong employment responsiveness to GDP fluctuations by international standards.

Conversely, the procyclical behavior of labor supply suggests that during economic downturns, the official unemployment rate may understate the true extent of labor market distress. The discouraged worker effect causes some individuals to exit the labor force altogether, thereby reducing the number of people officially counted as unemployed. As a result, policymakers may underestimate the severity of unemployment during recessions, potentially leading to insufficient or mistargeted policy responses.

References

Amarante, V. 2000. Long-run output-employment elasticity in Uruguay. Working paper IECON-FCEA UdelaR 6/00.

Balakrishnan, R., D.Mitali and K. Prakash. 2010. Unemployment dynamics during recessions and recoveries: Okun's law and beyond. In: World Economic Outlook: Rebalancing Growth, Washington, D.C. IMF, 69-107.

Ball L, D. Furceri, D. Leigh and P. Loungani. 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

Blanchard O, A. Amighini and F. Giavazzi. 2010. *Macroeconomics: A European perspective*. Pearson Education Limited, UK.

Boďa, M.and M. Považanová. 2023. How credible are Okun coefficients? The gap version of Okun's law for G7 economies. *Economic Change and Restructuring*, 56:1467–1514.

Cazes, S., S. Verick and F. Al Hussami. 2013. Why did unemployment respond so differently to the global financial crisis across countries? Insights from Okun's. Law. *IZA Journal of Labor Policy*, 2(10), 1-18. https://doi.org/10.1186/2193-9004-2-10

Hamermesh, D. 1993. *Labor Demand*. Princeton: Princeton University Press.

Herwartz, H. and A. Niebuhr. 2011. Growth, unemployment and labour market institutions: evidence from a cross-section of EU regions. *Applied Economics*, 43(30), 4663-4676 https://doi.org/10.1080/00036846.2010.493142

Humphrey, D.D. 1940. Alleged 'Additional Workers' in the measurement of unemployment. *Journal of Political Economy*, 48(3), 412–419. http://dx.doi.org/10.1086/255563

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

Leites, M. and M.S. Porras-Arena. 2016. Unemployment dynamics in Uruguay: an analysis using chain reaction theory. *Cepal Review* 120, 95-117. https://doi.org/10.18356/8235f62b-en

Lim, G.C., R. Dixon and J.C. Van Ours. 2021. Beyond Okun's law: output growth and labor market flows. *Empirical Economics*, 60,1387–1409. https://doi.org/10.1007/s00181-019-01794-2

Long, C.D. 1953. Impact of effective demand on the labor supply. *American Economic Review*, 43(2),458–467. http://www.jstor.org/stable/1831509

______1958. The labor force in severe depressions. In: C. D. Long (Ed.), *The labor force under changing income and employment*. Princeton: Princeton University Press, 181–201

Martín-Román, Á. 2022. Beyond the added-worker and the discouraged-worker effects: the entitled-worker effect. *Economic Modelling*, 110, 105812. https://doi.org/10.1016/j.econmod.2022.105812

Merlo, G. and M.S. Porras-Arena. 2019. GDP growth and unemployment: validity of Okun's law for Uruguay. Working paper IECON-FCEA, UdelaR 24/19.

Okun, A. 1962. Potential GNP: its measurement and significance. Cowles Foundation Paper 190. Cowles Foundation, Yale University, New Haven.

Pesaran, M.H. and Y. Shin. 1999. An Autoregressive Distributed-Lag Modelling Approach to cointegration analysis. In: Strøm S (ed) Econometrics and Economic Theory in the 20h Century: The Ragnar

Frisch Centennial Symposium. Econometric Society Monographs. Cambridge University Press: 371-413.

Pesaran, M.H., Y. Shin and R.J. Smith. 1996. Testing for the 'Existence of a Long-run Relationship'. Cambridge Working Papers in Economics 9622, Faculty of Economics, University of Cambridge.

______2001. Bounds testing approaches to the analysis of level relationships. *Journal of Applied Economics*, 16(3), 289-326. https://doi.org/10.1002/jae.616

Porras-Arena, M.S. and E. Melognio. 2012. Elasticity of labour demand in Uruguay. *Revista de Economía y Estadística*, 50(1), 93–121.

Porras-Arena, M.S. and Á. Martín-Román. 2023a. Okun's law: The relationship between unemployment and economic growth. In: Zimmermann, K.F. (eds) *Handbook of Labor, Human Resources and Population Economics*. Springer, Cham. https://doi.org/10.1007/978-3-319-57365-6_433-

______2023b. The correlation between unemployment and economic growth in Latin America – Okun's law estimates by country. *International Labour Review*, 162, 171-198. https://doi.org/10.1111/ilr.12398

______2023c. The heterogeneity of Okun's law: A metaregression analysis. *Economic Modelling*, 128, 106490. https://doi.org/10.1016/j.econmod.2023.106490

Sogner, L. and A. Stiassny. 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

Tapie, P., M. Suárez-Cal and V. Rodríguez. 2020. Okun's relationship in Uruguay: a review in the face of COVID-19 shock. Student Research Papers IECON-FCEA, UdelaR 04-20.

