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Revisiting the Okun relationship

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ABSTRACT

Our article revisits the Okun relationship between observed unemployment rates and output gaps. We include in the relationship the effect of labour market institutions as well as age and gender effects. Our empirical analysis is based on 20 OECD countries over the period 1985–2013. We find that the share of temporary workers (which includes a high and rising share of young workers) played a crucial role in explaining changes in the Okun coefficient (the impact of the output gap on the unemployment rate) over time. The Okun coefficient is not only different for young, prime-age and older workers but also it decreases with age. From a policy perspective, it follows that an increase in economic growth will not only have the desired outcome of reducing the overall unemployment rate but it will also have the distributional effect of lowering youth unemployment.

KEYWORDS

Okun's law; unemployment; equilibrium unemployment rates

JEL CLASSIFICATION

J64

I. Introduction

Fluctuations in unemployment and growth go hand in hand and there are numerous empirical studies of the relationship between the two. The simplest and most widely cited relationship is 'Okun's law', i.e. the relationship between unemployment and the cyclical component of GDP. It is a reduced-form relationship that has underpinned numerous academic and policy discussions about growth and employment.¹

Recent papers suggest that the nature of the relationship has changed over time and that it is also different during expansions and during recessions. For example, Owyang and Sekhposyan (2012) using quarterly data over the period 1949–2011 estimated various specifications of the Okun relationship and found that during the three most recent US recessions and the Great Recession, the unemployment rate was more sensitive to output growth and output gap fluctuations. Cazes, Verick and Al Hussami (2013) analysed country-specific changes in unemployment in the Great Recession and found that Okun's relationship varied across countries and

time. In some countries, unemployment was more responsive and in other countries, it was less responsive to negative economic growth shocks.

Okun (1962) examined three models including a 'difference version' which relates the change in the unemployment rate to the GDP growth rate and a 'gap version' which relates the unemployment rate to the output gap. There is by now an extensive literature covering both versions. We will be adopting the 'gap version' in keeping with our intention of examining the impact on unemployment of deviations from potential output.² Also we will incorporate into the Okun relationship labour market institutions meaning by that 'the system of laws, norms, or conventions resulting from a collective choice and providing constraints or incentives that alter individual choices over labour and pay' (Boeri and van Ours (2013), 8).

We revisit Okun's relationship using data from 20 OECD countries over the period 1985–2013. The aim of our article is to study the Okun relationship for a range of countries covering a sample period that

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¹Okun specified an empirical relationship without clear indications of causality. Perman and Stephan (2015) present a meta-analysis of 269 estimates of the Okun relationship from 28 studies. According to their overview, about 60% of all estimates have real output as the left-hand-side variable, about 75% use country level data and slightly more than half of the studies use a static model.

²The regression equation in Okun (1962) is $u = a + b(\text{gap})$. One of the criteria Okun used for judging the validity of his estimates is that the results should agree 'with the principle that potential GNP should equal actual GNP when $u = 4$ ', this is because he believed the target rate of unemployment (or full employment rate of unemployment) was 4%.

includes the Great Recession. In this regard, we will test for asymmetries in the relationship between the output gap and the unemployment rate, specifically whether the Okun coefficient is different in boom and bust periods. Furthermore, we will examine whether and by how much the Okun coefficient has changed over time, especially post the Great Recession.

We offer three contributions to the literature. First, we investigate how the relationship between the (equilibrium) unemployment rate, the output gap and labour market institutions differs depending upon age and gender. This is an important extension as the determinants of the equilibrium unemployment rate and the size of the Okun coefficient are likely to vary across age groups and across gender. Second, we allow labour market institutions to influence *both* the equilibrium rate of unemployment and the effect of the change in the output gap on the unemployment gap (i.e. the Okun coefficient). Third, we provide estimates of time-varying country-specific equilibrium unemployment rates and explore differences in the apparent trends in the equilibrium unemployment rates between countries (especially those in the Eurozone).

The analysis at the age–gender level, taken in conjunction with findings about labour-institutional factors, allows us to draw some policy implications. We show that equilibrium unemployment rates are positively related to union density, the unemployment insurance (UI) replacement rate and the tax wedge and negatively related to the level of wage coordination and the terms of trade. We also find that the effects of changes in the output gap on the unemployment rate decreases with age. From this, we infer that an increase in economic growth will not only reduce the overall unemployment rate but it will also bring about a more than proportional decline in the youth unemployment rate.

Our article is structured as follows. In [Section II](#), we provide a short overview of previous studies and a description of our empirical model. We also present the parameter estimates of Okun’s relationship assuming to begin with that each country has a constant equilibrium unemployment rate. In [Section III](#), we extend our analysis by allowing labour market institutional factors to affect the equilibrium unemployment rate while the effect of the

output gap on the unemployment rate is allowed to depend on the share of temporary workers in employment. [Section IV](#) presents estimates of the Okun relationship disaggregated by age and gender. [Section V](#) concludes.

II. Okun’s relationship at the country level

Previous studies

Nickell and Layard (1999), Bertola (1999), Nickell (1997), Siebert (1997), Arpaia and Mourre (2005), Di Tella and MacCulloch (2005) and Boeri and Jimeno (2016) provide empirical evidence on the impact of labour market institutions on labour market performance, especially the connection between labour market institutions and the equilibrium or natural rate of unemployment. Important studies that relate unemployment to labour market institutions but not to the output gap are Blanchard and Wolfers (2000), Belot and van Ours (2001), Belot and van Ours (2004) and Nickell, Nunziata, and Ochel (2005). Holmlund (2014) provides a recent discussion on the relevance of various labour market institutions and van Ours (2015) estimates a ‘difference version’ of the Okun relationship linking changes in unemployment to labour market institutions.

Previous studies relating the unemployment gap (or the unemployment rate) to the output gap and to labour market institutions mostly look at a subset of OECD countries. All of the studies we have examined find that the unemployment rate is negatively related to the output gap. The findings on the relationship between unemployment rates and labour market institutions vary. It is common for studies to include the unemployment benefit replacement rate and sometimes measures of the duration and eligibility requirements.³ All of the studies we have looked at find a positive relationship between the unemployment rate and the replacement rate. Most studies also include union density as an explanatory variable. While Adams and Coe (1990), Coe (1990) and Scarpetta (1996) find a positive relationship between the unemployment rate and union density, Elmeskov, Martin and Scarpetta (1998) and Bassanini and Duval (2009) do not find any statistically significant relationship between the two.

³Bassanini and Duval (2009) and Vandenberg (2010), for example, include measures of the duration and eligibility requirements.

Many researchers include a measure of employment protection as an explanatory variable. Again there are mixed results. While Scarpetta (1996) and Elmeskov, Martin and Scarpetta (1998) find a positive relationship between the unemployment rate and employment protection Griffith, Harrison and Macartney (2007), Bassanini and Duval (2009) and Vandenberg (2010) do not find any statistically significant relationship between them.

The influence of wage coordination and/or centralisation on the unemployment rate has also been examined. While Vandenberg (2010) finds no evidence of any impact of centralisation, others (e.g. Scarpetta 1996; Elmeskov, Martin, and Scarpetta 1998) conclude that there is a 'hump-shaped' relationship between the unemployment rate and centralisation as suggested by Calmfors and Driffill (1988).

The most common additional explanatory variables included in studies are active labour market programs (Scarpetta 1996; Elmeskov, Martin, and Scarpetta 1998), the tax wedge and non-wage labour costs (Adams, Fenton, and Larsen 1987; Coe 1990; Scarpetta 1996; Elmeskov, Martin, and Scarpetta 1998; Griffith, Harrison, and Macartney 2007; Bassanini and Duval 2009), the real exchange rate (Adams, Fenton, and Larsen 1987; Griffith, Harrison, and Macartney 2007) and the terms of trade (Scarpetta 1996). Other (less common) variables included are the minimum wage (Adams and Coe 1990; Coe 1990; Elmeskov, Martin, and Scarpetta 1998), the rate of structural change (Herwartz and Niebuhr 2011), the level of product market regulation (Bassanini and Duval 2009) and demographic factors such as the proportion of the labour force who are 'young' (Adams, Fenton, and Larsen 1987; Adams and Coe 1990).

The studies noted cover different sample periods. Ball, Leigh and Loungani (2013) studied the Okun relationship for the United States from 1948 to 2011 and for 20 OECD countries from 1980 to 2011. They concluded that there was a strong and stable relationship 'by the standards of macroeconomics' in most countries, although the magnitude of the relationship between output and unemployment varied across countries. Pereira (2013) analysed quarterly US data from 1948:1 to 2012:4 and found that there

are asymmetries in the Okun relationship with a weaker relationship between economic growth and unemployment during periods of expansion.

