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ORIGINAL PAPER

The role of labor market regulations on the sensitivity of unemployment to economic growth

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Abstract

Okun's law suggests that economic growth and unemployment are negatively correlated–i.e., a 1% increase in GNP is associated with a decrease in the unemployment rate of 0.3 percentage points. However, agreement on the magnitude of this effect, the so-called Okun's coefficient, is far from consistent. Empirical findings suggest that Okun's coefficient varies for males and females, across educational attainment levels, between countries with different labor market regulations, and over recession and expansion periods. This paper is among the first attempts to jointly consider the abovementioned aspects of the heterogeneity of Okun's law. Our empirical examinations are based on data from European Union countries over the 2000–2020 period. With quarterly data, we apply time-series regressions and estimate gender-, age- and educational attainment level-specific Okun's coefficients for each country. In the second step, we run cross-country regressions to establish whether labor market regulations influence the responsiveness of unemployment to output growth. We use panel specifications and time-varying Okun's coefficients to check robustness. Our results show that straightening labor market regulation would not significantly reduce the possibilities for growth to reduce unemployment.

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1 Introduction

A low unemployment level is one of the fundamental goals of macroeconomic policy, and theory suggests that economic growth is the main tool to achieve this goal. In a seminal paper published in 1962, Okun's findings based on US data suggested that when GNP rises by 1%, the unemployment rate decreases by 0.3 percentage points. Many empirical papers followed this research, aiming to estimate the reaction of unemployment rate to economic growth: the so-called Okun's coefficient. The results of most studies support the relationship between unemployment and GDP growth, with no consensus on the size of Okun's coefficient. The variability of these results inspired a new strand of research searching for potential sources of heterogeneity among estimates of Okun's law. A review of empirical studies shows that the magnitude of Okun's parameter is influenced by methodological issues (type of data—panel or time series data, annual or quarterly data, symmetric or asymmetric model, etc.), coverage (one country or a group of countries), and labor market characteristics (Porras-Arena & Martín-Román, 2022). Demographic characteristics (age, gender, education level) may also explain part of the observed heterogeneity.

Empirical findings in the literature on Okun's law commonly suggest that youth unemployment is more sensitive to economic growth compared to elderly cohorts or total unemployment, Okun's coefficients are higher for males than for females, and the unemployment of highly educated workers is less sensitive to output fluctuations (for more detailed discussion on age- and gender-specific Okun's coefficients, see Butkus et al., 2020; An et al., 2021).

Various studies support the relationship between youth unemployment and labor market regulation (Banerji et al., 2015; Dixon et al., 2017), emphasize the role of labor market regulations in explaining the unemployment gender gap (Baussola et al., 2015), and present evidence that economic growth and regulation can explain imbalances between young and adult unemployment (Banerji et al., 2015; Dietrich & Möller, 2016). Despite this, there is a lack of research on whether the response of unemployment to output fluctuations based on age and gender may depend on labor market regulation. This paper complements limited evidence in this field and aims to estimate the effect of various labor market regulations (relating to minimum wage, hiring, firing, working hours, centralized collective bargaining and mandated cost of worker dismissal) on Okun's coefficient, considering different age cohorts and gender. In addition, we contribute to the very limited field of empirical literature (Butkus et al., 2020) that tests education as a potential source of heterogeneity in Okun's coefficient.

Various studies present inconclusive findings on how labor market regulation impacts Okun's coefficients obtained by models with changes in the total unemployment rate as a dependent variable (see Sect. 1 for review). However, only a few of them consider age or gender. Banerji et al. (2015) found only limited evidence that labor market regulation may affect the way youth unemployment rates respond to output fluctuations. Dixon et al. (2017) confirmed that labor market flexibility (as proxied by the share of temporary workers) increases Okun's coefficient, except for in the case of older workers, regardless of their gender. The abovementioned studies estimate models based on the panel data of OECD countries and introduce the interaction between output and labor market regulation variables. In this paper, we apply a different methodology consisting of a two-step procedure. In the first step, we estimate gender-, age-, and educational attainment level-specific Okun's coefficients. Estimations are based on quarterly time-series data for European Union (EU) countries from 2000 to 2020. In the second step, we run cross-country regressions to test the role of labor market regulations on the sensitivity of unemployment rate to output changes (i.e., an estimated Okun's coefficient). As other authors' empirical findings suggest that Okun's coefficients vary in economic expansion and recession periods (Donayre, 2022; Kim et al., 2020; Oh, 2018; Omoshoro-Jones, 2021), this paper also tests the assumption that labor market regulations may have a growth-direction-specific effect on Okun's coefficients.

Piton and Rycx (2019) analyzed theoretical and empirical findings on the impact of labor market (de)regulation on unemployment and concluded that there are arguments to support both negative and positive effects, while the net effect on the unemployment rate remains ambiguous. Our study analyzes the validity of the neo-liberal argument that labor protection through more strict labor market regulations leads to higher unemployment rates (Sarkar, 2013), as the sensitivity of unemployment to growth may be dependent on the strictness of labor market regulations. The effect of labor market regulation on the growth–unemployment relationship depends on many factors, including the elasticity of substitution between capital and labor. For example, in a more regulated environment, firms may prefer capital-driven rather than labor-driven production increases in response to demand growth.

When examining the impact of labor market regulations on the sensitivity of unemployment rate to output changes, we did not find robust evidence that an increase in labor market regulation limits the positive impact of growth to reduce unemployment. Only hiring and firing regulations are significantly related to the growth–unemployment relationship: more flexible hiring and firing of workers is associated with a more significant reaction of female unemployment to output growth. Considering the nature of this effect across various educational attainment levels, we also found that increased hiring and firing regulations reduces the reaction of unemployment to growth for the least-educated individuals three times more than for the most-educated.

This paper is organized as follows: Sect. 2 provides empirical evidence on the impact of labor market regulation on Okun's coefficient; Sect. 3 presents the applied methodology, including the model, estimation strategy, and data; Sect. 4 discusses the main results; and the final section concludes the paper.

2 A review of empirical evidence on the impact of labor market regulation on Okun's coefficient

A possible explanation for the variations in Okun's coefficient across countries is that labor market regulations are different, as more restrictive regulations may cause distortions that would prevent the efficient allocation of labor and could have negative impacts on productivity (Duval & Loungani, 2019; Freeman, 2010). Restrictive regulations can also prevent shock adjustment by reducing work disruption and turnover. However, regulations can also reduce information asymmetry and solve coordination problems (Freeman, 2010).

Various studies have found that labor market regulations impact Okun's coefficient, but the results are inconclusive. The employment protection legislation (EPL) index provided by the OECD is the most commonly analyzed indicator of labor market regulation. Some studies (Ball et al., 2017; Cazes et al., 2013; Economou & Psarianos, 2016; Herwartz & Niebuhr, 2011; IMF, 2010; Maza, 2022) have shown that there exists a negative relationship between Okun's coefficient and the restrictiveness of employment protection. On the other hand, Obst (2022), Ball et al. (2017), and Dixon et al. (2017) found no relationship between EPL and Okun's coefficient.

Cazes et al. (2013) and Ball et al. (2017), analyzing evidence from several OECD countries, confirmed that in countries with higher employment protection, such as Germany, the response of unemployment to output changes during the Great Recession was lower. David et al. (2019) focused on hiring and firing practices, informal employment, the flexibility of wages and redundancy costs. The authors found a strong relationship between Okun's coefficient and the share of informal employment, while other labor market regulations were not statistically significant. Economou and Psarianos (2016) investigated the indicator of public expenditure as a percentage of GDP devoted to labor market protection programs in European countries, and their results revealed slightly lower Okun's coefficients for countries with low labor market protection expenditures—i.e., Austria, Ireland, Italy, Portugal, Spain, Sweden and the UK. The impact of unemployment insurance benefits, unions, wage bargaining, and employment protection legislation was emphasized by van Ours (2015), who found union power and employment legislation to be statistically insignificant. Meanwhile, wage coordination had a negative impact on Okun's coefficient, suggesting that less economic growth is needed to maintain constant unemployment when the level of wage coordination is higher. Dixon et al. (2017), using a panel of 20 OECD countries for the 1985–2013 period, analyzed the impact of union coverage, unemployment insurance, employment protection legislation, and the tax wedge, as well as considering the terms of trade on Okun's coefficient. The authors found no significant relationship between Okun's coefficient and union coverage, nor with employment protection legislation, but there was a positive and significant relationship observed with union density. A significant negative effect was confirmed between wage coordination and Okun's coefficient, while the unemployment insurance replacement rate had a significant positive effect. Obst (2022), estimating Okun's coefficient for EU15 countries between 1960 and 2018, found no relationship between Okun's coefficient and employment protection legislation, tax wedges or collective bargaining coverage. Instead, the research found a positive impact of trade union density on Okun's coefficient. The main explanatory variable of this is the percentage of permanent workers in total employment, which has a strong negative relationship with the estimated Okun's coefficient. This indicates that the unemployment rate reacts more strongly to production changes when the share of temporary workers increases. Herwartz and Niebuhr (2011), covering NUTS 2 data in the EU15 for the 1980–2002 period, found that labor market regulations can have a positive impact on the reaction of unemployment to output changes as the generosity of the benefit system and the strictness of the EPL appear to reduce the responsiveness of unemployment to growth. However, the authors also state that not all regulations affect the reaction of unemployment to output fluctuations. The IMF (2010) also found a negative impact of EPL on Okun's coefficient. The unemployment benefit replacement ratio has a positive effect, meaning that the effect of job destruction outweighs that of job creation. Furceri et al. (2020) found that deregulation in the labor market strengthens the response of unemployment to output changes based on 85 developed and developing economies during the 1978–2014 period. The authors analyzed labor market regulations proxied by the Fraser Institute's index. The results of the research show different effects in developed and developing countries: more deregulation is associated with a greater negative output–unemployment reaction, whereas the opposite results were obtained in developing economies.

The results of previous studies show ambiguous conclusions on the impact of labor market regulations on Okun's coefficient. The inconsistency of results may be related to varying research variables, countries, and economic cycle stages. Even less is known about the influence of regulations on age-, gender- and educational attainment level-specific Okun's coefficients, because very few such studies have been conducted to evaluate this specification. To our knowledge, only a few studies (Banerji et al., 2014, 2015; Dixon et al., 2017) distinguish the effect of labor market regulations on age- and gender-specific Okun's coefficients. Dixon et al. (2017) found that higher wage coordination was more beneficial to young workers. This could be because labor market regulations reduce the employer's power to negotiate wages. These results also show a higher impact of labor market institutions on Okun's coefficients for males. The findings of Banerji et al. (2015) were only limited in terms of the impact of labor market regulation on the response of youth unemployment to output changes.

We can thus state that there is a lack of studies analyzing the impact of labor market regulations on age-, gender- and educational attainment level-specific Okun's coefficients. Empirical research (for the review, see Butkus et al., 2020) indicates the heterogeneity of gender-, age- and educational attainment level-specific Okun's coefficients across EU countries. Some authors (Dixon et al., 2017; Zanin, 2018; Butkus & Seputiene, 2019; Ahn et al., 2019) clearly show the higher vulnerability of youth unemployment to output fluctuations. This could be related to lower experience and skill levels, and also to the fact that young workers are frequently engaged in temporary job arrangements when compared to other age cohorts. Previous research (An et al., 2021; Brincikova & Darmo, 2015; Butkus et al., 2020; Evans, 2018; Kim & Park, 2019) on gender-specific output–unemployment relationships confirms the higher sensitivity of male unemployment to economic growth, and this is associated with the fact that males usually work in more volatile sectors—i.e., construction or industry. The estimates of previous research (Aaronson et al., 2019; Askenazy et al., 2015; Ball et al., 2019; Estevão & Tsounta, 2011; Guisinger et al., 2018) also indicate that the level of educational attainment plays a pivotal role in explaining the heterogenous response of unemployment to fluctuations in output, which is related to the cost of highly educated workers as they are considered long-term investments due to their skills and experience.

3 Research methods

This paper aims to examine the cross-country relationship between the responsiveness of unemployment to growth and labor market regulation. Our methodology consists of a two-step procedure. In the first step, based on time-series analysis, we will estimate gender-, age- and educational attainment level-specific Okun's coefficients across EU countries (and the United Kingdom) using quarterly Eurostat data on unemployment and growth of GDP at constant prices from 2000–2020 (see Table 2 in the Appendix for descriptive statistics). As we estimate Okun's coefficients for each country separately, they are robust to the potential presence of cross-sectional dependence which could be induced by a single market condition. In addition, the value of an average coefficient over time will be estimated to give a general idea of the extent to which the heterogeneity of Okun's law applies across EU economies. It is important to recall that the heterogeneous approach dealing with cross-sectional dependence has an advantage compared to single estimations for a whole country panel, which makes it particularly attractive.

In the second step, these country-specific coefficients are employed as the dependent variable to run cross-country regressions to find a link between different indexes that proxy labor market regulation and estimated Okun's coefficients, which proxy the responsiveness of unemployment to growth. Due to data limitations (we do not estimate both time- and country-, just country-specific Okun's coefficients in the first step), we run a cross-sectional model that attempts to explain country differences. We should emphasize here that this cross-sectional model does not allow us to cope adequately with cross-sectional dependence, as in the first step.

To proxy labor market regulation, we will use indexes provided by the Fraser Institute:

(1) Hiring regulations and minimum wage (LMRI1), which is based on the World Bank's Doing Business Report and includes the following components: whether fixed-term contracts are prohibited for permanent tasks; whether the maximum

cumulative duration of fixed-term contracts is regulated; and whether, for a trainee or first-time employee, the ratio of the minimum wage to the average value added per worker is set;

(2) Hiring and firing regulations (LMRI2), which is based on the Global Competitiveness Report component: "The hiring and firing of workers is impeded by regulations or flexibly determined by employers";

(3) Centralized collective bargaining (LMRI3), which is based on the Global Competitiveness Report component: "Wages in your country are set by a centralized bargaining process or up to each individual company";

(4) Hours regulations (LMRI4), which is based on the World Bank's Doing Business Report and includes the following components: whether there are restrictions on night work; whether there are restrictions on holiday work; whether the length of the work week can be 5.5 days or longer; whether there are restrictions on overtime work; and whether the average paid annual leave is 21 working days or more;

(5) Mandated cost of worker dismissal (LMRI5), which is based on the World Bank's Doing Business data on the cost of advance notice requirements, severance payments, and penalties due when dismissing a redundant worker with a 10-year tenure;

(6) Total labor market regulation index (LMRI6) (see Table 3 for the descriptive statistics).

We did not use the OECD Employment Protection Legislation indexes to proxy labor market regulation due to the lack of data for five EU countries, their shorter time series, and inconsistency based on the revisions of the methodology.

The methodology for the first step of the empirical research is based on a time-series analysis to estimate the country-specific Okun's coefficient, which would proxy the responsiveness of unemployment to growth. Our estimations use seasonally adjusted quarterly data on GDP (Y) and unemployment (U). Following limited previous research on Okun's law that was based on time series data (Apap & Gravino, 2017; Hartwig, 2014; Şahin et al., 2015; Sawtelle, 2007) and the first-differenced version of Okun's equation, our most general model could be specified as:

$$\Delta U_t = \alpha + \beta \Delta \ln Y_t + \varepsilon_t, \tag{1}$$

where ΔU is the percentage point change in the unemployment rate when period t is compared to $t-1$, i.e., $U_t - U_{t-1}$. ΔlnY is the log real output change when period t is compared to period $t-1$, i.e., $lnY_t - lnY_{t-1}$. Logarithmic transformation allows us to deal with heteroskedasticity in macroeconomic time series since, in the case of strongly trending series such as GDP, higher variable levels are likely to be associated with higher variability in absolute terms. ε_t is the error term. α and β are coefficients to be estimated. β, showing the reaction of unemployment to growth, is Okun's coefficient.

The abovementioned studies also emphasize that when a higher frequency than yearly time series is used, we might expect the effect of growth on unemployment to lag. To grasp this possible lagged effect, we specify the distributed lag (DL) model:

$$\Delta U_t = \alpha + \beta_0 \Delta \ln Y_t + \beta_1 \Delta \ln Y_{t-1} + \cdots + \beta_q \Delta \ln Y_{t-q} + \varepsilon_t. \tag{2}$$

Usually, q is set to one or just one, meaning that the possible instant effect of growth on unemployment dynamics is ignored (for example, in Apap & Gravino, 2017). We set $q = (0, 1, 2)$ in our analysis.

Even the first-differenced version of Okun's equation already foresees regressing differenced variables, which are probably stationary, on each other. As specified in Eqs. (1) and (2), these variables in levels most likely have a unit root and thus might potentially be cointegrated. Existing cointegration would require prespecifying Eq. (2) into the error correction model (ECM):

$$\Delta U_t = \alpha + \beta_0 \Delta \ln Y_t + \beta_1 \Delta \ln Y_{t-1} + \cdots + \beta_q \Delta \ln Y_{t-q} + \gamma EC_{t-1} + \varepsilon_t, \tag{3}$$

where EC is the error from the linear interaction between U and Y.

Therefore, before applying any specification, we extensively tested our initial variables using the Augmented Dickey–Fuller (ADF) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests for unit root presence, and the Engle–Granger (E–G) test for cointegration.

