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# The Output Gap and Youth Unemployment: An Analysis Based on Okun's Law

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Received: 9 August 2019; Accepted: 23 September 2019; Published: 4 November 2019



**Abstract:** The impact of economic fluctuations on the total unemployment rate is widely studied, however, with respect to age- and gender-specific unemployment, this relationship is not so well examined. We apply the gap version of Okun's law, aiming to estimate youth unemployment rate sensitivity to output deviations from its potential level. Additionally, we aim to compare whether men or women have a higher equilibrium unemployment rate when output is at the potential level. Contrary to most studies on age- and gender-specific Okun's coefficients, which assume that the effect of output on unemployment is homogenous, we allow a different effect to occur, depending on the output gap's sign (positive/negative). The focus of the analysis is on 28 EU countries over the period of 2000–2018. The model is estimated by least squares dummy variable estimator (LSDV), using Prais–Winsten standard errors. We did not find evidence that higher equilibrium unemployment rates are more typical for men or for women. The estimates clearly show the equilibrium level of youth unemployment to be well above that of total unemployment, and this conclusion holds for both genders. We assess greater youth unemployment sensitivity to negative output shock, rather than to positive output shock, but when we take confidence intervals into consideration, this conclusion becomes less obvious.

**Keywords:** Okun's law; youth unemployment; economic fluctuations; European Union; gender

**JEL Classification:** E24; E32; J16

## 1. Introduction

Since Okun (1962) confirmed the inverse relationship between the unemployment rate and economic growth, much research has been conducted in various countries and regions. The results mostly support the validity of Okun's finding. According to seminal Okun (1962) estimation, an additional 1% of GNP results in 0.3 percentage points lower unemployment rate. The unemployment rate's sensitivity to GDP growth, or so-called Okun's coefficient, is important from the policy implementation perspective, as demand stimulus can be considered as a means for unemployment reduction. After the 'great recession' in most of the European Union countries, the youth (less than 25-year-old) unemployment rate increased tremendously and reached a peak in 2013. However, recorded unemployment rates vary from 7.8% in Germany to 58.3% in Greece and show extreme cross-country differences regarding the position of youth in the labour market. In the period of 2007–2013, changes in the youth unemployment are also incredibly distinct. While over 35 percentage points increases were recorded for Spain and Greece, Germany and Malta even managed to reduce them by 4 and 0.8 percentage points, respectively. Such a dramatic increase in youth unemployment and its extreme variation across European and other countries around the world has gained much attention and caused renewed interest in the relationship between economic growth and unemployment. Most studies support the negative reaction of changes in unemployment rates to output growth,

but in terms of youth and especially gender unemployment, this impact is less well documented (Bod'a and Považanová 2019). The estimations of age-specific Okun's coefficients indicate that the youth unemployment rate is much more sensitive to economic growth compared to elderly cohorts or total unemployment (Ahn et al. 2019; Dixon et al. 2017; Dunsch 2017; Dietrich and Möller 2016; Banerji et al. 2014, 2015; Hutengs and Stadtmann 2013, 2014a, 2014b; Zanin 2014; European Commission 2013). Only few studies jointly consider age and gender effects and conclude that the unemployment of young males is the most affected by output growth (Hutengs and Stadtmann 2014a; Zanin 2014; Dunsch 2017; Dixon et al. 2017). This research contributes to limited evidence of age and gender effects on Okun's law. We aim to estimate the equilibrium rate of young male and female unemployment, and to investigate youth unemployment sensitivity to the output gap, considering the possible heterogeneity of this relationship. It is worth mentioning here that, despite the economic recovery, youth unemployment is still one of the main economic problems in the EU (Dietrich and Möller 2016). In the first quarter of 2019, the youth unemployment rate (14.7%) was more than twice the overall unemployment rate (6.8%).

Our research complements the existing empirical studies in three aspects. Firstly, while the majority of studies on the age-dependent Okun's coefficient investigate how changes in youth unemployment respond to economic growth, we estimate the so-called gap version of Okun's law. This version allows to estimate unemployment sensitivity to output deviations from its potential level. The second contribution is that we take a close look at the intercept value in the Okun's law equation. The intercept indicates the unemployment rate when output is at potential level what corresponds to the definition of a natural (equilibrium) unemployment. As Banerji et al. (2015) pointed out, despite its importance, the intercept interpretation is overlooked. In this respect, our research is close to Banerji et al. (2015) and Dixon et al. (2017), however, only Dixon et al. (2017) analysed intercept values by gender. Also, contrary to the above-mentioned studies which assume that the output gap has a homogenous effect on unemployment, we allow different effects to occur depending on the gap's sign (positive/negative). We can find in the literature empirical support that total unemployment sensitivity to output is higher in recessions than in expansions (see Tang and Bethencourt (2017), Novák and Darmo (2019) for a literature review), but there is a lack of evidence whether this pattern holds for age- and gender-specific unemployment rates. Here, our research is close to Ahn et al. (2019), but with the focus on the unemployment rate, instead of its fluctuation from the equilibrium level, and its reaction to the changes in positive and negative output gap. In addition, we estimate the above-mentioned relationship for male and female.

Our model is grounded in the classical Okun's equation. Using a least squares dummy variable (LSDV) approach and multiplicative specification of the model, we estimate the equilibrium unemployment rate and Okun's coefficient for separate countries. Using the LSDV approach, we assume that labour market institutions are country-specific and time-invariant, and their effects are reflected in estimated parameters on equilibrium unemployment and Okun's coefficient.

Estimates show that young people, despite their gender, are more affected by economic fluctuations and have a higher equilibrium unemployment rate than the total labour force. Contrary to previous studies, our results raise some doubts whether the impact of economic expansion and recession on unemployment is significantly different.

As Zanin (2018) pointed out, it is important for both economists and policymakers to know how the unemployment rates (by age and gender) respond to changes in GDP. It can be used by banks and insurance companies for income risk assessment, to serve as indicator for policymakers in establishing effective labour market policies.

The rest of the paper is organized as follows. Section 2 presents the review of empirical research on age- and gender-specific Okun's coefficients, an overview of Okun's law estimation methods and data, as well as model specification for the research. Section 3 discusses general estimation and robustness. Section 4 concludes the paper.

## 2. Age- and Gender-Specific Okun's Coefficient

### 2.1. Empirical Evidence

Ample research has been conducted to investigate the reasons why youth have higher unemployment rates than other age cohorts. Bruno et al. (2017) presented a review of the literature on this topic and highlight four major groups of causes: (a) economic cycles; (b) demographic and structural conditions; (c) policies and institutions; (d) human capital, mismatch of skill, transition from school to work process. The literature on the economic cycle's (GDP growth) impact on youth unemployment focuses on Okun's law. Various studies have shown that Okun's coefficients depend on age. Ample evidence suggests that the youth unemployment rate responds to economic fluctuations much stronger than older age cohorts. Marconi et al. (2016) also confirmed this conclusion, however, when the authors replaced unemployment rate with unemployment ratio, they did not find any evidence that young people are more vulnerable to business cycle fluctuations than their older counterparts. Dunsch's (2016) estimations for Germany also show no significant difference in Okun's coefficient when comparing youth and other age cohorts. There are sound reasons to expect higher youth unemployment sensitivity to the business cycle. Young people have less work experience compared to the elder population and are less competitive in the labour market, and they have a higher tendency to be hired with temporary contracts which allow firing more easily during recessions, i.e., when company faces the need to reduce the number of employees, young people are more likely to be fired first as they have less company-specific skills (European Commission 2013). The World Bank (2012) points out that youth have a significantly higher share in employment with temporary contracts than other age cohorts. According to Scarpetta et al. (2010), this is the main factor why young people have the highest exposure to the business cycle.

The estimated magnitude of gender-specific Okun's coefficients suggests higher unemployment sensitivity to the business cycle for men than women (Brincikova and Darmo 2015; Dunsch 2016). This might be related to higher male representation in sectors (like building or construction) that are more dependent on the state of the economy (World Bank 2012).

Few studies jointly considered gender- and age-specific unemployment rates sensitivity to GDP growth. Hutengs and Stadtmann (2014a) estimated higher coefficients for male than female for all age cohorts in Scandinavian countries, but Dunsch (2017) did not confirm the same pattern in CEE countries where some age groups show stronger female unemployment reaction to growth. That the young male population is the most exposed to economic fluctuations was confirmed by Zanin (2014) in individual OECD countries, Dunsch (2017) in Central and Eastern European (CEE) countries, and Dixon et al. (2017) in the panel of 20 OECD countries. Contrary to these results are the findings of Zanin (2018). With data for Italy, she estimated higher young female's unemployment rate sensitivity to GDP growth. Moreover, Zanin (2018) restricted the analysis to the unemployment of the labour force with experience and found a similar size of Okun's coefficient among youth for both genders.

