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ASYMMETRIC EFFECTS OF ISCED4 GRADUATES ON TOTAL AND YOUTH UNEMPLOYMENT IN ROMANIA: EVIDENCE FROM A NARDL FRAMEWORK

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Abstract

The aim of this article is to analyse how changes in the number of post-secondary non-tertiary education (ISCED4) graduates influence the total unemployment rate and the youth unemployment rate in Romania over the period 1991-2023. Using a nonlinear autoregressive distributed lag (NARDL) framework, we decompose lnISCED4 into positive and negative partial sums to test for potential short-run and long-run asymmetries while controlling for EU accession and the global financial crisis. The NARDL results for total unemployment suggest a long-run relationship and significant short- and long-run asymmetry. However, with controls included, the long-run coefficients on lnISCED4^{+} and lnISCED4^{-} are imprecise, implying that asymmetry mainly reflects short-run adjustment. A benchmark linear ARDL model provides stronger evidence of cointegration and points to a modest negative long-run association between lnISCED4 and total unemployment. For youth unemployment, the NARDL estimates show robust short-run asymmetry. Increases in ISCED4 graduates are followed by short-run increases in youth unemployment, whereas decreases are also associated with subsequent short-run increases, while long-run education-related coefficients remain statistically insignificant. Robustness checks using labour force normalised ISCED4 intensity measures indicate that long-run asymmetry and levels relationships are sensitive to scaling and a shorter 1996-2023 window. These findings underline that expansions in intermediate vocational supply may generate temporary youth labour market pressures when absorption and matching mechanisms are weak and may support policymakers in designing complementary measures to improve school-to-work transitions.

Keywords: *unemployment, education, nonlinear, model, lag*

JEL Classification: *E24*

1. Introduction

In the context of globalisation and rapid technological advancements, education systems face constant pressure to provide individuals with the knowledge and skills needed for adaptability and employability. For a society to benefit from the capital invested, from the productivity of its educated human capital, and thus from the increased output driven by investment in education, graduates of various forms of education must be fully integrated into the labour market (Erdem and Tugcu 2012; Dănăcică et al. 2023).

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However, more often than not, there is no alignment between the needs of the labour market and the supply of qualified labour, resulting in the undesirable yet frequently encountered situation in which graduates transition directly from their period of educational preparation into unemployment (Dănăcică et al. 2023).

Among the various levels of education, post-secondary non-tertiary education (ISCED4) plays an important role in easing the transition from schooling to employment, yet its impact remains insufficiently explored empirically, especially in a country like Romania. The ISCED4 level of education, which includes post-secondary and foreman schools, is specifically designed to prepare graduates for specific occupations, requiring technical and professional competencies beyond upper secondary education but below the tertiary level. This intermediate qualification can strengthen job matching and labour market entry, particularly for cohorts exposed to school-to-work transition frictions (Levels et al. 2014; Bol et al. 2019).

Despite its potential contribution to employment outcomes, the role of post-secondary non-tertiary education continues to be marginal in Romania. Empirical evidence suggests that ISCED4 graduates fare better in terms of labour market integration compared to individuals who only have upper secondary or lower levels of education (Dănăcică 2013; Dănăcică 2014). For Romanian youth aged 15-29, graduates of post-secondary and foreman schools display, on average, shorter unemployment spells and a higher (re)employment probability compared to those holding university degrees, over the period under analysis (Dănăcică 2014). These findings highlight the importance of ISCED4 education in easing school-to-work transitions and in reducing unemployment among vulnerable groups. At the same time, micro-level evidence does not automatically settle the macro question of whether changes in ISCED4 graduate supply translate into measurable movements in aggregate unemployment, nor whether expansions and contractions operate through comparable adjustment mechanisms.

Although there are some studies addressing post-secondary education, macro-level empirical analyses focused exclusively on the impact of post-secondary non-tertiary education on both total and youth unemployment in Romania remain scarce. Research to date has largely focused on tertiary education, overlooking the distinctive impact of intermediate qualifications. This omission is increasingly relevant in a context in which policy debates emphasise skills mismatches, the absorption capacity of firms, and the institutional channels shaping school-to-work transitions.

This paper aims to fill this gap by analysing the extent to which changes in the number of ISCED4 graduates affect total and youth unemployment rates in Romania, during the 1991-2023 period (2023 was the most recent year for which data were available at the time of this study). The motivation for this research lies not only in the observed empirical gaps, but also in growing policy concerns regarding skills mismatches and labour market rigidities. We treat total and youth unemployment separately, given that youth labour market entry is typically characterised by stronger matching frictions and may therefore respond differently to shifts in graduate supply.

To capture the potential nonlinearity of this relationship, we employ the Nonlinear Autoregressive Distributed Lag (NARDL) model proposed by Shin et al. (2014), which allows for the identification of asymmetric short- and long-run effects. Specifically, the model tests whether increases and decreases in the number of ISCED4 graduates produce differential effects on unemployment dynamics. We estimate two separate NARDL models, one for the total unemployment rate and one for the youth unemployment rate, because we anticipate potentially distinct asymmetric effects of ISCED4 on each. Recent research underlines that skill mismatch and imperfect matching in the labour market can exacerbate unemployment and hinder the school-to-work transition, especially for young people, who face stronger entry frictions and are more vulnerable to economic downturns (Pompei and Selezneva 2021). Moreover, recent findings indicate that mismatch has a cyclical component and can shape short-run labour market adjustment mechanisms (Baley et al. 2021), while empirical analyses confirm the association between skill mismatch and adverse outcomes such as unemployment (Flórez and Gómez 2024). Therefore, this evidence supports analysing unemployment dynamics separately for total versus youth unemployment and motivates the use of empirical models that allow short-run adjustments to differ from long-run relationships (Pompei and Selezneva 2021; Baley et al. 2021; Flórez and Gómez 2024). The baseline specification is complemented with real GDP growth and emigration to reflect business cycle conditions

and labour supply shifts over the sample period. In addition, two structural dummy variables are included to account for Romania's European Union (EU) accession and the global financial crisis, two events that introduced substantial institutional and economic changes with direct implications for both educational and employment outcomes.

By focusing on a neglected level of the education system and employing an econometric framework that accounts for asymmetric effects, this study aims to contribute to the broader literature on education and labour markets in emerging economies.

The remainder of the paper is organised as follows: Section 2 reviews the related literature; Section 3 presents the data and methodology and reports the empirical results and robustness checks; Section 4 concludes.

2. Literature review

The nexus between education and labour market outcomes has long been an important topic in both economics and sociology. Grounded in human capital theory, this perspective emphasises that education is a significant investment in human capital, leading to higher labour productivity and potentially improving workers' adaptability to changing technologies and job requirements. In turn, increased productivity and efficiency are expected to result in better integration into the labour market and higher wages. Consequently, individuals with a higher level of education tend to enjoy an advantageous position in the labour market, as reflected in lower unemployment rates and higher earnings.

Numerous empirical papers have highlighted the existence of an inverse relationship between educational level and the unemployment rate. Highly educated individuals typically experience lower unemployment rates and shorter unemployment spells than those with lower educational qualifications (Becker 1964; Lubyova and van Ours 1997; Card 1999; D'Agostino and Mealli 2000; Grogan and van den Berg 2001; Domadenik and Pastore 2004; Farber 2003; Psacharopoulos and Patrinos 2004; Ollikainen 2006; Niepel 2010; Carneiro et al. 2011). At the same time, the empirical strength of this relationship varies with macroeconomic conditions, institutional settings, and the degree of matching between the education system and labour demand, particularly in countries undergoing structural transformation. However, while the relationship between highly educated graduates and unemployment has been widely investigated, limited attention has been given to analysing the short-run and long-run effects of post-secondary non-tertiary education (ISCED4) graduates on unemployment.

This gap matters for at least two reasons. First, ISCED4 programmes are explicitly designed to provide occupation-specific and practice-oriented skills beyond upper secondary education, often with the stated goal of facilitating school-to-work transitions. Second, the labour market implications of expanding or contracting intermediate post-secondary non-tertiary supply may differ across age groups and across time horizons, especially where absorption capacity is uneven and matching frictions are persistent. In this respect, the ISCED4 segment sits at the intersection of human capital accumulation and labour market institutions, and its macro-level effects remain less well documented than those of tertiary education.

Lavrinovicha et al. (2015) analysed the effect of various education levels on unemployment and incomes in Latvia and highlighted both the potential and limitations of ISCED3 and ISCED4 level of education in reducing unemployment. The authors show that the ISCED3 and ISCED4 level of education can mitigate unemployment by equipping individuals with skills that closely match labour market demands. However, the study by Lavrinovicha et al. (2015) also draws attention to a persistent mismatch between the technical training provided and the actual needs of employers, which prevents the full realisation of the benefits offered by educational programmes focused on acquiring practical skills. Although post-secondary non-tertiary education can enhance employability and thereby help reduce unemployment, its effectiveness depends on the quality and relevance of these programmes, as well as on policies aimed at better aligning graduates' skills with available job opportunities. These results highlight the potential of post-secondary non-tertiary education to address structural unemployment.