Our preliminary analysis showed that even though our time series are mostly stationary in their first differences, the Breusch–Godfrey (LM) and Ljung–Box Q tests indicate some remaining serial correlation in the models' error. Thus, residual autocorrelation is not so much a property of the data as a symptom of a misspecified model. Data may be persistent through time (i.e., inertial behavior of unemployment). Seasonal adjustment might also leave some unremoved cyclical patterns in the data. Conversely, it is possible to partially address the autocorrelation problem by including relevant variables in a time series model and fully specifying the model's dynamics. We developed the autoregressive distributed lag (ARDL) model with sessional dummies (sd):

$$\Delta U_t = \alpha + \delta \Delta U_{t-1} + \beta_0 \Delta \ln Y_t + \beta_1 \Delta \ln Y_{t-1} + \cdots + \beta_q \Delta \ln Y_{t-q} + sd + \varepsilon_t, \tag{4}$$

which, in case of detecting cointegration, is respecified into ECM:

$$\Delta U_t = \alpha + \delta \Delta U_{t-1} + \beta_0 \Delta \ln Y_t + \beta_1 \Delta \ln Y_{t-1} + \cdots + \beta_q \Delta \ln Y_{t-q} + sd + \gamma EC_{t-1} + \varepsilon_t, \tag{5}$$

Despite the points made above, some residual degree of heteroskedasticity may be present in time series data. The key point is that, in most cases, heteroskedasticity is likely to be combined with some remaining serial correlation (autocorrelation). This introduces a substantial complication in estimating standard errors and thus testing the significance of the estimated coefficients, and requires estimates of the covariance matrix that are asymptotically valid in the face of both heteroskedasticity and the autocorrelation of error. In our case, the HAC (heteroskedasticity and autocorrelation consistent) estimator is applied. More precisely, solutions offered by the Newey–West estimator (Newey & West, 1987) assign declining weights to the sample autocovariance as temporal separation increases. This is also known as a "sandwich" estimator. As regards the weights, we will use Parzen kernel estimation as the intermediary between the two extremes—i.e., the

Bartlett kernel (weights decline linearly) as used by Newey and West (1987), and the Quadratic Spectral (QS) kernel (where some weights can even achieve negative values). As regards the bandwidth, we use that which was recommended by Stock and Watson (2003).

The second step of the analysis is based on a simple cross-country specification:

$$OC_i^k = \pi_0 + \pi_1 LMRI_i^l + \epsilon_i, \tag{6}$$

where OC_i^k is the k-type (gender-, age- or educational attainment level-specific) of Okun's coefficient in the i-th country estimated in 2000–2020. It is calculated as the sum of statistically significant betas estimated in the first step of the analysis—i.e., $\beta0 + \ldots + \beta q$. $LMRI_i^l$ is the l-type index that proxies labor market regulation in the i-th country, averaged across 2000–2020. ϵ_i is the error term. π_0 and π_1 are coefficients to be estimated, where π_1 shows what effect labor market regulation has on the growth–unemployment relationship.

For the robustness check, we will estimate the relationship between time-varying k-type unemployment elasticity of growth and indexes that proxy labor market regulation for a panel of EU countries plus the UK. Time-varying unemployment elasticity will be calculated using the formula suggested by ILO (Islam & Nazara, 2000):

$$\varepsilon_{i,t}^k = \frac{\Delta UNEM_{i,t}^k / UNEM_{i,t-1}^k}{\Delta GDP_{i,t} / GDP_{i,t-1}}, \tag{7}$$

where $\varepsilon_{i,t}^k$ represents gender-, age- and educational attainment level-specific unemployment elasticity. $UNEM_{i,t}^k$ is the number of gender-, age- and educational attainment level-specific unemployed people in country i over year t. GDP stands for economy-wide yearly output at constant prices.

The relationship between labor market regulation and unemployment elasticity for the panel of countries is estimated using the following specification:

$$\varepsilon_{i,t}^k = \gamma_0 + \gamma_1 LMRI_{i,t}^l + \theta_t + \mu_i + u_{i,t}, \tag{8}$$

where θ_t represents time dummies, μ_i represents time-invariant factors, and $u_{i,t}$ is the idiosyncratic error term. Other terms are as specified before. We will estimate Eq. (8) using the least squares dummy variable estimator to control for both time- and country-fixed effects. We will use Arellano standard errors to account for heteroskedasticity and serial correlation in the error term.

Since previous research (Oh, 2018; Kim et al., 2020; Omoshoro-Jones, 2021; Donayre, 2022) emphasized the non-linear relationship between growth and unemployment, i.e., that unemployment is more elastic during an economic downturn compared to expansion, we might think that labor market regulation may also have a growth-direction-specific effect on the elasticity of unemployment. This assumption is based on the fact that labor market regulations are more focused on restrictions that are more relevant in periods of recession—for example, such regulations as rules for workers' dismissal, fixed-term contracts, and the level of minimum wage. With the following specification, we test the assumption that the effect of labor market regulation on the elasticity of unemployment differs during expansion compared to recession:

$$\varepsilon^k_{i,t} = \gamma_0 + \gamma_1 LMRI^l_{i,t} + \delta LMRI^l_{i,t} \bullet D_{i,t} + \gamma_2 D_{i,t} + \theta_t + \mu_i + u_{i,t}, \quad (9)$$

where $D_{i,t}$ is the dummy equal to 1 if $\Delta GDP_{i,t} < 0$. Thus, γ_1 shows the relationship between labor market regulation and the elasticity of unemployment during periods of expansion, and δ shows how the previously mentioned relationship differs during periods of recession compared to expansion. γ_2 shows how much the elasticity of unemployment differs during periods of recession compared to expansion.

The same specification, i.e., Eq. (9), will be used to test whether the effect of labor market regulation on unemployment elasticity changes over time, i.e., whether the effect is time persistent. Here we will compare the impact during 2011–2020, i.e., after the Great Financial Crisis, with the 2000–2010 period, i.e., before and during the crisis. In this estimation, $D_{i,t}$ will be country-fixed, i.e., D_{i} is equal to 1 for the 2011–2020 period, and 0 otherwise. Thus, in our specification, γ_1 shows the relationship between labor market regulation and the elasticity of unemployment during 2000–2010, and δ shows how the previously mentioned relationship differs in 2011–2020 compared to 2000–2010. γ_2 shows how much the elasticity of unemployment differs over 2011–2020 compared to in 2000–2010.

4 Estimation results

4.1 Age-, gender-, and educational attainment level-specific Okun's coefficient across countries

We started our analysis by testing for unit roots in our time series. Out of the 223 series we tested, 147 have unit roots according to all four tests, 56 according to three tests, 18 according to two, and 2 according to one. The results of the ADF and KPSS tests with and without trends for unemployment and GDP variables in levels are presented in Table 4 in the Appendix.

Since no time series are stationary according to all tests, we were looking for possible cointegration between the series of GDP and various types of unemployment across countries using the E–G test. The results of the E–G test with and without trends for unemployment and GDP variables are presented in Table 5 in the Appendix. We find evidence of cointegration: (i) between GDP and male unemployment and between GDP and those unemployed with ISCED 3–4 educational attainment levels in Luxembourg; (ii) between GDP and youth unemployment in Malta; (iii) between GDP and those unemployed with ISCED 3–4 educational attainment levels in Poland; (iv) between GDP and those unemployed with ISCED 0–2 educational attainment levels in Romania; and (v) between GDP and youth unemployment in Finland. For these relationships, we will use ECM, as specified in Eq. (5), and ARDL, as specified in Eq. (4), for most cases where cointegration is not detected.

Before estimating our equations, we tested for the unit root in our I(1) series. The results of the ADF and KPSS tests, both with and without trends for integrated unemployment and GDP variables, are presented in Table 6 in the Appendix. Correlation analysis between I(1) series of unemployment and GDP is available upon request from the corresponding author. Out of the 223 I(1) series we tested, 69 were stationary according to all four tests, 46 according to three tests, 64 according to two, 39 according to one, and 5 according to none of the tests. These results do not give us high confidence that using I(1) series will not produce spurious results in some models at some point.

Despite encountering challenges related to the specific data-generating process, we estimated our models as originally defined, for they serve as useful illustrations. The results of this are presented in Table 7 in the Appendix. Out of 195 estimated models (6 ECM and 189 ARDL), 24 had a serial correlation in their error terms. Since the time series in all of these 24 models have unit roots, we eliminated their estimates from further analysis, avoiding spurious results. Nevertheless, we realize that Okun's original estimations did not account for the possibility of non-stationary unemployment or output gaps. Recent theories suggest that various macroeconomic variables, including output, demonstrate notable persistence due to empirical evidence highlighting the dominance of permanent-effect shocks in macroeconomic fluctuations.

In recent times, fractional integration and fractional cointegration have gained tremendous significance. Traditionally, economic time series were described using deterministic I(0) or unit root models I(1). Although this approach is conceptually and computationally straightforward, it suffers from being excessively narrow and restrictive, as it fails to account for a wide range of dynamic behaviors that emerge when the integration order (d) extends beyond integer values. There is, in fact, no inherent limitation preventing a series from being integrated to a non-integer value.

However, this broader perspective introduces a complication. The challenge lies in defining a cointegrating relationship between series that possess different orders of integration, or even establishing such a relationship when the order of integration remains indeterminate. Pioneering work by Pesaran and Shin (1995) has demonstrated that the ARDL approach to cointegration offers a viable solution. This method allows us to test for cointegration (the presence of a long-term relation) in series that are I(0), I(1), or even I(d) (where d is a non-integer).

The estimation results reported in Table 7 show that educational attainment level affects the speed at which unemployment reacts to an output change. The unemployment of the least-educated reacts to output changes the fastest. Over the same period (quarter), the effect in the group with the highest level of education either does not appear at all or appears weaker than in the other groups of educational attainment level. When evaluating the one-period lagged effect, a tendency can be seen that the reaction of unemployment in the group with the highest education level is weaker than in other education groups. In the case of the two-period lagged effect, there is no consistent trend. In some countries, there is no significant effect. In other countries, it may be weaker than in other education groups or smaller than in only one education group. In Germany, France, the Netherlands, Portugal and the UK, the two-period lagged effect remains only in the group with the highest education level.

Still, in the Netherlands and the UK, output changes also have a non-lagged effect on the unemployment of the most educated.

Table 8 (see Appendix) presents calculated OC_i^k, i.e., gender-, age-, and educational attainment level-specific, Okun's coefficients across countries. Since β0, …, βq were estimated using level-log type specification, OC_i^k is equal to (β0 + … + βq)/100 and shows the effect of GDP change by one per cent on unemployment change in percentage points. Figure 1 shows the variability of OC_i^k by unemployment type across countries.

Our results are broadly consistent with most common conclusions in the literature on Okun's law. Figure 1 shows that female unemployment is less sensitive to output change than male. Greater sensitivity of male unemployment was found by Dixon et al. (2017), Butkus et al. (2020), and An et al. (2021). These results can be explained by the higher concentration of males in sectors which are more sensitive to business cycle fluctuations, such as industry or construction. Another reason is the lower level of participation of women in the labor market compared to men, due to inflexible working conditions that do not allow them to combine work and childcare. Youth unemployment is the most sensitive to growth, as was previously found by Banerji et al., (2014, 2015), Butkus et al. (2020), and An et al. (2021). An et al. (2021) suggested that youth unemployment is more responsive to output fluctuations compared to adults due to typically lower employment protection regulations for those with shorter job tenures and less experience. An increase in educational attainment level reduces the sensitivity of unemployment to output change, and the unemployment of the most educated is least sensitive to output changes. Butkus et al. (2020) assumed that highly educated workers can create more value added to companies due to their skills and experience compared to those less educated. Additionally, higher levels of education are associated with higher wages, which means

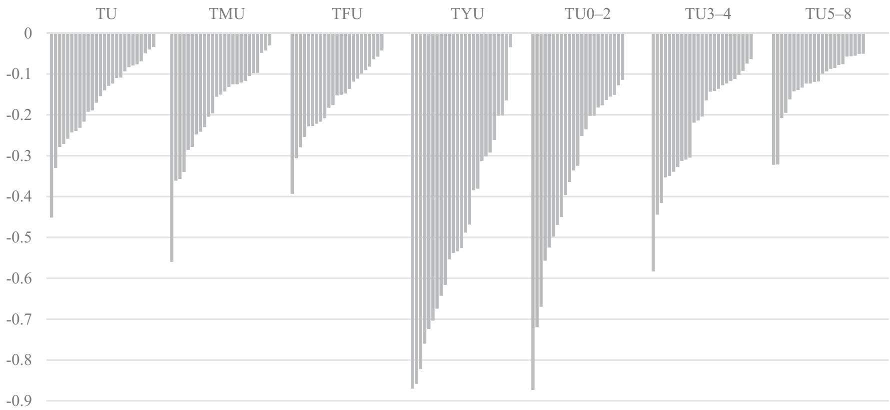

Fig. 1 OC_i^k by unemployment type across countries. TU, TMU, TFU, TYU, TU0–2, TU3–4, TU5–8 mean different types of unemployment, i.e., total, male, female, and youth unemployment rates respectively. TU0–2 means the unemployment rate of people with pre-primary, primary, and lower secondary education (ISCED 0–2); TU3–4 with upper secondary education and post-secondary non-tertiary education (ISCED 3–4); and TU5–8 with tertiary education (ISCED 5–8)

higher firing costs for employers. These differences of OC_i^k by type of unemployment are similar to the findings of previous research (Economou & Psarianos, 2016; Herwartz & Niebuhr, 2011; van Ours, 2015) analyzing EU panel estimates. Still, they are country-specific, and we aim to test whether cross-country variability of Okun's coefficient could be, to some degree, explained by labor market regulation.

4.2 Estimates of the relationship between labor market regulation and Okun's coefficient

The second step of the analysis is related to regressing estimated Okun's coefficients on indexes that proxy labor market regulation. OLS estimates of π_1 used to examine these relationships are presented in Table 1.

We find no solid supportive evidence that an increase in labor market regulation, which corresponds to a decrease in LMRI values, would drastically diminish possibilities for growth to reduce unemployment.

Our estimations show that hiring regulations and minimum wage (LMRI1)—which include such aspects as (1) whether fixed-term contracts are prohibited for permanent tasks, (2) whether the maximum cumulative duration of fixed-term contracts is regulated, and (3) whether the ratio of the minimum wage for a trainee or first-time employee to the average value added per worker is set—do not affect the output–unemployment relationship. We also find no evidence that centralized collective bargaining (LMRI3), i.e., whether the wages in the country are set by a centralized bargaining process or up to each company, would affect Okun's coefficients. Our results show that hours regulations (LMRI4)—i.e., (1) whether there are restrictions on night work, (2) whether there are restrictions on holiday work, (3) whether the length of the work week can be 5.5 days or longer, (4) whether there

Table 1 OLS estimates of π_1 using Eq. (6)

	TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
LMRI1	0.0037	−0.0011	−0.0045	0.0327	−0.0067	−0.0016	−0.0069
	(0.0107)	(0.0128)	(0.0095)	(0.0241)	(0.0233)	(0.0139)	(0.0083)
LMRI2	−0.0299	−0.0394*	−0.0374**	0.0210	−0.1043***	−0.0550**	−0.0325**
	(0.0178)	(0.0221)	(0.0153)	(0.0440)	(0.0359)	(0.0245)	(0.0127)
LMRI3	−0.0053	−0.0100	−0.0139	−0.0277	−0.0316	−0.0230	−0.0049
	(0.0121)	(0.0151)	(0.0107)	(0.0278)	(0.0261)	(0.0163)	(0.0097)
LMRI4	0.0050	0.0011	−0.0036	−0.0044	−0.0044	−0.0071	−0.0129
	(0.0124)	(0.0162)	(0.0126)	(0.0301)	(0.0287)	(0.0174)	(0.0100)
LMRI5	−0.0203	−0.0189	−0.0217*	−0.0094	−0.0503*	−0.0289	−0.0159
	(0.0128)	(0.0163)	(0.0110)	(0.0310)	(0.0264)	(0.0170)	(0.0095)
LMRI6	0.0180	0.0229	−0.0157	0.0453	−0.0041	0.0100	−0.0074
	(0.0229)	(0.0297)	(0.0253)	(0.0530)	(0.0598)	(0.0346)	(0.0178)

Heteroskedasticity robust standard errors are presented in parentheses. *, **, *** indicate significance at the 10, 5, and 1 percent levels, respectively are restrictions on overtime work, and (5) whether the average paid annual leave is 21 working days or more—do not change the possibilities for growth to reduce unemployment.

We find only marginal statistical evidence (at the 10% significance level) that an increase in the mandated cost of worker dismissal (LMRI5)—i.e., straightening the advanced notice requirements and increasing severance payments and penalties due when dismissing a redundant worker with a 10-year tenure—reduces the reaction of female and uneducated (ISCED 0–2) unemployment to growth.

We only find evidence that hiring and firing regulations (LMRI2), i.e., whether the hiring and firing of workers is impeded by regulations or flexibly determined by employers, are significantly related to the growth–unemployment relationship. More flexible hiring and firing of workers is related to the increased reaction of female unemployment to output fluctuations. More flexible hiring and firing conditions also increase the reaction of educational attainment level-specific unemployment to growth. Our results show that increasing regulations for hiring and firing workers will mostly reduce the reaction of the unemployment of the least educated to growth. In contrast, the reaction of the most educated will be affected three times less.