### 2.2. Overview of Okun's Law Estimation Methods

Okun (1962) examined the relationship between unemployment and output using two approaches—the first difference and the gap models. These models still are commonly used in the literature on Okun's law. The equation of the first difference model is:

$$\Delta u_t = \alpha + \beta \Delta y_t + \varepsilon_t, \quad (1)$$

where  $\Delta u_t$  is the change of the unemployment rate from period  $t - 1$  to  $t$ ,  $\Delta y_t$  is the output change,  $\beta$  is the so-called "Okun's coefficient", which is expected to be negative and measures the relationship between the variation of GDP change and the variation of unemployment change,  $\varepsilon_t$  is the error term, and  $\alpha$  is an intercept. Estimating Equation (1), researchers do not address the endogeneity problem arising from the possible reverse causality going from unemployment to economic growth.

Hutengs and Stadtmann (2013) estimated Equation (1) by OLS for several Eurozone countries, using time-series data of different age cohorts. Zanin (2014) applied the same methodology for OECD countries, estimating age- and gender-specific Okun's coefficients. Other researchers have run panel regressions. Brincikova and Darmo (2015) analysed how male and female unemployment responds to output fluctuations in a panel of the EU 28 countries and selected groups (the core countries, PIIGS, Northern countries and the Visegrad group). In the panel of European countries, Banerji et al. (2014, 2015) focused on the Okun's coefficient for youth, and Marconi et al. (2016) for different age cohorts.

Another alternative is to estimate Equation (1) with panel data for each country separately when different age cohorts are considered as cross-sectional units. In this case,  $\Delta u$  in Equation (1) is commonly associated with the change in the unemployment rate of a certain age group. Hutengs and Stadtmann (2014a, 2014b) and Dunsch (2016, 2017) constructed a panel for each analysed country and estimated it, using the LSDV approach:

$$\Delta u_{g,t} = \alpha_0 + \alpha_{1,g}d_g + \beta_0\Delta y_t + \beta_{1,g}(\Delta y_t \cdot d_g) + \varepsilon_{i,t}, \quad (2)$$

where  $\Delta u_{g,t}$  is the yearly changes in the unemployment rate for different age cohorts,  $d_g$  is a dummy variable indicating the  $g$ -th age cohort. Equation (2) allows to justify whether the size of the Okun's coefficient for one age cohort is significantly different from the coefficient of the other age cohort. This equation is estimated for each gender separately.

The second approach is a gap model estimated with the following equation:

$$u_t = u^* + \beta(y_t - y_t^*) + \varepsilon_t, \quad (3)$$

where  $y_t$  represents the actual real GDP, and  $y_t^*$  denotes the potential output,  $u^*$  is an intercept indicating unemployment rate in cases of full employment, i.e.,  $u^*$  corresponds to the natural unemployment rate,  $\beta$  is expected to be negative. By subtracting the potential output from the actual real GDP, we get the output gap, which may be either positive or negative. A negative gap implies that real GDP is below the economy's full capacity while a positive gap is associated with excess demand and an overheating economy. The shortcoming of the gap approach is that potential output is not directly measured by macroeconomic variables and can be derived only with assumptions. Okun calculated potential GDP, assuming that natural unemployment is 4 percent. Dixon et al. (2017) estimated age and gender specific Okun's relationship, using Equation (3) with a panel data of 20 OECD countries.

The gap model of Okun's law is often estimated subtracting  $u_t^*$  from both sides of Equation (3). Thus, the alternative gap version can then be written as follows:

$$u_t - u_t^* = \beta(y_t - y_t^*) + \varepsilon_t. \quad (4)$$

Banerji et al. (2014, 2015) utilized a panel of 22 advanced European countries and Equation (4) to compare how youth and adult unemployment deviation from its natural level reacts to the output gap.

Kangasharju et al. (2012) summarized what limitations of original Okun's equations are mostly highlighted in the literature. Criticism is mostly related to assumptions of linearity and the symmetry of the growth-unemployment relation, specifically (i) original Okun's equations do not consider feedback effects that are characteristic between goods and labour markets in the long-run; (ii) the method applied to time series to decompose short-run trend-cycle patterns highly affects the analysis results; (iii) it is assumed, without proper tests, that growth and unemployment are exogenous in the short-run; (iv) aggregate variables do not shed light on the age-, gender-, and region-specific growth-unemployment relation, since both the product and the labour market could be diverse and behave differently over the different stages of the business cycle; (v) positive economic growth may have smaller negative effect on unemployment than one positive that a negative economic growth could have due to difficulties while trying to find a job after longer unemployment duration.

Few studies extend the equations proposed by Okun (1962), including additional independent variables and/or interaction terms. Banerji et al. (2014, 2015) estimated alternative specifications of Equation (3), adding various measures of labour market institutions (one at a time), i.e., Equation (5) and their interaction with the output gap, i.e., Equation (6):

$$u_{i,t} = u_0^* + u_{1,i}^* c_i + \beta_i c_i (y_{i,t} - y_{i,t}^*) + \gamma x_{i,t} + \varepsilon_{i,t}, \quad (5)$$

$$u_{i,t} = u_0^* + u_{1,i}^* c_i + \beta_{0,i} c_i (y_{i,t} - y_{i,t}^*) + \beta_{1,i} c_i x_{i,t} (y_{i,t} - y_{i,t}^*) + \gamma x_{i,t} + \varepsilon_{i,t}, \quad (6)$$

where  $u_{i,t}$  is the level of the youth or adult unemployment rate,  $c_i$  is country dummy,  $y_{i,t} - y_{i,t}^*$  is the output gap, and  $x_{i,t}$  represents labour market institutions in the  $i$ -th country. These equations also allow for equilibrium unemployment and Okun's coefficient to vary across countries. Dixon et al. (2017) estimated the Okun's relationship in the following form:

$$u_{i,k,t} = (u_0^* + u_{1,i,t}^* z_{i,t}) + (\beta_0 + \beta_{1,i,k,t} q_{i,k,t}) (y_{i,t} - y_{i,t}^*) + \varepsilon_{i,k,t}, \quad (7)$$

where Equation (3) is modified, including various labour market institutions, i.e.,  $z_{i,t}$ , allowing equilibrium unemployment rates variation in time ( $u_0^* + u_{1,i,t}^* z_{i,t}$ ). Interaction between the output gap and the share of temporary workers, i.e.,  $q$ , allowed to test whether changes in the output gap have a stronger impact on unemployment in more flexible labour markets. Estimations are made for both males and females of three age groups, and  $k$  represents the age group.

In a panel of 58 middle- and low-income developing economies and in a panel of 38 high-income countries, Ahn et al. (2019) explored the link between the output and the unemployment gaps for both youth and adults and extend Equation (4) as follows:

$$u_{i,t} - u_{i,t}^* = \beta^p d_{i,t}^p (y_{i,t} - y_{i,t}^*) + \beta^n (1 - d_{i,t}^p) (y_{i,t} - y_{i,t}^*) + c_i + \varepsilon_{i,t}, \quad (8)$$

where  $d_{i,t}^p$  is a dummy variable taking the value of 1 in the case of a positive output gap, otherwise 0. Most studies confirm that the unemployment rate responds more robustly to output fall than to its growth. One can expect that firms react prominently to the economic crisis and lay-off workers as production falls. In opposite situation, reaction is not so quick. After the recession, firms have aimed to satisfy a growing demand by increasing labour productivity rather than hiring new employees (Novák and Darmo 2019). Wage flexibility is another important factor. If wage setting mechanisms impede wage flexibility, the presence of downward wage rigidity makes labour demand more responsive to recession than to expansion (Ahn et al. 2019). Silvapulle et al. (2004) suggested two reasons to expect stronger unemployment rate reaction to output changes on the upswing than on the downswing. The first reason is related to institutional restrictions on hiring and firing processes. If there are many restrictions to dismiss the employee and no strict regulations to hiring procedures, then unemployment would show a weaker response to economic slowdown compared to upturn. The second explanation is based on employee training costs. Firms would be unwilling to dismiss employees if they have invested heavily in their training. We would like to point out that reasons suggested by Silvapulle et al. (2004) are more appropriate to ground dynamic versions of Okun's equations, which include lagged output growth, assuming that the unemployment rate depends on current and previous values of output growth.