Villaverde, J. and A. Maza. 2009. The robustness of Okun's law in Spain, 1980–2004. Regional evidence. *Journal of Policy Modeling*, 31, 289–297. https://doi.org/10.1016/j.jpolmod.2008.09.003

Woytinsky, W.S. 1940. Additional workers on the labor market in depressions: A reply to Mr. Humphrey. *Journal of Political Economy*, 48(5), 735–739. http://dx.doi.org/10.1086/255613

Appendix

Table A1 Unit Root Test

		Augmented Dickey-Fuller				KPSS	
		Level		1st difference		1st difference	
Variables	Model with:	statistic	p-value	statistic	p-value	LM-Stat.	
n_t	constant	-0.9491	0.769	-12.0925	0.000		
	constant, linear trend	-1.9985	0.596	-12.0431	0.000		
lf_t	constant	-1.5556	0.502	-13.6175	0.000		
	constant, linear trend	-3.2323	0.083	-13.6251	0.000		
y_t	constant	-0.6472	0.855	-3.7009	0.005		
	constant, linear trend	-1.8391	0.679	-3.6848	0.027		
w_t	constant	-0.7179	0.837	-3.0921	0.030		
	constant, linear trend	-2.1188	0.530	-3.2283	0.084	0.0996	(a)
z_t	constant	-0.5121	0.884	-2.0959	0.247	0.1772	(b)
	constant, linear trend	-3.2464	0.081	-2.0925	0.544	0.1037	(a)
u_t	constant	-1.4804	0.540	-11.0560	0.000		
	constant, linear trend	-2.1962	0.487	-11.0465	0.000		

The variables are: employment (n), labor supply (lf), wages (w), GDP (y), unemployment (u), and working-age population (z), all in logarithms except for unemployment which is a rate. The null hypothesis in the ADF Unit Root test is rejected when the p-value is less than 0.05. When the ADF Unit Root test was inconclusive, the Kwiatkowski-Phillips-Schmidt-Shin Unit Root test was applied. The null hypothesis of the KPSS test is that the variable is stationary, and in all cases this hypothesis was not rejected. The LM-Stat was below the critical value at 5% in all cases, which was 0.146 in (a) and 0.463 in (b).

Table A2 Cointegration test

		Lags							
		i=4		**i=3**		**i=2**		**i=1**	
Employment:	$\Delta n_t = \alpha_0+\alpha_1 n_{t-1}+\alpha_2 y_{t-1}+\alpha_3 w_{t-1}+\sum\alpha_{ni}\Delta n_{t-i}+\sum\alpha_{yi}\Delta y_{t-i}+\sum\alpha_{wi}\Delta w_{t-i}+\sum\alpha_{Ds}D_{st}$								
Selection criteria	Akaike	-5.70		-5.69		-5.73	●	-5.72	
	Schwarz	-5.25		-5.32		-5.43		-5.49	●
Residual Diagnostics (2)	Normality	0.52		0.54		0.77		0.85	
	LM Test (4)	0.98		0.73		0.81		0.34	
	LM Test (1)	0.81		0.84		0.91		0.08	
	Heteroskedasticity	0.28		0.20		0.26		0.13	
Bounds test (3)	t-statistic (α_1=0)	-2.80		-3.17		-3.44	*	-4.15	***
	F-statistic ($\alpha_1=\alpha_2=\alpha_3$=0)	3.53		4.18		4.88	**	6.47	***
Labor supply:	$\Delta lf_t = \beta_0 + \beta_1 lf_{t-1}+\beta_2 y_{t-1}+\beta_3 w_{t-1}+\beta_4 z_{t-1}+\sum\beta_{lfi}\Delta lf_{t-i} + \sum\beta_{yi}\Delta y_{t-i} + \sum\beta_{wi}\Delta w_{t-i}+ \sum\beta_{zi}\Delta z_{t-i}+ \sum\beta_{Dm}D_{mt}$								
Selection criteria	Akaike	-5.54		-6.04		-6.09	●	-6.04	
	Schwarz	-5.89		-5.54		-5.68		-5.73	●
Residual Diagnostics	Normality	0.93		0.65		0.54		0.45	
	LM Test (4)	0.46		0.53		0.97		0.42	
	LM Test (1)	0.42		0.27		0.90		0.21	
	Heteroskedasticity	0.87		0.57		0.60		0.36	
Bounds test	t-statistic (β_1=0)	-2.70		-3.28		-3.43		-5.14	***
	F-statistic ($\beta_1=\beta_2=\beta_3=\beta_4$=0)	2.65		3.07		3.09		6.69	***
Wages:	$\Delta w_t = \gamma_0 + \gamma_1 w_{t-1}+ \gamma_2 y_{t-1}+\sum\gamma_{wi}\Delta w_{t-i} + \sum\gamma_{yi}\Delta y_{t-i} + \sum\gamma_{Dv}D_{vt}$								
Selection criteria	Akaike	-6.34		-6.37		-6.39	●	-6.33	
	Schwarz	-5.92		-5.99		-6.06	●	-6.05	
Residual Diagnostics	Normality	0.61		0.64		0.77		0.80	
	LM Test (4)	0.70		0.84		0.98		0.89	
	LM Test (1)	0.53		0.70		0.98		0.76	
	Heteroskedasticity	0.97		0.94		0.88		0.87	
Bounds test	t-statistic (γ_1=0)	-3.95	***	-4.07	***	-4.78	***	-3.94	***
	F-statistic ($\gamma_1=\gamma_2$=0)	8.89	***	9.52	***	12.65	***	9.19	***

The equations are specified in error-correction form. The variables include employment (n), labor supply (lf), wages (w), GDP (y), and the working-age population (Z), all expressed in logarithmic terms. Dummy variables (D) are included to account for outliers. Residual diagnostics are reported as p-values. The LM-Test (4) refers to the Lagrange Multiplier test for autocorrelation, with the null hypothesis of no autocorrelation up to four lags; LM-Test (1) tests for autocorrelation up to one lag. The Bound test is conducted using the critical values provided by Pesaran, Shin, and Smith (2001). * Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.