Empirical model

Okun's law is an empirical relationship between output and unemployment which in its 'gap' version may be written as

$$(u - u^*) = -\Phi(y - y^*) \quad (1)$$

where u is the unemployment rate; y is (log) output; y^* is (log) potential output, u^* indicates the equilibrium unemployment rate and Φ is the Okun coefficient.

Our baseline econometric model, for a panel dataset across countries and time periods, is

$$u_{it} = \alpha_i - \Phi(y_{it} - y_{it}^*) + \varepsilon_{it} \quad (2)$$

$$E(\varepsilon_{it}\varepsilon_{jt}) = \sigma_{ij}$$

$$E(\varepsilon_{is}\varepsilon_{it}) = 0; \quad s \neq t$$

The subscript i denotes the country and t is time in years. α_i are the country-specific fixed effects (which, in this model, are equal to u_i^* the country-specific equilibrium unemployment rates). It is assumed that the errors are related cross-sectionally (i.e. across countries), but not across periods (i.e. years). The model is estimated by generalised least squares allowing for cross-sectional heteroscedasticity.

As is common in the literature, the output gap is estimated using the Hodrick–Prescott filter. Specifically, the HP filter is a two-sided linear filter that computes the smoothed series y^* of y by minimising the variance of y around y^* subject to a penalty function that constrains the change in the trend growth of y^* :

$$\Theta = \sum_{t=1}^T (y_t - y_t^*)^2 + \lambda \sum_{t=2}^{T-1} ((y_{t+1}^* - y_t^*) - (y_t^* - y_{t-1}^*))^2 \quad (3)$$

The penalty parameter λ controls the smoothness of the series and the suggested value by HP is 100.⁴

⁴Ravn and Uhlig (2002) suggest 6.25 for annual data. The results using this value of λ are essentially the same as those reported using $\lambda = 100$. As an alternative to the HP filter, we used a Band-pass filter and a Beveridge–Nelson decomposition but neither led to any change in our main findings.

Data

Because of data availability, the focus of the analysis is on 20 OECD countries over the period 1985–2013. There are 5 countries outside Europe (Australia, Canada, Japan, New Zealand and the United States) and 15 countries in Europe of which 10 adopted the Euro (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain) and 5 did not (Denmark, Norway, Sweden, Switzerland and the United Kingdom).

Output gaps are created for each country in the data set. By construction, the mean value of each country's output gap is zero. [Figure 1](#) provides information about the evolution over time of the unemployment rates and the (inverse of the) output gap for the 20

countries in our sample. The vertical scales show the difference in the fluctuations in unemployment rate and/or output gap across the panel. Clearly, in all countries, variations in unemployment rates and output gaps go hand in hand. The output gap is associated with the Great Recession, which (because of the inverse scale is presented as a strong increase) has had a greater impact on some countries than on others. In Australia, for example, the increase in unemployment is relatively small while for Ireland, Portugal, Spain and the United States, for example, the increase was relatively large. While unemployment in Germany and the United States fell after the Great Recession, in other countries such as France, Italy, Portugal and Spain unemployment continued to be high.

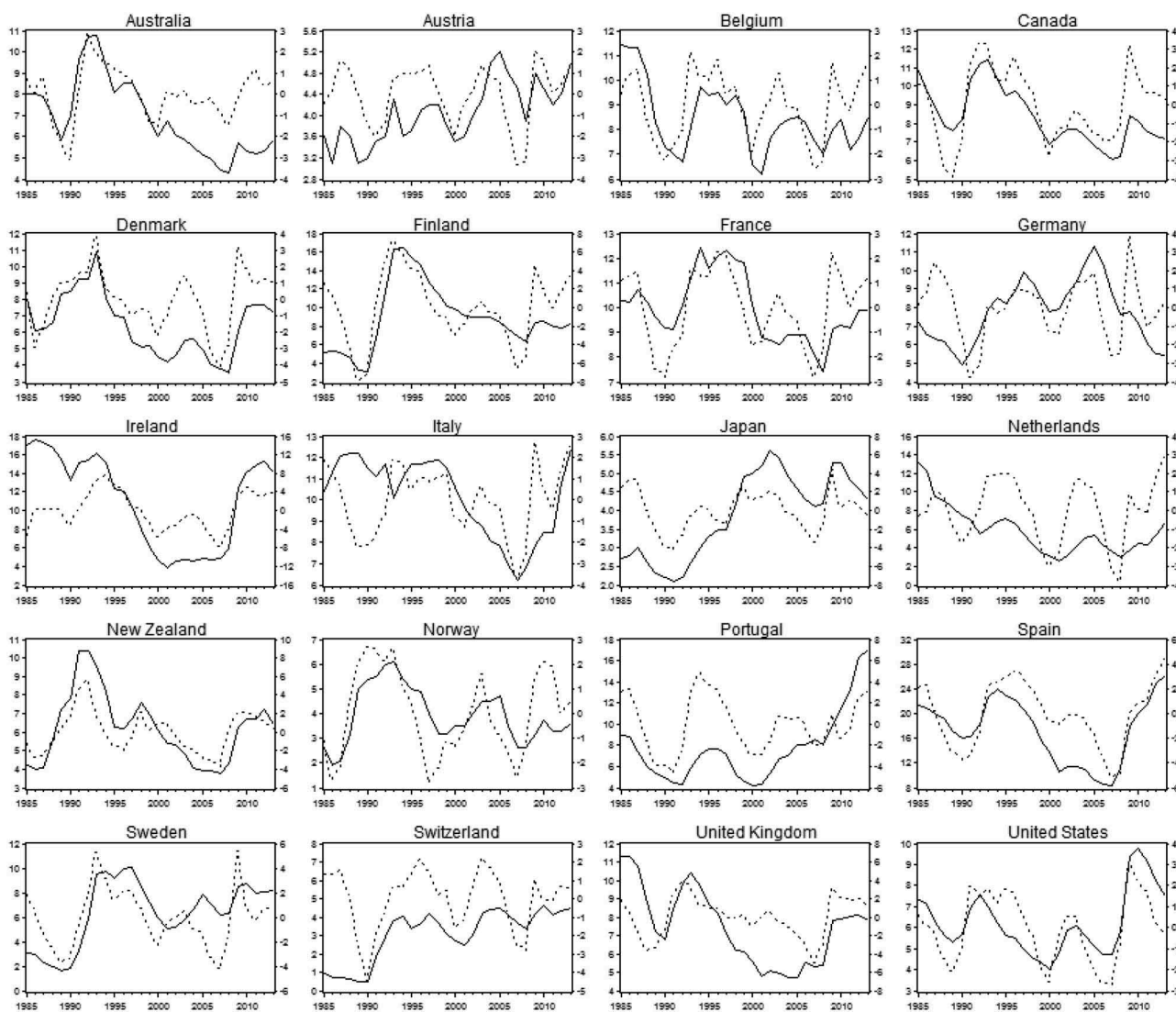


Figure 1. Unemployment rates and output gaps (inverse); 1985–2013.

The solid lines are the actual unemployment rates (LHS) and the dashed lines are the (inverse) output gaps (RHS).

Parameter estimates

Table 1 shows the parameter estimates of the baseline version of the Okun relationship, i.e. the estimation of Equation (2) above which assumes that the equilibrium rate of unemployment (u^*) varies across countries but, for each country, it is constant over time. The GDP-gap has a significant and negative effect on the unemployment rate. This is not surprising given the high correlation between the two as shown in Figure 1.

Table 1 also shows that there is considerable cross-country variation in the implied equilibrium unemployment rates, with estimates of α ranging from a low of 3% in Switzerland to a high of 17% for Spain. There is strong cross-country correlation between the average unemployment rate and the estimated values of the equilibrium unemployment rate.

Table 2 shows the parameter estimates when we modify Equation (2) to allow for asymmetry, in the sense that positive/negative output gaps have different effects on unemployment. As shown in the second column of Table 2, we are unable to reject the hypothesis of symmetry. The third column shows parameter estimates if we allow the effect of the output gap on unemployment to be different after

Table 1. Okun relationship – 1985–2013.