The inclusion of additional variables or dynamic versions of Okun's equations allows to clarify what factors might shape the output–unemployment trade-off, however, the shortcoming is that the interpretations of the modified equation and the original version are not the same (Knotek 2007).

### 2.3. Model Specification for the Research

In this paper, the focus of the analysis is on 28 EU countries over the period of 2000–2018. Contrary to the common approach in the literature to estimate the  $y^*$  for the gap calculation using the Hodrick–Prescott filter, we calculated the gap using  $y$  and  $y^*$  provided in the annual macro-economic

database of the European Commission’s Directorate General for Economic and Financial Affairs (AMECO). All variables used in the research and source of data are provided in Table 1.

**Table 1.** Variables and summary statistics.

| Variable | Description  | Mean | Std. Dev. | Min.              | Max.               | Source   |
|----------|--|------|-----------|-------------------|--------------------|----------|
| $y$      | Gross domestic product at 2010 reference levels, Bil. of national currency           | 1797 | 5136      | 5.4               | 33525              | AMECO    |
| $y^*$    | Potential gross domestic product at 2010 reference levels, Bil. of national currency | 1803 | 5144      | 5.3               | 32448              |          |
| $u$      | Total unemployment rate (%)  | 8.9  | 4.4       | 1.9<br>(LU, 2001) | 27.5<br>(EL, 2013) | Eurostat |
|          | Total male unemployment rate (%)   | 8.6  | 4.4       | 1.6<br>(LU, 2001) | 25.6<br>(ES, 2013) |          |
|          | Total female unemployment rate (%)   | 9.2  | 4.7       | 2.4<br>(LU, 2001) | 31.4<br>(EL, 2013) |          |
|          | Youth (less than 25 years) unemployment rate (%)                                     | 20.2 | 9.7       | 5.6<br>(AT, 2000) | 58.3<br>(EL, 2013) |          |
|          | Youth (less than 25 years) male unemployment rate (%)                                | 20.1 | 9.5       | 5.5<br>(AT, 2000) | 56.2<br>(ES, 2013) |          |
|          | Youth (less than 25 years) female unemployment rate (%)                              | 20.5 | 10.5      | 5.1<br>(DE, 2018) | 63.8<br>(EL, 2013) |          |

Notes: LU—Luxembourg, EL—Greece, ES—Spain, AT—Austria, DE—Germany.

Aiming in the research to estimate the equilibrium unemployment and gap-unemployment relationships (like in Equation (3)) that are country specific (like in Equation (5) but without labour market institutions), and to test whether the gap-unemployment relationship could potentially depend on cyclical upturns and downturns (like in Equation (8)), we ground our model on the gap version of Okun’s law. Our baseline econometric specification of the additive model for panel dataset across countries (subscript  $i$ ) and time periods (subscript  $t$ ) can be written as:

$$u_{i,t} = u_i^* + \beta(y_{i,t} - y_{i,t}^*) + \varepsilon_{i,t}, \tag{9}$$

where  $u_{i,t}$  is the unemployment rate,  $u_i^*$  is the country-specific equilibrium unemployment rates, i.e., we assume here that  $u^*$  varies cross-sectionally (i.e., across countries), but not across periods (i.e., years).  $y$  is (log) actual output, and  $y^*$  is (log) potential output.

We extend our baseline Equation (9), assuming that: (i) the responsiveness of the unemployment rate to output fluctuations, i.e., Okun’s coefficient, is not the same over the periods of positive and negative output gaps, and (ii) not just equilibrium unemployment rate is country-specific, but coefficient  $\beta$  could also depend on country-specific factors, such as labour market regulation, economic structure, etc., thus we allow in our model  $\beta$  to vary across countries. The model, when country-specific differing effects of positive and negative gaps are introduced, for a panel of 28 EU countries can be written as:

$$u_{i,t} = u_i^* + \left[ \left\{ \beta_1^p d_{1,t}^p (y_{1,t} - y_{1,t}^*) + \sum_{i=2}^{28} \beta_i^p d_{i,t}^p (y_{i,t} - y_{i,t}^*) \cdot c_i \right\} + \left\{ \beta_1^n (1 - d_{1,t}^p) (y_{1,t} - y_{1,t}^*) + \sum_{i=2}^{28} \beta_i^n (1 - d_{i,t}^p) (y_{i,t} - y_{i,t}^*) \cdot c_i \right\} \right] + \varepsilon_{i,t}, \tag{10}$$

where  $d_{i,t}^p$  is a dummy taking the value of 1 when actual output is greater than potential, and zero otherwise. The coefficients  $\beta^p$  and  $\beta^n$  measure the short-run responsiveness of the unemployment rate to the positive and negative output gap, respectively.

To see whether equilibrium unemployment and the gap-unemployment relationship depends on age and gender, we estimated Equation (10) separately for total and youth, male and female unemployment, obviating additional interactions in the right-hand side of the Equation (10). To see

whether the effects are significantly different for males and females, youth and whole population, besides point estimates, we provide confidence intervals. The model is estimated by LSDV, using Prais–Winsten standard errors in order to minimise the probability that heteroscedasticity and serial correlation could lead to inefficient estimates with biased regular standard errors and, therefore, misleading results.

### 3. Results and Discussion

#### 3.1. The Equilibrium Unemployment Rates of Youth

Table 2 reports estimated equilibrium unemployment rates, using Equation (10).

**Table 2.** Point estimates of youth equilibrium unemployment, i.e.,  $\hat{u}^*$ .

|                | Total |            | Male  |             | Female |             |
|----------------|-------|------------|-------|-------------|--------|-------------|
|                | (1)   | (2)        | (1)   | (2)         | (1)    | (2)         |
| Belgium        | 19.41 | (2.99) **  | 19.78 | (8.03) **   | 18.92  | (7.43) **   |
| Bulgaria       | 21.16 | (2.63) *** | 22.14 | (6.37) ***  | 19.82  | (7.05) ***  |
| Czechia        | 14.91 | (2.49) *** | 14.45 | (5.56) **   | 15.54  | (6.94) **   |
| Denmark        | 9.50  | (1.86) *** | 9.70  | (2.79) ***  | 9.31   | (2.89) ***  |
| Germany        | 8.78  | (1.84) *** | 9.79  | (3.15) ***  | 7.65   | (3.45) **   |
| Estonia        | 19.21 | (3.51) *** | 19.41 | (6.10) ***  | 19.20  | (6.55) ***  |
| Ireland        | 16.99 | (2.79) *** | 19.49 | (6.21) ***  | 14.15  | (5.41) ***  |
| Greece         | 27.31 | (6.76) **  | 21.05 | (7.82) ***  | 34.81  | (13.59) **  |
| Spain          | 34.86 | (7.04) **  | 35.92 | (12.89) *** | 33.55  | (12.09) *** |
| France         | 22.02 | (3.54) *** | 21.81 | (9.32) **   | 22.16  | (9.88) **   |
| Croatia        | 29.43 | (5.24) **  | 27.88 | (11.77) **  | 31.52  | (14.00) **  |
| Italy          | 28.36 | (4.34) **  | 26.13 | (9.71) ***  | 31.44  | (9.41) ***  |
| Cyprus         | 17.00 | (2.47) *** | 16.45 | (6.38) **   | 17.52  | (5.55) ***  |
| Latvia         | 19.57 | (3.32) *** | 19.02 | (7.46) **   | 20.41  | (7.76) ***  |
| Lithuania      | 21.37 | (4.02) *** | 21.81 | (6.89) ***  | 20.71  | (6.56) ***  |
| Luxembourg     | 15.77 | (1.73) *** | 15.61 | (4.89) ***  | 16.00  | (4.91) ***  |
| Hungary        | 13.75 | (2.37) **  | 14.17 | (5.32) ***  | 13.21  | (6.00) **   |
| Malta          | 15.47 | (2.57) *** | 16.24 | (4.64) ***  | 14.60  | (5.90) **   |
| Netherlands    | 8.72  | (1.63) *** | 9.17  | (3.72) **   | 8.29   | (3.18) ***  |
| Austria        | 8.95  | (1.96) **  | 9.26  | (3.00) ***  | 8.58   | (2.50) ***  |
| Poland         | 23.70 | (3.53) *** | 22.47 | (6.82) ***  | 25.34  | (10.22) **  |
| Portugal       | 22.04 | (2.63) *** | 20.62 | (8.13) **   | 23.72  | (6.79) ***  |
| Romania        | 19.09 | (2.16) *** | 19.04 | (6.71) ***  | 19.19  | (6.13) ***  |
| Slovenia       | 15.61 | (2.41) *** | 14.29 | (4.14) ***  | 17.34  | (6.26) ***  |
| Slovakia       | 23.30 | (3.91) *** | 22.38 | (8.52) ***  | 24.80  | (7.09) ***  |
| Finland        | 19.99 | (3.31) **  | 20.54 | (6.98) ***  | 19.43  | (6.33) ***  |
| Sweden         | 19.07 | (2.65) **  | 19.98 | (6.76) ***  | 18.08  | (6.44) ***  |
| United Kingdom | 13.98 | (1.77) *** | 15.66 | (6.09) **   | 12.12  | (4.73) **   |