Mitrakos et al. (2010) provided important empirical evidence regarding the relationship between different levels of education and youth unemployment risks. The authors emphasised that young people in Greece experience high unemployment rates, including those who have completed higher education. However, the

unemployment rates tend to decline after a few years of professional experience. Beyond their primary focus on tertiary education graduates, the authors also examine the outcomes of individuals who completed post-secondary non-tertiary education (ISCED4), particularly graduates of Institute of Vocational Training (IEK) and similar programmes. Their findings indicate that post-secondary vocational graduates, especially IEK graduates, face higher unemployment rates than those who only completed upper secondary education, particularly in the first year following graduation. Moreover, these rates often remain elevated over time, especially among women. The authors emphasise that the effectiveness of post-secondary vocational education in reducing youth unemployment is conditional, depending heavily on the alignment between educational programmes and labour market demands. Importantly, this line of evidence also suggests that vocational expansion may generate short-run pressures on youth labour market entry, if matching and absorption do not adjust sufficiently fast, an issue that becomes particularly relevant in countries experiencing migration, demographic change, and cyclical volatility.

Blatna (2018) analysed the relationship between educational attainment and unemployment in the Czech Republic, with a specific focus on different ISCED levels during the period 2005-2017. Her results show that individuals holding ISCED3-4 qualifications display higher unemployment rates than tertiary graduates but significantly lower rates than those who do not surpass lower secondary education. Her analysis also highlights the dynamic nature of these trends: the unemployment rate among ISCED3-4 graduates is significantly influenced by macroeconomic factors, rising in tandem with increases in social benefit expenditure and falling during periods of high employment. Another central topic she addresses is early school leaving and its negative impact on employment prospects. Young people who do not complete upper secondary education face considerable difficulties when entering the labour market, being exposed to greater risks of long-term unemployment and social exclusion. In contrast, completing upper secondary education and subsequently acquiring additional qualifications through ISCED4 programmes significantly improves employment prospects and reduces the risk of social vulnerability.

A further limitation of much of the existing macro evidence is methodological. Many studies rely on linear specifications that impose symmetric adjustment, implicitly assuming that increases and decreases in education supply operate through the same channels and with comparable magnitudes. Yet labour market adjustment can plausibly be nonlinear. Expansions in graduate cohorts may generate transitional congestion or slower absorption, whereas contractions may alleviate short-run competition, with effects potentially differing between total and youth unemployment. In this context, nonlinear time-series approaches, such as the NARDL model proposed by Shin et al. (2014), offer a useful framework to test whether positive and negative changes in education variables have distinct short-run and long-run effects. Recent work using asymmetric ARDL-type models in labour market settings has reinforced the value of distinguishing between adjustment horizons and the sign of shocks, particularly when institutional breaks and macroeconomic controls matter for inference.

Although there is substantial empirical research on education and unemployment, papers focusing specifically on the impact of ISCED4 graduates on total and youth unemployment in Romania are rare. Existing literature tends either to generalise the effects of vocational education or to concentrate predominantly on tertiary education. Moreover, there is a notable lack of studies employing advanced econometric models, such as NARDL, to analyse the short- and long-run effects of post-secondary non-tertiary education on unemployment within the Romanian context. This study seeks to fill this gap by providing, for the first time, a comprehensive analysis of the dynamic effects of ISCED4 graduates on both total and youth unemployment, using the NARDL model to explore these dynamic relationships over time. In addition, by reporting benchmark linear ARDL results alongside the nonlinear specification, the analysis provides a transparent robustness check and clarifies when asymmetry adds empirical value and when a parsimonious symmetric representation is sufficient.

3. Methodological approach

To investigate whether variations in the number of ISCED4 graduates exert asymmetric effects on both the total and the youth unemployment rates in

Romania, we employ annual data covering the period 1991-2023. Data on ISCED4 graduates (post-secondary non-tertiary education, including post-secondary schools and foreman schools) are gathered from the Romanian National Institute of Statistics, Tempo-Online database (2026). The total unemployment rate (percent of the labour force) is obtained from ILOSTAT (2026). The youth unemployment rate (ages 15-24, percent of the labour force) is sourced from the World Development Indicators (WDI) series SL.UEM.1524.ZS (modelled ILO estimate) accessed via FRED. This series is used to ensure complete annual coverage over the full sample. Values are reported rounded to one decimal.

We use a nonlinear Autoregressive Distributed Lag (NARDL) model, developed by Shin et al. (2014), to capture potential asymmetries in how changes in the number of ISCED4 graduates influence unemployment dynamics. Unlike the standard ARDL specification, which assumes symmetric linear adjustment, the NARDL framework allows for positive and negative changes in the explanatory variable to exert distinct short-run and long-run effects.

The ISCED4 series is expressed in natural logarithms, while the unemployment rates remain in percent. This semi-logarithmic specification implies that a 1% change in the number of graduates is associated with a 0.01×(estimated coefficient) change in the unemployment rate, interpreted in percentage points.

Accordingly, the baseline log-linear relationships for total and youth unemployment rates are formulated as follows:

$$U_{total,t} = \beta_0 + \beta_1 lnISCED4_t + \varepsilon_t \quad (1)$$

$$U_{youth,t} = \gamma_0 + \gamma_1 lnISCED4_t + \eta_t \quad (2)$$

where: $U_{total,t}$ and $U_{youth,t}$ denote the total and youth unemployment rates, expressed as percentages of the labour force (hence, changes are interpreted in percentage points); $lnISCED4_t$ is the natural logarithm of the number of ISCED4 graduates; β_0, $\beta_1$are the intercept and slope coefficients in the first equation; γ_0 and γ_1 are the intercept and slope coefficients in the second equation; ε_t and η_t are the respective error terms.

A central feature of the NARDL methodology is the partial sum decomposition of the explanatory variable. In this study, $\mathrm{lnISCED4_t}$ is first differenced and then decomposed into its positive and negative changes as follows:

$$\Delta\mathrm{lnISCED4_t}^{+} = \max\{\Delta\mathrm{lnISCED4_t}, 0\} \quad (3a)$$

$$\Delta\mathrm{lnISCED4_t}^{-} = \min\{\Delta\mathrm{lnISCED4_t}, 0\} \quad (3b)$$

The cumulative sums of these positive and negative changes generate two separate explanatory variables, $lnISCED4_t{}^{+}$ and $lnISCED4_t{}^{-}$, which are incorporated into the NARDL model as follows:

$$\begin{aligned} U_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i U_{t-i} + \sum_{j=0}^{q^+} \beta_j^{+} \Delta lnISCED4_{t-j}^{+} \\ + \sum_{j=0}^{q^-} \beta_j^{-} \Delta lnISCED4_{t-j}^{-} \\ + \varphi^{+} lnISCED4_{t-1}^{+} \\ + \varphi^{-} lnISCED4_{t-1}^{-} + \varepsilon_t \end{aligned} \quad (4)$$

where U_t denotes the unemployment rate (either total or youth), p, q^+ , q^- denote the optimal lag orders selected according to an information criterion; β_j^+ and β_j^- represent the short-run effects of positive and negative changes in ISCED4 graduates; φ^+ and φ^- denote the corresponding long-run effects. The term ε_t is the error term.

Given that unemployment is shaped by both cyclical and structural factors, we augmented the original model with two additional controls. Real gross domestic product (GDP) growth (annual, %) is incorporated to reflect aggregate demand and business-cycle effects, whereas the natural logarithm of annual emigration, $\mathrm{lnE_t}$, is included to account for demographic shifts and changes in labour supply that may affect unemployment dynamics over the sample period. Data on real GDP growth (annual, %) are sourced from the World Bank's World Development Indicators (indicator NY.GDP.MKTP.KD.ZG, 2026). Annual emigration data (persons) are retrieved from the Romanian National Institute of Statistics (INSSE), Tempo-Online database (2026).