Still, analyzing the effect of LMRI6, which sums up the overall level of labor market regulation, we find no statistically significant evidence that more strict labor market regulation would diminish the responsiveness of unemployment to growth, which is consistent with van Ours (2015), Dixon et al. (2017), David et al. (2019), and Obst (2022).

4.3 Robustness check

For the robustness check, we alternatively estimated the relationship between time-varying gender-, age- and educational attainment level-specific unemployment elasticity and time-varying labor market regulation indexes for a panel of the EU countries plus the UK. Estimates of Eq. (8) are presented in Table 9. We find no evidence that stricter labor market regulation would reduce the possibilities for growth to tackle unemployment problems.

Next, we estimated Eq. (9) to examine whether we do not see a significant relationship between unemployment elasticity and labor market regulation because of possible opposite relationships during the period of economic expansion and recession. The results presented in Table 10 (see Appendix) show no evidence of a statistically significantly different relationship between the elasticity of unemployment and labor market regulation during periods of economic growth and decline. Moreover, these results once again suggest that there is no relationship between unemployment elasticity and the strictness of labor market regulation. Instead, we simply see that during the economic downturn, unemployment elasticity is higher—i.e., unemployment reacts more vitally to a one percent decrease in output than a one percent increase, which is supported by previous research (Aguiar-Conraria et al., 2020; An et al., 2021; Butkus & Seputiene, 2019; Butkus et al., 2020; Kim & Park, 2019; Kim et al., 2020; Novák & Darmo, 2019; Owyang & Sekhposyan, 2012; Owyang & Vermann, 2013).

Our last estimations presented in Table 11 (see Appendix) test whether we do not see a significant relationship between unemployment elasticity and labor market regulation because of possible existing opposite relationships during the analyzed 20-year period. The findings suggest that the effect of labor market regulation on unemployment did not change during 2011–2020 compared to 2000–2010. On the contrary, we did not find any effect of labor market regulation on unemployment elasticity. Findings suggest that elasticity, i.e., the reaction of unemployment to output change, was higher during 2011–2020 compared to 2000–2010.

5 Conclusions

Our two-stage research made it possible to estimate gender-, age-, and educational attainment level-specific Okun's coefficients based on quarterly time-series data and to verify the role of labor market regulations on the sensitivity of unemployment to output changes. We found that male unemployment is more sensitive to output change than female, but the difference is small. The highest level of sensitivity of unemployment to growth was found for youth and in the groups with the lowest educational attainment levels. Even though the results of several countries show some differences in the effect of output growth on unemployment in different educational attainment level groups, there is a trend for weaker unemployment reactions as the level of education increases. We found that the higher the educational attainment level, the weaker the reaction of unemployment to output growth. The results of this study complement the results of our previous panel data-based research (Butkus et al., 2020) which suggested that education is a possible cause of heterogeneity in Okun's coefficient; at the same time, they allow us to check the effect of educational attainment level on the output-unemployment interaction by employing time series data.

Testing the impact of labor market regulations on the sensitivity of unemployment rate to output changes, we did not find evidence that an increase in labor market regulation limits the possibilities of growth to reduce unemployment. There were only a few cases where the effect of labor market regulation on the response of unemployment to output changes was found. For example, increasing the mandated cost of worker dismissal reduces the reaction of unemployment to growth in the female and least educated groups. Increasing regulations for hiring and firing also reduces the reaction of unemployment to growth in the female and least educated groups. However, when the effect of the overall level of labor market regulation is assessed, we do not find a dampening effect on the reaction of unemployment to output growth.

We estimated Okun's coefficients for countries representing different economies with different development levels—for example, represented by the United Nations (WESP, 2022), the International Monetary Fund (IMF, 2023), MSCI classification (MSCI, 2023), etc. The results of our research did not show significant differences in Okun's coefficient in different groups of countries regarding these classifications. Bulgaria's coefficients in all labor market groups tend to be high, but only youth employment reacts to output changes more strongly than in other countries.

Considering MSCI classification, we found that Okun's coefficients in the developed countries group vary from the smallest to the largest. It can be observed that the coefficients tend to be of moderate level in the group of emerging countries and higher in the group of frontier countries compared to the coefficients of all countries, but it should be noted that these country groups are represented by a small number of countries. When comparing country groups according to labor market regulation indicators, we also did not find any significant differences.

Aiming for a deeper assessment of the impact of labor market regulation, we additionally tested the relationship between time-varying gender-, age- and educational attainment level-specific unemployment elasticity and time-varying labor market regulation indices for a panel of EU countries (plus the UK). We also tested potentially different relationships during the periods of economic expansion and recession and during two periods of time: 2011–2020 and 2000–2010. Still, in all these specifications, we did not find any evidence that stricter labor market regulation would reduce the possibilities of output growth to reduce unemployment. Our findings suggest that while labor market regulations protect employees' rights, they do not limit the economic growth opportunities for the unemployed, which is highly important in the context of the shocks of the last few years (COVID-19, the energy crisis, etc.).

The results of the empirical analysis underscore significant policy implications concerning the relationship between unemployment and fluctuations in output in terms of labor market regulations. Since our results show that straightening labor market regulation would not significantly reduce the possibilities for growth to reduce unemployment, countries with lower LMR levels can increase the level of protection of employees without fear that economic growth would not ensure a decrease in unemployment. In countries with a higher level of LMR, there is no necessity to yield to pressure regarding labor market flexibility or easing business conditions, as this is not an obstacle to economic growth reducing unemployment.

Our future research will leverage the testing and estimating procedure for the ARDL model developed by Pesaran and Shin (1995) and Pesaran et al. (2001). This approach empowers us to handle regressors that are I(1), I(0), or even fractionally integrated, and enables robust testing for the existence of a long-run relationship between the variables under investigation, regardless of their integration order.

Appendix A

See Tables 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11.

Table 2 Descriptive statistics of unemployment and output change across countries

Country	Variable	Mean	Std. Dev	Min	Max
Belgium (BE)	TU	7.49	1.01	5.10	8.80
	TMU	7.25	1.10	5.20	9.40
	TFU	7.80	1.31	4.60	10.20
	TYU	19.60	3.02	12.20	26.30
	TU0–2	13.50	1.96	8.70	17.20
	TU3–4	7.49	1.11	4.90	9.20
	TU5–8	4.09	0.62	2.90	5.40
	ΔlnY	0.003	0.020	−0.124	0.112
Bulgaria (BG)	TU	10.20	4.38	4.10	20.70
	TMU	10.70	4.60	4.30	21.50
	TFU	9.74	4.18	3.80	19.70
	TYU	22.30	8.52	8.20	40.70
	TU0–2	22.30	6.10	12.20	34.40
	TU3–4	9.44	4.45	3.20	20.30
	TU5–8	4.66	2.11	1.30	10.00
	ΔlnY	0.007	0.014	−0.076	0.038
Czechia (CZ)	TU	5.94	2.13	2.00	9.20
	TMU	4.97	1.80	1.60	7.90
	TFU	7.18	2.56	2.30	10.80
	TYU	14.70	4.90	4.90	21.50
	TU0–2	21.00	5.43	8.40	29.20
	TU3–4	5.45	1.98	1.70	8.40
	TU5–8	2.20	0.61	0.80	3.30
	ΔlnY	0.006	0.016	−0.093	0.067
Denmark (DK)	TU	5.66	1.31	3.40	8.20
	TMU	5.46	1.57	2.90	9.00
	TFU	5.89	1.12	3.70	8.20
	TYU	11.10	3.11	5.80	16.90
	TU0–2	8.97	2.26	5.10	13.20
	TU3–4	4.94	1.27	2.60	7.50
	TU5–8	4.14	0.80	2.20	5.60
	ΔlnY	0.003	0.013	−0.062	0.061
Germany (DE)	TU	6.78	2.54	3.10	11.30
	TMU	6.99	2.47	3.40	11.50
	TFU	6.52	2.62	2.70	11.00
	TYU	9.41	2.67	5.30	15.90
	TU0–2	13.60	3.52	7.50	19.50
	TU3–4	6.41	2.81	2.60	11.40
	TU5–8	3.16	1.24	1.70	5.80
	ΔlnY	0.003	0.017	−0.100	0.086

Table 2 (continued)

Country	Variable	Mean	Std. Dev	Min	Max
Estonia (EE)	TU	8.94	3.62	4.00	19.30
	TMU	9.73	4.37	3.50	24.30
	TFU	8.12	3.02	3.50	14.90
	TYU	18.00	6.37	7.40	38.00
	TU0–2	17.40	6.72	7.90	33.30
	TU3–4	9.73	4.10	4.10	23.10
	TU5–8	5.20	2.07	2.10	10.90
	ΔlnY	0.009	0.022	−0.126	0.047
Ireland (IE)	TU	8.07	4.08	4.00	16.00
	TMU	8.77	4.95	3.80	18.30
	TFU	7.23	3.07	4.20	13.20
	TYU	16.00	8.02	6.50	31.60
	TU0–2	13.00	6.45	6.10	26.80
	TU3–4	9.18	5.59	2.60	19.70
	TU5–8	4.58	2.17	1.60	8.50
	ΔlnY	0.011	0.035	−0.057	0.191
Greece (EL)	TU	15.70	6.64	7.60	27.60
	TMU	12.40	6.72	5.00	24.60
	TFU	20.20	6.33	11.30	31.60
	TYU	35.80	11.50	21.00	59.40
	TU0–2	16.30	8.11	7.30	30.20
	TU3–4	18.20	7.09	8.70	31.40
	TU5–8	12.00	5.00	6.20	20.70
	ΔlnY	−0.001	0.024	−0.143	0.053
Spain (ES)	TU	15.90	5.58	8.00	26.30
	TMU	14.20	6.38	6.10	26.00
	TFU	18.20	4.64	10.50	26.90
	TYU	34.20	12.50	17.20	55.80
	TU0–2	21.10	8.49	10.10	35.60
	TU3–4	15.70	5.50	7.90	26.20
	TU5–8	10.10	2.96	5.10	16.30
	ΔlnY	0.003	0.029	−0.196	0.154
France (FR)	TU	9.10	0.86	7.20	10.50
	TMU	8.93	1.08	6.90	10.90
	TFU	9.29	0.75	7.10	10.30
	TYU	22.00	2.20	17.70	26.30
	TU0–2	16.40	1.47	12.20	18.30
	TU3–4	9.97	0.78	8.40	11.00
	TU5–8	5.61	0.53	4.80	6.70
	ΔlnY	0.003	0.026	−0.146	0.169

Table 2 (continued)

Country	Variable	Mean	Std. Dev	Min	Max
Croatia (HR)	TU	12.60	3.28	6.30	18.10
	TMU	11.80	3.37	6.00	17.90
	TFU	13.60	3.35	6.50	19.40
	TYU	32.50	8.41	14.30	51.50
	TU0–2	15.00	4.92	8.10	27.20
	TU3–4	13.20	3.72	6.50	19.50
	TU5–8	7.56	1.98	4.40	13.00
	ΔlnY	0.004	0.022	−0.152	0.051
Italy (IT)	TU	9.43	1.90	6.00	12.80
	TMU	8.22	2.13	4.80	12.10
	TFU	11.20	1.85	7.70	15.10
	TYU	29.90	6.46	19.40	43.30
	TU0–2	11.90	2.93	7.00	17.00
	TU3–4	8.86	1.89	5.50	12.20
	TU5–8	5.93	0.904	4.20	8.10
	ΔlnY	−0.0002	0.024	−0.135	0.149
Cyprus (CY)	TU	7.84	4.21	3.30	16.60
	TMU	7.49	4.74	2.60	17.60
	TFU	8.28	3.66	4.10	16.00
	TYU	18.30	9.80	7.10	40.00
	TU0–2	9.89	5.45	3.80	22.10
	TU3–4	9.16	4.88	3.20	21.00
	TU5–8	7.29	3.44	2.30	14.70
	ΔlnY	0.005	0.023	−0.140	0.093
Latvia (LV)	TU	11.20	3.79	5.40	20.90
	TMU	12.30	4.52	5.60	26.30
	TFU	10.20	3.25	5.00	17.40
	TYU	20.00	7.37	7.50	40.60
	TU0–2	20.70	6.27	9.10	34.10
	TU3–4	11.80	4.43	5.20	22.50
	TU5–8	5.45	1.86	3.00	11.70
	ΔlnY	0.008	0.024	−0.077	0.055
Lithuania (LT)	TU	10.60	4.12	4.10	18.10
	TMU	11.80	5.03	3.80	22.10
	TFU	9.41	3.36	4.00	15.20
	TYU	20.50	8.26	6.70	37.20
	TU0–2	22.90	9.48	6.20	40.60
	TU3–4	12.10	4.49	4.60	22.60
	TU5–8	4.53	1.74	1.40	8.10
	ΔlnY	0.010	0.021	−0.138	0.043

Table 2 (continued)

Country	Variable	Mean	Std. Dev	Min	Max
Luxembourg (LU)	TU	4.89	1.30	1.90	7.80
	TMU	4.32	1.53	1.60	8.30
	TFU	5.64	1.29	2.30	8.70
	TYU	16.00	4.76	7.00	35.70
	TU0–2	8.33	2.47	4.00	16.00
	TU3–4	5.16	1.31	2.70	8.10
	TU5–8	3.97	0.71	2.60	6.20
	ΔlnY	0.006	0.018	−0.058	0.080
Hungary (HU)	TU	7.07	2.41	3.40	11.40
	TMU	7.10	2.52	3.30	11.90
	TFU	7.03	2.34	3.30	11.20
	TYU	17.60	6.02	9.90	29.30
	TU0–2	16.10	5.40	9.50	26.40
	TU3–4	6.66	2.39	2.90	11.20
	TU5–8	2.60	1.06	1.20	5.00
	ΔlnY	0.006	0.023	−0.152	0.109
Malta (MT)	TU	5.97	1.22	3.50	8.30
	TMU	5.66	1.13	3.20	7.70
	TFU	6.59	1.72	3.30	10.20
	TYU	-	-	-	-
	TU0–2	8.13	1.62	3.90	10.40
	TU3–4	4.61	0.96	2.60	6.90
	TU5–8	3.02	0.75	2.20	4.50
	ΔlnY	0.009	0.026	−0.151	0.066
Netherlands (NL)	TU	4.70	1.44	2.20	7.80
	TMU	4.30	1.47	1.70	7.50
	TFU	5.18	1.47	2.60	8.10
	TYU	9.16	2.51	4.30	13.60
	TU0–2	7.49	2.36	3.10	12.50
	TU3–4	4.40	1.60	1.70	7.80
	TU5–8	2.88	0.72	1.40	4.40
	ΔlnY	0.003	0.013	−0.082	0.060
Austria (AT)	TU	4.92	0.73	3.40	6.20
	TMU	4.95	0.87	3.10	6.60
	TFU	4.89	0.68	3.60	6.10
	TYU	9.12	1.82	4.40	11.90
	TU0–2	9.94	2.02	5.40	14.50
	TU3–4	4.38	0.75	2.80	6.10
	TU5–8	2.81	0.74	1.20	4.20
	ΔlnY	0.003	0.020	−0.124	0.106

Table 2 (continued)

Country	Variable	Mean	Std. Dev	Min	Max
Poland (PL)	TU	10.80	5.53	2.90	20.40
	TMU	10.20	5.21	2.70	19.60
	TFU	11.50	5.95	3.00	21.60
	TYU	25.60	10.30	7.80	43.60
	TU0–2	18.20	5.96	7.70	28.40
	TU3–4	11.70	5.83	3.20	21.60
	TU5–8	4.81	1.75	1.70	8.10
	ΔlnY	0.009	0.016	−0.095	0.071
Portugal (PT)	TU	9.08	3.58	3.80	17.30
	TMU	8.46	3.85	2.90	17.50
	TFU	9.77	3.29	4.80	17.10
	TYU	21.70	8.77	8.30	41.10
	TU0–2	9.52	3.97	3.80	18.30
	TU3–4	9.79	3.85	4.40	18.50
	TU5–8	6.99	2.45	2.90	13.70
	ΔlnY	0.001	0.025	−0.165	0.137
Romania (RO)	TU	6.51	1.19	3.80	9.20
	TMU	7.16	1.27	4.00	9.90
	TFU	5.70	1.16	3.10	8.30
	TYU	20.50	2.42	15.40	25.30
	TU0–2	6.77	1.08	4.40	9.00
	TU3–4	7.18	1.57	3.90	10.10
	TU5–8	3.76	1.21	1.40	6.30
	ΔlnY	0.009	0.021	−0.112	0.054
Slovenia (SI)	TU	6.78	1.68	4.10	10.60
	TMU	6.30	1.69	3.70	10.10
	TFU	7.34	1.77	4.50	11.40
	TYU	15.00	3.88	6.60	24.70
	TU0–2	10.90	3.15	5.10	18.40
	TU3–4	7.10	1.85	4.10	11.70
	TU5–8	4.02	1.41	2.10	6.90
	ΔlnY	0.005	0.021	−0.099	0.111
Slovakia (SK)	TU	13.00	4.16	5.70	19.30
	TMU	12.50	4.35	5.50	19.80
	TFU	13.50	4.02	5.90	19.50
	TYU	27.90	7.48	13.10	39.30
	TU0–2	40.90	7.12	28.10	54.40
	TU3–4	12.10	4.12	4.60	18.70
	TU5–8	4.94	1.34	2.40	7.60
	ΔlnY	0.009	0.021	−0.101	0.087