Notes: Col. (1) reports estimated parameters on  $u^*$ , col. (2)—Prais–Winsten standard errors associated with  $u^*$ . \*\*, \*\*\* indicate statistical significance at the 5%, and 1% levels, respectively.

Out of 28 countries that our research is focused on, 13 are the same as in the research by Dixon et al. (2017). Our estimates of equilibrium unemployment rates for young males and females are close to Dixon et al. (2017), however, some discrepancy exists and points to equilibrium unemployment variation over time as these studies analyse different time periods.

Like in Dixon et al. (2017), so in this research, countries show different patterns regarding which gender has a higher equilibrium unemployment rate, but there is no doubt that young people, regardless of their gender, experience higher unemployment rates, even when the economy operates at a full employment level (for comparison see the estimated equilibrium unemployment rates for the total labour force in Table A1, Appendix A).

### 3.2. Youth Unemployment Rate Sensitivity to the Output Gap

Assuming the heterogeneous gap effect on unemployment, using Equation (10), we separated the effects of the positive and negative gaps. Estimation results are presented in Tables 3 and 4.

**Table 3.** Point estimates of the output gap–youth unemployment relationship, when the gap is positive, i.e.,  $\hat{\beta}^p$ .

|                | Total |            | Male  |            | Female |            |
|----------------|-------|------------|-------|------------|--------|------------|
|                | (1)   | (2)        | (1)   | (2)        | (1)    | (2)        |
| Belgium        | −0.47 | (0.18) *** | −1.49 | (0.64) **  | −0.80  | (0.33) **  |
| Bulgaria       | −1.96 | (0.57) *** | −2.21 | (0.67) *** | −1.66  | (0.62) *** |
| Czechia        | −0.45 | (0.19) **  | −0.41 | (0.17) **  | −0.51  | (0.24) **  |
| Denmark        | −0.71 | (0.16) *** | −0.76 | (0.23) *** | −0.68  | (0.22) *** |
| Germany        | −0.28 | (0.12) **  | 0.14  | (0.07) *   | −0.38  | (0.18) *** |
| Estonia        | −0.72 | (0.16) *** | −0.71 | (0.23) *** | −0.75  | (0.27) *** |
| Ireland        | −1.69 | (0.50) *** | −2.09 | (0.70) *** | −1.25  | (0.50) **  |
| Greece         | −0.72 | (0.21) *** | −0.91 | (0.36) **  | −0.40  | (0.16) **  |
| Spain          | −2.18 | (0.85) **  | −1.68 | (0.63) *** | −2.21  | (0.84) *** |
| France         | −0.93 | (0.20) *** | −1.80 | (0.81) **  | −0.89  | (0.42) **  |
| Croatia        | −0.60 | (0.19) *** | −0.84 | (0.37) **  | −0.23  | (0.11) **  |
| Italy          | −2.17 | (0.53) *** | −2.39 | (0.93) **  | −1.90  | (0.60) *** |
| Cyprus         | −1.47 | (0.44) *** | −1.35 | (0.55) **  | −1.56  | (0.52) *** |
| Latvia         | −0.94 | (0.28) *** | −0.94 | (0.39) **  | −0.95  | (0.38) **  |
| Lithuania      | −1.23 | (0.36) *** | −1.63 | (0.54) *** | −0.72  | (0.24) *** |
| Luxembourg     | −0.34 | (0.08) *** | −0.43 | (0.14) *** | −0.21  | (0.07) *** |
| Hungary        | −0.87 | (0.35) **  | −0.59 | (0.23) **  | −1.23  | (0.59) **  |
| Malta          | −0.74 | (0.22) *** | −0.72 | (0.22) *** | −0.76  | (0.32) **  |
| Netherlands    | −0.30 | (0.10) *** | −0.51 | (0.22) **  | −0.15  | (0.06) **  |
| Austria        | −0.44 | (0.08) *** | −0.67 | (0.23) *** | −0.16  | (0.05) *** |
| Poland         | −2.50 | (0.86) *** | −2.52 | (0.81) *** | −2.47  | (1.05) **  |
| Portugal       | −3.01 | (0.65) *** | −3.26 | (1.35) **  | −2.62  | (0.79) *** |
| Romania        | 0.01  | (0.01)     | 0.11  | (0.06)     | −0.16  | (0.08) *   |
| Slovenia       | −0.86 | (0.17) *** | −0.80 | (0.24) *** | −0.30  | (0.11) *** |
| Slovakia       | −0.59 | (0.19) *** | −0.48 | (0.19) **  | −0.76  | (0.23) *** |
| Finland        | −0.31 | (0.09) **  | −0.80 | (0.29) *** | 0.17   | (0.09) *   |
| Sweden         | −0.37 | (0.12) *** | −0.82 | (0.29) *** | 0.13   | (0.08)     |
| United Kingdom | −0.93 | (0.24) *** | −1.15 | (0.47) **  | −0.74  | (0.30) **  |

Notes: Col. (1) reports estimated parameters on  $\beta^p$ , col. (2)—Prais–Winsten standard errors associated with  $\beta^p$ . Since we use level–log type model, estimated parameters on  $\beta^p$  as well as Prais–Winsten standard errors are divided by 100 and show how 1 percent positive gap ( $y - y^*$ ) is associated with a difference between short–term unemployment and equilibrium unemployment rates \*, \*\*, \*\*\* indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

**Table 4.** Point estimates of output gap–youth unemployment relationship, when the gap is negative, i.e.,  $\hat{\beta}^n$ .

|          | Total |            | Male  |            | Female |            |
|----------|-------|------------|-------|------------|--------|------------|
|          | (1)   | (2)        | (1)   | (2)        | (1)    | (2)        |
| Belgium  | −2.48 | (1.00) **  | −2.54 | (0.99) **  | −2.47  | (0.93) *** |
| Bulgaria | −2.75 | (0.85) *** | −3.03 | (0.83) *** | −2.46  | (0.84) *** |
| Czechia  | −1.33 | (0.58) **  | −1.45 | (0.53) *** | −1.20  | (0.51) **  |
| Denmark  | −1.14 | (0.35) *** | −1.49 | (0.41) *** | −0.77  | (0.23) *** |
| Germany  | −1.05 | (0.49) **  | −1.12 | (0.52) **  | −0.93  | (0.40) **  |
| Estonia  | −1.23 | (0.38) *** | −1.61 | (0.48) *** | −0.70  | (0.23) *** |
| Ireland  | −1.72 | (0.54) *** | −2.46 | (0.75) *** | −0.93  | (0.34) *** |
| Greece   | −1.70 | (0.51) *** | −1.80 | (0.64) *** | −1.56  | (0.58) *** |



Table 4. Cont.