\bar{u}^*	7.50	(0.00)			
GDP-gap	0.54	(0.00)			
u_j^*					
Australia	6.89	(0.00)	Japan	3.88	(0.00)
Austria	4.04	(0.00)	Netherlands	5.89	(0.00)
Belgium	8.46	(0.00)	New Zealand	6.21	(0.00)
Canada	8.33	(0.00)	Norway	3.93	(0.00)
Denmark	6.47	(0.00)	Portugal	7.71	(0.00)
Finland	8.90	(0.00)	Spain	17.31	(0.00)
France	9.94	(0.00)	Sweden	6.35	(0.00)
Germany	7.73	(0.00)	Switzerland	3.06	(0.00)
Ireland	11.12	(0.00)	United Kingdom	7.46	(0.00)
Italy	10.14	(0.00)	United States	6.23	(0.00)

p -values in parentheses.

Table 2. Symmetry and stability of the Okun relationship.

Variable	(1)	(2)	(3)
u^*	7.50 (0.00)	7.34 (0.00)	7.53 (0.00)
GDP-gap	0.54 (0.00)		
GDP-gap_pos		0.44 (0.00)	
GDP-gap_neg		0.64 (0.00)	
GDP-gap_pre GR			0.58 (0.00)
GDP-gap_post GR			0.37 (0.00)
Wald test			
No asymmetric effects		2.36 (0.12)	
No difference pre-post GR			4.16 (0.04)

All estimates contain country fixed effects; the estimates in the first column are identical to the ones presented in Table 1; p -values in parentheses.

the Great Recession from that before the Great Recession. We cannot reject the hypothesis that they are different for this simple model.

III. Introducing labour market institutions

Labour market institutions

So far, equilibrium unemployment rates have been assumed to be constant over time. However, previous studies suggest that labour market institutions may affect the equilibrium unemployment rate. We investigate the significance of the following labour market institutions: union coverage, union density, wage coordination, UI replacement rate, employment protection legislation (EPL) and the tax wedge and additionally the terms of trade. Furthermore, since labour markets have become more flexible in the past decades we investigate whether the responsiveness of unemployment to a change in the output gap is influenced by the ratio of temporary workers to total employees since the larger the share of temporary workers the easier (*ceteris paribus*) the adjustment of employment to output shocks and thus (*ceteris paribus*) the bigger the effect of an output shock on unemployment.

Figure 2 gives a graphical representation of the developments in the labour market institutions. Appendix A provides details on the data used. Each of the graphs in Figure 2 plots, for each country, the values of the variables at two points in time – 1985 and 2013. Clearly, for many countries, not much has happened between these 2 years as they are on the diagonal or close to it. However, there are also some exceptions. The graphs in panel a indicate the evolution in union coverage (left) and union density (right). Union coverage is high in Austria, Belgium and France and low in Japan and the United States. If a country is below the diagonal, it indicates a drop in union coverage or union density. The fall in union coverage has been greatest in Australia, New Zealand, Portugal and the United Kingdom. For these countries, the fall in union density has been substantial as well. Union density is high in the Scandinavian countries (which has to do with UI benefits run by unions) while union density is low in France, the United States and Spain. Panel b shows the evolution of wage coordination (left) and UI replacement rate (right). There is quite a wide

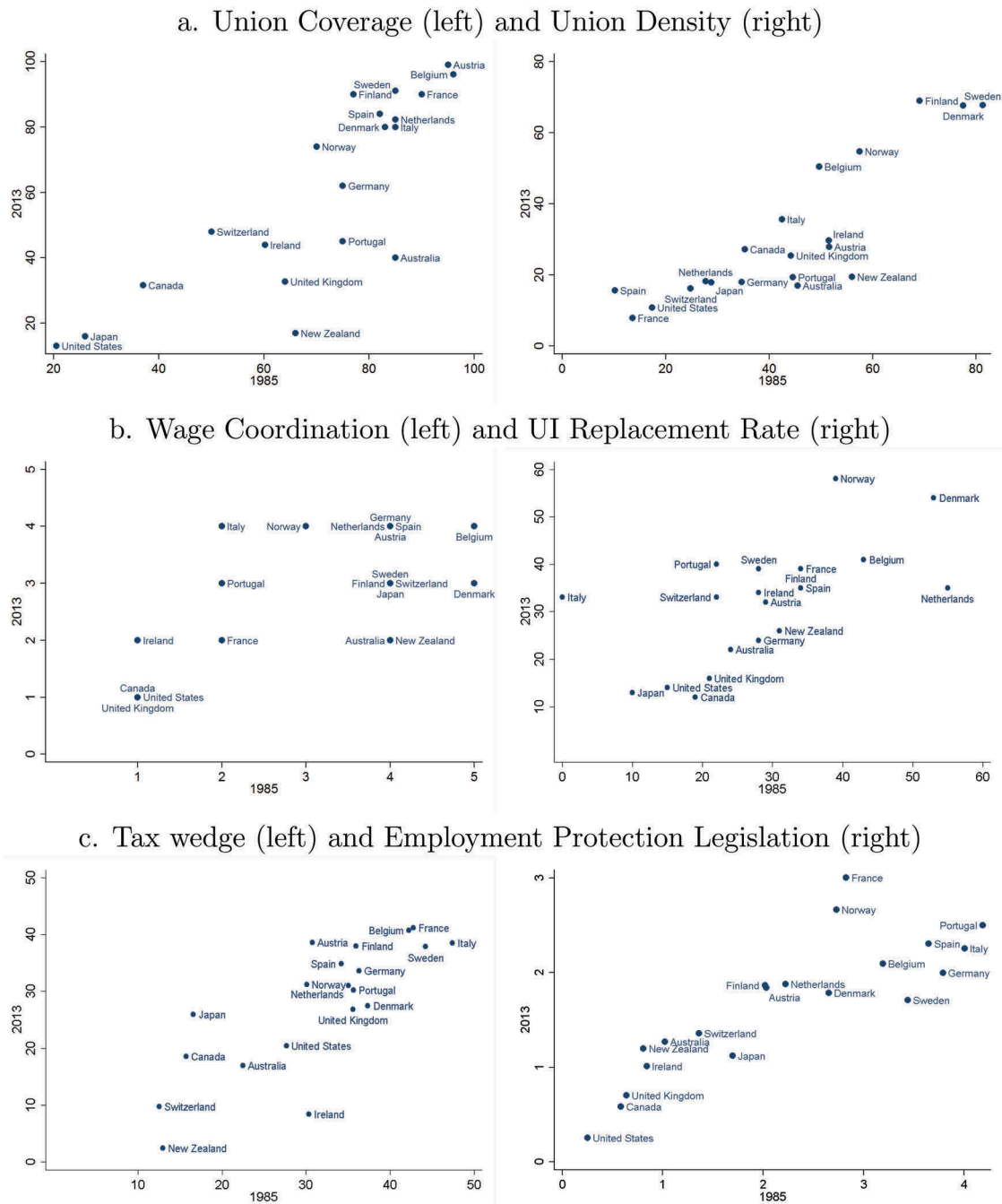


Figure 2. Labour market characteristics 1985 and 2013. (a) Union coverage (left) and union density (right). (b) Wage coordination (left) and UI replacement rate (right). (c) Tax wedge (left) and employment protection legislation (right).

range of wage coordination with Canada, the United Kingdom and the United States having the lowest value of the indicator. In Australia and New Zealand, wage coordination has fallen while in Italy, wage coordination has increased substantially. With respect to the UI replacement rate in most countries, there was a decrease over our sample period but for Italy, Portugal and Norway, there was a substantial increase. Panel c shows the

developments in the tax wedge (left) and EPL (right). In many countries, the tax wedge did not change a lot but in Ireland, there was a substantial drop while in Japan, there was a substantial increase. Finally, as shown in the bottom-right graph, in many countries, EPL shows persistence over time but there are also countries for which EPL was reduced a lot (Belgium, Italy, Germany, Portugal, Spain and Sweden).

Okun relationship with labour market institutions

To take the effect of labour market institutions into account, we estimate the Okun relationship in the following form:

$$u_{it} = \alpha_i + \beta z_{it} - (\Phi_0 + \Phi_1 q_{it})(y_{it} - y_{it}^*) + \varepsilon_{it} \quad (4)$$

where z represents a vector of labour market institutions and q is the share of temporary workers in employment. Thus, the time-varying equilibrium rates of unemployment are modelled as $u_{it}^* = \alpha_i + \beta z_{it}$. By introducing the share of temporary workers as a possible determinant of the magnitude of the Okun coefficient, we allow for the possibility that in more flexible labour markets, there is a stronger unemployment response to a change in the output gap.⁵

Table 3 shows the results of estimating Equation (4) under two different assumptions about the variability of the Okun coefficient (Φ). Column (1) shows the results when imposing the restriction that there is no variation in the Okun coefficient across time and without allowing for it to interact with the share of temporary workers (i.e. Φ_1 is set equal to zero).