Table 2 (continued)

Country	Variable	Mean	Std. Dev	Min	Max
Finland (FI)	TU	8.23	0.94	6.20	10.50
	TMU	8.39	1.01	5.80	10.00
	TFU	8.07	1.09	6.00	11.30
	TYU	19.90	1.96	15.40	23.50
	TU0–2	15.60	1.79	12.10	20.40
	TU3–4	8.82	1.08	6.00	11.10
	TU5–8	4.40	0.69	3.20	6.10
	ΔlnY	0.003	0.015	– 0.067	0.048
Sweden (SE)	TU	6.95	1.12	4.70	8.90
	TMU	7.09	1.11	4.80	9.20
	TFU	6.78	1.18	4.40	8.80
	TYU	19.50	4.30	9.00	26.20
	TU0–2	15.20	4.71	7.80	26.30
	TU3–4	6.11	1.09	4.30	8.70
	TU5–8	3.97	0.65	2.30	5.30
	ΔlnY	0.005	0.015	– 0.084	0.071
United Kingdom (UK)	TU	5.63	1.35	3.70	8.30
	TMU	6.02	1.52	3.80	9.10
	TFU	5.17	1.19	3.50	7.60
	TYU	14.80	3.52	10.70	22.20
	TU0–2	9.56	2.65	6.10	14.70
	TU3–4	5.75	1.59	3.90	8.90
	TU5–8	3.10	0.64	2.30	4.60
	ΔlnY	0.003	0.029	– 0.208	0.148

TU is the total unemployment rate (age 15–74), %; TMU—male unemployment rate (age 15–74), %; TFU—female unemployment rate (age 15–74), %; TYU—youth unemployment rate (age 15–24), %; TU0–2 is the unemployment rate of people with pre-primary, primary and lower secondary education (ISCED 0–2*, age 15–74), %; TU3–4—the unemployment rate of people with upper secondary education and post-secondary non-tertiary education (ISCED 3–4*, age 15–74); TU5–8—the unemployment rate of people with tertiary education (ISCED 5–8*, age 15–74); ΔlnY is the log difference of gross domestic product (constant (2015) prices, million euros)

*ISCED 0–2, ISCED 3–4, ISCED 5–8 represent different education attainment levels of International Standard Classification of Education

Table 3 Descriptive statistics of variables that proxy labor market regulation

Country code	Variable	Mean	Std. Dev	Min	Max
BE	LMRI1	8.54	1.14	5.10	8.90
	LMRI2	3.07	0.58	1.50	3.70
	LMRI3	4.53	0.79	3.30	5.80
	LMRI4	6.07	1.37	2.70	8.00
	LMRI5	9.36	0.76	8.50	10.0
	LMRI6	6.93	0.57	5.50	7.40
BG	LMRI1	6.27	1.59	2.60	8.30
	LMRI2	5.02	0.43	4.30	5.80
	LMRI3	7.36	0.36	6.70	7.90
	LMRI4	6.55	0.86	6.00	8.00
	LMRI5	9.27	0.09	9.20	9.60
	LMRI6	7.01	0.67	5.60	7.80
CZ	LMRI1	7.86	1.56	5.10	10.00
	LMRI2	4.18	0.84	3.30	6.30
	LMRI3	7.59	0.43	6.80	8.30
	LMRI4	9.52	1.50	5.00	10.00
	LMRI5	7.93	0.22	7.80	8.80
	LMRI6	7.57	0.74	5.70	8.40
DK	LMRI1	9.40	1.56	4.80	10.00
	LMRI2	7.33	0.57	6.50	8.50
	LMRI3	5.61	0.44	4.70	6.40
	LMRI4	7.62	1.20	4.00	8.00
	LMRI5	10.00	0.00	10.00	10.00
	LMRI6	7.18	0.56	5.50	7.50
DE	LMRI1	6.92	1.44	4.60	8.90
	LMRI2	3.50	1.74	1.30	6.20
	LMRI3	3.81	1.34	1.80	6.00
	LMRI4	6.38	2.02	2.50	8.00
	LMRI5	5.13	1.36	3.60	6.30
	LMRI6	5.35	1.73	2.90	7.50
EE	LMRI1	6.15	1.18	2.90	6.70
	LMRI2	5.54	0.65	4.30	6.30
	LMRI3	8.59	0.17	8.20	8.80
	LMRI4	4.00	0.00	4.00	4.00
	LMRI5	8.19	1.24	6.80	9.30
	LMRI6	5.91	0.39	5.00	6.30
IE	LMRI1	8.50	1.26	4.70	8.90
	LMRI2	4.68	0.65	3.60	6.30
	LMRI3	5.05	1.64	2.90	7.30
	LMRI4	9.55	1.41	5.30	10.00
	LMRI5	7.60	1.07	6.40	9.10
	LMRI6	7.56	0.58	5.90	8.10

Table 3 (continued)

Country code	Variable	Mean	Std. Dev	Min	Max
EL	LMRI1	5.51	0.53	4.10	6.70
	LMRI2	3.60	0.68	2.30	4.60
	LMRI3	4.44	0.85	3.50	5.70
	LMRI4	4.65	1.29	3.30	6.30
	LMRI5	6.70	1.18	5.50	7.80
	LMRI6	4.53	0.34	4.00	5.00
ES	LMRI1	2.93	0.98	2.20	5.60
	LMRI2	3.20	0.52	2.20	3.80
	LMRI3	5.63	0.86	4.30	6.80
	LMRI4	6.38	1.32	4.00	8.00
	LMRI5	4.98	0.16	4.80	5.20
	LMRI6	5.45	0.57	4.10	6.30
FR	LMRI1	3.00	0.73	2.20	4.50
	LMRI2	2.79	0.81	1.70	4.50
	LMRI3	6.37	0.52	5.30	7.20
	LMRI4	3.83	0.48	2.00	4.00
	LMRI5	7.75	0.69	7.00	8.50
	LMRI6	5.62	0.23	5.30	5.90
HR	LMRI1	4.22	1.27	2.20	5.60
	LMRI2	3.68	0.85	2.60	5.10
	LMRI3	6.79	0.30	6.20	7.40
	LMRI4	6.29	0.72	6.00	8.00
	LMRI5	6.77	1.17	3.60	7.60
	LMRI6	5.96	0.66	4.40	6.80
IT	LMRI1	5.67	1.05	3.90	7.20
	LMRI2	2.75	0.45	1.80	3.30
	LMRI3	3.73	0.27	3.00	4.20
	LMRI4	7.03	1.20	4.80	8.00
	LMRI5	9.84	0.29	9.00	10.0
	LMRI6	6.24	0.82	4.60	7.00
CY	LMRI1	6.07	0.57	5.60	6.70
	LMRI2	4.63	0.50	3.60	5.40
	LMRI3	5.71	0.48	5.00	6.30
	LMRI4	10.0	0.00	10.0	10.0
	LMRI5	9.16	2.14	4.10	10.0
	LMRI6	5.37	1.36	2.90	6.30
LV	LMRI1	3.80	1.25	2.20	5.00
	LMRI2	4.96	0.48	3.90	5.70
	LMRI3	7.98	0.40	7.00	8.40
	LMRI4	7.81	1.78	6.00	10.00
	LMRI5	8.09	0.31	7.80	8.40
	LMRI6	6.76	0.85	5.40	7.70

Table 3 (continued)

Country code	Variable	Mean	Std. Dev	Min	Max
LT	LMRI1	6.84	1.64	3.00	8.30
	LMRI2	3.88	0.58	2.80	5.00
	LMRI3	8.20	0.14	7.70	8.30
	LMRI4	6.57	2.38	4.00	10.00
	LMRI5	7.17	0.79	6.30	8.50
	LMRI6	6.29	0.98	4.70	7.90
LU	LMRI1	2.48	0.49	2.20	3.30
	LMRI2	4.30	0.74	3.20	5.70
	LMRI3	6.12	0.48	5.50	6.80
	LMRI4	4.88	1.02	4.00	6.00
	LMRI5	7.84	1.10	5.20	8.50
	LMRI6	6.11	0.46	5.30	6.90
HU	LMRI1	7.68	1.48	4.60	10.0
	LMRI2	5.13	0.39	4.60	6.00
	LMRI3	6.96	0.52	6.20	7.80
	LMRI4	4.13	1.13	2.00	6.00
	LMRI5	7.38	0.52	6.80	8.00
	LMRI6	6.72	0.45	5.80	7.30
MT	LMRI1	6.98	0.46	6.10	7.20
	LMRI2	4.22	0.70	3.30	5.20
	LMRI3	7.01	0.45	6.10	7.90
	LMRI4	7.64	1.21	6.00	10.0
	LMRI5	10.0	0.00	10.0	10.0
	LMRI6	7.31	0.53	6.60	8.00
NL	LMRI1	6.92	1.05	4.50	8.30
	LMRI2	3.97	1.31	2.60	6.40
	LMRI3	4.43	0.49	3.50	5.20
	LMRI4	7.29	2.07	4.50	10.00
	LMRI5	8.60	0.98	7.50	10.00
	LMRI6	6.86	0.56	5.70	7.60
AT	LMRI1	8.86	1.51	4.60	10.00
	LMRI2	4.08	0.49	3.10	4.80
	LMRI3	2.65	0.57	2.10	4.50
	LMRI4	6.63	0.90	5.20	8.00
	LMRI5	9.91	0.10	9.80	10.00
	LMRI6	5.87	0.35	4.90	6.30
PL	LMRI1	7.33	2.07	3.40	10.00
	LMRI2	4.04	0.42	2.70	4.80
	LMRI3	7.22	0.42	6.10	7.60
	LMRI4	7.26	1.02	4.80	8.00
	LMRI5	8.44	0.71	7.80	10.00
	LMRI6	6.88	0.79	5.00	7.70

Table 3 (continued)

Country code	Variable	Mean	Std. Dev	Min	Max
PT	LMRI1	4.33	1.91	2.20	6.70
	LMRI2	3.01	0.53	2.20	3.90
	LMRI3	5.86	0.39	4.90	6.50
	LMRI4	5.72	0.34	5.30	6.00
	LMRI5	3.75	2.76	1.00	7.00
	LMRI6	5.30	0.72	3.90	6.50
RO	LMRI1	3.64	0.82	2.20	5.00
	LMRI2	4.97	1.08	3.50	8.80
	LMRI3	7.12	0.63	6.30	8.70
	LMRI4	7.14	1.01	6.00	8.00
	LMRI5	9.68	0.32	9.30	10.0
	LMRI6	6.70	0.80	5.30	7.50
SI	LMRI1	2.70	0.80	2.20	4.00
	LMRI2	2.70	0.38	2.10	3.40
	LMRI3	5.49	0.40	4.70	6.10
	LMRI4	6.30	1.57	4.70	8.00
	LMRI5	7.32	0.87	6.30	8.10
	LMRI6	5.59	0.63	4.20	6.20
SK	LMRI1	6.68	1.27	4.20	8.30
	LMRI2	4.30	1.07	3.00	6.80
	LMRI3	7.18	0.63	6.00	8.30
	LMRI4	7.68	0.99	4.80	8.00
	LMRI5	8.21	0.65	7.60	10.0
	LMRI6	7.04	0.69	5.20	8.00
FI	LMRI1	4.54	0.80	3.90	5.60
	LMRI2	4.36	0.44	3.20	5.20
	LMRI3	2.99	0.65	2.00	4.10
	LMRI4	6.84	1.64	2.80	8.00
	LMRI5	8.97	1.22	7.60	10.0
	LMRI6	5.10	0.41	4.00	5.60
SE	LMRI1	6.76	0.97	4.40	8.30
	LMRI2	3.31	0.86	1.90	4.40
	LMRI3	3.94	0.39	3.30	4.50
	LMRI4	5.76	0.75	3.50	6.00
	LMRI5	8.97	1.22	7.60	10.0
	LMRI6	5.78	0.92	4.10	6.90
UK	LMRI1	8.49	1.29	4.60	8.90
	LMRI2	5.88	0.64	4.90	6.90
	LMRI3	7.94	0.29	7.40	8.60
	LMRI4	8.33	1.05	6.50	10.00
	LMRI5	8.38	0.39	8.00	9.10
	LMRI6	8.18	0.38	7.10	8.50

Table 4 Results of Augmented Dickey–Fuller (ADF) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests for quarterly *ln(Y)* and unemployment in EU countries

Country	Test		The p-value for ADF test* and KPSS test statistics**							
			ln(Y)	TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
BE	ADF	Without trend	0.4242	0.2757	0.1387	0.8443	0.211	0.214	0.3578	0.0663
		With trend	0.8279	0.3106	0.5019	0.3125	0.4088	0.8352	0.4644	0.1837
	KPSS	Without trend	1.6893	0.3996	0.2679	1.1293	0.2566	0.6593	0.3200	0.1802
		With trend	0.2307	0.2237	0.2299	0.1925	0.2314	0.2473	0.1954	0.1745
BG	ADF	Without trend	0.1043	0.0004	0.0006	0.0038	0.0703	0.1100	0.0004	0.0700
		With trend	0.7347	0.0159	0.0222	0.0484	0.3279	0.4055	0.0131	0.4165
	KPSS	Without trend	1.5862	0.9303	0.8219	1.0658	0.8723	0.4242	0.8795	0.8293
		With trend	0.3695	0.1971	0.1914	0.2053	0.1883	0.1855	0.1952	0.1913
CZ	ADF	Without trend	0.4867	0.7238	0.6554	0.7305	0.2969	0.4341	0.5057	0.4999
		With trend	0.6814	0.4210	0.3345	0.5526	0.1838	0.4249	0.3530	0.7025
	KPSS	Without trend	1.6147	1.2922	1.2013	1.3645	0.9028	0.7592	1.1533	0.4970
		With trend	0.2256	0.1807	0.1808	0.1853	0.1808	0.2928	0.1809	0.2251
DK	ADF	Without trend	0.8897	0.1691	0.1929	0.2396	0.4561	0.3392	0.2086	0.2427
		With trend	0.6000	0.2953	0.3841	0.4453	0.8041	0.5542	0.4904	0.3937
	KPSS	Without trend	1.5182	0.4940	0.4906	0.4420	0.8153	0.6959	0.3205	0.4703
		With trend	0.1853	0.2062	0.2183	0.1760	0.2819	0.2211	0.1918	0.0971
DE	ADF	Without trend	0.8680	0.3854	0.4922	0.5608	0.6588	0.8389	0.2802	0.2478
		With trend	0.0737	0.3857	0.5591	0.3334	0.0723	0.0098	0.3417	0.6689
	KPSS	Without trend	1.6788	1.4954	1.4394	1.5522	1.0142	1.3655	1.3702	1.2531
		With trend	0.0975	0.1981	0.1871	0.2074	0.2193	0.0874	0.2049	0.2807
EE	ADF	Without trend	0.4681	0.0283	0.0420	0.0118	0.0641	0.1485	0.0168	0.1140
		With trend	0.2150	0.0793	0.0873	0.0753	0.2347	0.3127	0.0556	0.3210
	KPSS	Without trend	1.4227	0.5314	0.5217	0.5219	0.2988	0.5242	0.4811	0.3784
		With trend	0.1889	0.1128	0.1107	0.1181	0.0963	0.1301	0.1087	0.1180
IE	ADF	Without trend	0.9850	0.3961	0.4129	0.3678	0.3344	0.3861	0.3235	0.3973
		With trend	0.9212	0.8185	0.8346	0.7654	0.6783	0.8682	0.7307	0.7190
	KPSS	Without trend	1.5211	0.5173	0.5004	0.5450	0.6811	0.5766	0.6433	0.6369
		With trend	0.2962	0.3324	0.3344	0.3218	0.3205	0.3340	0.3356	0.3246
EL	ADF	Without trend	0.7982	0.2146	0.1413	0.3075	0.1743	0.3681	0.2186	0.3829
		With trend	0.5253	0.2488	0.1346	0.4123	0.1524	0.6121	0.3610	0.3870
	KPSS	Without trend	0.9736	1.0722	1.0995	0.9705	0.9117	1.2674	0.9757	1.0725
		With trend	0.2721	0.1992	0.2044	0.1941	0.2052	0.1974	0.1975	0.2030
ES	ADF	Without trend	0.1964	0.2590	0.3033	0.4554	0.3176	0.3117	0.3144	0.3138
		With trend	0.8397	0.8273	0.8387	0.9029	0.5514	0.847	0.6987	0.7559
	KPSS	Without trend	1.1108	0.7965	0.8680	0.5634	1.0035	1.0114	0.8403	0.5013
		With trend	0.2223	0.2482	0.2741	0.2154	0.2481	0.2636	0.2347	0.2039
FR	ADF	Without trend	0.4762	0.7204	0.6646	0.9415	0.7691	0.8985	0.7295	0.4746
		With trend	0.8745	0.3628	0.4830	0.6294	0.7143	0.6126	0.4020	0.9332
	KPSS	Without trend	1.6199	0.3656	0.6177	0.1785	0.3896	0.5306	0.5902	0.5353
		With trend	0.1451	0.2206	0.2425	0.1825	0.2660	0.1641	0.1318	0.1215