|                | Total |            | Male  |            | Female |            |
|----------------|-------|------------|-------|------------|--------|------------|
|                | (1)   | (2)        | (1)   | (2)        | (1)    | (2)        |
| Spain          | −5.03 | (2.07) **  | −2.15 | (0.74) *** | −2.92  | (1.01) *** |
| France         | −1.38 | (0.39) *** | −1.84 | (0.75) **  | −3.37  | (1.44) **  |
| Croatia        | −3.41 | (1.11) *** | −3.72 | (1.50) **  | −2.99  | (1.27) **  |
| Italy          | −3.03 | (1.02) *** | −2.38 | (0.85) *** | −2.61  | (0.75) *** |
| Cyprus         | −2.51 | (0.78) *** | −2.80 | (1.04) *** | −2.23  | (0.68) *** |
| Latvia         | −1.35 | (0.42) *** | −1.53 | (0.57) *** | −1.09  | (0.4) ***  |
| Lithuania      | −1.93 | (0.59) *** | −2.06 | (0.62) *** | −1.73  | (0.52) *** |
| Luxembourg     | −1.61 | (0.54) *** | −1.74 | (0.52) *** | −1.41  | (0.41) *** |
| Hungary        | −3.14 | (1.31) **  | −3.24 | (1.16) *** | −3.01  | (1.31) **  |
| Malta          | −1.71 | (0.52) *** | −1.53 | (0.42) *** | −1.92  | (0.74) **  |
| Netherlands    | −1.14 | (0.38) *** | −1.19 | (0.46) **  | −1.07  | (0.39) *** |
| Austria        | −0.74 | (0.24) *** | −0.77 | (0.24) *** | −0.70  | (0.19) *** |
| Poland         | −3.71 | (1.34) *** | −3.74 | (1.09) *** | −3.66  | (1.41) **  |
| Portugal       | −3.44 | (1.37) **  | −3.48 | (1.31) *** | −3.38  | (0.93) *** |
| Romania        | −0.53 | (0.24) **  | −0.56 | (0.30) **  | −0.50  | (0.23) **  |
| Slovenia       | −0.57 | (0.19) *** | −0.79 | (0.22) *** | −0.91  | (0.31) *** |
| Slovakia       | −3.93 | (1.32) *** | −4.69 | (1.71) *** | −2.86  | (0.78) *** |
| Finland        | −0.64 | (0.20) *** | −0.83 | (0.27) *** | −0.50  | (0.24) **  |
| Sweden         | −1.29 | (0.43) *** | −1.38 | (0.45) *** | −1.20  | (0.65) **  |
| United Kingdom | −1.70 | (0.45) *** | −1.92 | (0.71) *** | −1.46  | (0.55) *** |

Notes: Col. (1) reports estimated parameters on  $\beta^p$ , col. (2)—Prais–Winsten standard errors associated with  $\beta^p$ . Since we use level–log type model, estimated parameters on  $\beta^p$  as well as Prais–Winsten standard errors are divided by 100 and show how 1 percent positive gap ( $y - y^*$ ) is associated with a difference between short–term unemployment and equilibrium unemployment rates \*\*, \*\*\* indicate statistical significance at the 5%, and 1% levels, respectively.

Our results are in line with the finding (e.g., [Ahn et al. 2019](#); [Dixon et al. 2017](#); [Dunsch 2017](#)) that young people are more vulnerable to economic fluctuations with respect to their unemployment. For almost all countries, we confirm a higher youth—rather than total—unemployment rate sensitivity to both positive and negative output gap fluctuations (for comparison see the estimated Okun’s coefficients for total labour force in [Tables A2 and A3](#), Appendix A). This conclusion holds for both genders.

In accordance with [Banerji et al. \(2014, 2015\)](#), we allow for the impact of the output gap variation across countries and confirm that the magnitude of Okun’s coefficient is country specific. For example, a 1% GDP decrease from its potential level results in a higher youth total unemployment rate from 0.53 percentage points in Romania to 5.03 percentage points in Spain. We found only few cases where Okun’s law does not work as expected. It looks like influence of the positive gap on the youth—both male and female—unemployment rate is insignificant in Romania. [Dinu et al. \(2011\)](#) pointed out that the cyclical total unemployment rate in Romania depends not on the current but lagged output gap. In Finland and Sweden, the economy’s performance above potential limits also has no relevant effect on female unemployment. Observed cross-country variability in the magnitude of Okun’s coefficients can be related to institutional, political, and other country-specific factors. It is expected that stricter labour market regulations, especially legislation related to employment protection, reduce unemployment as a reaction to output changes ([IMF International Monetary Fund](#)). The coefficient’s magnitude also depends on the costs of new worker training, and on flows into and from the labour force ([An et al. 2019](#)). Empirical evidence is inconsistent. For example, [Banerji et al. \(2015\)](#) analysed whether the tax wedge, union density, and active labour market policy spending, etc. affect the way unemployment rates respond to the output gap. The same labour market variable was found to amplify the impact of the output fluctuation on the unemployment rate in few countries and to diminish in others. [Ball et al. \(2017\)](#) observed an insignificant relationship between employment protection legislation and unemployment sensitivity to output movements. As this research aims to differentiate youth unemployment reaction to GDP fluctuations by gender and state of the business cycle (positive

or negative output gap), we do not get deep into the factors explaining cross-country variation of the variable of interest. However, cross-country variation of Okun's coefficients shows that panel data models with impact heterogeneity are preferred against those assuming a constant unemployment reaction to the output.

The estimated Okun's coefficients (Tables 3 and 4) support the idea of nonlinearity in Okun's law (Tang and Bethencourt 2017). Virén (2001) for OECD countries, Cuaresma (2003) and Knotek (2007) for the US economy, and Novák and Darmo (2019) for EU28 estimated that total unemployment reaction to output volatility is significantly higher in recessions than in expansions. Our estimates (Tables 3 and 4) mostly support this conclusion for youth unemployment of both genders, only with some exceptions. In Slovenia, total youth—as well as young male—unemployment is more affected during the expansion of the economy rather than during contraction, and the same results were found for male unemployment in Italy as well as female unemployment in Estonia and Ireland. Our point estimates are consistent with those reported in the above-mentioned studies, but confidence intervals of point estimates raise some doubts whether youth unemployment is more affected by economic downturn than upturn (see Tables A4–A6 in Appendix B for confidence intervals). For eight countries out of 28, the estimated negative output gap's impact on youth unemployment falls within the confidence interval estimated for the positive gap. As regards estimations for young female and male, positive and negative gap estimates in 10 and 14 countries respectively fall in the same confidence interval. Since the studies we refer to do not report confidence intervals, we cannot compare whether these intervals related to point estimates of total unemployment responsiveness to recessions and expansions also overlap.

We cannot confirm with confidence the conclusion of Zanin (2014), Dunsch (2017), and Dixon et al. (2017), that young males are more affected by output volatility than women as, for a few countries, our results confirm the opposite. Despite that estimates mainly support higher male unemployment rate sensitivity to negative economic shocks compared to females, in most countries, coefficients for women fall within the confidence interval for men and vice versa.

### 3.3. Robustness

With respect to conclusions related to gender-specific youth unemployment reaction to output movements, the same holds for models with total unemployment data (see Appendix A). Whether the equilibrium unemployment rate of men or women is higher depends on the country. In most cases, in countries where the unemployment rate of young men was higher than that of women, the total male unemployment rate is also higher than that of female.

Only in a few countries and only for female unemployment did we notice a higher impact of the positive gap rather than the negative one. However, only point estimates support the conclusion presented by Tang and Bethencourt (2017), Virén (2001), Cuaresma (2003), Knotek (2007), and Novák and Darmo (2019), that unemployment is more sensitive to economic recessions than expansions. The cases where coefficients of both gaps are within the same confidence interval (see Appendix B) do not allow to conclude with confidence that the reaction of the unemployment rate to economic upturns and downswings is significantly different.

For more than 20 out of 28 countries we found greater male than female unemployment responsiveness to GDP movements above and below potential levels. Here, our estimates correspond to Brincikova and Darmo (2015), as well as Dunsch's (2016) results about higher male unemployment sensitivity to the business cycle than women but, again, if we take confidence intervals (see Appendix B) into consideration, the conclusion is not so obvious anymore.

## 4. Conclusions

The impacts of economic growth and output fluctuations from the potential level on the unemployment rate have been widely discussed and estimated in the empirical literature. After the great recession, extreme increases in youth unemployment rates across most of the European

Union and other countries around the world have renewed the interest in Okun's law in general, and on its differences taking age and gender into account. In line with existing literature that youth unemployment is more responsive to economic growth than older cohorts, we estimated higher young male and female unemployment rate sensitivity to output gap fluctuations compared to the total unemployment of that gender. With only some exceptions did the results confirm a higher youth unemployment reaction to the negative output gap than to a positive one, which was verified by other studies for total unemployment. Unlike previous studies, we took the confidence intervals into consideration and, after that, some doubts occurred whether the impact of economic expansion and recession on unemployment is significantly different.