We estimate two separate NARDL models, one for the total unemployment rate and one for the youth unemployment rate, to assess whether positive and negative shocks in the number of ISCED4 graduates exert symmetric or asymmetric effects in both the

short- and the long-run. In addition to the core education variable, the specification includes two time-varying controls, real GDP growth and emigration, to account for macroeconomic conditions and labour supply developments over the sample period. Moreover, two structural dummy variables are introduced to capture major exogenous events that may have affected unemployment dynamics. The first, $Dummy\_EU_t$, takes the value 1 from 2007 onwards to reflect Romania's accession to the European Union (EU). EU membership marked a structural break in the country's institutional, economic, and labour market settings, affecting employment policies, educational frameworks, labour mobility, and investment flows. Including this variable allows the model to control for the impact of EU integration and to isolate the effects attributed specifically to ISCED4 dynamics. The second, $Dummy\_crisis_t$, takes the value 1 for the years 2008, 2009 and 2010, corresponding to the global financial crisis and its immediate aftermath. This period was characterised by significant disruptions in the Romanian labour market, particularly in youth employment and vulnerable sectors. By incorporating this variable, we aim to mitigate the confounding effects of the global downturn and avoid attributing short-term fluctuations in unemployment rates solely to educational indicators. These two dummy variables improve the robustness of the model by accounting for major institutional and cyclical shocks, thereby enhancing the interpretability of both short- and long-run estimates

Accordingly, equation (4) is extended to include the two control variables and the structural dummies, yielding the following augmented NARDL specification:

$$\begin{aligned} U_t = \alpha_0 &+ \sum_{i=1}^{p} \alpha_i U_{t-i} + \sum_{j=0}^{q^+} \beta_j^+ \Delta lnISCED4_{t-j}^+ \\ &+ \sum_{j=0}^{q^-} \beta_j^- \Delta lnISCED4_{t-j}^- \\ &+ \sum_{m=0}^{r} \delta_m \Delta GDP\_growth_{t-m} \\ &+ \sum_{n=0}^{s} \kappa_n \Delta lnE_{t-n} + \varphi^+ lnISCED4_{t-1}^+ \\ &+ \varphi^- lnISCED4_{t-1}^- \\ &+ \lambda\, GDP\_growth_{t-1} + \mu\, lnE_{t-1} \\ &+ \theta_1 Dummy\_EU_t \\ &+ \theta_2 Dummy\_crisis_t + \varepsilon_t \end{aligned} \tag{5}$$

where $\mathrm{GDP\_growth_t}$ denotes real GDP growth (annual, %), $\mathrm{lnE_t}$ denotes the natural logarithm of annual emigration, and the remaining notation follows equation (4).

3.1. Results of the unit root tests

Prior to estimating the NARDL model, it is essential to examine the stationarity of the time series under investigation. Since the NARDL framework proposed by Shin et al. (2014) allows for variables that are integrated of order zero, I(0), or one, I(1), but not of order two, I(2), the first step involves testing the order of integration of each variable. The Augmented

Table 1. Results of the ADF test for lnISCED4, U_total, U_youth, GDP_growth and lnE (1991-2023)

Variables	Integration level	Intercept			Trend and Intercept		
		ADF	5% crit. val.	Prob.	ADF	5% crit. val.	Prob.
U_total	0	-1.921	-2.957	0.319	-3.622	-3.568	0.0447
	1	-5.367	-2.960	p<0.001	-		
U_youth	0	-3.974	-2.968	0.005	-3.836	-3.574	0.029
	1	Not applicable (stationary in levels)					
lnISCED4	0	-1.820	-2.960	0.364	-2.201	-3.563	0.473
	1	-5.817	-2.960	p<0.001	-		
GDP_growth	0	-4.541	-2.957	0.001	-		
	1	Not applicable (stationary in levels)					
lnE	0	-1.800	-2.957	0.374	-2.216	-3.558	0.465
	1	-6.105	-2.960	p<0.001	-		

Source: Author's calculations, using EViews 10.0; critical values are those introduced by MacKinnon (1996).

Dickey-Fuller (ADF) test was employed to assess unit root properties, both in levels and in first differences. The optimal lag length was selected based on the Schwarz Information Criterion (SIC), with the maximum lag order restricted to four to account for the relatively short sample size and annual data structure. The actual lag order selected for each variable ranged between zero and four. This approach balances parsimony with the need to avoid residual autocorrelation and overfitting. All estimations were conducted using EViews 10.

The ADF results indicate a mixed order of integration: U_youth and GDP_growth are stationary in levels (I(0)), whereas lnISCED4 and lnE are stationary after first differencing (I(1)). Total unemployment rate (U_total) appears non-stationary under an intercept, but stationary once a linear trend is included, and becomes clearly stationary in first differences. Given that the subsequent NARDL and ARDL estimations are conducted under an unrestricted constant and no trend (Case 3), we classify U_total as I(1) on the basis of the intercept-only ADF specification and its strong stationarity in first differences. We underline that none of these series appears to be integrated of order two, supporting the applicability of the NARDL framework.

3.2. Results of the NARDL model

Based on the stationarity results reported above, we estimate two NARDL models, one for the total unemployment rate and another for the youth unemployment rate. Following Shin et al. (2014), the education variable is decomposed into positive and negative partial sums of lnISCED4, allowing the data to reveal whether increases and decreases in ISCED4 graduates are associated with different unemployment responses.

To place this relationship in its macroeconomic setting, we include two time-varying controls, real GDP growth (annual, %) as a proxy for cyclical demand conditions, and the logarithm of emigration, to capture labour supply and demographic shifts. We also control for major discrete shocks through two structural dummies, *Dummy_EU* and *Dummy_crisis*, as described in Section 3.

Lag orders are selected using the Akaike Information Criterion (AIC), allowing up to three lags for the dependent variable and each regressor, which is consistent with annual data and the relatively limited sample size. Both models are estimated under

Table 2. Estimated NARDL model for total unemployment rate

Variable	Coefficient	Std. Error	*t*-Statistic	*p*-value
Constant	7.988430	5.445903	1.466870	0.1681
U_total(-1)	0.075759	0.230918	0.328078	0.7485
U_total(-2)	0.259800	0.226913	1.144933	0.2746
$\ln ISCED4^{+}$	3.548553	3.257301	1.089415	0.2974
$\ln ISCED4^{+}(-1)$	3.576926	3.289777	1.087285	0.2983
$\ln ISCED4^{+}(-2)$	−5.716172	2.682652	−2.130792	0.0545*
$\ln ISCED4^{-}$	−6.386056	3.511552	−1.818585	0.0940*
$\ln ISCED4^{-}(-1)$	−6.698857	3.289537	−2.036414	0.0644*
$\ln ISCED4^{-}(-2)$	1.865222	4.421147	0.421887	0.6806
$\ln ISCED4^{-}(-3)$	10.739872	4.324311	2.483603	0.0288**
GDP_growth	−0.136970	0.059152	−2.315557	0.0391**
GDP_growth(-1)	−0.166383	0.049897	−3.334551	0.0059***
GDP_growth(-2)	−0.137366	0.045568	−3.014539	0.0108**
GDP_growth(-3)	−0.075412	0.033617	−2.243293	0.0445**
lnE	−0.127768	0.435525	−0.293365	0.7743
lnE(-1)	−0.684493	0.491292	−1.393251	0.1888
Dummy_EU	−0.257800	0.931566	−0.276738	0.7867
Dummy_crisis	0.779726	0.705317	1.105499	0.2906
R-squared	**0.8923**			
Durbin-Watson	**2.4520**			

*, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

Source: Author's calculations, using EViews 10 (Case 3; AIC-selected ARDL(2,2,3,3,1); adjusted sample 1994-2023); $\ln ISCED4^{+}$ and $\ln ISCED4^{-}$ denote the cumulative partial sums of positive and negative changes in lnISCED4, as in Shin et al. (2014).

Case 3, unrestricted constant and no trend (Pesaran et al. 2001; Shin et al. 2014). The partial-sum components of lnISCED4 were constructed following the Shin et al. (2014) partial-sum decomposition and were initialised at zero in the first available sample year to preserve the maximum common estimation sample implied by the lag structure. Table 2 presents the estimated coefficients of the NARDL model for the total unemployment rate. For the $(U_t, \ln ISCED4^+, \ln ISCED4^-, GDP\_growth, \ln E)$ specification, the selected NARDL-ARDL representation is ARDL(2,2,3,3,1) over the adjusted sample 1994-2023 (30 observations).

As shown in Table 2, the estimated NARDL specification for total unemployment shows substantial explanatory power, with $R^2 = 0.8923$. The Durbin-Watson statistic (2.4520) does not suggest strong residual autocorrelation. However, the autoregressive terms are not statistically significant in the selected specification. The regression coefficients for U_total(-1) and U_total(-2) are positive, but not statistically significant (p=0.7485 and p=0.2746, respectively), suggesting limited evidence of short-run persistence once the remaining dynamics are accounted for.

Regarding the positive and negative components of the logarithm of the number of ISCED4 graduates, the estimated dynamic distributed lag coefficients in the ARDL model indicate a more differentiated and lag-dependent pattern. The coefficients on $\ln ISCED4^+$ and $\ln ISCED4^+(-1)$ are positive but not statistically significant, while $\ln ISCED4^+(-2)$ is negative and marginally significant (p=0.0545). For the negative component, $\ln ISCED4^-$ and$\ln ISCED4^-(-1)$ are negative and marginally significant (p=0.0940 and p=0.0644), whereas $\ln ISCED4^-(-3)$ is positive and statistically significant (p=0.0288). These estimates suggest that changes in ISCED4 graduates may affect total unemployment with delays and with signs that differ across lags, rather than through a single robust contemporaneous effect.