Column (2) shows the parameter estimates if we allow the Okun coefficient to have different values before and after the Great Recession having removed labour market institutions which do not have a significant effect on the unemployment rates.

Column (3) shows the results when we allow for the Okun coefficient (Φ_0) to be different pre- and post-the Great Recession and the Okun coefficient is allowed to interact with the share of temporary workers (q_{it}). Thus, the effect of a unit change in the size of the output gap upon the unemployment rate is allowed to vary across countries and across time (as the share of temporary workers varies across countries and across time).⁶ Column (4) of Table 3 shows the results of Equation (4) on the assumption that the Okun coefficient (Φ_0) is the same pre- and post-the Great Recession (consistent with the findings reported in column (3)).

Inspection of the estimated values of the coefficients and their p -values in the top part of the table (the part which reports coefficients on the output gaps) and also the result of a Wald test for a significant difference between the value of the Okun coefficient before and after the Great Recession (this is reported at the bottom of the Table) leads us to conclude that (a) for the base model, we reject the hypothesis that the Okun coefficient has remained the same over time. (b) Once we introduce labour market institutions and allow the size of the Okun coefficient to vary with the share of temporary workers, the magnitude of the Okun coefficient pre- and post-the Great Recession is virtually identical. This suggests that the apparent change in the Okun coefficient after the Great Recession noted earlier when

Table 3. Parameter estimates – including labour market institutions.

Variable	(1)		(2)		(3)		(4)		(5)	
GDP-gap	0.48	(0.00)					0.47	(0.00)	0.47	(0.00)
GDP-gap_pre GR			0.46	(0.00)	0.47	(0.00)				
GDP-gap_post GR			0.53	(0.00)	0.48	(0.00)				
GDP-gap*share temp					0.05	(0.00)	0.05	(0.00)	0.04	(0.00)
Union coverage	0.01	(0.33)								
Union density	0.05	(0.00)	0.06	(0.00)	0.06	(0.00)	0.06	(0.00)	0.04	(0.00)
Wage coordination	-0.76	(0.00)	-0.68	(0.00)	-0.65	(0.00)	0.65	(0.00)	-0.90	(0.00)
UI replacement rate	0.04	(0.02)	0.04	(0.01)	0.04	(0.01)	0.04	(0.00)	0.04	(0.00)
Employment protection	-0.01	(0.97)								
Tax wedge	0.13	(0.00)	0.14	(0.00)	0.14	(0.00)	0.14	(0.00)	0.22	(0.00)
Terms of trade	-0.06	(0.00)	-0.06	(0.00)	-0.06	(0.00)	-0.06	(0.00)	-0.04	(0.04)
Constant	7.50	(0.00)	7.50	(0.00)	7.51	(0.00)	7.51	(0.00)	7.91	(0.00)

Columns (1)–(4): 20 OECD countries; column (5): 15 European countries; all estimates contain country fixed effects; p -values in parentheses. Column (2): the Wald test that pre–post Okun coefficients are not statistically different from each other: 0.561 (0.454).

⁵In many countries, the share of temporary workers in employment has increased substantially in the past decades. This is related to reforms of employment protection legislation which are predominantly on the use of temporary contracts and not so much on the employment protection of regular workers (Boeri and Van Ours 2013). In Spain, for example, the share of temporary workers increased a lot when temporary workers were allowed to perform regular activities (Dolado, Garcia-Serrano, and Jimeno 2002). Faccini (2014) argues that temporary contracts became more popular as a screening device, whereas Segal and Sullivan (1997) indicate that the use of temporary workers offers firms a greater flexibility in case of volatile demand. It is this greater flexibility that we capture by including the share of temporary workers as a determinant of the Okun coefficient.

⁶We think that compared with non-temporary workers, a higher proportion of temporary workers are likely to move between employment and not in the labour force (or 'inactive') relative to the proportion who move between employment and unemployment. As a result, the effect of a change in the output gap (and thus the number of temporary workers employed) may impact more on the labour force participation rate than on the unemployment rate.

discussing Table 2 may be due to the omission of labour market institutions. (c) The sign of the coefficient on the interaction term implies that the larger is the share of temporary workers, the ‘larger’ (i.e. the more negative) is the impact of a change in the output gap on the unemployment gap.⁷ Since the share of temporary workers has been rising on average and across all age groups, this implies that the Okun coefficient, i.e. the impact of a change in the output gap on the unemployment gap, has likely been trending upwards (becoming more negative) over time. Note that similar conclusions were reached in an IMF study of Okun’s Law. ‘The responsiveness of unemployment to output has increased over the past 20 years in many countries. This reflects (*inter alia*) the greater use of temporary employment contracts’ (International Monetary Fund (2010), Ch 3, 1).

We turn now to the effect of labour market variables in explaining differences in the unemployment rate across countries and over time. The signs and significance of most of these variables are robust across the different specifications. The results given in column (1) in the lower part of Table 3 show that there is no significant relationship between the (equilibrium) unemployment rate and union coverage (defined as the proportion of workers covered by collective bargaining) but we find a significant and, as expected, positive relationship between the unemployment rate and union density (defined as the proportion of workers who are union members). Furthermore, wage coordination has a significant negative effect on unemployment while the UI replacement rate has a significant positive effect. EPL has no significant effect on unemployment. The tax wedge has a significant positive effect⁸ and terms of trade has a significant negative effect on unemployment. We removed union coverage and EPL from the analysis.⁹

As a check of robustness, we also estimated the model for different groups of countries. Column (5) of Table 3 shows the parameter estimates if we

restrict the sample to 15 European countries. Not reported are estimates for the 13 European Union countries and for the 10 Eurozone countries. The results are robust across these different combinations of European countries.

Equilibrium unemployment rates

Figure 3 plots the observed and our estimated equilibrium unemployment rates over the sample period 1985–2013. The equilibrium rates have been generated from Equation (4), where the relevant coefficients are those reported in the fourth column of Table 3.¹⁰

What is noteworthy about these figures is the different behaviour of the equilibrium rate over time. For some countries (Belgium, Finland, France, Portugal, Spain and Sweden), their equilibrium rates were roughly constant over the period as the labour market institutions hardly changed. For others (Austria, Japan, Norway and Switzerland), their equilibrium rates of unemployment were rising over the period, albeit at markedly different rates (compare Japan with Switzerland for example). While for a larger group of countries (Canada, Denmark, Germany, Ireland, Italy, the Netherlands, New Zealand, the United Kingdom and the United States) with improved labour market institutions, their equilibrium rates were falling over the period, albeit again at markedly different speeds (compare the United Kingdom with the Netherlands for example).

What is particularly interesting about this is that for the ten countries in our sample who are in the Eurozone (and thus have fixed exchange rates vis-à-vis each other) – namely Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal and Spain – five (Belgium, Finland, France, Portugal and Spain) experienced roughly constant equilibrium rates, one (Austria) experienced a rising equilibrium rate and four (Germany, Ireland, Italy and the Netherlands) experienced falling equilibrium rates.

⁷In order to allow for the possible effect of endogeneity in the share of temporary workers, we also estimated the model described in column (3) (our preferred model) using the lagged value of the temporary share variable as well as using the predicted temporary share variable (with lags of the other variables as instruments). The results are robust.

⁸Note that Lehmann et al. (2014) find that for a given overall level of labour income taxation, a more progressive tax schedule reduces the unemployment rate.

⁹To investigate the nature of the country fixed effects, we also used the Mundlak (1978) approach. The results confirm that time variation in equilibrium unemployment rates can be attributed to changes in labour market institutions, but that persistent cross-country differences cannot be explained solely by differences in labour market institutions.

¹⁰As noted above, the signs and size of the labour market coefficients do not vary markedly under different specifications of the model.