Table 4 (continued)

Country	Test		The p-value for ADF test* and KPSS test statistics**							
			ln(Y)	TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
CR	ADF	Without trend	0.1045	0.1724	0.0533	0.7406	0.5748	0.5056	0.0371	0.5606
		With trend	0.3790	0.4447	0.1896	0.9204	0.8513	0.8541	0.1589	0.8583
	KPSS	Without trend	1.0298	0.3337	0.2332	0.5135	0.2491	0.3218	0.2419	0.2527
		With trend	0.2540	0.1908	0.1882	0.2009	0.018	0.2262	0.2127	0.2506
IT	ADF	Without trend	0.4276	0.5129	0.6021	0.4681	0.5210	0.6246	0.5525	0.4019
		With trend	0.4811	0.6865	0.5829	0.7492	0.6611	0.5932	0.7130	0.7346
	KPSS	Without trend	0.4272	0.6921	0.9936	0.2884	0.7602	1.1153	0.6793	0.4477
		With trend	0.1554	0.2327	0.2143	0.2721	0.2083	0.2200	0.2348	0.1753
CY	ADF	Without trend	0.0876	0.4076	0.4281	0.5346	0.4433	0.4844	0.3380	0.2399
		With trend	0.0912	0.6436	0.7437	0.8102	0.8371	0.8292	0.5869	0.3321
	KPSS	Without trend	1.2726	0.9549	0.9926	0.8623	1.0142	0.6576	0.7280	0.7823
		With trend	0.2280	0.1969	0.2075	0.1835	0.2140	0.2278	0.2327	0.2345
LV	ADF	Without trend	0.1298	0.1176	0.0891	0.1314	0.2576	0.1973	0.1360	0.1660
		With trend	0.0397	0.2641	0.2484	0.2830	0.5317	0.4905	0.3652	0.3512
	KPSS	Without trend	0.3512	0.3023	0.2248	0.4373	0.2267	0.2294	0.2073	0.2409
		With trend	0.2227	0.1634	0.1663	0.1556	0.1867	0.2251	0.1912	0.1793
LT	ADF	Without trend	0.6050	0.0340	0.0223	0.1136	0.1202	0.4106	0.0150	0.0517
		With trend	0.1534	0.1361	0.0979	0.3518	0.3519	0.7207	0.0730	0.1587
	KPSS	Without trend	1.5570	0.3981	0.2993	0.5566	0.3255	0.3905	0.1693	0.3810
		With trend	0.2325	0.1405	0.1430	0.1341	0.1304	0.2337	0.1627	0.1107
LU	ADF	Without trend	0.5548	0.5597	0.6426	0.0216	0.1763	0.4649	0.2457	0.1659
		With trend	0.4383	0.0999	0.0801	0.0763	0.3005	0.3527	0.0098	0.0714
	KPSS	Without trend	1.7115	1.4072	1.5803	0.7945	1.0467	1.0437	1.1604	0.4634
		With trend	0.2184	0.1475	0.0860	0.1686	0.2386	0.1295	0.0509	0.0667
HU	ADF	Without trend	0.5556	0.5337	0.4579	0.6702	0.6170	0.5631	0.5129	0.4123
		With trend	0.4803	0.7665	0.6879	0.8795	0.8787	0.8783	0.7591	0.7583
	KPSS	Without trend	1.4642	0.4253	0.4363	0.4165	0.3859	0.4070	0.4053	0.3839
		With trend	0.1901	0.3807	0.3601	0.3995	0.3859	0.4032	0.3672	0.3810
MT	ADF	Without trend	0.9285	0.6746	0.5757	0.8140	0.2158	0.8654	0.4744	
		With trend	0.7759	0.5257	0.5813	0.3395	0.1726	0.8624	0.6204	
	KPSS	Without trend	1.6842	1.3905	1.2530	1.4237	1.2811	0.8467	1.0797	
		With trend	0.3549	0.2858	0.2311	0.2667	0.1220	0.2934	0.1009	
NL	ADF	Without trend	0.7068	0.0417	0.1356	0.0763	0.1393	0.0348	0.0513	0.0447
		With trend	0.3319	0.2947	0.6768	0.3771	0.5739	0.1357	0.2620	0.2551
	KPSS	Without trend	1.6151	0.5233	0.6328	0.3874	0.5795	0.6893	0.6215	0.5144
		With trend	0.1319	0.2313	0.2167	0.2422	0.3041	0.2294	0.2212	0.2133
AT	ADF	Without trend	0.4256	0.0933	0.1042	0.1178	0.0714	0.3060	0.1068	0.2771
		With trend	0.4172	0.2614	0.2474	0.3590	0.2769	0.1403	0.1158	0.4202
	KPSS	Without trend	1.6326	0.6530	0.9088	0.2919	0.7598	1.1911	0.7578	0.9345
		With trend	0.2011	0.1272	0.1097	0.1471	0.2112	0.0928	0.0999	0.0947

Table 4 (continued)

Country	Test		The p-value for ADF test* and KPSS test statistics**							
			ln(Y)	TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
PL	ADF	Without trend	0.7655	0.3075	0.4414	0.4604	0.4572	0.4474	0.2968	0.6623
		With trend	0.4990	0.0341	0.0928	0.0822	0.2640	0.0438	0.0575	0.0588
	KPSS	Without trend	1.7545	1.4747	1.4327	1.5119	1.3684	1.1619	1.4460	1.2523
		With trend	0.2084	0.1260	0.1205	0.1296	0.1182	0.1043	0.1219	0.1377
PT	ADF	Without trend	0.0825	0.2689	0.2718	0.3043	0.2763	0.3326	0.2523	0.1600
		With trend	0.2912	0.7209	0.7344	0.7868	0.3821	0.8782	0.5977	0.4773
	KPSS	Without trend	0.4627	0.6880	0.7307	0.6273	0.9531	0.7014	0.7477	0.6033
		With trend	0.1425	0.3338	0.3175	0.3509	0.2821	0.3395	0.3086	0.2991
RO	ADF	Without trend	0.5561	0.7110	0.8764	0.4610	0.5500	0.0045	0.7560	0.4618
		With trend	0.6097	0.3653	0.3631	0.4108	0.7208	0.0203	0.5360	0.7157
	KPSS	Without trend	1.6334	1.0930	1.1431	1.0154	0.3415	0.3288	1.2773	0.3563
		With trend	0.2211	0.1820	0.2146	0.1435	0.2637	0.1345	0.1543	0.2442
SI	ADF	Without trend	0.3929	0.2495	0.4417	0.1746	0.2534	0.4132	0.3536	0.5453
		With trend	0.4067	0.6040	0.8019	0.4678	0.5362	0.6902	0.7108	0.9738
	KPSS	Without trend	1.4339	0.2548	0.2448	0.2519	0.2411	0.5508	0.2657	0.8270
		With trend	0.2197	0.2165	0.2251	0.1982	0.1531	0.1886	0.2094	0.2627
SK	ADF	Without trend	0.2575	0.6474	0.4185	0.8416	0.2410	0.8128	0.2996	0.4135
		With trend	0.8380	0.5834	0.4408	0.6104	0.4024	0.2198	0.2496	0.7144
	KPSS	Without trend	1.6735	1.3311	1.2693	1.3837	0.8627	1.1899	1.1913	0.2132
		With trend	0.3641	0.1429	0.1484	0.1412	0.1581	0.2237	0.1547	0.1988
FI	ADF	Without trend	0.3722	0.0511	0.0744	0.0290	0.0111	0.6781	0.0440	0.0601
		With trend	0.4057	0.1775	0.2446	0.1247	0.0553	0.3279	0.1804	0.1329
	KPSS	Without trend	1.3358	0.3470	0.1305	0.7404	0.1021	1.0293	0.2206	0.3249
		With trend	0.2536	0.1774	0.1368	0.2368	0.0791	0.1533	0.1805	0.1593
SE	ADF	Without trend	0.6717	0.0932	0.0375	0.2291	0.1469	0.9574	0.0331	0.0195
		With trend	0.0660	0.1980	0.0994	0.3331	0.4308	0.1777	0.1370	0.0717
	KPSS	Without trend	1.7087	0.7299	0.6649	0.7533	0.7445	1.6710	0.2683	0.5942
		With trend	0.1152	0.2544	0.2114	0.2823	0.3408	0.1292	0.2635	0.2160
UK	ADF	Without trend	0.2801	0.4822	0.4762	0.4205	0.5182	0.5758	0.3242	0.2775
		With trend	0.8755	0.7950	0.7872	0.7819	0.8472	0.8851	0.6432	0.5715
	KPSS	Without trend	1.5389	0.3361	0.3468	0.3432	0.3855	0.3592	0.4139	0.3088
		With trend	0.1253	0.3341	0.3260	0.3413	0.3492	0.3579	0.3370	0.2713

*P-value for testing the null: unit-root. **Test statistics of the null: time series is stationary. Null is not rejected for the test without trend if the test statistic is below the critical value of 0.350 (10%), 0.462 (5%), and 0.732 (1%), and for the test with the trend if the test statistic is below the critical value of 0.120 (10%). 0.148 (5%). and 0.215 (1%)

Table 5 Results of Engle–Granger (E–G) test for cointegration between quarterly ln(Y) and unemployment in EU countries

Country	Test	P-value for testing the null: unite-root on residuals						
		TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
BE	Without trend	0.3370	0.3688	0.5384	0.3678	0.5781	0.4751	0.1802
	With trend	0.3301	0.5130	0.3183	0.5072	0.6703	0.5336	0.2752
BG	Without trend	0.2192	0.2546	0.2514	0.4481	0.5742	0.1263	0.652
	With trend	0.7698	0.8289	0.6927	0.8003	0.9171	0.6476	0.9448
CZ	Without trend	0.4001	0.3798	0.4419	0.2730	0.4600	0.3144	0.6734
	With trend	0.632	0.6327	0.6627	0.5984	0.6325	0.5795	0.9173
DK	Without trend	0.3484	0.3814	0.4493	0.6953	0.4970	0.4454	0.3816
	With trend	0.1812	0.3979	0.2493	0.3979	0.4850	0.1960	0.5180
DE	Without trend	0.3326	0.2672	0.3894	0.2698	0.2659	0.6703	0.7385
	With trend	0.4399	0.4649	0.5201	0.6255	0.0896	0.6068	0.6863
EE	Without trend	0.2058	0.1655	0.2889	0.2832	0.3879	0.1609	0.3538
	With trend	0.6454	0.5689	0.5646	0.5894	0.7360	0.5906	0.4858
IE	Without trend	0.6382	0.6544	0.6278	0.5711	0.6342	0.5672	0.6384
	With trend	0.4306	0.4303	0.2997	0.4703	0.1316	0.4393	0.5036
EL	Without trend	0.7714	0.7883	0.6865	0.7728	0.6385	0.6957	0.8097
	With trend	0.9408	0.9611	0.8865	0.8914	0.9750	0.9007	0.9685
ES	Without trend	0.5455	0.5092	0.6856	0.5521	0.5368	0.5644	0.5210
	With trend	0.9841	0.9657	0.9947	0.9493	0.9850	0.9895	0.9916
FR	Without trend	0.8722	0.8199	0.4108	0.7911	0.8432	0.8678	0.7292
	With trend	0.8875	0.9547	0.6900	0.9006	0.8489	0.7807	0.8845
CR	Without trend	0.7343	0.6015	0.9188	0.7487	0.6946	0.7403	0.6985
	With trend	0.9635	0.9422	0.9870	0.9505	0.8763	0.9186	0.8655
IT	Without trend	0.7854	0.8155	0.6285	0.8216	0.7765	0.7588	0.7705
	With trend	0.9348	0.9531	0.8517	0.9531	0.9342	0.9062	0.9383
CY	Without trend	0.5752	0.6158	0.6795	0.6639	0.7403	0.6127	0.4700
	With trend	0.9814	0.9809	0.9574	0.9651	0.9171	0.9684	0.8955
LV	Without trend	0.2614	0.2804	0.3570	0.5205	0.5360	0.4189	0.2936
	With trend	0.7062	0.7586	0.7583	0.8992	0.8961	0.7819	0.6149
LT	Without trend	0.3534	0.2708	0.5272	0.4170	0.6289	0.1350	0.3363
	With trend	0.8974	0.9180	0.7915	0.8571	0.9655	0.8859	0.5912
LU	Without trend	0.0612	0.0224	0.1886	0.3379	0.2936	0.0068	0.1043
	With trend	0.2270	0.1300	0.3717	0.5789	0.5374	0.0304	0.1416
HU	Without trend	0.5645	0.5497	0.7198	0.7433	0.7491	0.5888	0.6237
	With trend	0.8808	0.9082	0.8962	0.9145	0.9475	0.8849	0.8660
MT	Without trend	0.1334	0.1358	0.1527	0.0197	0.4018	0.4279	
	With trend	0.0863	0.1502	0.4046	0.0979	0.5693	0.6499	
NL	Without trend	0.1234	0.3198	0.2059	0.3572	0.0571	0.1122	0.1773
	With trend	0.8991	0.9564	0.8000	0.8264	0.8895	0.9179	0.8263
AT	Without trend	0.1286	0.0884	0.2593	0.1144	0.0699	0.0576	0.2727
	With trend	0.5438	0.5961	0.5520	0.4505	0.3673	0.3825	0.6465

Table 5 (continued)

Country	Test	P-value for testing the null: unite-root on residuals						
		TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
PL	Without trend	0.0740	0.1224	0.1204	0.2768	0.0659	0.0388	0.0983
	With trend	0.4066	0.4152	0.3918	0.6029	0.7163	0.4099	0.4439
PT	Without trend	0.6132	0.5756	0.6356	0.6549	0.6766	0.6186	0.4114
	With trend	0.9975	0.9968	0.9938	0.9935	0.9974	0.9966	0.8888
RO	Without trend	0.2453	0.2662	0.2680	0.5925	0.0212	0.3927	0.6633
	With trend	0.4763	0.4984	0.4822	0.8378	0.0569	0.6593	0.9216
SI	Without trend	0.4924	0.6921	0.3982	0.4603	0.6292	0.6352	0.8210
	With trend	0.9547	0.9819	0.8516	0.5848	0.8584	0.9750	0.9794
SK	Without trend	0.5602	0.4722	0.5947	0.5737	0.4987	0.4399	0.6186
	With trend	0.7855	0.7414	0.7997	0.8286	0.3875	0.7017	0.8349
FI	Without trend	0.1653	0.2014	0.0792	0.0449	0.6632	0.2037	0.1947
	With trend	0.0685	0.2338	0.0849	0.0899	0.0557	0.0802	0.2001
SE	Without trend	0.1732	0.0826	0.2851	0.4109	0.1515	0.1071	0.0565
	With trend	0.3157	0.3685	0.4888	0.7166	0.3071	0.3782	0.2117
UK	Without trend	0.7187	0.7307	0.6373	0.7531	0.7914	0.5733	0.5298
	With trend	0.9790	0.9790	0.9459	0.9768	0.9806	0.9576	0.9536

Table 6 Results of Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests for integrated I(1) quarterly ln(Y) and unemployment in EU countries

Country	Test		The p-value for ADF test* and KPSS test statistics**							
			ln(Y)	TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
BE	ADF	Without trend	0.0263	0.0576	0.0506	0.0007	0.0013	0.0072	0.0010	0.0029
		With trend	0.0599	0.1356	0.1323	0.0022	0.0049	0.0177	0.0017	0.0151
	KPSS	Without trend	0.1239	0.1442	0.1468	0.0946	0.1305	0.0908	0.1296	0.1119
		With trend	0.0349	0.0474	0.0536	0.0392	0.0350	0.0559	0.0421	0.0402
BG	ADF	Without trend	0.0198	0.0225	0.0283	0.0142	0.0213	0.0142	0.0093	0.0312
		With trend	0.0067	0.0591	0.0800	0.0347	0.0694	0.0740	0.0274	0.1062
	KPSS	Without trend	0.5504	0.1154	0.1087	0.1282	0.1274	0.1084	0.1067	0.0965
		With trend	0.0805	0.0995	0.1036	0.0908	0.0906	0.1071	0.0945	0.0927
CZ	ADF	Without trend	0.0611	0.0125	0.0019	0.0245	0.0048	0.0004	0.0083	0.0104
		With trend	0.1429	0.0628	0.0130	0.116	0.0282	0.0028	0.0451	0.0564
	KPSS	Without trend	0.1864	0.0627	0.0598	0.0663	0.0681	0.1145	0.0648	0.0692
		With trend	0.0692	0.0650	0.0621	0.0667	0.0595	0.0562	0.0673	0.0712
DK	ADF	Without trend	0.0057	0.0162	0.0185	0.0745	0.0012	0.0597	0.0210	0.0280
		With trend	0.0306	0.0763	0.0792	0.2574	0.0098	0.2076	0.0906	0.1326
	KPSS	Without trend	0.0716	0.0876	0.0805	0.0862	0.1127	0.0882	0.0788	0.0555
		With trend	0.0680	0.0843	0.0731	0.0853	0.0848	0.0887	0.0737	0.0529

