FACULTEIT ECONOMIE
EN BEDRIJFSKUNDE

TWEEKERKENSTRAAT 2
B-9000 GENT
Tel. : 32 - (0)9 – 264.34.61
Fax. : 32 - (0)9 – 264.35.92

WORKING PAPER

Labour Taxes and Unemployment
Evidence from a Panel Unobserved Component Model

Tino Berger

Gerdie Everaert

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Tino Berger[†] Gerdie Everaert[‡]

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Abstract

This paper estimates the impact of labour taxes on unemployment using a panel of yearly observations (1970-2001) for 16 OECD countries. Possible heterogeneity of the unemployment incidence of taxes is taken into account by grouping countries according to their wage-setting institutions. Panel data unit root and cointegration tests show that unemployment and labour tax rates are non-stationary but not cointegrated. As this finding may be induced by missing non-stationary variables we set up a panel unobserved component model. Labour taxes are found to have a positive impact on unemployment only in countries characterised by strong but decentralised unions.

1 Introduction

After a sharp increase from the mid 1970s onwards, the unemployment rate has fluctuated around a persistent high level ever since the mid 1980s in many OECD countries. The dominant view nowadays is that the increase in unemployment is driven by institutional changes and their interaction with macroeconomic shocks (see e.g. Nickell et al., 2005; Blanchard and Wolfers, 2000; Blanchard, 2006). One institutional factor that gained particular attention is labour taxes. The effective tax rate on employed labour in the EU15 (i.e. the 15 member countries of the European Union since 1995), calculated as the ratio of social security contributions and personal income taxes to total gross wages, has increased from 28.6% in 1970 to a maximum of 40.1% in 1996

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[†]SHERPPA, Ghent University, Tino.Berger@UGent.be, www.sherppa.be

[‡]SHERPPA, Ghent University, Gerdie.Everaert@UGent.be, www.sherppa.be

(Martinez-Mongay, 2000, table BI.6.). As the EU15 unemployment rate rose sharply over more or less the same period[1], it is a widespread belief, especially among policy makers, that the increase in labour taxes is one of the prime factors responsible for the increase in unemployment. Not surprisingly, the alleviation of the high tax burden on labour has been declared to be one of the prime instruments to fight high unemployment.

The question whether cutting labour taxes is the answer to Europe's unemployment problem has also been at the forefront of academic discussion. Yet, extensive empirical research has not succeeded in providing robust evidence confirming the alleged positive relation between taxes and unemployment. Surveying the literature, the estimated elasticity of unemployment with respect to taxes ranges from zero (Bean et al., 1986; Layard et al., 2005; Nickell, 1997; Blanchard and Wolfers, 2000) over medium-sized (Elmeskov et al., 1998; Nickell and Layard, 1999; Nickell et al., 2005; Planas et al., 2007) up to large (Daveri and Tabellini, 2000). In our opinion, the reason for these conflicting results is threefold. First, standard labour market theory suggests that the impact of taxes on unemployment depends on labour market institutions. Cross-country variation in these institutions implies cross-country variation in the unemployment incidence of taxes. Daveri and Tabellini (2000) indeed find the largest tax incidence for countries with labour market institutions which are identified as being unfavourable. Second, the major part of the recent literature estimates tax elasticities using panel data. As both unemployment and labour taxes are potentially non-stationary, the observed strong long-run correlation may be an artefact of the fact that these series exhibit a similar, but independent, upward trend. Although the possibility of a spurious regressions problem is acknowledged in the literature, most studies do not formally test for cointegration. One exception is Berger and Everaert (2006) who show that unemployment rates do not cointegrate with labour market institutions in the panel of OECD countries studied by Nickell et al. (2005). Third, as emphasised by Daveri (2003), the empirical results in the literature potentially suffer from an important missing variables problem. This problem arises because theory suggests a variety of variables affecting structural unemployment but some of them are difficult to measure or even unobservable, e.g. the reservation wage which is a function of, among others, the value of leisure. If these omitted variables are correlated with the tax rate, their explanatory power gets misattributed to those explanatory variables that are included in the model. Even more