Regarding the control variables, GDP_growth enters with a consistently negative sign across the contemporaneous term and all included lags, and the coefficients are statistically significant (p=0.0391 for GDP_growth, and p=0.0059, p=0.0108 and p=0.0445 for lags 1-3). Taken together, these results indicate that stronger economic growth is associated with lower total unemployment in Romania, even after controlling for the model's dynamics and the other covariates. Emigration, in logs, enters with the expected negative sign, but the effect is not statistically significant, either contemporaneously or with one lag (p=0.7743 and p=0.1888). Similarly, neither the EU accession dummy nor the crisis dummy is statistically significant (p=0.7867 and p=0.2906). This result suggests that, conditional on unemployment dynamics and the macroeconomic controls, these discrete events do not contribute additional explanatory power in the selected specification.

Before conducting the asymmetry tests, a set of standard diagnostic checks was performed to evaluate the adequacy of the estimated specification. The diagnostic results for the NARDL model estimated for the total unemployment rate are presented in Table 3. The Breusch-Godfrey LM test (F-version) does not indicate residual serial correlation, while the Breusch-Pagan-Godfrey test does not reject the null hypothesis of homoskedasticity. Also, the Jarque-Bera statistic does not reject the null hypothesis of normality. Therefore, the results support the adequacy of the estimated model for inference.

To assess whether total unemployment reacts differently to increases and decreases in the number of ISCED4 graduates, we test for asymmetry within the NARDL framework, using Wald restrictions. In the selected specification, ARDL(2,2,3,3,1), we evaluate asymmetry in both the short and the long-run. In the short-run we test whether the sum of short-run coefficients on $\Delta \ln ISCED4^+$ equals the corresponding sum on $\Delta \ln ISCED4^-$. The Wald test rejects the null of short-run symmetry (Chi-square=6.024, p=0.014),

Table 3. Diagnostic statistics of the NARDL model (dependent variable total unemployment rate)

Test	Statistic	*p*-value	Conclusion
Breusch-Godfrey Serial Correlation LM Test (*F*, 2 lags)	1.215017	0.3370	No serial correlation
Heteroskedasticity Breusch-Pagan-Godfrey (BPG)	1.454137	0.2579	No heteroskedasticity
Jarque-Bera Normality	1.178452	0.554757	Residuals are normally distributed

Source: Author's calculations, using EViews 10.

Table 4. Wald test results, NARDL model

Restriction	Difference	Std. Error	Chi-square	*p*-value
Short-run	38.99575	15.88817	6.024023	0.0141
Long-run	1.889126	0.806343	5.488861	0.0191

Source: Author's calculations, using EViews 10.

indicating that positive and negative movements in ISCED4 graduates have statistically different short-run effects on total unemployment within the ECM dynamics.

In the long-run, we test whether the implied long-run effect associated with $\ln ISCED4^{+}$ equals the corresponding effect associated with $\ln ISCED4^{-}$. The null of long-run symmetry is also rejected (Chi-square=5.489, *p*=0.019), suggesting that the long-run relationship differs depending on whether ISCED4 graduate numbers increase or decrease. These results support the presence of statistically significant asymmetry, even after controlling for GDP growth, emigration, and the structural dummies included in the model.

The Long Run Form and Bounds Test suggests the presence of a long-run relationship among the variables. The *F*-statistic (4.933) exceeds the 5% upper bound based on the finite-sample critical values for *n*=30 (I(1)=4.774), indicating cointegration. The corresponding *t*-statistic (-3.390) falls between the 5% lower and upper bounds (I(0)=-2.86 and I(1)=-3.99), implying an inconclusive outcome under the *t*-bounds criterion, although it is close to the 1% lower bound (-3.43) but does not cross it. Consistent with this evidence, the error-correction term is negative and statistically significant (ECT(-1)=-0.664, *t*=-5.735, *p*=0.0001), implying that deviations from the long-run equilibrium are corrected over time. The short-run and long-run coefficients are reported in Table 5, combining the ECM regression for short-run dynamics with the implied levels equation for long-run effects, summarising the dynamic adjustment of total unemployment to changes in ISCED4 graduates, GDP growth, and emigration.

While the NARDL estimates presented in Table 2 describe the selected ARDL representation in levels, Table 5 summarises the same specification in its error-

Table 5. Estimated short-run and long-run dynamics of the NARDL model for total unemployment rate and ISCED4 graduates, with controls

Variable	Coefficient	Std. Error	t-Statistic	p-value
Short-run (ECM)				
Constant	7.988430	1.370452	5.829047	0.0001***
$\Delta U\_total(-1)$	-0.259800	0.140925	-1.843535	0.0901*
$\Delta \ln ISCED4^{+}$	3.548553	2.275764	1.559280	0.1449
$\Delta \ln ISCED4^{+}(-1)$	5.716172	2.013700	2.838641	0.0149**
$\Delta \ln ISCED4^{-}$	-6.386056	2.360487	-2.705397	0.0191**
$\Delta \ln ISCED4^{-}(-1)$	-12.60509	3.340197	-3.773757	0.0027***
$\Delta \ln ISCED4^{-}(-2)$	-10.73987	2.777752	-3.866390	0.0022***
ΔGDP_growth	-0.136970	0.037681	-3.635016	0.0034***
$\Delta GDP\_growth(-1)$	0.212778	0.045631	4.663012	0.0005***
$\Delta GDP\_growth(-2)$	0.075412	0.026111	2.888102	0.0136**
$\Delta \ln E$	-0.127768	0.325430	-0.392613	0.7015
Dummy_EU	-0.257800	0.326693	-0.789122	0.4454
Dummy_crisis	0.779726	0.390904	1.994673	0.0693*
ECT(-1)	-0.664440	0.115861	-5.734816	0.0001***
Long-run				
$\ln ISCED4^{+}$	2.121042	1.916552	1.106697	0.2901
$\ln ISCED4^{-}$	-0.722141	1.792101	-0.402958	0.6941
GDP_growth	-0.776790	0.283679	-2.738270	0.0180**
lnE	-1.222473	0.561800	-2.175994	0.0503*

Source: Author's calculations, using EViews 10; *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

correction form, separating short-run adjustment dynamics from the implied long-run equilibrium relationship. In the short-run, changes in total unemployment do not display strong inertia. The coefficient of $\Delta U\_total(-1)$ is negative and marginally significant at the 10% level (p=0.0901), suggesting some evidence that last year's change in unemployment systematically carries over into the current year once the remaining dynamics are accounted for.

Turning to the education variable, the short-run coefficients associated with the decomposed ISCED4 series point to a lagged and asymmetric adjustment pattern. For positive changes, $\Delta \ln ISCED4^{+}$ is not statistically significant contemporaneously (p=0.1449), while its one-period lag is positive and statistically significant at the 5% level (p=0.0149). By contrast, for the negative component, $\Delta \ln ISCED4^{-}$ is negative and statistically significant on impact (p=0.0191), and the subsequent lags remain negative and statistically significant (p=0.0027 and p=0.0022). Taken together, these estimates suggest that declines in ISCED4 graduates are followed by increases in total unemployment in the short-run, whereas increases in graduates do not generate an equally clear and immediate short-run response beyond the one-period lag.

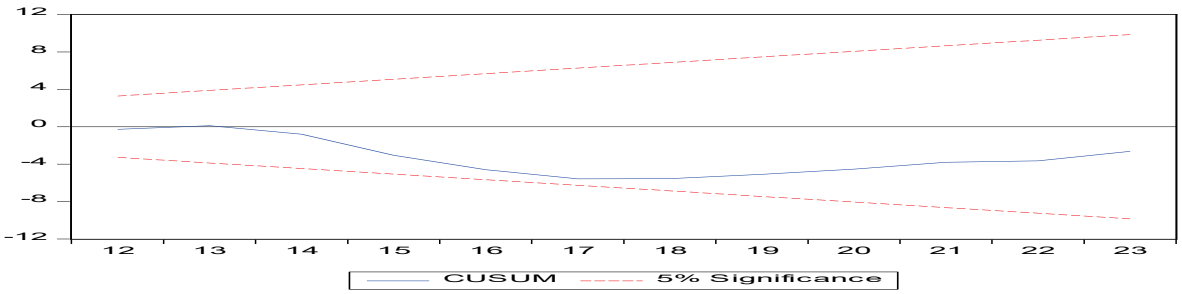
The macroeconomic controls play a more robust role in the short-run adjustment. GDP growth has a negative contemporaneous effect on changes in total unemployment (p=0.0034), consistent with cyclical interpretations. At the same time, the lagged changes in GDP_growth enter with positive and statistically significant coefficients (p=0.0005 and p=0.0136), pointing to a more complex dynamic transmission, where initial improvements in growth reduce unemployment changes on impact, but part of this effect is subsequently offset as the system adjusts. By contrast, changes in emigration are not statistically significant (p=0.7015). The structural dummies are not statistically significant for EU membership, while the crisis dummy is marginally significant at the 10% level (p=0.0693), suggesting limited additional short-run explanatory power beyond the included dynamics and controls.

In the long-run, the coefficients of $\ln ISCED4^{+}$ and $\ln ISCED4^{-}$ are not statistically significant, thus the data do not support a stable long-run equilibrium effect of the ISCED4 graduate series on the total unemployment once the controls are included. By contrast, the long-run coefficients of the macroeconomic variables are economically and statistically more informative. GDP growth is negative and significant (p=0.018), while emigration, in logs, is negative and borderline significant (p=0.0503), suggesting that stronger growth and outward migration are associated with lower total unemployment in the long-run.