Table 6 (continued)

Country	Test		The p-value for ADF test* and KPSS test statistics**							
			ln(Y)	TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
DE	ADF	Without trend	0.0016	0.0098	0.0148	0.0170	0.0047	0.0268	0.0098	0.0952
		With trend	0.0112	0.0352	0.0482	0.0719	0.0372	0.1692	0.0269	0.1576
	KPSS	Without trend	0.0388	0.2536	0.2369	0.2501	0.2021	0.2571	0.1008	0.1242
		With trend	0.0387	0.1968	0.1808	0.2006	0.1523	0.1376	0.0989	0.0912
EE	ADF	Without trend	0.0387	0.0509	0.0159	0.1056	0.0077	0.0059	0.0532	0.0356
		With trend	0.1319	0.1748	0.0726	0.2633	0.0379	0.0325	0.1802	0.1295
	KPSS	Without trend	0.1855	0.0985	0.0662	0.1541	0.0719	0.0842	0.0707	0.1369
		With trend	0.1034	0.0666	0.0535	0.0810	0.0509	0.0653	0.0551	0.0780
IE	ADF	Without trend	0.0361	0.3149	0.2773	0.3595	0.1612	0.3843	0.2655	0.1062
		With trend	0.0990	0.5899	0.5368	0.6774	0.4081	0.6152	0.5156	0.3136
	KPSS	Without trend	0.2031	0.3000	0.2985	0.2754	0.2329	0.4572	0.3462	0.2100
		With trend	0.1325	0.1573	0.1471	0.1684	0.1382	0.1662	0.1540	0.1146
EL	ADF	Without trend	0.2817	0.3929	0.5004	0.3318	0.3131	0.5045	0.4688	0.4673
		With trend	0.4900	0.6910	0.7824	0.6331	0.6210	0.7731	0.7706	0.7707
	KPSS	Without trend	0.4240	0.2594	0.2623	0.2430	0.2166	0.2725	0.2396	0.2493
		With trend	0.1981	0.2376	0.2322	0.2342	0.1963	0.2391	0.2324	0.2274
ES	ADF	Without trend	0.7202	0.1368	0.1249	0.0983	0.1385	0.1183	0.1648	0.1055
		With trend	0.8355	0.3375	0.2841	0.2898	0.3581	0.2758	0.4068	0.3132
	KPSS	Without trend	0.2423	0.2020	0.2303	0.2197	0.1833	0.2318	0.1844	0.1869
		With trend	0.0670	0.1968	0.1836	0.2107	0.1810	0.2040	0.1869	0.1741
FR	ADF	Without trend	0.6733	0.3428	0.1142	0.1554	0.3660	0.1430	0.1926	0.0626
		With trend	0.9859	0.9707	0.7868	0.3758	0.7782	0.1854	0.8416	0.0598
	KPSS	Without trend	0.0850	0.2166	0.2547	0.1504	0.2571	0.2391	0.2058	0.1578
		With trend	0.0325	0.0846	0.0908	0.0757	0.0391	0.0880	0.1248	0.1018
CR	ADF	Without trend	0.1168	0.5809	0.4813	0.1308	0.0219	0.0223	0.6106	0.0134
		With trend	0.3045	0.8898	0.8308	0.3796	0.0824	0.0841	0.9084	0.0674
	KPSS	Without trend	0.2595	0.1581	0.1403	0.1681	0.1442	0.1409	0.1608	0.1063
		With trend	0.1003	0.1402	0.1351	0.1305	0.1151	0.1024	0.1548	0.0878
IT	ADF	Without trend	0.0356	0.0534	0.0663	0.0123	0.0937	0.0811	0.0957	0.0007
		With trend	0.1004	0.1929	0.2259	0.0618	0.2919	0.2607	0.3325	0.0050
	KPSS	Without trend	0.1211	0.2785	0.2438	0.3271	0.2204	0.2168	0.3125	0.0965
		With trend	0.0449	0.2496	0.2347	0.2496	0.2174	0.1985	0.2755	0.0906
CY	ADF	Without trend	0.2201	0.2209	0.2881	0.1154	0.0145	0.0587	0.235	0.2490
		With trend	0.5089	0.5386	0.6061	0.3709	0.0567	0.1768	0.4996	0.5638
	KPSS	Without trend	0.1766	0.1795	0.1833	0.1688	0.1477	0.2101	0.2113	0.1824
		With trend	0.1189	0.1604	0.1449	0.1680	0.1194	0.1174	0.1260	0.1194
LV	ADF	Without trend	0.1209	0.0281	0.0694	0.0681	0.0660	0.0496	0.0187	0.0344
		With trend	0.3520	0.1162	0.2293	0.2352	0.2125	0.1876	0.0807	0.1397
	KPSS	Without trend	0.2464	0.0688	0.0679	0.0685	0.0824	0.0875	0.0769	0.0544
		With trend	0.1000	0.0675	0.0657	0.0681	0.0648	0.0668	0.0731	0.0538

Table 6 (continued)

Country	Test		The p-value for ADF test* and KPSS test statistics**							
			ln(Y)	TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
LT	ADF	Without trend	0.0202	0.2078	0.0768	0.3084	0.1546	0.1268	0.2390	0.1341
		With trend	0.0866	0.4881	0.2511	0.5848	0.4027	0.3700	0.5422	0.3308
	KPSS	Without trend	0.2246	0.1022	0.0948	0.1083	0.0815	0.1115	0.1287	0.1367
		With trend	0.0855	0.0848	0.0832	0.0844	0.0743	0.1164	0.1118	0.0831
LU	ADF	Without trend	0.0088	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		With trend	0.0372	0.0003	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
	KPSS	Without trend	0.0988	0.0492	0.0432	0.0500	0.0578	0.0510	0.0517	0.0952
		With trend	0.0439	0.0337	0.0289	0.0465	0.0599	0.0419	0.0338	0.0535
HU	ADF	Without trend	0.0228	0.1354	0.0937	0.0779	0.0379	0.1366	0.0936	0.0287
		With trend	0.0905	0.2631	0.2255	0.1288	0.0642	0.2537	0.1971	0.0626
	KPSS	Without trend	0.1391	0.3252	0.2621	0.3826	0.3374	0.4577	0.2768	0.2711
		With trend	0.1214	0.1443	0.1369	0.1379	0.0952	0.1504	0.1315	0.1057
MT	ADF	Without trend	0.0475	0.0381	0.0025	0.0000	0.0005	0.0025	0.0026	
		With trend	0.2790	0.1487	0.0160	0.0002	0.0025	0.0154	0.0183	
	KPSS	Without trend	0.1432	0.1299	0.0659	0.1399	0.0716	0.0846	0.0869	
		With trend	0.0758	0.0660	0.0456	0.0720	0.0524	0.0498	0.0578	
NL	ADF	Without trend	0.0102	0.0728	0.0809	0.0551	0.0037	0.0611	0.0974	0.0046
		With trend	0.0489	0.1323	0.1385	0.1128	0.0095	0.1204	0.1920	0.0133
	KPSS	Without trend	0.0910	0.1951	0.1943	0.1784	0.1337	0.1650	0.1976	0.1366
		With trend	0.0523	0.0752	0.0844	0.0632	0.0520	0.0801	0.0783	0.0592
AT	ADF	Without trend	0.0257	0.0024	0.0030	0.0012	0.0003	0.0024	0.0042	0.0001
		With trend	0.0682	0.0127	0.0140	0.0079	0.0014	0.0153	0.0253	0.0008
	KPSS	Without trend	0.1718	0.0483	0.0454	0.0541	0.0938	0.0379	0.0429	0.0483
		With trend	0.0451	0.0435	0.0380	0.0528	0.0389	0.0382	0.0430	0.0482
PL	ADF	Without trend	0.0093	0.0730	0.0417	0.1102	0.0995	0.2026	0.0668	0.0636
		With trend	0.0481	0.2927	0.2073	0.3578	0.3997	0.5414	0.2790	0.2193
	KPSS	Without trend	0.0963	0.1292	0.1414	0.1111	0.0971	0.1612	0.1364	0.2412
		With trend	0.0623	0.1182	0.1226	0.1076	0.0948	0.0894	0.1199	0.0982
PT	ADF	Without trend	0.0577	0.1076	0.0923	0.1076	0.3517	0.0956	0.1061	0.1258
		With trend	0.2263	0.2099	0.1818	0.2333	0.7255	0.1384	0.2433	0.3122
	KPSS	Without trend	0.0589	0.4080	0.3335	0.4876	0.2171	0.4960	0.3217	0.2247
		With trend	0.0540	0.1265	0.1229	0.1211	0.1095	0.1491	0.1112	0.0686
RO	ADF	Without trend	0.0151	0.0000	0.0000	0.0039	0.0000	0.0000	0.0001	0.0007
		With trend	0.0508	0.0000	0.0000	0.0250	0.0000	0.0000	0.0011	0.0048
	KPSS	Without trend	0.1403	0.0460	0.0503	0.0552	0.1013	0.0521	0.0506	0.1041
		With trend	0.0791	0.0446	0.0356	0.0555	0.0477	0.0526	0.0502	0.0527
SI	ADF	Without trend	0.0307	0.0333	0.0176	0.1165	0.0035	0.0059	0.0316	0.0095
		With trend	0.0943	0.1082	0.0692	0.3011	0.0220	0.0321	0.1088	0.0206
	KPSS	Without trend	0.1537	0.1679	0.1482	0.1583	0.0631	0.0897	0.1290	0.2488
		With trend	0.0899	0.1363	0.1290	0.1255	0.0637	0.0865	0.1050	0.0910

Table 6 (continued)

Country	Test		The p-value for ADF test* and KPSS test statistics**							
			ln(Y)	TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
SK	ADF	Without trend	0.0052	0.0105	0.0178	0.0021	0.0364	0.0000	0.0128	0.0001
		With trend	0.0050	0.0560	0.0799	0.0151	0.1425	0.0001	0.0634	0.0015
	KPSS	Without trend	0.3080	0.0769	0.0780	0.0819	0.0848	0.2107	0.0802	0.0803
		With trend	0.0499	0.0755	0.0775	0.0686	0.0850	0.0665	0.0799	0.0708
FI	ADF	Without trend	0.0013	0.0017	0.0003	0.0190	0.0004	0.0091	0.0022	0.0230
		With trend	0.0059	0.0107	0.0024	0.0713	0.0030	0.0381	0.0119	0.0939
	KPSS	Without trend	0.1757	0.1380	0.0748	0.2234	0.0996	0.1473	0.1357	0.0968
		With trend	0.0651	0.0616	0.0562	0.0620	0.0437	0.0487	0.0478	0.0784
SE	ADF	Without trend	0.0003	0.0080	0.0040	0.0127	0.0183	0.0088	0.0198	0.0122
		With trend	0.0017	0.0407	0.0227	0.0660	0.0830	0.0415	0.0831	0.0591
	KPSS	Without trend	0.0925	0.0664	0.0513	0.0894	0.1116	0.1118	0.0626	0.0568
		With trend	0.0399	0.0708	0.0546	0.0925	0.0840	0.0747	0.0585	0.0557
UK	ADF	Without trend	0.3804	0.0222	0.0155	0.0232	0.1039	0.1417	0.0148	0.0185
		With trend	0.5567	0.0793	0.0749	0.0619	0.2957	0.2701	0.0612	0.0849
	KPSS	Without trend	0.1714	0.1818	0.1468	0.2308	0.2074	0.3434	0.1734	0.0965
		With trend	0.0571	0.1386	0.1244	0.1663	0.1395	0.1610	0.1378	0.1028

*P-value for testing the null: unit-root. **Test statistics of the null: time series is stationary. Null is not rejected for the test without trend if the test statistic is below the critical value of 0.350 (10%), 0.462 (5%), and 0.732 (1%), and for the test with the trend if the test statistic is below the critical value of 0.120 (10%). 0.148 (5%). and 0.215 (1%)

Table 7 Estimates of Okun's coefficients based on Eq. (4) and (5)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
BE	Coeffi	β0	0.226	0.987	− 0.939	− 21.582***	14.299***	− 6.421***	− 1.176
			(0.969)	(1.590)	(0.971)	(5.712)	(2.213)	(1.881)	(0.943)
		β1	− 9.050***	− 9.128***	− 8.552***	− 30.320***	− 11.789***	− 9.444***	− 6.293***
			(1.433)	(1.948)	(1.631)	(5.356)	(3.340)	(1.542)	(1.588)
		β2	− 6.398***	− 6.473**	− 6.679***	− 15.566**	− 15.297***	− 5.515**	− 7.068***
			(1.949)	(2.627)	(1.878)	(6.486)	(3.913)	(2.161)	(2.002)
	Stat	B-G(1)	0.123	0.633	0.290	0.753	0.0239	0.398	0.55
		L-B Q(2)	0.656	0.656	0.975	0.692	0.0324	0.318	0.67
BG	Coeffi	β0	− 18.279***	− 19.649***	− 17.665***	− 48.785***	− 15.317**	− 23.728***	− 11.862***
			(2.861)	(2.973)	(3.517)	(5.788)	(6.598)	(3.815)	(4.183)
		β1	− 5.344	− 6.199*	− 5.168	− 17.429**	− 18.300***	− 2.002	− 8.943***
			(4.449)	(3.673)	(6.661)	(7.539)	(6.243)	(6.630)	(3.057)
		β2	− 8.866***	− 7.667*	− 10.276***	− 20.791***	− 16.422*	− 11.565***	− 3.201
			(2.729)	(4.471)	(1.965)	(7.350)	(9.614)	(2.811)	(3.056)
	Stat	B-G(1)	0.224	0.067	0.356	0.285	0.383	0.102	0.138
		L-B Q(2)	0.226	0.075	0.329	0.188	0.536	0.080	0.385
CZ	Coeffi	β0	− 5.514***	− 6.847***	− 3.686***	− 22.365***	− 18.774***	− 6.000***	− 0.689
			(1.620)	(2.191)	(1.355)	(4.737)	(5.184)	(1.753)	(0.971)
		β1	− 4.163***	− 4.842***	− 3.927***	− 15.763***	− 3.958	− 4.067***	− 4.331***
			(1.463)	(1.715)	(1.188)	(4.909)	(5.211)	(1.429)	(0.843)
		β2	− 3.244**	− 3.344**	− 6.071***	− 23.542***	− 20.877***	− 4.269***	− 4.427**
			(1.279)	(1.337)	(1.087)	(7.104)	(5.714)	(1.334)	(1.746)
	Stat	B-G(1)	0.130	0.775	0.120	0.583	0.068	0.084	0.434
		L-B Q(2)	0.186	0.752	0.079	0.534	0.243	0.063	0.508

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
DK	Coeffi	β0	− 6.077**	− 7.224	− 7.145**	− 21.476***	− 21.854***	− 7.020**	3.120
			(2.324)	(4.768)	(2.716)	(5.125)	(7.072)	(2.860)	(2.303)
		β1	− 15.079***	− 19.568***	− 13.144***	− 16.627**	− 21.842***	− 18.757***	− 13.991***
			(2.618)	(4.076)	(3.259)	(7.138)	(4.894)	(4.084)	(2.243)
		β2	− 11.884***	− 16.569***	− 10.360**	− 14.722*	− 23.296***	− 9.206***	− 18.169***
			(2.736)	(3.784)	(4.010)	(8.204)	(6.262)	(3.350)	(3.205)
	Stat	B-G(1)	0.086	0.230	0.176	0.407	0.687	0.284	0.520
		L-B Q(2)	0.073	0.321	0.125	0.809	0.698	0.374	0.379
DE	Coeffi	β0	− 3.435**	− 4.823***	− 3.025***	− 12.310***	− 1.592	− 6.384***	0.000
			(1.360)	(1.127)	(0.935)	(2.022)	(4.276)	(2.122)	(2.008)
		β1	− 4.834***	− 4.047***	− 5.183***	− 8.374***	− 16.385***	− 7.803*	− 6.029*
			(1.104)	(1.332)	(1.484)	(2.635)	(4.510)	(4.097)	(3.151)
		β2	− 2.739**	− 3.659**	− 2.270	− 8.553***	− 6.658	− 3.473	− 5.740**
			(1.155)	(1.544)	(1.373)	(3.076)	(6.577)	(2.785)	(2.717)
	Stat	B-G(1)	0.268	0.105	0.173	0.284	0.512	0.064	0.253
		L-B Q(2)	0.158	0.126	0.113	0.374	0.390	0.058	0.163