[1]The EU15 average correlation coefficient between the effective tax rate on employed labour and the unemployment rate equals 0.94 over the period 1970-1998.

problematic, one obtains spurious regression results if the omitted variables are non-stationary. The finding in Berger and Everaert (2006), for instance, that unemployment does not cointegrate with a large set of labour market institutions might be caused by omitted non-stationary variables and, as such, does not imply that there is no long-run relation between unemployment and labour market institutions. To the best of our knowledge, Planas et al. (2007) is the only empirical paper on this subject to account for the missing variables problem. They estimate the impact of labour taxes on unemployment within an unobserved component (UC) model in which omitted variables are identified through the Kalman filter. Using euro area aggregate yearly data over the period 1970-2004, the unemployment tax elasticity is found to be 0.30 but is not significantly different from zero at the 5% level. A possible reason for the large standard error of the estimate is the use of euro area aggregates which (i) ignores possible heterogeneity of the unemployment incidence of taxes over countries and (ii) implies that only 35 observations are available.

This paper estimates the impact of labour taxes on unemployment using a panel of yearly observations over the period 1970-2001 for 16 OECD countries. Panel data unit root and cointegration tests show that unemployment and labour tax rates are non-stationary but not cointegrated. As this finding may be induced by missing non-stationary variables we set up a panel UC model similar to Planas et al. (2007). The main difference is that instead of aggregating the data we add a cross-sectional dimension by pooling countries. Our dataset is also richer in terms of the number of countries and labour market characteristics of the countries included, i.e. in addition to the countries in the euro area (except Luxemburg) it also includes Denmark, Sweden, Japan, the UK and the US. In line with Daveri and Tabellini (2000) possible heterogeneity of the unemployment incidence of taxes is taken into account by grouping countries according to their wage-setting institutions. The increased information set due to the panel dimension and the heterogeneity by grouping leads to a more precise estimate. Labour taxes are found to have a significant positive impact on unemployment in countries characterised by strong but decentralised unions. In countries with competitive labour markets or with a high degree of centralisation in wage bargaining, the impact of labour taxes is insignificant.

The plan of the paper is as follows. In Section 2 we briefly review the literature on the relation between labour taxes and unemployment and present our empirical specification. Section 3 presents panel data unit root and cointegration tests. Section 4 introduces taxes and unemployment in a panel UC model and presents the results. Section 5 concludes.

2 Labour taxes and labour market performance

2.1 Labour taxes in standard wage bargaining models

Taxation affects the labour market through its impact on both labour demand and supply. On the demand side, the employment incidence of an increase in labour taxes depends on the proportion of the tax burden that is borne by the employer. This shifting forward onto the employer's labour costs reflects the degree to which employees can successfully oppose a reduction in their consumption wage induced by a tax increase. Standard bargaining models suggest a large variety of factors that determine the degree of tax shifting and consequently the employment incidence of taxes (see e.g. Layard et al., 2005). A crucial determinant is the tax treatment of alternative income sources for workers, e.g. unemployment benefits (Pissarides, 1998; Nickell and Layard, 1999; Daveri and Tabellini, 2000). These alternative income sources represent the fall-back position of workers. If these are indexed to the net wage, the fall-back position, and consequently the bargaining strength of the union, deteriorates proportional to the tax increase. In this case, the burden of the tax is borne entirely by the employees in terms of lower consumption wages. As labour taxes do not affect labour costs they induce no employment incidence (this is referred to as labour tax neutrality). Unions may only effectively resist a long-run fall in net wages if alternative income sources are not equally affected by the increase in taxes. In this case, labour taxes have a negative effect on employment as they drive a wedge between labour income and alternative income. The extent of this negative effect depends on (i) the amount of product market competition, (ii) the amount of labour market competition, and (iii) the degree of centralisation or co-ordination of the wage bargaining system. First, the stronger the competition on the product market, i.e. the more elastic labour demand, the less the employer is willing/able to accept higher product wages and therefore the less scope for forward shifting of labour taxes. Second, the degree of tax shifting is negatively related to the amount of labour market competition. Low competition on the labour market, i.e. the wage-setting schedule is flatter or more elastic, corresponds to unions being more concerned with preserving wages and less concerned with employment. This implies a higher proportion of taxes being shifted forward to labour costs. Excessive labour market regulations (e.g. extensive employment protection and high minimum wages), a high union bargaining power and insider-behaviour of employed workers all hinder the competition on the labour market and therefore increase the employment incidence of taxes. Third, the degree of centralisation of wage bargaining and/or the degree of co-ordination by firms and employers across firms may also be a crucial factor explaining the amount of tax-shifting. Calmfors and Driffill (1988) have argued that in both highly centralised/co-ordinated wage bargaining systems and in fully decentralised/competitive systems, unions are likely to take a more moderate stand in response to adverse shocks, e.g. a tax increase, hitting the economy. In addition to the employment incidence of labour taxes, unemployment is also affected by the impact of labour taxes on the supply of labour. Higher taxes may (i) reduce labour supply as the opportunity costs of leisure decline (substitution effect) and (ii) increase labour supply as the disposable income of households declines (income effect). Theory is generally inconclusive in determining which effect dominates.