A central result is the error-correction term, which is negative and statistically significant (ECT(-1)=-0.664, p=0.0001). This result confirms convergence towards the long-run equilibrium after shocks. The magnitude implies a relatively rapid speed of adjustment, roughly two-thirds of the deviation from the equilibrium is corrected within one year, indicating fast reversion dynamics in the Romanian total unemployment rate over the analysed period.

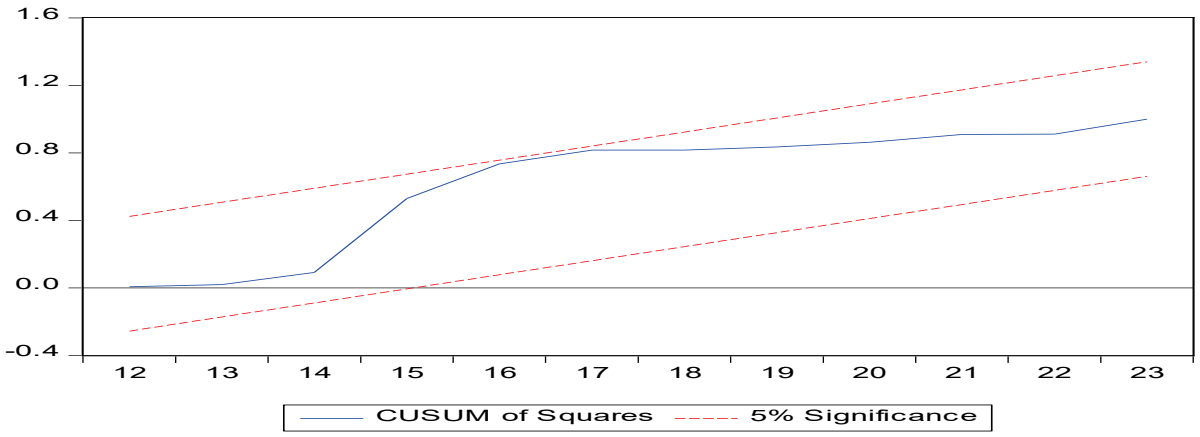
As shown in Figure 1 and Figure 2, both the CUSUM and the CUSUM of Squares statistics remain within the 5% critical bounds over the estimation sample. This provides no indication of coefficient instability and supports the stability of the estimated relationships over time.

Figure 1. CUSUM Test



Source: Author's processing, using EViews 10.

Figure 2. CUSUM of Squares Test



Source: Author's processing, using EViews 10.

As a robustness check, we next estimate a standard linear ARDL model in which lnISCED4 enters in its aggregate form, without the positive and negative decomposition. This benchmark is useful for assessing how much is gained by allowing for asymmetric adjustment in the NARDL model. The linear ARDL specification imposes symmetry by construction and thus provides a parsimonious reference point against which the asymmetric results can be compared. The linear ARDL specification retains the same set of controls, real GDP growth (annual, %) and emigration, as well as the structural *Dummy_EU* and *Dummy_crisis*. The model is estimated under Case 3, unrestricted constant and no trend, and lag orders are selected using the AIC, with a maximum of three lags for both the dependent variable and the regressors, consistent with the annual frequency and the relatively limited sample size.

The ARDL Long Run Form and Bounds Test provides strong evidence of a long-run relationship between the total unemployment rate, ISCED4 graduates, GDP growth, and emigration. The *F*-statistic is 6.889, which exceeds the 5% upper bound when finite-sample critical values for n=30 are considered (I(1)=5.018 at 5%), indicating cointegration. The *t*-statistic is -4.754, which is more negative than the 1% I(1) bound (-4.37), offering additional support for a levels relationship. Consistent with this finding, the error-correction term is negative and highly significant (ECT(-1)=-0.727, t=-5.694, $p<0.001$), indicating that deviations from the long-run equilibrium are corrected relatively quickly. The short-run adjustment dynamics and the implied long-run coefficients from the ECM representation are presented in Table 6, while the bounds test statistics are presented in Table 7

Table 6. Estimated short-run and long-run dynamics of the linear ARDL model, dependent variable total unemployment rate

Variable	Coefficient	Std. Error	t-Statistic	*p*-value
Short-run (ECM)				
Constant	24.87411	4.366627	5.696413	0.0000***
ΔU_total(−1)	0.098665	0.134428	0.733958	0.4730
ΔU_total(−2)	0.447113	0.167164	2.674703	0.0160**
ΔGDP_growth	-0.065718	0.026075	-2.520361	0.0220**
ΔGDP_growth(-1)	0.067893	0.027697	2.451271	0.0253**
ΔGDP_growth(-2)	0.044207	0.023047	1.918167	0.0720*
ΔlnE	-0.501023	0.354707	-1.412496	0.1758
Dummy_EU	-0.153498	0.204115	-0.752017	0.4623
Dummy_crisis	-0.322025	0.375854	-0.856782	0.4035
ECT(-1)	-0.726831	0.127650	-5.693951	0.0000***
Long-run				
lnISCED4	-1.377615	0.666190	-2.067902	0.0542*
GDP_growth	-0.229805	0.075178	-3.056821	0.0071***
lnE	-1.337811	0.463764	-2.884682	0.0103**

Source: Author's calculations using EViews 10 (Case 3: unrestricted constant and no trend); *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

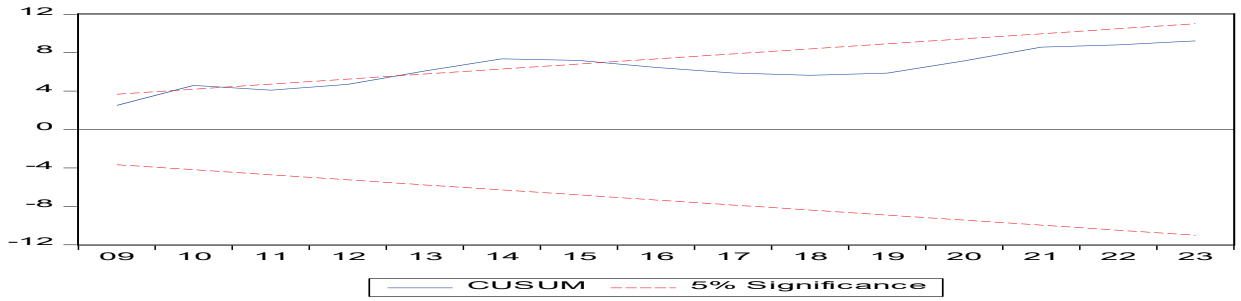
Table 7. Bounds test results, ARDL model

Test statistic	Value	Conclusion
F-statistic (k=3)	6.889479	Reject H_0: no levels relationship
t-statistic	-4.753713	Supports cointegration

Source: Author's calculations using EViews 10.

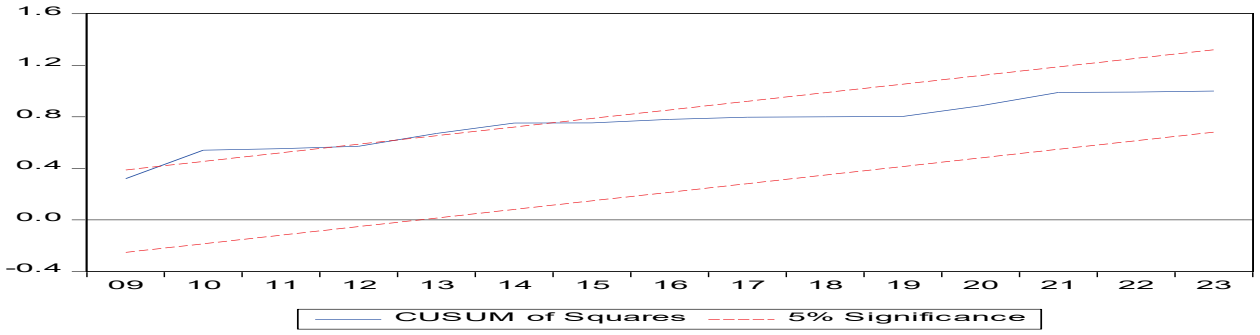
As we can notice from Figures 3 and 4, the CUSUM and CUSUM of Squares statistics indicate small and localised departures from the 5% critical bounds over short parts of the sample, which points to mild coefficient instability in the standard linear ARDL model. However, these departures are limited in magnitude and duration, and do not suggest a pervasive structural breakdown of the estimated relationship. We therefore interpret the ARDL results as a useful robustness benchmark for the long-run association, while acknowledging that coefficient stability may be slightly weaker in the linear specification than in the preferred NARDL model.

Figure 3. CUSUM test, ARDL model



Source: Author's processing, using EViews 10.