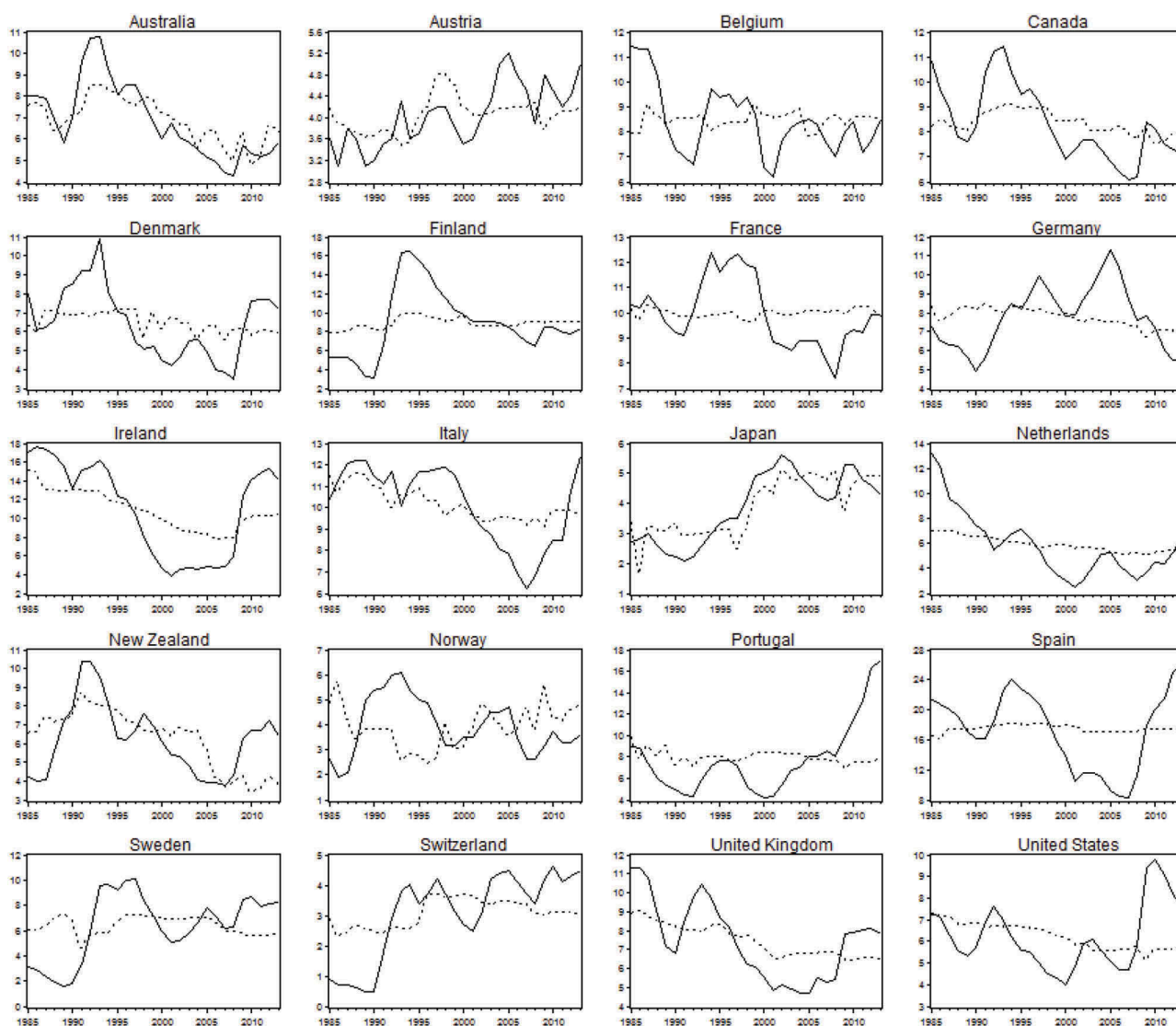


Figure 3. Actual unemployment rates and equilibrium unemployment rates; 1985–2013.

The solid lines are the actual unemployment rates and the dashed lines are the equilibrium unemployment rates computed using the estimates in column (4) of Table 3.

Given the model of unemployment used to generate the equilibrium rates of unemployment in this article, the explanation for the different trends in the equilibrium rate reflects different trends in labour market institutions. We make two observations here about the equilibrium rates of unemployment. To the extent, for example, that different trends in the equilibrium rate reflect different trends at the national levels in the amount of frictional unemployment – where frictional unemployment in this context is defined as a situation where the characteristics of an unemployed worker in one EU country are matched by the characteristics of a vacancy in that or another EU country – then

facilitating labour mobility would seem to be the desirable and effective policy response. To the extent that low mobility is a reflection of current labour market institutions, a change in the institutions in a way that would enhance mobility will lead to convergence in the equilibrium rates. Another example would be differences in the equilibrium rate resulting from differences in the UI replacement rate, differences which effectively ensures differences in the minimum reservation wage. Here, again a harmonisation of labour market institutions – and specifically in this case social protection objectives and policies – would lead to convergence in the equilibrium rates.

Sensitivity analysis

To explore the robustness of our findings, we performed additional sensitivity analyses. First, we added a common global factor into the Okun model. As discussed in more detail in Appendix B1, this hardly influences our parameter estimates. Second, we introduced product market regulation as an additional explanatory variable. Although product market regulation has a significant positive effect on unemployment rates, it has not been retained. This is because product market regulation and union density are highly correlated and it is not clear what product market regulation is picking up (see for details Appendix B2). Furthermore, because of the reunification of Germany, we estimated a model allowing for a shift in the German data at that time. This did not lead to any essential difference in our results. Finally, because changes in the collection of the European labour force survey might have introduced breaks in the unemployment series in 2003, data for 2003 were dropped from our sample period as a robustness check. This did not lead to any change in our main findings.

IV. Okun's relationship by age and gender

Unemployment rates by age and gender

There are large and persistent differences in the labour market characteristics of workers according to their age and gender. Table 4 provides an overview of country-specific averages of the unemployment rates by age and gender. Clearly, there are substantial differences both within and between countries. Youth unemployment rates are on average twice as high as unemployment rates among prime age workers, whereas unemployment rates among old men and women are on average the lowest. There are differences between unemployment rates of young men and young women but the dominant difference amongst the young is according to country, not gender. Whereas on average, youth unemployment rates in Austria, Germany, Japan and Switzerland are below 10%, they are above 25% for young men and women in Italy and Spain. There are also differences for prime age workers but they are substantially

Table 4. Country-specific unemployment rates by age and gender; average 1985–2013 (%).

	Women			Men		
	15–24	25–54	55–64	15–24	25–54	55–64
Australia	12.7	5.5	3.4	14.0	5.3	6.3
Austria	7.6	4.1	3.1	7.3	3.5	4.2
Belgium	21.7	9.6	5.0	17.5	5.9	4.1
Canada	12.3	7.1	6.5	15.6	7.3	7.1
Denmark	10.4	6.5	6.0	9.9	5.1	5.2
Finland	18.6	7.0	8.6	18.7	7.5	9.2
France	24.6	10.2	6.7	21.0	7.3	6.7
Germany	8.5	7.8	10.8	9.3	6.7	9.5
Ireland	16.5	9.2	5.7	20.5	10.5	6.9
Italy	34.9	11.0	3.3	25.9	5.7	3.6
Japan	6.5	3.6	2.6	7.7	3.1	5.1
Netherlands	10.4	6.2	3.8	9.6	4.3	3.6
New Zealand	13.0	4.9	3.1	13.8	4.8	3.9
Norway	9.7	2.9	1.3	10.4	3.3	1.9
Portugal	19.3	7.6	4.1	14.2	5.4	5.5
Spain	39.2	19.5	10.0	29.7	12.2	10.2
Sweden	15.2	4.8	4.1	16.5	5.3	5.3
Switzerland	6.5	4.0	2.7	6.7	2.7	3.0
United Kingdom	12.4	5.5	3.8	16.6	6.5	7.2
United States	11.7	5.1	3.7	13.6	5.1	4.3
Average	15.8	7.2	5.0	15.1	5.9	5.7

Note that the data for Austria refer to the period from 1994 onwards, for New Zealand from 1986 onwards and for Switzerland from 1991 onwards.

smaller in absolute terms. The lowest unemployment rates over the time period for prime age men and women are in Norway and Japan (below 4%). The highest unemployment rates for old men are in Spain with 10.2% and for old women in Germany with almost 11%, while the lowest rates for old men and women are in Norway (both less than 2%).

Figure 4 shows the evolution of unemployment rates over the period 1985–2013 averaged for the 20 countries and disaggregated by age and gender. The unemployment rates shown in panel a are very different depending on age. The unemployment rates of young individuals are by far the highest and they fluctuate much more than the unemployment rates of prime age and old individuals. Conditional on age, the differences between men and women are small.