Taking stock, theory suggests ample reasons for why there may not be a clear-cut relation between labour taxes and unemployment. This inability of theory to provide an unconditional answer implies that the analysis of the unemployment incidence of labour taxes is essentially an empirical matter.

2.2 Empirical specification

Let the equilibrium rate of unemployment, u_{it}^{*} be given by

$$u_{it}^{*} = \gamma\tau_{it} + u_{it}^{NR}, \qquad i = 1, \ldots, N, \qquad t = 1, \ldots, T, \tag{1}$$

where N is the number of countries, T is the number of time series observations, τ_{it} is the labour tax rate and u_{it}^{NR} is a factor that captures all other shifters of labour supply (e.g. the benefit replacement rate, benefit duration, ...) and labour demand (e.g. productivity growth, employment protection, ...). Letting u_{it}^{C} denote short-run fluctuations around the equilibrium rate, actual unemployment u_{it} can be written as

$$u_{it} = \gamma\tau_{it} + u_{it}^{NR} + u_{it}^{C}. \tag{2}$$

This empirical specification is standard in the literature (see e.g. Nickell et al., 2005; Daveri and Tabellini, 2000; Planas et al., 2007). The goal of this paper is to estimate γ, which measures the impact of labour taxes on unemployment. As a robustness check, we will also estimate the relation between labour taxes and employment. In section 3 we first look at the time series properties of u_{it} and τ_{it}, i.e. we check for unit roots and cointegration. At this stage, variables affecting u_{it}^{NR} and u_{it}^{C} are ignored. The main reason is that especially u_{it}^{NR} is hard to capture, i.e. there are many labour market institutions which potentially affect unemployment, most of them being difficult to measure. In section 4 we will therefore treat u_{it}^{NR} and u_{it}^{C} as being unobserved but include them in the analysis using an UC model. As a robustness check, we will add data on six observed labour market institutions which potentially are part of u_{it}^{NR}.

2.3 Data and country grouping

Our dataset consists of yearly observations for 16 OECD countries over the period 1970-2001. The unemployment rate is taken from the OECD Economic Outlook. As a measure of labour taxes we use the effective tax rates on employed labour from Martinez-Mongay (2000). This tax rate has been calculated with the so-called Mendoza-Razin-Tezar approach (see Mendoza et al., 1994) using the EU AMECO database. It is defined as the ratio of labour tax revenue, including social contributions, to the taxable base. Tax indicators based on this approach have been used in the vast majority of empirical studies on the relation between unemployment and taxes (e.g. Planas et al., 2007; Daveri and Tabellini, 2000). However, as effective tax revenues are directly linked to macro-economic variables, like the unemployment rate, there is a potential endogeneity problem. In response to increasing unemployment, for instance, governments may raise labour taxes in order to finance higher unemployment benefits outlays. Therefore, we check the robustness of our results by using the tax wedge taken from the OECD Taxing Wages database as an alternative measure for labour taxes. It is defined as the difference between labour costs to the employer and the after-tax pay of the employee relative to the employer's labour costs. The main advantage is that its calculation is based on micro-simulation of national tax legislation. This is done for two socio-economic groups: (i) a single person without children and (ii) a one-earner married couple with two children. The period for which these data are available ranges from 1979 to 2004. Furthermore, from 1979 until 1990 there is only one observation every two years. For this period we (linearly) interpolate the data. Still by starting in 1979 only we miss the period in which unemployment started increasing sharply in many OECD countries. Therefore we base our analysis on the effective tax rate but use the tax wedge as a robustness check.