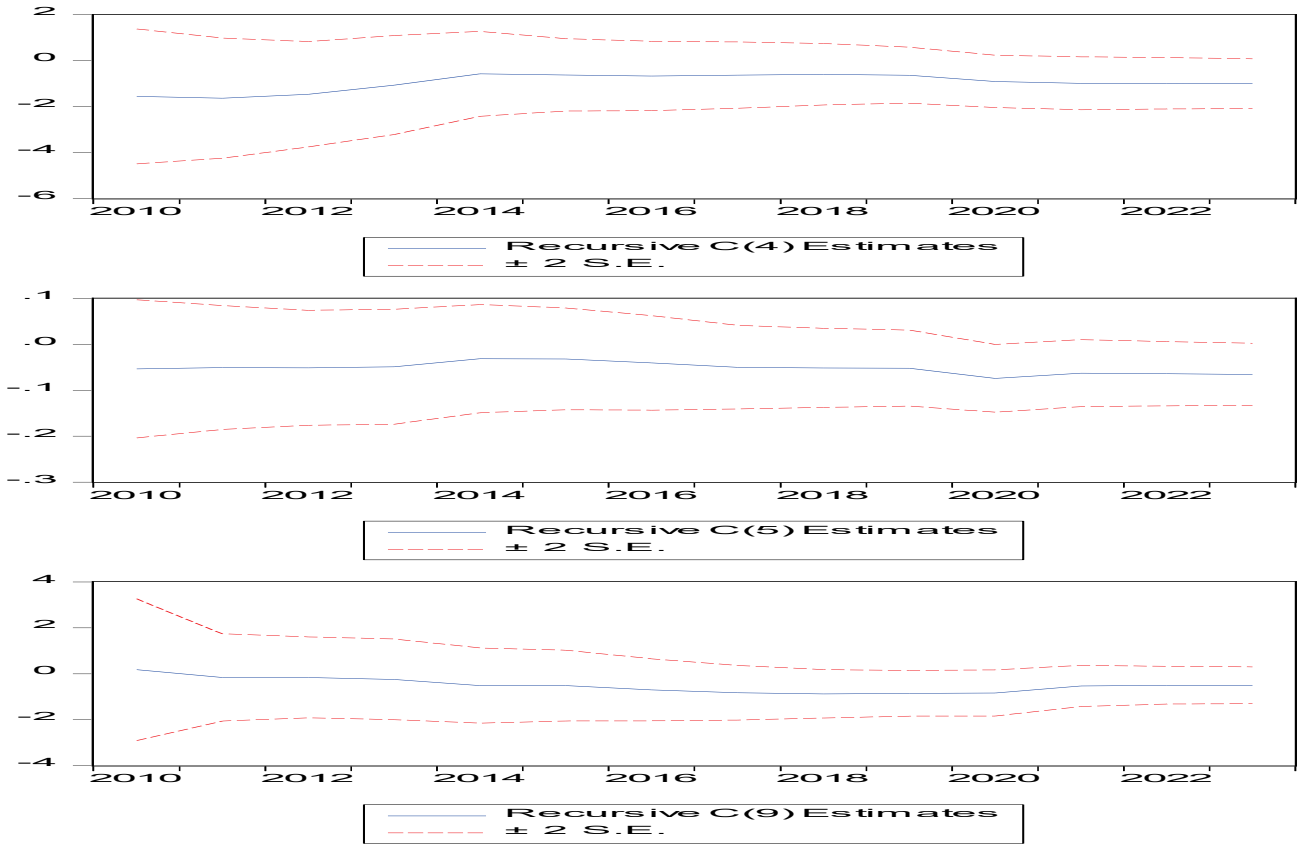
Figure 4. CUSUM of Squares test, ARDL model



Source: Author's processing, using EViews 10.

As an additional check of coefficient stability, we examine recursive coefficient estimates for the standard linear ARDL specification, focusing on the key level regressors (lnISCED4, GDP_growth and lnE). As shown in Figure 5, the recursive paths remain within ±2 standard error bands throughout the recursive sample, with no evidence of abrupt coefficient shifts. The trajectories display only mild and gradual movements, which is consistent with the earlier CUSUM diagnostics, and suggests at most localised instability. Thus, the recursive estimates support the interpretation that the ARDL coefficients are broadly stable over the analysed period and that any departures from stability are limited in magnitude

Figure 5. Recursive coefficient estimates (±2 S.E.) for the ARDL model, total unemployment rate



Source: Author's processing, using EViews 10.

As an additional robustness exercise addressing potential scale effects in the education variable, we re-estimate the nonlinear ARDL specification using a labour force normalised proxy for the ISCED4 explanatory variable. The active population series (labour force, persons) is taken from INSSE Tempo-Online (LFS, indicator AMG101A), available for 1996-2023. We construct an intensity measure defined as ISCED4 graduates per 1,000 active population and express it in logs (lnISCED4rate). The unit root test indicates that lnISCED4rate is I(1), satisfying the ARDL/NARDL requirement of excluding I(2) variables. The new specification is estimated under Case 3, unrestricted constant and no trend, with lag orders selected by AIC (maximum two lags given the reduced sample). In this specification only the dependent variable and the decomposed components of lnISCED4rate are treated as dynamic regressors, while GDP growth, lnE, Dummy_EU and Dummy_crisis enter as additional regressors. The selected representation is NARDL-ARDL (1,2,0) and the error-correction term remains negative and statistically significant (ECT(-1)=-0.352, p=0.025), indicating error-correction adjustment. However, the Long Run Form and Bounds Test does not support a levels relationship in this specification (F=1.812, t=-2.191). In addition, the Wald test suggests that long-run symmetry cannot be rejected. The long-run asymmetry identified in the baseline NARDL is not robust to normalising ISCED4 by the active population. This result should be interpreted in the light of the reduced sample window implied by labour force data availability, which jointly tests sensitivity to scale normalisation and to the shorter estimation period. Given space constraints, the full estimation output is available from the author upon request.

In the next step we extend the analysis to the youth unemployment rate. Given that the dependent variable U_youth is stationary in levels (I(0)), the NARDL approach remains valid. To ensure comparability, the NARDL model for the youth unemployment rate was estimated following the same methodological approach as for the total unemployment rate model. The partial-sum components of lnISCED4 were constructed following Shin et al. (2014) and were initialised at zero in the first available sample year, in order to preserve the maximum common estimation sample implied by the lag structure, as in the case of total unemployment. The model includes the same macroeconomic controls, real GDP growth (annual, %) and emigration (in logs), as well as structural dummies for EU accession and the financial crisis. Lag orders are selected using the Akaike Information Criterion (AIC), allowing up to three lags for the dependent variable and each regressor, and the model is estimated under Case 3 (unrestricted constant and no trend). For the $(\mathrm{U\_youth_t}, \mathrm{lnISCED4^+}, \mathrm{lnISCED4^-}, \mathrm{GDP\_growth}, \mathrm{lnE})$ specification, the selected NARDL-ARDL representation is ARDL(3,2,3,2,0), estimated over the adjusted sample 1994-2023 (30 observations).

The presence of a long-run relationship for the youth unemployment model is examined using the ARDL Long Run Form and Bounds Test. The bounds evidence is supportive of cointegration. The F-statistic equals 5.6707, which is above the 5% upper bound for the finite-sample critical values (n=30; I(1)=4.774), indicating a levels relationship among the variables. At the same time, the t-bounds statistic is -3.2016, which lies between the 5% bounds (I(0)=-2.86; I(1)=-3.99), so the t-test alone remains inconclusive. The error-correction term is negative and statistically significant (ECT(-1)=-0.5212, $p< 0.001$), confirming that deviations from the long-run equilibrium are corrected over time. The key short-run and long-run coefficients implied by the ECM representation, together with the asymmetry tests and diagnostic checks, are summarised in Table 8. Taken together, the F-bounds statistic and the negative, highly significant ECT indicate the existence of an error-correcting relationship in the system for youth unemployment. We underline that cointegration, at the system level, does not require that every individual long-run coefficient be precisely estimated. In our case, the long-run variations appear to be driven mainly by macroeconomic conditions, while the education-related long-run coefficients remain imprecisely estimated. This pattern is consistent with a model in which the educational channel operates primarily through short-run adjustment and asymmetric dynamics. Full estimation output is available upon request.