The magnitude of Okun's coefficient undoubtedly shows its country-specific nature, which suggests that models assuming a constant unemployment reaction to output across countries are not very accurate. With respect to equilibrium unemployment, we did not find that a higher rate is more typical to a certain gender but, comparing total unemployment, young people of both genders experience a higher unemployment rate, even when the economy operates at its potential level.

Compared with the total labour force, young people are more affected by economic fluctuations and have a higher equilibrium unemployment rate, which points to the necessity of age-specific means of dealing with unemployment. High youth unemployment rates when output is at the potential level point to the structural nature of unemployment and its persistence despite a growing economy. It follows that structural reforms should be implemented to address this problem as demand stimulating policies would be less effective. The equilibrium youth unemployment rates differ widely across the EU countries which suggests that policy recommendations and actions should be largely country-specific. However, some common recommendations are provided by the [European Commission \(2013\)](#), namely, to facilitate the transition from school to work, to improve the matching of skills with labour market needs, and to prevent early school leaving.

The structural nature of unemployment should not downplay the importance of GDP growth in policy recommendations. Young people have a stronger exposure to economic fluctuations than the total labour force and, therefore, during an economic downturn, particular attention should be paid to this age group when designing labour market policies.

Further investigation should be done to explain what determines the different size of Okun's coefficient across countries. The literature review suggests that this variation can be related to labour market regulations, new worker training costs, flows into and from the labour force, and other country-specific factors.

**Author Contributions:** J.S. carried out a literature review and put up an idea of the empirical analysis; M.B. designed the empirical analysis, collected and analysed the data and performed the econometric analysis. Both authors wrote the paper.

**Funding:** This research received no external funding.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

**Table A1.** Point estimates of equilibrium unemployment for the whole labour force, i.e.,  $\hat{u}^*$ .

|          | Total |            | Male  |            | Female |            |
|----------|-------|------------|-------|------------|--------|------------|
|          | (1)   | (2)        | (1)   | (2)        | (1)    | (2)        |
| Belgium  | 7.56  | (2.84) *** | 7.39  | (2.93) **  | 7.77   | (3.13) **  |
| Bulgaria | 9.86  | (4.19) **  | 10.46 | (4.67) **  | 9.14   | (2.81) *** |
| Czechia  | 6.39  | (2.64) **  | 5.29  | (2.30) **  | 7.75   | (3.39) **  |
| Denmark  | 5.39  | (1.81) *** | 5.00  | (1.76) *** | 5.93   | (1.42) *** |
| Germany  | 6.13  | (2.72) **  | 6.44  | (3.00) **  | 5.76   | (2.70) **  |

Table A1. Cont.

|                | Total |            | Male  |            | Female |            |
|----------------|-------|------------|-------|------------|--------|------------|
|                | (1)   | (2)        | (1)   | (2)        | (1)    | (2)        |
| Estonia        | 10.11 | (3.38) *** | 10.76 | (3.78) *** | 9.45   | (2.24) *** |
| Ireland        | 8.60  | (2.63) *** | 9.32  | (3.00) *** | 7.77   | (2.42) *** |
| Greece         | 10.72 | (4.59) **  | 7.23  | (3.26) **  | 15.82  | (4.75) *** |
| Spain          | 15.53 | (6.39) **  | 14.42 | (6.25) **  | 16.68  | (6.83) **  |
| France         | 9.34  | (3.01) *** | 9.15  | (3.10) *** | 9.53   | (2.14) *** |
| Croatia        | 12.12 | (3.98) *** | 10.96 | (3.78) *** | 13.49  | (4.37) *** |
| Italy          | 9.32  | (3.41) *** | 8.07  | (3.11) **  | 11.08  | (2.82) *** |
| Cyprus         | 7.22  | (2.11) *** | 6.76  | (2.08) *** | 7.80   | (2.43) *** |
| Latvia         | 11.31 | (5.10) **  | 12.03 | (5.71) **  | 10.61  | (3.28) *** |
| Lithuania      | 11.63 | (3.63) *** | 12.59 | (4.13) *** | 10.70  | (3.27) *** |
| Luxembourg     | 5.21  | (1.93) *** | 4.53  | (1.77) **  | 6.05   | (1.53) *** |
| Hungary        | 6.10  | (2.48) **  | 6.27  | (2.68) **  | 5.85   | (2.44) **  |
| Malta          | 6.71  | (3.02) **  | 6.20  | (2.93) **  | 7.93   | (2.42) *** |
| Netherlands    | 4.61  | (1.51) *** | 3.98  | (1.37) *** | 5.36   | (1.79) *** |
| Austria        | 5.07  | (1.49) *** | 5.14  | (1.59) *** | 4.97   | (0.99) *** |
| Poland         | 9.26  | (3.28) *** | 8.63  | (3.22) *** | 10.01  | (3.59) *** |
| Portugal       | 8.87  | (2.97) *** | 8.66  | (3.05) *** | 9.07   | (2.05) *** |
| Romania        | 6.42  | (2.33) *** | 7.03  | (2.68) *** | 5.66   | (2.07) *** |
| Slovenia       | 6.66  | (1.99) *** | 6.30  | (1.98) *** | 7.11   | (1.44) *** |
| Slovakia       | 10.66 | (3.42) *** | 9.91  | (3.35) *** | 11.56  | (3.87) *** |
| Finland        | 8.55  | (3.74) **  | 8.58  | (3.95) **  | 8.52   | (2.60) *** |
| Sweden         | 6.95  | (2.36) *** | 7.13  | (2.55) *** | 6.74   | (2.25) *** |
| United Kingdom | 5.33  | (1.99) *** | 5.74  | (2.25) **  | 4.97   | (1.32) *** |

Notes: Col. (1) reports estimated parameters on  $u^*$ , col. (2)—Prais–Winsten standard errors associated with  $u^*$ , \*\*, \*\*\* indicate statistical significance at the 5%, and 1% levels, respectively.

**Table A2.** Point estimates of output gap–unemployment relationship for the whole labour force, when the gap is positive, i.e.,  $\beta^p$ .

|             | Total |            | Male  |            | Female |            |
|-------------|-------|------------|-------|------------|--------|------------|
|             | (1)   | (2)        | (1)   | (2)        | (1)    | (2)        |
| Belgium     | −0.08 | (0.06)     | −0.46 | (0.20) **  | −0.38  | (0.17) **  |
| Bulgaria    | −0.84 | (0.39) **  | −1.09 | (0.54) **  | −0.54  | (0.16) *** |
| Czechia     | −0.19 | (0.08) **  | −0.18 | (0.09) **  | −0.17  | (0.08) **  |
| Denmark     | −0.45 | (0.19) **  | −0.49 | (0.19) **  | −0.24  | (0.09) *** |
| Germany     | −0.57 | (0.27) **  | −0.36 | (0.19) **  | −0.86  | (0.44) **  |
| Estonia     | −0.46 | (0.19) **  | −0.45 | (0.18) **  | −0.32  | (0.12) *** |
| Ireland     | −0.80 | (0.31) *** | −0.98 | (0.35) *** | −0.60  | (0.20) *** |
| Greece      | −0.42 | (0.15) *** | −0.38 | (0.19) **  | −0.49  | (0.19) **  |
| Spain       | −1.12 | (0.38) *** | −1.45 | (0.70) **  | −0.89  | (0.38) **  |
| France      | −0.30 | (0.12) **  | −0.45 | (0.17) *** | −0.13  | (0.06) **  |
| Croatia     | −0.38 | (0.16) **  | −0.40 | (0.15) *** | −0.33  | (0.11) *** |
| Italy       | −0.43 | (0.20) **  | −0.56 | (0.24) **  | −0.24  | (0.10) **  |
| Cyprus      | −0.63 | (0.23) *** | −0.70 | (0.24) *** | −0.55  | (0.19) *** |
| Latvia      | −0.56 | (0.24) **  | −0.60 | (0.32) *** | −0.52  | (0.02) *** |
| Lithuania   | −0.51 | (0.20) **  | −0.75 | (0.27) *** | −0.28  | (0.09) *** |
| Luxembourg  | −0.57 | (0.26) **  | −0.53 | (0.23) **  | 0.02   | (0.01)     |
| Hungary     | 0.04  | (0.04)     | −0.12 | (0.06) **  | −0.23  | (0.10) **  |
| Malta       | −0.53 | (0.22) **  | 0.02  | (0.01) *   | −0.34  | (0.13) *** |
| Netherlands | −0.48 | (0.20) **  | −0.57 | (0.22) *** | −0.36  | (0.13) *** |
| Austria     | −0.38 | (0.14) *** | −0.23 | (0.08) *** | −0.16  | (0.05) *** |
| Poland      | −0.92 | (0.41) **  | −0.81 | (0.34) **  | −1.06  | (0.40) *** |
| Portugal    | −1.30 | (0.54) **  | −1.24 | (0.48) **  | −1.34  | (0.21) *** |