Modified Okun relationship

It is well known and has been illustrated in the previous subsection that unemployment rates of young workers are on average higher and more volatile than unemployment rates of prime age and old workers (Bell and Blanchflower 2011). There are

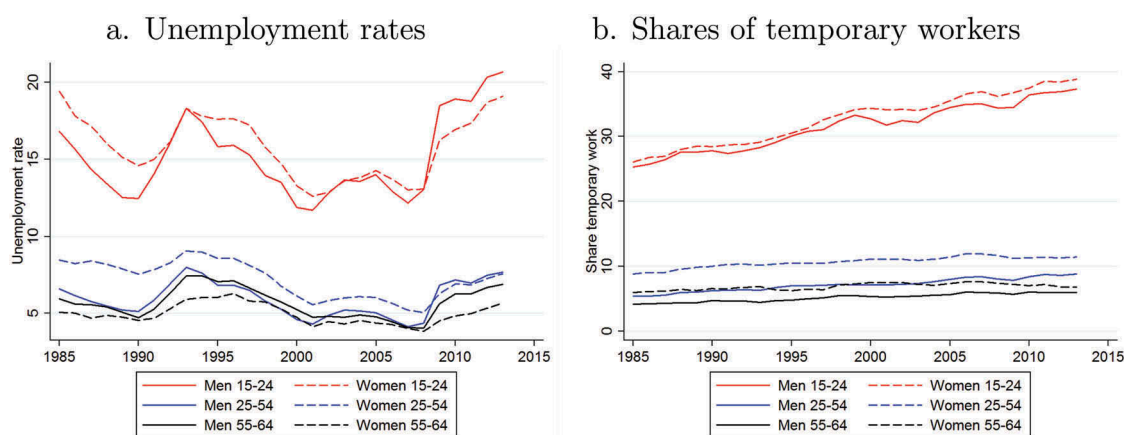


Figure 4. Unemployment rates and shares of temporary workers by age and gender – averaged over 20 countries; 1985–2013. (a) Unemployment rates. (b) Shares of temporary workers.

various reasons why Okun's relationship may be age-specific.¹¹ Compared to older workers, young workers have less company-specific skills and less dismissal protection (Dunsch 2015; O'Higgins 1997). Furthermore, to the extent that age is related to experience, Becker (1964) argues that the amount of specific training affects the incentives of firms and workers to separate – an idea developed by Cairo and Cajner (2014). Since the labour market position of females is different from the labour market position of males, it is likely that Okun's relationship is both age and gender-specific.

We begin by modifying our baseline model (2) to allow estimation of the unemployment rates by age and gender for six groups:

$$u_{ikt} = \alpha_{ik} - \Phi_k(y_{it} - y_{it}^*) + \varepsilon_{ikt} \quad (5)$$

where k represents three age groups (15–24, 25–54, 55–64) for both males and females ($k = 1, \dots, 6$). We assume that the equilibrium rates not only differ across countries, they also differ across age groups.

Parameter estimates

The parameter estimates of Equation (5) are presented in Table 5. There are clear differences in the Okun relationship by age and gender. To start with, the effect of the GDP-gap on the unemployment rate decreases with age. Whereas the Okun coefficient

has a value of 1.14 for young males, it has a value of 0.56 for prime age males and a value of 0.45 for old males. A similar pattern though at smaller magnitudes is present for females. When output changes, the effect on unemployment rates is more than twice as large for young workers than it is for older workers. This explains Figure 4 which shows that, while fluctuations in unemployment rates are highly correlated across age and gender, they are substantially larger for young workers.

Figure 5 shows the cross-country relationship between the estimated equilibrium unemployment rates for young and prime age workers, separately for males and females. Panel a shows the relationship for males. There is across countries a strong correlation between the unemployment rates of young and prime age males. The ratio of the two unemployment rates is about 2.5. Clear outliers are Italy with a relatively high male youth unemployment rate and Germany with a relative low male youth unemployment rate. Panel b shows the same relationship for females. In many countries, the female equilibrium unemployment rates are substantially higher for both prime age and young females. Across countries, Italy and Germany are likewise outliers, as for males.

Finally, we allow labour institutions to affect the separate Okun relationships by age and gender (thereby allowing the equilibrium rates and the effect

¹¹There are three studies that have investigated age-specific versions of the difference form of Okun's law. Hutengs and Stadtmann (2013) estimated Okun's relationship over the period 1984–2011 for 11 Eurozone countries and 5 age groups. Zanin (2014) studied 5 age cohorts by gender for 33 OECD countries over the period 1998–2012. Hutengs and Stadtmann (2014) estimated Okun's relationship for five Scandinavian countries and five age groups over the period 1984–2011. All studies found that the change in unemployment is more sensitive to economic growth for young workers than for prime age and older workers.

Table 5. Okun's relationship by age and gender; 1985–2013.

	15–24		25–54		55–64							
	Males	Females	Males	Females	Males	Females						
GDP-gap u^*	1.14	(0.00)	0.76	(0.00)	0.56	(0.00)	0.36	(0.00)	0.45	(0.00)	0.26	(0.00)
Australia	13.97	(0.00)	12.74	(0.00)	5.28	(0.00)	5.47	(0.00)	6.29	(0.00)	3.41	(0.00)
Austria	7.18	(0.00)	7.52	(0.00)	3.46	(0.00)	4.03	(0.00)	4.19	(0.00)	3.04	(0.00)
Belgium	17.48	(0.00)	21.68	(0.00)	5.93	(0.00)	9.56	(0.00)	4.11	(0.00)	4.96	(0.00)
Canada	15.61	(0.00)	12.26	(0.00)	7.26	(0.00)	7.08	(0.00)	7.13	(0.00)	6.48	(0.00)
Denmark	9.90	(0.00)	10.37	(0.00)	5.12	(0.00)	6.46	(0.00)	5.21	(0.00)	6.03	(0.00)
Finland	18.66	(0.00)	18.56	(0.00)	7.50	(0.00)	6.97	(0.00)	9.23	(0.00)	8.61	(0.00)
France	20.99	(0.00)	24.59	(0.00)	7.29	(0.00)	10.18	(0.00)	6.67	(0.00)	6.71	(0.00)
Germany	9.35	(0.00)	8.53	(0.00)	6.70	(0.00)	7.81	(0.00)	9.52	(0.00)	10.80	(0.00)
Ireland	20.49	(0.00)	16.48	(0.00)	10.48	(0.00)	9.22	(0.00)	6.94	(0.00)	5.66	(0.00)
Italy	25.89	(0.00)	34.86	(0.00)	5.71	(0.00)	11.05	(0.00)	3.55	(0.00)	3.35	(0.00)
Japan	7.70	(0.00)	6.48	(0.00)	3.13	(0.00)	3.57	(0.00)	5.06	(0.00)	2.56	(0.00)
Netherlands	9.65	(0.00)	10.35	(0.00)	4.33	(0.00)	6.19	(0.00)	3.58	(0.00)	3.83	(0.00)
New Zealand	13.79	(0.00)	12.96	(0.00)	4.74	(0.00)	4.90	(0.00)	3.92	(0.00)	3.09	(0.00)
Norway	10.37	(0.00)	9.66	(0.00)	3.27	(0.00)	2.91	(0.00)	1.94	(0.00)	1.29	(0.00)
Portugal	14.18	(0.00)	19.29	(0.00)	5.41	(0.00)	7.65	(0.00)	5.51	(0.00)	4.13	(0.00)
Spain	29.66	(0.00)	39.21	(0.00)	12.16	(0.00)	19.53	(0.00)	10.19	(0.00)	10.03	(0.00)
Sweden	16.54	(0.00)	15.15	(0.00)	5.27	(0.00)	4.77	(0.00)	5.35	(0.00)	4.14	(0.00)
Switzerland	6.57	(0.00)	6.38	(0.00)	2.64	(0.00)	3.93	(0.00)	2.92	(0.00)	2.67	(0.00)
United Kingdom	16.58	(0.00)	12.43	(0.00)	6.48	(0.00)	5.53	(0.00)	7.20	(0.00)	3.77	(0.00)
United States	13.58	(0.00)	11.70	(0.00)	5.12	(0.00)	5.07	(0.00)	4.29	(0.00)	3.71	(0.00)

p -values in parentheses.