Table 8. NARDL results for youth unemployment

Component	Variable/Test	Coefficient	p-value	Conclusion
Short-run effects (ECM)	$\Delta U\_youth(-1)$	-0.257214	0.0815	Marginally significant
	$\Delta U\_youth(-2)$	0.414450	0.0186	Significant
	$\Delta \ln ISCED4^{+}$	19.286552	0.0078	Significant
	$\Delta \ln ISCED4^{+}(-1)$	16.562902	0.0084	Significant
	$\Delta \ln ISCED4^{-}$	-21.348685	0.0083	Significant
	$\Delta \ln ISCED4^{-}(-1)$	-44.847997	0.0002	Highly significant
	$\Delta \ln ISCED4^{-}(-2)$	-27.403854	0.0026	Significant
	ΔGDP_growth	-0.344828	0.0040	Significant
	$\Delta GDP\_growth(-1)$	0.385169	0.0012	Significant
	$\Delta \ln E$	0.234948	0.7907	Not significant
	Dummy_EU	2.028228	0.0622	Marginally significant
	Dummy_crisis	2.670748	0.0325	Significant
	Constant	-7.203066	0.0016	Significant
Long-run effects	$\ln ISCED4^{+}$	11.474480	0.1486	Not significant
	$\ln ISCED4^{-}$	2.890463	0.6244	Not significant
	GDP_growth	-2.152421	0.0490	Significant
	lnE	0.450780	0.7893	Not significant
Error Correction	ECT(-1)	-0.521203	0.0000	Significant adjustment to equilibrium
Asymmetry tests	Short-run	Chi-square = 9.460503	0.0021	Reject symmetry
	Long-run	Chi-square = 3.414020	0.0646	Fail to reject symmetry at 5%; reject at 10% (marginal evidence of long-run asymmetry)
Diagnostics	Breusch-Godfrey Serial Correlation LM Test (F, 2 lags)	1.792616	0.2119	No serial correlation
	Heteroskedasticity BPG (F)	2.620023	0.0432	Evidence of heteroskedasticity
	Jarque-Bera Normality	0.073321	0.9640	Residuals are normally distributed

Source: Author's calculations, using EViews 10.

The results presented in Table 8 highlight several statistically relevant short-run adjustments in the youth unemployment rate and, importantly, a differentiated response to increases versus decreases in ISCED4 graduates. Youth unemployment displays a degree of short-run persistence, as the second lag of the change in youth unemployment rate, $\Delta U\_youth(-2)$, is statistically significant (p=0.0186), suggesting that changes from two years earlier can still shape current short-run movements.

Regarding the education variable, the short-run coefficients associated with the decomposed ISCED4 series point to an asymmetric and lagged adjustment pattern. For the positive component, $\Delta \ln ISCED4^{+}$ is positive and statistically significant (p=0.0078), and its first lag, $\Delta \ln ISCED4^{+}(-1)$ remains positive and significant (p=0.0084). This indicates that increases in the number of post-secondary non-tertiary graduates are followed, within the short-run adjustment horizon, by upward pressure on youth unemployment, with effects distributed over the current and the following year. For the negative component, the estimated short-run response is also statistically meaningful, but with a different profile. $\Delta \ln ISCED4^{-}$ is negative and significant (p=0.0083), and the effect becomes even stronger at one lag, $\Delta \ln ISCED4^{-}(-1)$, which is highly significant (p=0.0002). The second lag, $\Delta \ln ISCED4^{-}(-2)$, also remains negative and significant (p=0.0026). Taken together, these results suggest that negative changes in ISCED4 graduates are followed by a persistent short-run increase in youth unemployment, with a stronger response than

in the case of positive changes. Consistent with this asymmetric distributed response, the Wald test rejects the null of short-run symmetry, providing robust evidence that youth unemployment reacts differently to positive versus negative movements in ISCED4 graduates in the short-run.

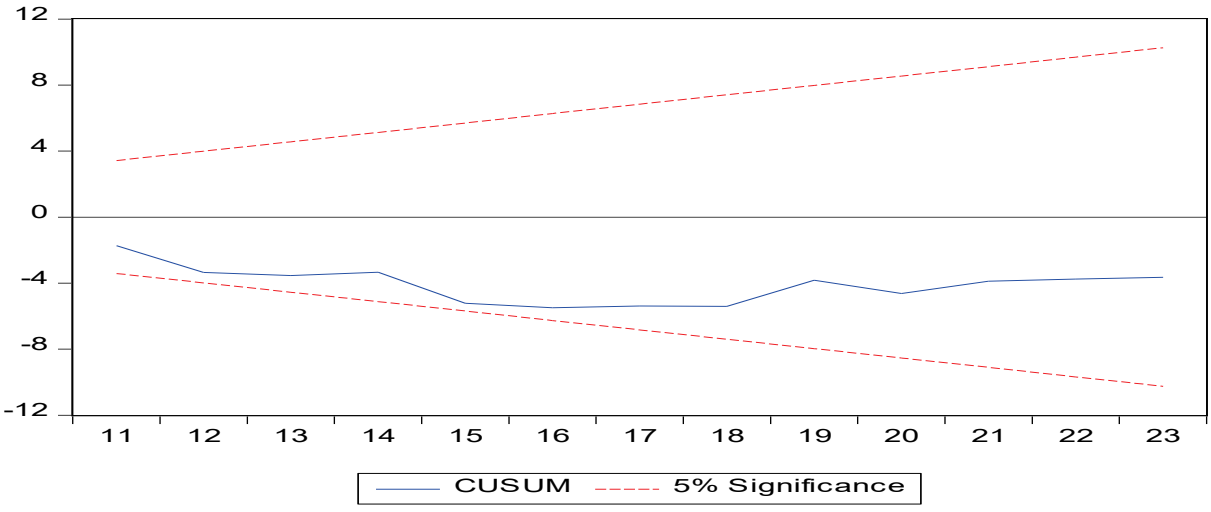
In the long-run, the evidence points to a levels relationship in the youth unemployment system, but the education-related equilibrium coefficients are not precisely estimated. The level coefficients for both $\ln ISCED4^{+}$ and $\ln ISCED4^{-}$ are not statistically significant (p=0.1486 and p=0.6244 respectively), indicating that the long-run education channel is weakly identified in this specification once controls are included. By contrast, GDP growth retains a negative and statistically significant long-run coefficient (p=0.0490), consistent with standard macroeconomic mechanisms. The error-correction term is negative and statistically significant (ECT(-1)=-0.5212, $p< 0.001$), supporting adjustment towards a long-run relationship and indicating that roughly half of any disequilibrium is corrected within one year.

Finally, the diagnostic tests are mixed but overall informative for inference. Residuals appear normally distributed (Jarque-Bera, p=0.964), and the Breusch-Godfrey LM test does not indicate serial correlation (p=0.2119). At the same time, the Breusch-Pagan-Godfrey test suggests heteroskedasticity (p=0.0432), which calls for caution when relying solely on conventional standard errors in short-run inference. In addition, the evidence of heteroskedasticity in the youth unemployment specification suggests that coefficient significance should be interpreted with caution, especially given the relatively small sample size. Even so, the main conclusion regarding short-run asymmetry remains well supported by both the coefficient pattern and the Wald test results.

As we can notice from Figure 6 and Figure 7, the CUSUM and CUSUM of Squares plots remain within the critical bounds, validating the structural stability of the model over the sample period.

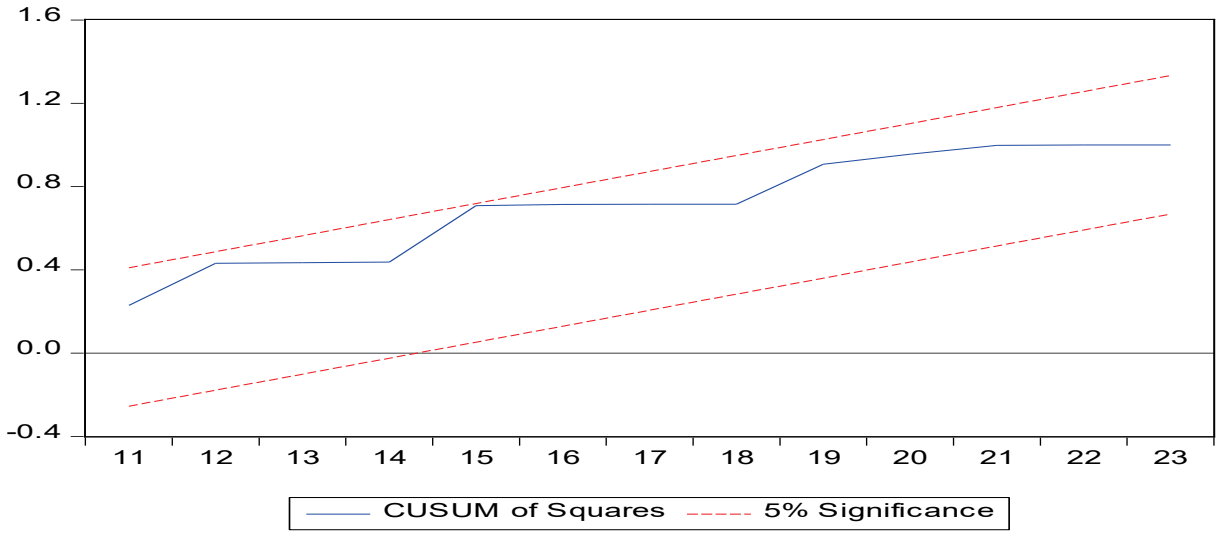
As an additional robustness check, we estimate a standard linear ARDL model for the youth unemployment rate in which lnISCED4 enters in its aggregate form, without the positive and negative partial-sum decomposition, while keeping the same set of controls GDP_growth, emigration (lnE) and the structural dummies (with the same Case 3: unrestricted constant, no trend). The AIC selected model is ARDL (3,0,1,0), over the adjusted sample 1994-2023, 30 observations. The bounds-testing evidence is mixed and, at conventional levels, does not provide decisive support for cointegration. The *F*-statistic is 3.107 (k=3), which lies below the 5% lower bound, therefore fails to reject the null hypothesis of no levels relationship. At the 10% level it falls between the bounds, implying an inconclusive outcome. The corresponding *t*-statistic is -3.3296, which also falls between the relevant bounds. Hence, based on the bounds test alone, inference on cointegration is not decisive.