Table A2. Cont.

|                | Total |            | Male  |            | Female |            |
|----------------|-------|------------|-------|------------|--------|------------|
|                | (1)   | (2)        | (1)   | (2)        | (1)    | (2)        |
| Romania        | 0.04  | (0.03)     | 0.07  | (0.03) *   | 0.01   | (0.01)     |
| Slovenia       | −0.30 | (0.11) *** | −0.36 | (0.13) *** | −0.23  | (0.08) *** |
| Slovakia       | −0.06 | (0.02) **  | −0.13 | (0.05) *** | −0.03  | (0.02)     |
| Finland        | −0.29 | (0.13) **  | −0.16 | (0.08) **  | −0.14  | (0.06) **  |
| Sweden         | −0.26 | (0.11) **  | −0.32 | (0.13) **  | −0.11  | (0.04) *** |
| United Kingdom | −0.32 | (0.15) **  | −0.42 | (0.18) **  | −0.34  | (0.11) *** |

Notes: Col. (1) reports estimated parameters on  $\beta^p$ , col. (2)—Prais–Winsten standard errors associated with  $\beta^p$ . Since we use level–log type model, estimated parameters on  $\beta^p$  as well as Prais–Winsten standard errors are divided by 100 and show how 1 percent positive gap ( $y - y^*$ ) is associated with a difference between short–term unemployment and equilibrium unemployment rates \*\*, \*\*\* indicate statistical significance at the 5%, and 1% levels, respectively.

**Table A3.** Point estimates of output gap–unemployment relationship for the whole labour force, when the gap is negative, i.e.,  $\hat{\beta}^n$ .

|                | Total |            | Male  |            | Female |            |
|----------------|-------|------------|-------|------------|--------|------------|
|                | (1)   | (2)        | (1)   | (2)        | (1)    | (2)        |
| Belgium        | −0.53 | (0.22) **  | −0.71 | (0.31) **  | −0.36  | (0.18) **  |
| Bulgaria       | −1.47 | (0.69) **  | −1.46 | (0.57) **  | −1.52  | (0.52) *** |
| Czechia        | −0.20 | (0.09) **  | −0.25 | (0.12) **  | −0.14  | (0.05) *** |
| Denmark        | −0.53 | (0.20) *** | −0.68 | (0.21) *** | −0.49  | (0.23) **  |
| Germany        | −0.85 | (0.42) **  | −0.85 | (0.40) **  | −0.85  | (0.48) **  |
| Estonia        | −0.58 | (0.22) *** | −0.84 | (0.25) *** | −0.46  | (0.21) **  |
| Ireland        | −0.92 | (0.31) *** | −1.21 | (0.46) *** | −0.53  | (0.19) *** |
| Greece         | −0.96 | (0.46) **  | −0.99 | (0.38) *** | −0.87  | (0.27) *** |
| Spain          | −1.88 | (0.86) **  | −1.80 | (0.82) **  | −1.05  | (0.49) **  |
| France         | −0.56 | (0.20) *** | −0.66 | (0.19) *** | −0.43  | (0.16) *** |
| Croatia        | −0.98 | (0.36) *** | −1.18 | (0.48) **  | −0.75  | (0.27) *** |
| Italy          | −0.80 | (0.33) **  | −1.02 | (0.33) *** | −0.42  | (0.14) *** |
| Cyprus         | −1.09 | (0.35) *** | −1.25 | (0.45) *** | −0.91  | (0.35) *** |
| Latvia         | −0.64 | (0.32) **  | −0.85 | (0.34) **  | −0.42  | (0.20) **  |
| Lithuania      | −1.12 | (0.39) *** | −1.26 | (0.46) *** | −1.00  | (0.34) *** |
| Luxembourg     | −1.00 | (0.41) **  | −1.01 | (0.33) *** | −0.60  | (0.20) *** |
| Hungary        | −1.10 | (0.50) **  | −1.11 | (0.54) **  | −1.08  | (0.53) **  |
| Malta          | −0.97 | (0.48) **  | −0.39 | (0.16) **  | −0.90  | (0.21) *** |
| Netherlands    | −0.92 | (0.33) *** | −0.62 | (0.24) **  | −0.42  | (0.16) **  |
| Austria        | −0.82 | (0.27) *** | −0.55 | (0.14) *** | −0.14  | (0.06) **  |
| Poland         | −1.36 | (0.54) **  | −2.12 | (0.91) **  | −1.26  | (0.52) **  |
| Portugal       | −1.74 | (0.65) *** | −1.59 | (0.47) *** | −1.48  | (0.54) *** |
| Romania        | −0.40 | (0.16) **  | −0.14 | (0.06) **  | −0.15  | (0.06) **  |
| Slovenia       | −0.74 | (0.25) *** | −0.43 | (0.11) *** | −0.46  | (0.19) **  |
| Slovakia       | −0.50 | (0.18) *** | −1.13 | (0.44) **  | −1.70  | (0.68) **  |
| Finland        | −0.73 | (0.35) **  | −0.44 | (0.16) *** | −0.17  | (0.05) *** |
| Sweden         | −0.70 | (0.26) *** | −0.37 | (0.16) **  | −0.29  | (0.11) *** |
| United Kingdom | −0.76 | (0.32) **  | −0.74 | (0.25) *** | −0.54  | (0.21) *** |

Notes: Col. (1) reports estimated parameters on  $\beta^n$ , col. (2)—Prais–Winsten standard errors associated with  $\beta^n$ . Since we use level–log type model, estimated parameters on  $\beta^n$  as well as Prais–Winsten standard errors are divided by 100 and show how 1 percent negative gap ( $y - y^*$ ) is associated with a difference between short–term unemployment and equilibrium unemployment rates \*\*, \*\*\* indicate statistical significance at the 5%, and 1% levels, respectively.

## Appendix B

Table A4. Confidence interval of point estimates on output gap–total youth unemployment relationship.

|                | $\hat{\beta}^p$ | 95% CI      |             | $\hat{\beta}^n$ | 95% CI      |             |
|----------------|-----------------|-------------|-------------|-----------------|-------------|-------------|
|                |                 | Lower Limit | Upper Limit |                 | Lower Limit | Upper Limit |
| Belgium        | -0.47           | -0.82       | -0.12       | -2.48           | -4.44       | -0.52       |
| Bulgaria       | -1.96           | -3.08       | -0.84       | -2.75           | -4.42       | -1.08       |
| Czechia        | -0.45           | -0.82       | -0.08       | -1.33           | -2.47       | -0.19       |
| Denmark        | -0.71           | -1.02       | -0.40       | -1.14           | -1.83       | -0.45       |
| Germany        | -0.28           | -0.52       | -0.04       | -1.05           | -2.01       | -0.09       |
| Estonia        | -0.72           | -1.03       | -0.41       | -1.23           | -1.97       | -0.49       |
| Ireland        | -1.69           | -2.67       | -0.71       | -1.72           | -2.78       | -0.66       |
| Greece         | -0.72           | -1.13       | -0.31       | -1.70           | -2.70       | -0.70       |
| Spain          | -2.18           | -3.85       | -0.51       | -5.03           | -9.09       | -0.97       |
| France         | -0.93           | -1.32       | -0.54       | -1.38           | -2.14       | -0.62       |
| Croatia        | -0.60           | -0.97       | -0.23       | -3.41           | -5.59       | -1.23       |
| Italy          | -2.17           | -3.21       | -1.13       | -3.03           | -5.03       | -1.03       |
| Cyprus         | -1.47           | -2.33       | -0.61       | -2.51           | -4.04       | -0.98       |
| Latvia         | -0.94           | -1.49       | -0.39       | -1.35           | -2.17       | -0.53       |
| Lithuania      | -1.23           | -1.94       | -0.52       | -1.93           | -3.09       | -0.77       |
| Luxembourg     | -0.34           | -0.50       | -0.18       | -1.61           | -2.67       | -0.55       |
| Hungary        | -0.87           | -1.56       | -0.18       | -3.14           | -5.71       | -0.57       |
| Malta          | -0.74           | -1.17       | -0.31       | -1.71           | -2.73       | -0.69       |
| Netherlands    | -0.30           | -0.50       | -0.10       | -1.14           | -1.88       | -0.40       |
| Austria        | -0.44           | -0.60       | -0.28       | -0.74           | -1.21       | -0.27       |
| Poland         | -2.50           | -4.19       | -0.81       | -3.71           | -6.34       | -1.08       |
| Portugal       | -3.01           | -4.28       | -1.74       | -3.44           | -6.13       | -0.75       |
| Romania        | 0.01            | -0.01       | 0.03        | -0.53           | -1.00       | -0.06       |
| Slovenia       | -0.86           | -1.19       | -0.53       | -0.57           | -0.94       | -0.20       |
| Slovakia       | -0.59           | -0.96       | -0.22       | -3.93           | -6.52       | -1.34       |
| Finland        | -0.31           | -0.49       | -0.13       | -0.64           | -1.03       | -0.25       |
| Sweden         | -0.37           | -0.61       | -0.13       | -1.29           | -2.13       | -0.45       |
| United Kingdom | -0.93           | -1.40       | -0.46       | -1.70           | -2.58       | -0.82       |