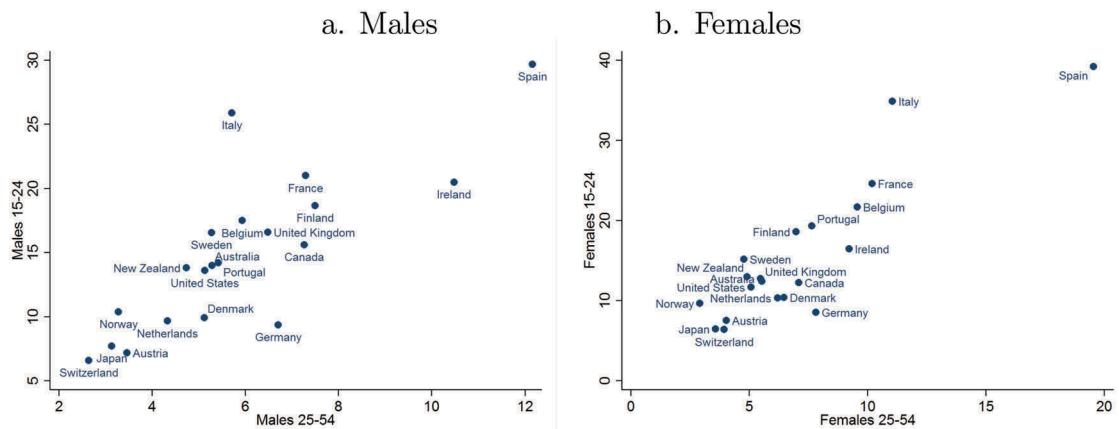


Figure 5. Equilibrium unemployment rates by country and age and by gender; 1985–2013. (a) Males. (b) Females. Based on parameter estimates from Table 5.

of the output gap on the unemployment rate to be time-varying); for $k = 1, \dots, 6$

$$u_{ikt} = (\alpha_{ik} + \beta_k z_{it}) - (\Phi_0 + \Phi_k q_{ikt})(y_{it} - y_{it}^*) + \varepsilon_{ikt} \quad (6)$$

where z represents labour market institutions, q is the share of temporary workers and k represents 3 age groups (15–24, 25–54, 55–64) for both males and females. As shown in panel b of Figure 4, the share of temporary workers is substantially higher among young workers and also increasing much faster than among prime age and older workers. The increase in the share of temporary workers over the sample

period is on average about 10 percentage-point higher from 25% to 35%.

Table 6 shows the relevant parameter estimates of Equation (6). Clearly, the estimated gap-coefficients are not very different from those in Table 5. The share of temporary workers has a significant effect on the gap-coefficient except for older workers. This may be due to the low share of old temporary workers as well as with the relative stability of that share. The parameter estimate for the interaction term between the output gap and their share of temporary workers is smaller for young workers but one has to take into account the fact that the share of temporary workers is

Table 6. Parameter estimates, effect institutions by age and gender.

	Males						Females					
	15–24		25–54		55–64		15–24		25–54		55–64	
GDP-gap	1.05	(0.00)	0.52	(0.00)	0.45	(0.00)	0.70	(0.00)	0.29	(0.00)	0.23	(0.00)
GDP-gap*share temp	0.03	(0.00)	0.07	(0.00)	0.03	(0.28)	0.02	(0.03)	0.05	(0.03)	−0.01	(0.52)
Union density	−0.04	(0.14)	0.04	(0.00)	0.05	(0.00)	0.01	(0.83)	0.08	(0.00)	0.04	(0.00)
Wage coordination	−0.91	(0.00)	−0.45	(0.00)	−0.38	(0.00)	−0.83	(0.00)	−0.52	(0.00)	−0.30	(0.00)
UI replacement rate	0.03	(0.29)	0.09	(0.00)	0.06	(0.00)	−0.04	(0.14)	0.03	(0.03)	0.05	(0.00)
Tax wedge	0.05	(0.25)	0.09	(0.00)	0.03	(0.08)	0.12	(0.00)	0.15	(0.00)	0.07	(0.00)
Terms of trade	−0.10	(0.00)	−0.07	(0.00)	−0.05	(0.00)	−0.05	(0.02)	−0.03	(0.00)	−0.03	(0.00)
Constant	15.07	(0.00)	5.92	(0.00)	5.69	(0.00)	15.77	(0.00)	7.19	(0.00)	4.96	(0.00)

All estimates contain country fixed effects; *p*-values in parentheses.

much higher and increasing. Finally, the magnitude of the effects of labour market institutions on the unemployment rates is age and gender specific. In particular, a high level of wage coordination seems to be mostly beneficial for young workers. A possible explanation is that a high level of wage coordination more strongly internalizes the unemployment effects of wage negotiations, especially youngsters suffer high unemployment rates. Therefore, they may be more affected by a high level of wage negotiations, i.e. for them, the dampening effect on unemployment rates is strongest. Nevertheless, the overall results are not very different from those presented in Table 3.

As a final sensitivity analysis we included in the estimates for old workers, the average age of retirement. While the variable is significantly different from zero, the other parameter estimates were hardly affected (see Appendix B3 for details).

V. Conclusions

Okun's empirical relationship has been shown repeatedly, in a large number of studies to be an enduring stylised fact. In this article, we revisit the Okun relationship using a hybrid specification, namely we relate the unemployment rate, on the one hand, to the (determinants of the) equilibrium unemployment rate and the output gap, on the other.

The computation of the output gap follows standard practice in the literature, namely the output gap is the difference between the actual (log) GDP less the trend (log) output (estimated using the Hodrick–Prescott filter). However, we augment the estimating equation to allow labour market institutional factors to affect the equilibrium rate of unemployment and moreover, we also allow the share of temporary

workers to affect the relationship between the output gap and the unemployment rate. These features improved the analysis first, because the introduction of institutional labour factors which changed over time allowed the derivation of time-varying equilibrium unemployment rates and second, the introduction of a term to capture flexibility in the labour market (the share of temporary workers) was particularly important as it captured effectively changes in the Okun coefficient over time and allows us to avoid the need to arbitrarily impose different coefficients pre- and post-the Great Recession. Introducing an interaction between the share of temporary workers and the output gap is also relevant from an economic point of view. Labour markets have become more flexible in the past decades and especially among young workers, the share of temporary workers is not only high but also increasing fast. In terms of the Okun relationship, this means that the unemployment effects of shocks to output have increased over time.

The empirical analysis was conducted using a panel dataset covering 20 OECD countries over the sample period 1985–2013. Although the observations were diverse over space and time, they are all indicative of economic behaviour in advanced economies linked by significant trade and financial flows. The study focused on drawing broad inferences, but we have also drawn attention to country-specific differences. We find that the equilibrium unemployment rate is (as expected) positively related to union density, the replacement rate and the tax wedge and is (again as expected) negatively related to the level of the wage coordination and the terms of trade.

Finally, since the unemployment rates for younger workers (aged between 15 and 24 years) were considerably higher than unemployment rates of both prime age

and older workers, we also estimated Okun's relationship using unemployment rates disaggregated by age and gender. The results provide statistically significant empirical evidence that the effect of changes in the output gap on the unemployment rate decreases with age. In particular, that a positive change in the output gap is likely to result in a greater reduction in unemployment among younger job-seekers compared to the other age groups. From a policy perspective, it follows that an increase in economic growth (to close the output gap) will not only have the desired outcome of reducing the unemployment rate but it will also have the distributional effect of lowering youth unemployment.

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No potential conflict of interest was reported by the authors.

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Appendix A. Details on data

- (1) Unemployment and employment data: Unemployment national averages for 20 countries. Sources: (1) 1985–2003: Bassanini and Duval (2006), (2) 2004–2013: OECD labour force statistics. Unemployment rates and employment rates by gender and age. Source: OECD labour force statistics.
- (2) GDP. Source: World Bank.

- (3) Unions and wage bargaining: Visser (2011) published a database for the period 1960–2010 on institutional characteristics of trade unions, wage setting, state intervention and social pacts. In case of missing observations in recent years, numbers are assumed to be constant from the last available year onwards. From this database, the following series are used: (1) Union density: union membership as a percentage of wage and salary earners in employment. (2) Union coverage:

employees in workplaces covered by unions or works councils as a percentage of all wage and salary earners in employment, adjusted for the possibility that some sectors or occupations are excluded from the right to bargain. (3) Coordination of wage bargaining: discrete values ranging from 5 (economy-wide bargaining) to 1 (fragmented bargaining, mostly at company level).

- (4) UI replacement rate: unemployment insurance and unemployment assistance benefits as a percentage of the Average Production Worker wage; this OECD summary measure is defined as the average of the gross unemployment benefit replacement rates for two earnings levels, three family situations and three durations of unemployment. Series 1985–2005 available for odd years – even years are calculated as average of adjacent odd years; from 2006 onwards, unemployment insurance and unemployment assistance benefits as a percentage of the Average Worker wage; the jump in series from 2005 to 2006 has been accounted for by the authors. Source: OECD statistics.
- (5) Tax wedge: One-earner married couple at 100% of average earnings with two children expressed as a percentage of labour costs. Source: OECD Taxing Wages – Comparative tables, Average Tax Wedge (%).
- (6) Employment protection legislation; scale 0–6, low–high. Series available from 1985. Source: OECD (2013).
- (7) Average retirement age: OECD average effective age of retirement calculated as a weighted average of (net) withdrawals from the labour market at different ages over a 5-year period for workers initially aged 40 and over. Source: OECD labour force statistics.
- (8) Terms of trade: Calculated as the ratio of the Deflators for Exports and Imports. Source: OECD Economic Outlook – Country Tables Annual Data, Deflators and CPI.
- (9) Share of temporary workers, average and by gender and age. Source: OECD labour force statistics.
- (10) Product market regulation: Summary indicator of regulatory impediments to product market competition in seven non-manufacturing industries. Source: OECD Regulatory Base.