Figure 6. CUSUM Test, youth unemployment rate



Source: Author's processing, using EViews 10.

Figure 7. CUSUM of Squares Test, youth unemployment rate



Source: Author's processing, using EViews 10.

The conditional ECM representation indicates a clear adjustment mechanism, as the error-correction coefficient is negative and statistically significant (ECT=-0.486, *p*=0.0012), suggesting that deviations from the implied long-run equilibrium tend to be corrected over time, with 48.6% of disequilibrium eliminated within one year. Given space constraints, the complete estimation output, including the full coefficient tables, residual diagnostic tests, and stability checks (CUSUM, CUSUMQ and recursive coefficient plots) can be made available by the author upon request.

To account for potential scale effects in the education variable, we re-estimate the NARDL model for youth unemployment using an age-specific labour force normalised proxy for the ISCED4 explanatory variable. The active population series for ages 20-24 (labour force, persons) is taken from INSSE Tempo-Online (LFS, indicator AMG101A), available for 1996-2023. Analogous to the total unemployment rate specification, we construct an intensity measure defined as ISCED4 graduates per 1,000 active population aged 20-24 and express it in logs (lnISCED4rate_youth). The unit root test indicates that lnISCED4rate_youth is I(1), satisfying the ARDL/NARDL requirement of excluding I(2) variables. The model is estimated under Case 3, unrestricted constant and no trend, with lag orders selected by AIC (maximum two lags given the limited sample). Only the dependent variable and the decomposed partial-sum components of lnISCED4rate_youth are treated as dynamic regressors, while GDP_growth, lnE, Dummy_EU and Dummy_crisis enter as additional regressors. The selected model is NARDL-ARDL(1,2,0) and the error-correction term remains negative and statistically significant (ECT(-1)=-0.516, p=0.015), indicating error-correction adjustment. However, the bounds-testing evidence does not support a levels relationship in this model (*F*=2.194; *t*=-2.721). In addition, the Wald tests do not reject symmetry in either the short-run (*p*=0.167) or the long-run (*p*=0.204). Overall, the asymmetric long-run effects identified in the baseline youth NARDL are not robust to normalising ISCED4 graduates by the 20-24 active population. This result should also be interpreted in light of the reduced sample window implied by data availability. Given space constraints, the full estimation output is available from the author upon request.

4. Conclusions

The aim of this paper was to analyse the extent to which changes in the number of ISCED4 graduates (post-secondary schools and foreman schools) are associated with asymmetric effects on both total and youth unemployment rates in Romania. Using annual data for 1991-2023, we employed the NARDL approach of Shin et al. (2014), which is particularly appropriate when increases and decreases in an explanatory variable may have different labour market consequences. The baseline specification was

complemented with real GDP growth and emigration, alongside structural dummies capturing Romania's EU accession and the global financial crisis, to mitigate omitted-variable concerns and to place the education-unemployment nexus in a broader macroeconomic setting.

For the total unemployment rate, the empirical analysis suggests support for a long-run relationship within the estimated NARDL framework. While the bounds-testing evidence is mixed across criteria, the error-correction term is negative and highly significant, indicating a relatively rapid return towards the long-run equilibrium after shocks. The magnitude of ECT(-1) suggests that approximately two-thirds of disequilibrium is corrected within one year, highlighting a strong adjustment mechanism.

At the same time, the long-run education channel in the total unemployment NARDL is not precisely identified once controls are introduced. In the levels equations, the coefficients associated with $\ln\mathrm{ISCED4}^{+}$ and $\ln\mathrm{ISCED4}^{-}$ are not statistically significant, whereas GDP growth and, to a lesser extent, emigration, carry clearer long-run information. The short-run dynamics, however, reveal a lagged and asymmetric pattern. The positive component becomes relevant mainly with a one-year delay, while negative changes exhibit statistically significant effects over several short-run lags. This suggests that, for total unemployment, asymmetry is more visible in the adjustment dynamics than in a stable long-run education coefficient.

To verify that these findings are not an artefact of the nonlinear specification, we estimated a benchmark linear ARDL model in which lnISCED4 enters in aggregate form. Here, the bounds-testing results provide stronger and more decisive evidence of cointegration using finite-sample critical values. The error-correction term is again negative and highly significant, confirming rapid adjustment. In this linear benchmark, the long-run coefficient on lnISCED4 is negative and marginally significant, implying a modest long-run association whereby sustained increases in ISCED4 graduates are linked to lower total unemployment in equilibrium (under a semi-log interpretation). The linear benchmark reinforces the idea that the long-run relationship is dynamically meaningful, while the additional empirical gain from modelling asymmetry for total unemployment lies mainly in the short-run adjustment profile.

A labour-force-normalised robustness check (ISCED4 graduates per 1,000 active population; 1996-2023) suggests that long-run asymmetry and levels relationships are sensitive to normalisation and to the shorter sample window.

For youth unemployment, the evidence is more clearly asymmetric in the short-run. The NARDL estimates show that positive changes in ISCED4 graduates are followed by short-run increases in youth unemployment, whereas negative changes are associated with even larger short-run increases, confirming significant asymmetry in the magnitude of adjustment. This asymmetry is confirmed by the Wald test, which rejects short-run symmetry at conventional levels. In the long-run, however, the education-related coefficients $\ln\mathrm{ISCED4}^{+}$ and $\ln\mathrm{ISCED4}^{-}$ are not statistically significant, while GDP growth retains a negative and significant long-run effect. As in the total unemployment model, the adjustment mechanism is strong. The error-correction coefficient is negative and highly significant, suggesting that roughly half of disequilibrium is eliminated within one year. The bounds-testing evidence supports cointegration primarily through the *F*-statistic, whereas the *t*-bounds statistic remains inconclusive.

The linear ARDL robustness check for youth unemployment yields mixed bounds evidence. The *F*-statistic falls below the 5% lower bound (and is between bounds at 10%), while the *t*-statistic also lies between the relevant bounds. Hence, the bounds test alone does not provide decisive support for cointegration in the linear youth specification. Nevertheless, the ECM still indicates a negative and statistically significant error-correction term, suggesting an adjustment mechanism even in the benchmark model. The linear ARDL results should be interpreted primarily as a benchmark specification rather than as conclusive evidence of a long-run relationship. Taken together, the robustness exercise suggests that allowing for nonlinear asymmetry is empirically more informative for youth unemployment than for total unemployment, particularly in the short-run.

For youth unemployment, an age-specific normalisation (ISCED4 graduates per 1,000 active population aged 20-24; 1996-2023) likewise does not support cointegration and does not reject symmetry, indicating sensitivity to scaling and sample coverage.

From a policy perspective, the results point to a meaningful distinction between the two labour

market segments. For total unemployment, the role of ISCED4 graduates appears to manifest primarily through the broader long-run association identified most clearly in the linear benchmark, while macroeconomic conditions remain central. For youth unemployment, the results instead point to short-run asymmetry that is consistent with an absorption and matching constraint. Increases in the supply of ISCED4 graduates can be followed by a temporary rise in youth unemployment, particularly when the school-to-work transition is not supported by complementary measures such as work-based learning, apprenticeships, employer incentives, targeted active labour market programmes, and closer alignment between curricula and local labour demand. Under these conditions, expanding educational supply on its own may not ensure immediate labour market integration for young people. This result should, however, be interpreted with caution, as the estimated short-run association does not by itself establish a causal mechanism. An alternative explanation is reverse causality, whereby weaker labour market conditions for young people may increase enrolment in post-secondary non-tertiary education, thus affecting the observed relationship between ISCED4 graduates and youth unemployment.

Finally, the stability diagnostics provide supportive evidence for coefficient stability in the NARDL specifications. For total unemployment, CUSUM and CUSUM of Squares remain within the 5% bounds, indicating stable coefficients. For the linear ARDL benchmark, the CUSUM-based diagnostics show only small and localised departures from the critical bounds, pointing to mildly weaker stability than in the nonlinear specification, but not to a pervasive structural breakdown. For youth unemployment, stability plots remain within the critical bounds in the NARDL model.

Future research could explore structural change more explicitly (e.g. alternative break specifications, sub-sample estimation, or additional labour market controls where data permit). While the analysis is anchored in Romania's institutional and demographic context, the findings may also be informative for countries facing similar challenges in aligning post-secondary non-tertiary education with labour market absorption capacity, particularly where youth labour market entry remains structurally fragile.

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