Table A5. Confidence interval of point estimates on output gap–male youth unemployment relationship.

|           | $\hat{\beta}^p$ | 95% CI      |             | $\hat{\beta}^n$ | 95% CI      |             |
|-----------|-----------------|-------------|-------------|-----------------|-------------|-------------|
|           |                 | Lower Limit | Upper Limit |                 | Lower Limit | Upper Limit |
| Belgium   | -1.49           | -2.74       | -0.24       | -2.54           | -4.48       | -0.60       |
| Bulgaria  | -2.21           | -3.52       | -0.90       | -3.03           | -4.66       | -1.40       |
| Czechia   | -0.41           | -0.74       | -0.08       | -1.45           | -2.49       | -0.41       |
| Denmark   | -0.76           | -1.21       | -0.31       | -1.49           | -2.29       | -0.69       |
| Germany   | 0.14            | 0.00        | 0.28        | -1.12           | -2.14       | -0.10       |
| Estonia   | -0.71           | -1.16       | -0.26       | -1.61           | -2.55       | -0.67       |
| Ireland   | -2.09           | -3.46       | -0.72       | -2.46           | -3.93       | -0.99       |
| Greece    | -0.91           | -1.62       | -0.20       | -1.80           | -3.05       | -0.55       |
| Spain     | -1.68           | -2.91       | -0.45       | -2.15           | -3.60       | -0.70       |
| France    | -1.80           | -3.39       | -0.21       | -1.84           | -3.31       | -0.37       |
| Croatia   | -0.84           | -1.57       | -0.11       | -3.72           | -6.66       | -0.78       |
| Italy     | -2.39           | -4.21       | -0.57       | -2.38           | -4.05       | -0.71       |
| Cyprus    | -1.35           | -2.43       | -0.27       | -2.80           | -4.84       | -0.76       |
| Latvia    | -0.94           | -1.70       | -0.18       | -1.53           | -2.65       | -0.41       |
| Lithuania | -1.63           | -2.69       | -0.57       | -2.06           | -3.28       | -0.84       |

Table A5. Cont.

|                | $\hat{\beta}^p$ | 95% CI      |             | $\hat{\beta}^n$ | 95% CI      |             |
|----------------|-----------------|-------------|-------------|-----------------|-------------|-------------|
|                |                 | Lower Limit | Upper Limit |                 | Lower Limit | Upper Limit |
| Luxembourg     | -0.43           | -0.70       | -0.16       | -1.74           | -2.76       | -0.72       |
| Hungary        | -0.59           | -1.04       | -0.14       | -3.24           | -5.51       | -0.97       |
| Malta          | -0.72           | -1.15       | -0.29       | -1.53           | -2.35       | -0.71       |
| Netherlands    | -0.51           | -0.94       | -0.08       | -1.19           | -2.09       | -0.29       |
| Austria        | -0.67           | -1.12       | -0.22       | -0.77           | -1.24       | -0.30       |
| Poland         | -2.52           | -4.11       | -0.93       | -3.74           | -5.88       | -1.60       |
| Portugal       | -3.26           | -5.91       | -0.61       | -3.48           | -6.05       | -0.91       |
| Romania        | 0.11            | -0.01       | 0.23        | -0.56           | -1.15       | 0.03        |
| Slovenia       | -0.80           | -1.27       | -0.33       | -0.79           | -1.22       | -0.36       |
| Slovakia       | -0.48           | -0.85       | -0.11       | -4.69           | -8.04       | -1.34       |
| Finland        | -0.80           | -1.37       | -0.23       | -0.83           | -1.36       | -0.30       |
| Sweden         | -0.82           | -1.39       | -0.25       | -1.38           | -2.26       | -0.50       |
| United Kingdom | -1.15           | -2.07       | -0.23       | -1.92           | -3.31       | -0.53       |

Table A6. Confidence interval of point estimates on output gap–female youth unemployment relationship.

|                | $\hat{\beta}^p$ | 95% CI      |             | $\hat{\beta}^n$ | 95% CI      |             |
|----------------|-----------------|-------------|-------------|-----------------|-------------|-------------|
|                |                 | Lower Limit | Upper Limit |                 | Lower Limit | Upper Limit |
| Belgium        | -0.80           | -1.45       | -0.15       | -2.47           | -4.29       | -0.65       |
| Bulgaria       | -1.66           | -2.88       | -0.44       | -2.46           | -4.11       | -0.81       |
| Czechia        | -0.51           | -0.98       | -0.04       | -1.20           | -2.20       | -0.20       |
| Denmark        | -0.68           | -1.11       | -0.25       | -0.77           | -1.22       | -0.32       |
| Germany        | -0.38           | -0.73       | -0.03       | -0.93           | -1.71       | -0.15       |
| Estonia        | -0.75           | -1.28       | -0.22       | -0.70           | -1.15       | -0.25       |
| Ireland        | -1.25           | -2.23       | -0.27       | -0.93           | -1.60       | -0.26       |
| Greece         | -0.40           | -0.71       | -0.09       | -1.56           | -2.70       | -0.42       |
| Spain          | -2.21           | -3.86       | -0.56       | -2.92           | -4.90       | -0.94       |
| France         | -0.89           | -1.71       | -0.07       | -3.37           | -6.19       | -0.55       |
| Croatia        | -0.23           | -0.45       | -0.01       | -2.99           | -5.48       | -0.50       |
| Italy          | -1.90           | -3.08       | -0.72       | -2.61           | -4.08       | -1.14       |
| Cyprus         | -1.56           | -2.58       | -0.54       | -2.23           | -3.56       | -0.90       |
| Latvia         | -0.95           | -1.69       | -0.21       | -1.09           | -1.87       | -0.31       |
| Lithuania      | -0.72           | -1.19       | -0.25       | -1.73           | -2.75       | -0.71       |
| Luxembourg     | -0.21           | -0.35       | -0.07       | -1.41           | -2.21       | -0.61       |
| Hungary        | -1.23           | -2.39       | -0.07       | -3.01           | -5.58       | -0.44       |
| Malta          | -0.76           | -1.39       | -0.13       | -1.92           | -3.37       | -0.47       |
| Netherlands    | -0.15           | -0.27       | -0.03       | -1.07           | -1.83       | -0.31       |
| Austria        | -0.16           | -0.26       | -0.06       | -0.70           | -1.07       | -0.33       |
| Poland         | -2.47           | -4.53       | -0.41       | -3.66           | -6.42       | -0.90       |
| Portugal       | -2.62           | -4.17       | -1.07       | -3.38           | -5.20       | -1.56       |
| Romania        | -0.16           | -0.32       | 0.00        | -0.50           | -0.95       | -0.05       |
| Slovenia       | -0.30           | -0.52       | -0.08       | -0.91           | -1.52       | -0.30       |
| Slovakia       | -0.76           | -1.21       | -0.31       | -2.86           | -4.39       | -1.33       |
| Finland        | 0.17            | -0.01       | 0.35        | -0.50           | -0.97       | -0.03       |
| Sweden         | 0.13            | -0.03       | 0.29        | -1.20           | -2.47       | 0.07        |
| United Kingdom | -0.74           | -1.33       | -0.15       | -1.46           | -2.54       | -0.38       |

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