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
EE	Coeffi	β0	− 14.825***	− 12.862**	− 16.816***	− 25.377*	− 25.149***	− 14.444***	− 13.928**
			(3.716)	(5.341)	(3.644)	(13.543)	(7.577)	(4.558)	(6.287)
		β1	− 17.047***	− 26.366***	− 11.234***	− 26.385**	− 27.196***	− 28.173***	− 5.173
			(3.323)	(3.654)	(3.824)	(12.422)	(8.443)	(6.000)	(4.963)
		β2	− 13.294***	− 16.783**	− 11.295***	− 37.919**	− 35.004**	− 15.700**	− 6.049
			(4.672)	(6.985)	(3.955)	(15.841)	(16.318)	(7.854)	(7.251)
	Stat	B-G(1)	0.080	0.107	0.064	0.090	0.363	0.144	0.176
		L-B Q(2)	0.332	0.208	0.501	0.317	0.308	0.188	0.125
IE	Coeffi	β0	− 0.281	− 1.567	− 1.142	− 3.309	− 2.589	− 0.414	− 0.609
			(1.445)	(1.362)	(2.191)	(3.978)	(3.294)	(2.692)	(2.125)
		β1	− 4.756**	− 3.291*	− 5.555**	− 10.341***	− 10.154**	− 8.194***	− 5.069**
			(2.073)	(1.831)	(2.168)	(3.076)	(4.728)	(2.566)	(2.157)
		β2	− 3.580**	− 1.481	− 6.351***	− 9.878**	− 10.071***	− 5.462***	− 3.431*
			(1.465)	(1.306)	(1.765)	(4.034)	(3.719)	(1.839)	(1.954)
	Stat	B-G(1)	0.059	< 0.05	0.333	0.408	0.053	0.066	0.907
		L-B Q(2)	0.055	< 0.05	0.303	0.509	0.067	0.073	0.934

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
EL	Coeffi	β0	−10.891***	−10.535***	11.296***	−30.634***	20.690***	−11.235***	−9.676***
			(1.215)	(1.424)	(1.423)	(4.095)	(4.298)	(1.424)	(1.624)
		β1	1.560	2.413	−0.677	−8.458	3.939	1.166	−2.672**
			(1.437)	(1.876)	(1.426)	(7.140)	(5.576)	(1.283)	(1.189)
		β2	−1.416	−1.873	−2.182	−7.826**	−0.846	−4.065*	−1.466
			(1.253)	(1.422)	(1.482)	(3.845)	(2.526)	(2.356)	(1.295)
	Stat	B-G(1)	0.512	0.054	< 0.05	0.061	< 0.05	0.112	0.208
		L-B Q(2)	0.390	0.063	< 0.05	0.073	< 0.05	0.115	0.414
ES	Coeffi	β0	−7.644***	−5.313***	−6.389***	−29.905***	−6.886***	−10.210***	−5.926***
			(1.436)	(1.943)	(1.311)	(3.440)	(1.477)	(2.779)	(2.171)
		β1	−1.839	−4.438**	−1.730	−16.948***	−4.570***	−6.255***	−6.410***
			(1.108)	(1.744)	(1.188)	(4.504)	(1.135)	(2.362)	(2.229)
		β2	2.069	−2.166	0.639	−1.406	2.543	−4.215*	−3.806
			(1.490)	(2.105)	(1.587)	(5.516)	(1.914)	(2.350)	(2.427)
	Stat	B-G(1)	0.069	0.356	0.217	0.285	0.268	0.175	0.073
		L-B Q(2)	0.056	0.329	0.149	0.188	0.185	0.166	0.113

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
FR	Coeffi	β0	– 2.680**	– 4.845***	– 0.0826	– 7.801*	– 12.629***	– 2.469***	– 1.060*
			(1.140)	(1.490)	(1.337)	(4.185)	(0.872)	(0.642)	(0.574)
		β1	– 6.680***	– 7.697***	– 4.257***	– 16.473***	– 5.069**	– 4.993***	– 1.788***
			(1.287)	(1.895)	(1.509)	(3.635)	(2.266)	(0.933)	(0.528)
		β2	– 0.129	– 2.292	– 1.710	– 0.091	– 1.142	– 2.055	– 3.890***
			(1.506)	(2.284)	(1.748)	(4.386)	(2.413)	(1.501)	(0.816)
	Stat	B-G(1)	0.290	0.099	0.753	0.050	0.647	0.630	0.055
		L-B Q(2)	0.975	0.174	0.692	0.102	0.423	0.792	0.065
CR	Coeffi	β0	– 7.278***	– 6.813***	– 7.902***	– 31.75***	– 3.530	– 11.356***	0.656
			(1.664)	(1.368)	(2.878)	(6.247)	(4.201)	(2.527)	(2.360)
		β1	– 10.016***	6.421**	– 13.780***	– 23.601**	– 18.204***	– 13.696***	– 1.242
			(2.668)	(2.852)	(3.261)	(9.235)	(4.156)	(2.833)	(3.571)
		β2	– 6.679***	– 7.248***	– 6.791*	– 7.662	– 8.321	– 8.898***	– 11.843***
			(2.198)	(1.845)	(3.803)	(10.139)	(7.329)	(2.819)	(3.595)
	Stat	B-G(1)	0.160	0.322	0.252	0.608	0.417	0.058	0.108
		L-B Q(2)	0.103	0.323	0.175	0.551	0.266	0.066	0.052

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
IT	Coeffi	β0	3.553**	3.593**	−3.774*	11.597	−9.676***	−3.297**	2.861
			(1.668)	(1.525)	(1.962)	(8.093)	(3.168)	(1.436)	(1.719)
		β1	−7.565***	−6.595***	−9.068***	−30.174***	−9.324***	−9.474***	−9.363***
			(1.475)	(1.409)	(1.823)	(6.940)	(2.851)	(1.463)	(1.658)
		β2	−0.824	−2.604	0.611	−17.379*	−6.198**	−1.492	−0.458
			(2.075)	(2.054)	(2.353)	(9.085)	(3.059)	(1.558)	(2.308)
	Stat	B-G(1)	0.285	0.268	0.066	0.253	0.068	0.157	0.206
		L-B Q(2)	0.188	0.185	0.059	0.155	0.085	0.105	0.134
CY	Coeffi	β0	−6.936***	−8.010***	−8.717***	−30.030***	−6.994	−9.513***	−7.672***
			(1.759)	(2.593)	(2.128)	(6.094)	(5.544)	(3.463)	(2.203)
		β1	−8.158***	−13.125***	−7.679***	−40.333***	−25.057***	−20.515***	−13.542***
			(1.901)	(2.538)	(2.878)	(8.654)	(7.394)	(5.088)	(3.056)
		β2	−3.848***	−6.742***	−7.009***	−17.206*	−19.993**	−14.400***	−11.040***
			(1.370)	(2.169)	(2.272)	(8.9313)	(7.683)	(4.327)	(2.609)
	Stat	B-G(1)	0.622	0.437	< 0.05	0.551	0.974	0.797	0.228
		L-B Q(2)	0.623	0.528	< 0.05	0.482	0.992	0.738	0.177

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
LV	Coeffi	β0	− 10.721***	− 15.290***	− 9.936**	− 38.072***	− 36.334***	− 13.469***	− 7.413
			(3.810)	(5.604)	(4.612)	(13.869)	(12.426)	(5.055)	(6.483)
		β1	− 15.158***	− 20.405***	− 12.872***	− 47.794***	− 35.654***	− 17.025***	− 12.187*
			(5.122)	(7.117)	(3.607)	(13.428)	(10.442)	(5.656)	(6.796)
		β2	− 2.685	− 7.890	− 2.704	3.696	1.455	− 12.443	− 0.469
			(4.510)	(6.308)	(3.597)	(14.698)	(9.022)	(8.098)	(6.179)
	Stat	B-G(1)	0.519	0.592	0.956	0.542	0.744	0.200	< 0.05
		L-B Q(2)	0.563	0.590	0.963	0.481	0.797	0.689	< 0.05
LT	Coeffi	β0	− 19.258***	− 28.602***	− 10.939***	− 46.746***	− 52.465**	− 28.104***	− 7.812***
			(1.868)	(2.409)	(3.065)	(11.452)	(21.252)	(4.419)	(1.676)
		β1	− 4.015	− 4.979	− 9.914***	− 35.503**	− 18.345	− 13.470***	− 7.986
			(2.765)	(3.969)	(3.148)	(13.445)	(26.387)	(2.886)	(1.646)
		β2	0.422	− 2.423	− 1.222	− 7.623	− 11.269	1.272	− 3.740*
			(2.381)	(2.551)	(3.489)	(11.852)	(8.502)	(2.7380)	(1.974)
	Stat	B-G(1)	0.240	0.639	0.050	0.911	0.054	0.574	0.404
		L-B Q(2)	0.401	0.724	0.063	0.905	0.044	0.483	0.661

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
LU	Coeffi	β0	− 0.134	0.594	− 0.062	− 19.953	− 12.542	− 3.536	− 2.409
			(3.297)	(4.080)	(6.407)	(14.178)	(9.170)	(4.612)	(4.558)
		β1	− 6.290*	− 9.809**	− 5.055	− 21.487	− 15.257	− 12.327**	1.452
			(3.688)	(3.758)	(6.285)	(24.140)	(10.466)	(4.742)	(5.273)
		β2	4.948	1.445	2.185	41.673	− 9.730	7.773	− 0.195
			(4.039)	(4.713)	(6.084)	(30.238)	(9.937)	(5.315)	(4.065)
		EC		− 0.489***				− 0.553***	
				(0.103)				(0.157)	
	Stat	B-G(1)	< 0.05	0.912	< 0.05	< 0.05	< 0.05	0.673	< 0.05
		L-B Q(2)	< 0.05	0.973	< 0.05	< 0.05	< 0.05	0.962	< 0.05
HU	Coeffi	β0	− 7.927***	− 8.461***	− 6.888***	− 26.165***	− 13.227***	− 10.234***	− 4.282***
			(1.106)	(1.623)	(1.187)	(4.912)	(3.364)	(1.006)	(0.875)
		β1	− 2.560	− 5.842***	0.090	− 7.564	− 6.989*	− 3.376*	− 0.367
			(1.791)	(1.864)	(1.698)	(7.971)	(3.572)	(1.917)	(1.279)
		β2	− 2.677	− 3.826*	− 3.048**	− 2.608	− 7.044**	− 1.734	− 3.324***
			(1.662)	(2.130)	(1.282)	(6.564)	(3.124)	(1.847)	(1.187)
	Stat	B-G(1)	0.247	0.230	0.206	0.209	0.253	0.208	0.291
		L-B Q(2)	0.223	0.292	0.134	0.195	0.155	0.121	0.277

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
MT	Coeffi	β0	−2.090	−1.074	−2.413	−2.608	−6.452*	−5.006	
			(1.759)	(1.675)	(2.707)	(3.479)	(3.411)	(3.101)	
		β1	−4.933***	−4.856**	−5.781**	−3.552	−0.527	−3.149	
			(1.480)	(1.959)	(2.536)	(4.758)	(3.792)	(3.219)	
		β2	1.733	1.536	−0.057	0.016	4.801	0.492	
			(1.097)	(1.729)	(1.932)	(5.149)	(2.975)	(2.328)	
		EC				−0.635***			
						(0.272)			
	Stat	B-G(1)	0.226	0.507	0.219	< 0.05	< 0.05	< 0.05	
		L-B Q(2)	0.274	0.561	0.665	< 0.05	< 0.05	< 0.05	
NL	Coeffi	β0	−7.784***	−7.874***	−6.908***	−28.372***	−11.580***	−9.219***	−4.787***
			(1.461)	(1.115)	(1.876)	(4.054)	(3.002)	(1.582)	(1.091)
		β1	−9.274***	−4.216**	−15.309***	−20.447***	−20.907***	−11.191***	−5.602***
			(1.774)	(1.834)	(1.950)	(3.041)	(2.247)	(2.258)	(1.596)
		β2	−1.765	−0.863	−4.027	−1.333	−5.234	−3.138	−5.830***
			(2.218)	(1.843)	(2.464)	(3.730)	(4.227)	(3.451)	(1.549)
	Stat	B-G(1)	0.364	0.103	0.240	0.539	0.115	0.583	0.102
		L-B Q(2)	0.287	0.050	0.219	0.722	0.168	0.542	0.423

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
AT	Coeffi	β0	−9.119***	−10.405***	−6.700***	−18.793***	−19.326***	−6.449***	−5.562***
			(0.799)	(1.180)	(1.004)	(3.236)	(2.496)	(0.896)	(1.181)
		β1	−7.925***	−9.854***	−6.375***	−12.553***	−22.531***	−9.373***	−3.175*
			(1.618)	(2.010)	(1.316)	(4.335)	(2.769)	(1.204)	(1.627)
		β2	−4.653***	−4.550**	−4.552***	−1.585	−7.948**	−6.100***	−3.334
			(1.616)	(2.165)	(1.246)	(4.665)	(3.625)	(1.494)	(2.789)
	Stat	B-G(1)	0.334	0.343	0.323	0.097	0.219	0.469	0.664
		L-B Q(2)	0.262	0.351	0.278	0.101	0.136	0.599	0.719
PL	Coeffi	β0	−6.929***	−4.133*	−9.817**	−19.610***	−15.517**	−4.824**	−4.122**
			(2.267)	(2.438)	(3.844)	(6.571)	(6.485)	(2.157)	(1.945)
		β1	−3.407	−1.012	−8.474**	−15.795***	−3.644	−1.726	−4.427**
			(2.649)	(2.143)	(3.483)	(5.809)	(7.320)	(2.564)	(1.831)
		β2	−2.171	−3.477	−1.532	−17.211***	−7.777	−4.438**	−2.370
			(2.628)	(2.285)	(3.364)	(6.505)	(6.176)	(2.272)	(1.747)
		EC						−0.049***	
								(0.011)	
	Stat	B-G(1)	0.415	0.209	0.060	0.129	0.128	0.113	0.072
		L-B Q(2)	0.351	0.331	0.099	0.059	0.239	0.285	0.240

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
PT	Coeffi	β0	3.362	0.030	−4.149*	−12.828*	5.221	−0.318	−2.808
			(2.066)	(2.925)	(2.434)	(6.744)	(3.197)	(4.263)	(2.628)
		β1	−12.345***	−13.210***	−11.177***	−39.355***	−15.150***	−11.741***	−5.526**
			(1.238)	(2.233)	(1.905)	(4.586)	(2.131)	(3.288)	(2.563)
		β2	2.398	−0.333	−0.713	−14.067**	2.178	−5.744	−6.427***
			(1.777)	(2.670)	(2.865)	(6.397)	(3.040)	(4.125)	(2.406)
	Stat	B-G(1)	0.104	0.072	0.182	0.126	0.060	0.163	0.134
		L-B Q(2)	0.082	0.240	0.359	0.236	0.102	0.156	0.078
RO	Coeffi	β0	−3.327	−0.947	−6.144	−0.224	1.984	−5.361	−3.680
			(3.836)	(3.485)	(4.277)	(5.225)	(5.938)	(3.250)	(3.253)
		β1	−1.082	−0.838	−1.354	−2.598	0.785	−1.434	0.783
			(1.449)	(1.492)	(1.919)	(7.170)	(2.446)	(1.596)	(2.967)
		β2	−0.436	0.577	−1.772	−1.463	−1.455	0.374	−4.563
			(1.957)	(1.805)	(2.439)	(7.663)	(3.811)	(2.095)	(3.515)
		EC					−0.322***		
							(0.119)		
	Stat	B-G(1)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
		L-B Q(2)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
SI	Coeffi	β0	−7.963***	−7.106***	−8.848***	−34.958***	4.441	−8.931***	−9.915***
			(1.110)	(1.495)	(1.740)	(7.468)	(4.796)	(2.066)	(1.605)
		β1	−7.439***	−7.619***	−8.383***	−41.079***	−26.865***	−16.256***	2.850
			(1.984)	(2.539)	(2.000)	(7.628)	(4.308)	(2.295)	(2.022)
		β2	−7.798***	−9.427***	−8.222***	−16.131*	−28.841***	−6.101**	−0.545
			(1.596)	(1.858)	(2.294)	(8.108)	(7.826)	(2.587)	(2.479)
	Stat	B-G(1)	0.116	0.091	0.253	0.135	0.681	0.265	0.728
		L-B Q(2)	0.099	0.132	0.153	0.159	0.744	0.173	0.645
SK	Coeffi	β0	−6.365***	−6.804***	−5.43708*	−20.159***	−23.540***	−6.282**	−3.371*
			(2.059)	(1.056)	(2.763)	(4.988)	(7.516)	(2.543)	(1.695)
		β1	−3.973***	−4.934***	−3.720**	−8.217*	1.696	−7.885***	−3.752
			(1.142)	(1.486)	(1.741)	(4.297)	(12.378)	(1.251)	(2.396)
		β2	−3.665**	−2.634	−5.626***	−8.734*	4.928	−1.087	−2.575
			(1.694)	(2.517)	(1.336)	(4.597)	(14.458)	(1.755)	(2.260)
	Stat	B-G(1)	0.247	0.075	0.160	0.258	0.069	0.780	0.0002
		L-B Q(2)	0.224	0.063	0.210	0.422	0.959	0.751	0.0003