Table A1 provides information about averages of unemployment rates (%) and annual GDP-growth rates (%) over the period 1985–2013. Averaged over the 20 countries, the unemployment rate was 7.5% and the annual GDP-growth rate was 2.3%.

Table A2 presents correlations between labour market institutions. To remove cross-sectional correlation, all series are transformed to differences from country-averages. Clearly, the correlations between union coverage and union density, between product market regulation and union density and between product market regulation and employment protection legislation are quite high.

Table A1. Unemployment and GDP growth; averages 1985–2013.

	<i>u</i>	Growth		<i>u</i>	Growth
Australia	6.9	3.4	Japan	3.9	1.8
Austria	4.0	2.2	Netherlands	5.9	2.2
Belgium	8.5	1.9	New Zealand	6.2	2.4
Canada	8.3	2.5	Norway	3.9	2.4
Denmark	6.5	1.5	Portugal	7.7	2.1
Finland	9.0	2.1	Spain	17.3	2.4
France	9.9	1.8	Sweden	6.4	2.2
Germany	7.7	1.8	Switzerland	3.1	1.8
Ireland	11.1	4.4	United Kingdom	7.5	2.4
Italy	10.1	1.2	United States	6.2	2.7

Note that by construction, the average output-gap is 0 for every country.

Table A2. Correlations between labour market institutions 1985–2013.

	1.	2.	3.	4.	5.	6.	7.	8.
1. Union coverage	–							
2. Union density	0.73	–						
3. Wage coordination	0.31	0.29	–					
4. UI replacement rate	0.05	–0.10	0.08	–				
5. Tax wedge	0.46	0.45	–0.06	–0.16	–			
6. Terms of trade	–0.01	0.02	–0.03	–0.04	0.00	–		
7. EPL	0.02	0.21	–0.02	–0.38	0.11	0.15	–	
8. PMR	0.39	0.67	0.14	–0.23	0.33	0.11	0.63	–

Appendix B. Sensitivity analysis

B1: Adding a common factor

As a further check on the robustness of our results, we also introduced an additional common factor into the Okun model:

$$u_{it} = \alpha_i + \beta x_{it} + \phi(y_{it} - y_{it}^*) + \kappa F_t + e_{it} \quad (7)$$

with κ as additional parameter and $F_t = F_{t-1} + v_t$. That is the equilibrium unemployment rates are driven by labour market institutions and a common (global) latent variable. Preliminary factor analysis using a principle components approach showed that the first principle component accounts for around 40% of the variation of unemployment rate in the panel and it needs at least five factors to account for about 90% of the variations. The results with a common factor are shown **Table B1**. This table compares the parameter estimates of our baseline model where column (1) replicates column (4) of **Table 3** while column (2) present the parameter estimates of the common factor approach.

From a comparison of the parameter estimates in both columns, it is clear that some of the parameter estimates are affected but with the exception of union density the parameter estimates are not quantitatively different from each other. It would seem that the common factor is mainly picking up the effect of union density. Since our aim is to be explicit about labour market institutions, we have opted to concentrate on the model with the union density variable rather than the one with the common (global) factor.

Table B1. Adding a common factor.

	Baseline		Common factor	
GDP-gap	0.47	(0.00)	0.41	(0.00)
GDP-gap*share temp	0.05	(0.00)	0.03	(0.00)
Union density	0.06	(0.00)	0.01	(0.36)
Wage coordination	-0.65	(0.00)	-0.70	(0.00)
UI Replacement rate	0.04	(0.01)	0.06	(0.04)
Tax wedge	0.14	(0.00)	0.14	(0.00)
Terms of trade	-0.06	(0.00)	-0.06	(0.01)
Common factor			0.46	(0.00)
Constant	7.51	(0.00)	7.51	(0.00)

p-values in parentheses.

B2: Product market regulation

By way of sensitivity analysis, we introduced an indicator for product market regulations as additional explanatory variable (see also Appendix A). The results are shown in Table B2.

Product market regulations have a significant positive effect on the unemployment rate. However, now union density becomes insignificant. If we remove union density, the effect of product market regulations remains significantly positive. As shown in Table A2, product market regulation and union density are highly correlated. This correlation could arise because in many countries over time, PMR has been reduced at the same time as union density also dropped. For illustrative purposes, Table B3 shows estimates of the Okun relationship by age and gender when we remove union density as explanatory variable and introduce PMR instead.

Table B2. Introducing product market regulations.

Variable	(1)		(2)	
GDP-gap	0.48	(0.00)	0.48	(0.00)
Union density	0.00	(0.95)		
Wage coordination	-0.63	(0.00)	-0.63	(0.00)
UI replacement rate	0.06	(0.00)	0.05	(0.00)
Tax wedge	0.14	(0.00)	0.14	(0.00)
Terms of trade	-0.07	(0.00)	-0.07	(0.00)
PMR	0.36	(0.00)	0.36	(0.00)
Constant	7.50	(0.00)	7.50	(0.00)

p-values in parentheses.

Now, we find that that PMR has significant negative effects on the unemployment rate of young and prime age men. This is an odd result. Since these groups make up such a large proportion of the total labour force, the finding that PMR has significant negative effects on the unemployment rate of young and prime age men strengthens the case against including PMR in the 'aggregate model'. We think that the effect of PMR is actually picking up the effect of union density going down.

B3: Retirement ages

As a final sensitivity analysis, we include the average age of retirement in the Okun relationship for older workers. We do not have the average age of retirement in the main model because this variable is potentially endogenous. After all, it could be that retirement age is reduced to reduce unemployment rates of old workers. The parameter estimates shown in Table B4 indicate that the average retirement age has a significant positive effect on the unemployment rate of older workers. This would imply that an increase in retirement age increases unemployment rates of old workers. Leaving aside the endogeneity issue, this suggests that an increase in retirement age stops some workers to make a transition to out of the labour force. Instead, these workers become unemployed. However, the other parameter estimates are hardly affected by the inclusion of this variable.

Table B4. Additional estimates workers aged 55–64.

	Males		Females	
GDP-gap	0.46	(0.00)	0.25	(0.00)
GDP-gap*share temp	0.02	(0.36)	-0.02	(0.38)
Union density	0.05	(0.00)	0.04	(0.00)
Wage coordination	-0.41	(0.00)	-0.31	(0.00)
UI Replacement rate	0.08	(0.00)	0.06	(0.00)
Tax wedge	0.05	(0.00)	0.08	(0.00)
Terms of trade	-0.05	(0.00)	-0.03	(0.00)
Retirement age	0.17	(0.05)	0.10	(0.04)
Constant	5.70	(0.00)	4.96	(0.00)

p-values in parentheses.

Table B3. Estimates by age and gender with PMR.

	Males						Females					
	15–24		25–54		55–64		15–24		25–54		55–64	
GDP-gap	1.07	(0.00)	0.52	(0.00)	0.46	(0.00)	0.70	(0.00)	0.30	(0.00)	0.24	(0.00)
GDP-gap*share temp	0.03	(0.00)	0.07	(0.00)	0.03	(0.19)	0.02	(0.02)	0.06	(0.00)	-0.01	(0.48)
Wage coordination	-0.65	(0.00)	-0.22	(0.01)	-0.25	(0.01)	-0.87	(0.00)	-0.57	(0.00)	-0.18	(0.01)
UI Replacement rate	-0.01	(0.84)	0.07	(0.00)	0.06	(0.01)	-0.03	(0.25)	0.07	(0.01)	0.05	(0.01)
Tax wedge	0.07	(0.12)	0.12	(0.00)	0.05	(0.01)	0.11	(0.01)	0.14	(0.00)	0.08	(0.01)
Terms of trade	-0.10	(0.00)	-0.07	(0.02)	-0.05	(0.00)	-0.05	(0.02)	-0.04	(0.00)	-0.03	(0.00)
PMR	-0.71	(0.00)	-0.11	(0.04)	0.07	(0.05)	0.22	(0.07)	0.63	(0.00)	0.08	(0.05)
Constant	15.06	(0.00)	5.91	(0.00)	5.68	(0.00)	15.78	(0.00)	7.20	(0.00)	4.96	(0.00)

p-values in parentheses.