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
FI	Coeffi	β0	− 6.863***	− 7.431***	− 6.443*	− 14.123	− 10.468	− 13.934***	− 3.089*
			(1.630)	(1.405)	(3.322)	(8.870)	(12.089)	(2.093)	(1.574)
		β1	− 12.167***	− 15.580***	− 8.475***	− 30.970***	− 24.246***	− 11.429***	− 5.110***
			(1.832)	(1.764)	(2.703)	(5.376)	(6.302)	(2.652)	(1.399)
		β2	− 5.256***	− 2.044	− 6.629***	− 22.871***	− 12.204**	− 7.431***	− 1.609
			(1.755)	(2.159)	(1.863)	(5.171)	(5.525)	(1.809)	(1.237)
		EC				− 0.136***			
						(0.0315)			
	Stat	B-G(1)	0.200	0.614	0.596	0.621	0.644	0.586	0.477
		L-B Q(2)	0.422	0.917	0.828	0.550	0.810	0.983	0.395
SE	Coeffi	β0	− 8.909***	− 12.296***	− 4.067**	− 26.707***	− 5.791	− 14.242***	− 3.758**
			(1.552)	(1.806)	(1.859)	(6.251)	(6.540)	(1.805)	(1.725)
		β1	− 11.007***	− 13.955***	− 8.746***	− 28.634***	− 26.250***	− 11.532***	− 9.590***
			(1.73)	(2.019)	(1.529)	(4.643)	(5.591)	(3.161)	(1.783)
		β2	− 7.950***	− 7.754**	− 9.927***	− 17.086*	− 20.714***	− 5.185**	− 6.186***
			(2.662)	(3.169)	(2.607)	(9.178)	(6.154)	(2.576)	(2.185)
	Stat	B-G(1)	0.190	0.445	0.127	0.334	0.081	0.082	0.541
		L-B Q(2)	0.241	0.651	0.234	0.458	0.052	0.550	0.702

Table 7 (continued)

			TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
UK	Coeffi	β0	0.380	0.146	−0.702	−3.475**	0.413	−1.081	−1.044**
			(0.765)	(1.066)	(0.555)	(1.691)	(1.514)	(0.942)	(0.437)
		β1	−3.309***	−4.252**	−1.507*	−5.097*	−1.134	−3.353*	−1.980***
			(1.160)	(1.663)	(0.842)	(2.733)	(2.600)	(1.753)	(0.737)
		β2	−2.061	−6.656	−1.445	−28.196*	−11.083	−14.029	−11.237**
			(5.552)	(8.135)	(4.591)	(15.045)	(11.615)	(10.052)	(4.254)
	Stat	B-G(1)	0.137	0.130	<0.05	0.194	<0.05	<0.05	0.954
		L-B Q(2)	0.144	0.246	<0.05	0.221	<0.05	<0.05	0.959

P-values of (1)Breusch–Godfrey (LM) and (2)Ljung–Box Q tests for serial correlation. A low p-value counts against the null hypothesis that there is no serial correlation up to order 4 in favor of the alternative—serial correlation. *, **, *** indicate significance at the 10, 5 and 1 percent levels, respectively. Other goodness-of-fit statistics are calculated but not included due to the limited length of the paper and are available upon request from the corresponding author

Table 8 Calculated gender-, age-, and educational attainment level-specific Okun's coefficients across countries, i.e. OC_i^k, based on estimates in Table 5

	TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
BE	−0.15448	−0.15601	−0.15231	−0.67468	−0.12787	−0.2138	−0.13361
BG	−0.27145	−0.19649	−0.27941	−0.87005	−0.33617	−0.35293	−0.20805
CZ	−0.12921	−0.15033	−0.13684	−0.6167	−0.39651	−0.14336	−0.08758
DK	−0.3304	−0.36137	−0.30649	−0.38103	−0.66992	−0.34983	−0.3216
DE	−0.11008	−0.12529	−0.08208	−0.29237	−0.16385	−0.06384	−0.0574
EE	−0.45166	−0.56011	−0.39345	−0.64304	−0.87349	−0.58317	−0.13928
IE	−0.08336	–	−0.11906	−0.20219	−0.20225	−0.13656	−0.05069
EL	−0.10891	−0.10535	–	−0.3846	–	−0.11235	−0.12348
ES	−0.07644	−0.09751	−0.06389	−0.46853	−0.11456	−0.16465	−0.12336
FR	−0.0936	−0.12542	−0.04257	−0.16473	−0.17698	−0.07462	−0.05678
CR	−0.23973	−0.20482	−0.21682	−0.55351	−0.18204	−0.3395	−0.11843
IT	−0.04012	−0.03002	−0.09068	−0.30174	−0.25198	−0.12771	−0.09363
CY	−0.18942	−0.27877	–	−0.70363	−0.4505	−0.44428	−0.32254
LV	−0.25879	−0.35695	−0.22808	−0.85866	−0.71988	−0.30494	–
LT	−0.19258	−0.28602	−0.20853	−0.82249	−0.52465	−0.41574	−0.07812
LU	–	−0.09809	–	–	–	−0.12327	–
HU	−0.07927	−0.14303	−0.09936	−0.26165	−0.20271	−0.10234	−0.07606
MT	−0.04933	−0.04856	−0.05781	–	–	–	–
NL	−0.17058	−0.1209	−0.22217	−0.48819	−0.32487	−0.2041	−0.16219
AT	−0.21697	−0.24809	−0.17627	−0.31346	−0.49805	−0.21922	−0.05562
PL	−0.06929	0	−0.18291	−0.52616	−0.15517	−0.09262	−0.08549
PT	−0.12345	−0.1321	−0.11177	−0.53422	−0.1515	−0.11741	−0.11953
RO	–	–	–	–	–	–	–
SI	−0.232	−0.24152	−0.25453	−0.76037	−0.55706	−0.31288	−0.09915
SK	−0.14003	−0.11738	−0.14783	−0.20159	−0.2354	−0.14167	–
FI	−0.24286	−0.23011	−0.15104	−0.53841	−0.3645	−0.32794	−0.0511
SE	−0.27866	−0.34005	−0.2274	−0.72427	−0.46964	−0.30959	−0.19534
UK	−0.03309	−0.04252	–	−0.03475	–	–	−0.14261

Since β_0, …, β_q were estimated (see Table 7) using level-log type specification (see Eqs. (3) and (4)), OC_i^k is equal to $(\beta_0 + \ldots + \beta_q)/100$ and shows the effect of GDP change by one per cent on unemployment change in percentage points

Table 9 LSDV estimates of γ_1 using Eq. (8)

	TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
LMRI1	0.0488	0.1555	0.1057	−0.1172	0.0018	0.0867	0.1064
	(0.2416)	(0.2389)	(0.2268)	(0.3499)	(0.2464)	(0.2763)	(0.3588)
LMRI2	−0.1517	−0.2632	−0.1375	−0.4169	−0.0238	−0.6157*	−0.3215
	(0.3006)	(0.2814)	(0.3188)	(0.4692)	(0.3484)	(0.3342)	(0.4160)
LMRI3	0.0375	−0.2875	0.3471	−0.0621	0.0737	−0.1980	−0.0408
	(0.3952)	(0.3929)	(0.3641)	(0.5353)	(0.4052)	(0.4236)	(0.5124)
LMRI4	0.2623	0.1376	0.1959	0.0739	0.2372	0.3321	0.1861
	(0.2564)	(0.2477)	(0.2482)	(0.3330)	(0.2516)	(0.2876)	(0.3266)
LMRI5	−0.1974	−0.1434	−0.2663	−0.3684	0.0911	0.0583	−0.2073
	(0.2824)	(0.2648)	(0.2373)	(0.3507)	(0.2978)	(0.2607)	(0.4056)
LMRI6	0.4150	0.4444	0.3368	0.1825	0.9513*	0.9629*	1.1624*
	(0.5017)	(0.5162)	(0.4848)	(0.7256)	(0.5042)	(0.5504)	(0.6750)

Heteroskedasticity and autocorrelation robust standard errors are presented in parentheses. All estimates include time and country dummies. *, **, *** indicate significance at the 10, 5 and 1 percent levels, respectively. Goodness-of-fit statistics are calculated but not included due to the limited length of the paper. Also, we do not provide here all estimated coefficients of Eq. (8). Goodness-of-fit statistics and full estimations are available upon request from the corresponding author

Table 10 LSDV estimates of γ_1, δ and γ_2 using Eq. (9) when comparing the effect of labor market regulation on unemployment elasticity over economic growth and decline

		TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
LMRI1	γ1	0.1417	0.3037	0.3086	0.0655	−0.0176	0.3102	0.0528
		(0.2642)	(0.2534)	(0.2592)	(0.3767)	(0.2571)	(0.3178)	(0.4209)
	δ	−0.2057	−0.3035*	−0.3686*	−0.3462	−0.0799	−0.4671*	−0.0241
		(0.1806)	(0.1814)	(0.1918)	(0.2707)	(0.1913)	(0.2926)	(0.2948)
	γ2	−3.4441**	−2.9274**	−1.6773	−2.5742	−3.5729***	−1.7016	−3.4184
		(1.3579)	(1.3087)	(1.3930)	(1.7492)	(1.3571)	(1.6880)	(2.1489)
LMRI2	γ1	−0.1129	−0.2105	0.0418	0.0942	−0.3869	−0.3857	−0.5446
		(0.4163)	(0.3829)	(0.4352)	(0.5916)	(0.4254)	(0.4478)	(0.5892)
	δ	0.5822	0.5051	0.2489	−0.1657	0.9265*	0.0187	0.6299
		(0.3822)	(0.3729)	(0.4059)	(0.6903)	(0.5095)	(0.4447)	(0.6132)
	γ2	−7.1423***	−6.8817***	−4.9531***	−3.9824	−7.8813***	−4.5423**	−6.4179**
		(1.7813)	(1.6365)	(1.8302)	(2.9187)	(1.9349)	(2.0442)	(2.7929)
LMRI3	γ1	0.3634	0.1132	0.5618	−0.0328	0.2213	0.0018	0.5705
		(0.4416)	(0.4107)	(0.4125)	(0.6019)	(0.4304)	(0.4723)	(0.5738)
	δ	0.1369	−0.0192	0.1725	0.7398*	0.1465	0.1502	−0.7530*
		(0.3077)	(0.3016)	(0.2932)	(0.3962)	(0.2975)	(0.3309)	(0.4209)
	γ2	−5.5492***	−4.6642**	−4.9947***	−9.0595***	−4.8392**	−5.4165**	0.6712
		(2.0425)	(1.9561)	(1.9217)	(2.5822)	(1.9619)	(2.2044)	(2.6361)
LMRI4	γ1	0.0324	−0.0256	−0.0062	−0.1852	−0.0657	0.1012	−0.1884
		(0.3103)	(0.2980)	(0.3099)	(0.3884)	(0.3113)	(0.3599)	(0.4197)
	δ	0.4067*	0.2806	0.3402	0.4124	0.3970	0.2613	0.5261
		(0.2302)	(0.2452)	(0.2362)	(0.3086)	(0.2703)	(0.2633)	(0.3551)
	γ2	−7.3850***	−6.6251***	−6.1297***	−7.4525***	−6.6889***	−6.3433***	−7.0529***
		(1.6521)	(1.7329)	(1.6877)	(2.3351)	(2.0066)	(1.8544)	(2.6585)
LMRI5	γ1	−0.1368	−0.0938	−0.1153	0.0323	−0.0590	0.2238	−0.4569
		(0.3170)	(0.2874)	(0.2741)	(0.3968)	(0.2935)	(0.3068)	(0.4680)
	δ	−0.0477	−0.0723	−0.2656	−0.8520*	0.3508	−0.3958	0.6380
		(0.3242)	(0.2774)	(0.2981)	(0.5209)	(0.3177)	(0.3053)	(0.4219)
	γ2	−4.3124	−4.1989*	−1.7831	2.1419	−6.9135**	−1.3983	−8.6949**
		(2.7120)	(2.2118)	(2.5099)	(3.5631)	(2.6790)	(2.5142)	(3.6197)
LMRI6	γ1	0.5232	0.49176	0.5865	0.2804	0.8169	1.2228*	0.8882
		(0.5559)	(0.5422)	(0.5338)	(0.7750)	(0.5633)	(0.6510)	(0.8459)
	δ	0.2191	0.2719	−0.1585	0.2881	0.3309	−0.4086	0.5208
		(0.4259)	(0.4440)	(0.4368)	(0.6328)	(0.4873)	(0.5109)	(0.6979)
	γ2	−6.0806**	−6.4913**	−2.9134	−6.5055	−6.0641*	−1.9209	−7.1346
		(2.8143)	(2.8472)	(2.8248)	(4.1048)	(3.2768)	(3.3739)	(4.6052)

Heteroskedasticity and autocorrelation robust standard errors are presented in parentheses. All estimates include time and country dummies. *, **, *** indicate significance at the 10, 5 and 1 percent levels, respectively. Goodness-of-fit statistics are calculated but not included due to the limited length of the paper. Also, we do not provide here all estimated coefficients of Eq. (9). Goodness-of-fit statistics and full estimations are available upon request from the corresponding author

Table 11 LSDV estimates of γ_1, δ and γ_2 using Eq. (9) when comparing the effect of labor market regulation on unemployment elasticity over 2000–2010 and 2011–2020

		TU	TMU	TFU	TYU	TU0–2	TU3–4	TU5–8
LMRI1	γ1	0.0851	0.2376	0.0988	−0.1772	0.0488	0.0931	−0.2190
		(0.2694)	(0.2702)	(0.2594)	(0.4007)	(0.2721)	(0.3213)	(0.3929)
	δ	−0.0675	−0.1544	0.0130	0.1137	−0.0914	−0.0122	0.6339*
		(0.2028)	(0.2006)	(0.1998)	(0.2839)	(0.2190)	(0.2562)	(0.3968)
	γ2	−1.8830	−2.6810*	−1.8016	−4.7026**	2.0255	−4.1911**	−10.5784***
		(1.6555)	(1.6164)	(1.7245)	(2.2165)	(1.7893)	(2.0460)	(2.5608)
LMRI2	γ1	−0.1567	−0.0943	−0.1787	−0.7057	0.0788	−0.4698	−1.0126*
		(0.34740	(0.3158)	(0.3639)	(0.6144)	(0.4147)	(0.4051)	(0.6100)
	δ	0.0125	−0.4253	0.1057	0.7471	−0.2516	−0.3442	1.6596*
		(0.3800)	(0.3793)	(0.3980)	(0.7306)	(0.4183)	(0.4708)	(0.9908)
	γ2	−1.5860	−0.9074	−1.7431	−7.1536**	2.6876	−2.1446	−14.1682***
		(2.0842)	(2.0344)	(2.2423)	(3.4323)	(2.3431)	(2.6426)	(3.3280)
LMRI3	γ1	0.1039	−0.2355	0.3486	−0.1147	0.1597	−0.1070	−0.0811
		(0.4010)	(0.4024)	(0.3786)	(0.5436)	(0.4241)	(0.4218)	(0.5273)
	δ	−0.2555	−0.1924	−0.0063	0.2047	−0.3125	−0.3114	0.1535
		(0.2827)	(0.2898)	(0.2625)	(0.3782)	(0.2733)	(0.3077)	(0.3618)
	γ2	−0.1352	−1.6234	−1.5546	−5.3799*	3.3975	−2.0523	−7.8755***
		(2.1015)	(2.1022)	(2.0600)	(2.9352)	(2.1541)	(2.4644)	(2.8876)
LMRI4	γ1	0.3616	0.1957	0.2852	0.0526	0.3786	0.3336	−0.2029
		(0.2712)	(0.2715)	(0.2629)	(0.4016)	(0.2858)	(0.2970)	(0.3635)
	δ	−0.2046	−0.1202	−0.1848	0.0447	−0.3033	−0.0031	0.5234*
		(0.2460)	(0.2616)	(0.2528)	(0.3569)	(0.2751)	(0.2811)	(0.3639)
	γ2	−1.4708	−1.7430	−0.8638	−4.7517*	2.9234	−4.8620*	−12.7817***
		(2.0682)	(2.1047)	(2.1973)	(2.8485)	(2.2398)	(2.4953)	(3.0361)
LMRI5	γ1	−0.3991	−0.3430	−0.4701*	−0.5045	−0.0588	−0.2351	−0.6523
		(0.3137)	(0.2676)	(0.2538)	(0.3863)	(0.3192)	(0.2782)	(0.4266)
	δ	0.7077**	0.6649*	0.6434**	0.5037	0.4556	0.8963**	1.3434**
		(0.3412)	(0.3615)	(0.3139)	(0.5142)	(0.3419)	(0.3774)	(0.5389)
	γ2	−7.6171***	−8.3145***	−6.4303**	−8.1382*	−2.1344	−11.3026***	−17.7119***
		(2.8991)	(3.0953)	(2.7304)	(4.2905)	(2.9387)	(3.3612)	(4.7830)
LMRI6	γ1	0.4158	0.4293	0.3028	0.1267	1.1284*	0.9939*	0.6322
		(0.5099)	(0.5278)	(0.4956)	(0.7508)	(0.6278)	(0.5571)	(0.6728)
	δ	−0.0034	0.0690	0.1560	0.2676	−0.6884	−0.1154	2.0459*
		(0.4875)	(0.5295)	(0.4676)	(0.6733)	(0.5359)	(0.5504)	(1.2304)
	γ2	−2.3173	−4.1434	−2.9580	−6.2331	4.4755	−4.8258	−21.9162***
		(3.4601)	(3.6942)	(3.3143)	(4.6866)	(3.6815)	(3.9748)	(5.2162)

Heteroskedasticity and autocorrelation robust standard errors are presented in parentheses. All estimates include time and country dummies. *, **, *** indicate significance at the 10, 5 and 1 percent levels, respectively. Goodness-of-fit statistics are calculated but not included due to the limited length of the paper. Also, we do not provide here all estimated coefficients of Eq. (9). Goodness-of-fit statistics and full estimations are available upon request from the corresponding author

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Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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