The standard wage bargaining models outlined above suggest that the unemployment incidence of labour taxes depends on prevailing wage-setting institutions, i.e. γ is potentially heterogeneous over countries. Instead of estimating a fully heterogeneous panel, we pool countries with similar wage-setting institutions. Following Daveri and Tabellini (2000) and Domenech and Garcia (2007), and using the same notation, we classify countries in three different groups. The first group (NORDIC) includes Austria, Denmark, Finland and Sweden. These countries are characterised by strong unions, wage bargaining at a central level and/or a high degree of co-ordination. The unemployment incidence of labour taxes is expected to be moderate in these countries. The second group (EUCON) includes Belgium, France, Germany, Italy, the Netherlands, Portugal, Spain and Greece. In these countries, wages are generally bargained at the intermediate level without a strong tendency for co-ordination across bargaining units. In this setting, unions are expected to use their bargaining power to shift the burden of labour taxes onto employers. The third group (ANGLO) includes Japan, Ireland, the US and the UK. In these countries unions are not strong enough to shift the tax burden. Moreover, the sharp trade-off between wage increases and employment faced by the firm-based unions moderates wage claims. In section 4.3 we shall test how sensitive our results are to a modification of the country grouping.

3 A first look at the data

In this section we take a look at the time series properties of unemployment and labour tax rates. We first check for non-stationarity using country-specific and panel unit root tests. We next estimate the relation between unemployment and labour taxes and, upon detecting non-stationarity in these series, check for cointegration using panel cointegration tests.

3.1 Unit root tests

We test for a unit root in unemployment and labour tax rates using country-specific Augmented Dickey-Fuller (ADF) and Maddala and Wu (1999) (MW-ADF) panel unit root tests. The latter combines the p-values, denoted p_i, from the country-specific ADF unit root tests as

$$P_{MW} = -2 \sum_{i=1}^{N} \log p_i, \qquad i = 1, \ldots, N. \tag{3}$$

P_{MW} has a χ^2_{2N} distribution if the underlying country-specific tests are independent. As both unemployment and labour tax rates are highly correlated over countries[2], this assumption is clearly not satisfied. Therefore, we simulate the distribution of P_{MW} using a bootstrap procedure. Under the null hypothesis of a unit root, we assume that the data are generated as

$$\begin{aligned} \beta_i(L)\Delta y_{it} &= \mu_{it}, && (4)\\ E[\mu_{it}] &= 0 \quad \forall it, \qquad E[\mu_t\mu_t'] = \Omega \quad \forall t, \qquad E[\mu_t\mu_s'] = 0 \quad \forall s \neq t, && (5) \end{aligned}$$

where y_{it} is either unemployment or labour taxes, $\beta_i(L)$ is a lag polynomial of order q_i and $\mu_t = [\mu_{1t}, \ldots, \mu_{Nt}]'$. The variance-covariance matrix Ω is, besides positive definiteness, left unrestricted to allow for (i) heteroscedasticity across countries and (ii) contemporaneous cross-country correlation. To obtain a bootstrap sample $\widetilde{y}_{it}$ we first estimate equation (4) using OLS to obtain the estimate $\hat{\beta}_i(L)$ and the estimated residuals $\hat{\mu}_{it}$. The appropriate lag length q_i is selected using a sequential testing procedure, starting from $q_i = 5$ and reducing the lag length until the t-statistic corresponding to the highest-order lag turns out to be significant at the 10% level. Next, we resample $\hat{\mu}_{it}$ to obtain $\widetilde{\mu}_{it}$ and generate $\widetilde{y}_{it}$ from equation (4) with initialisation $\widetilde{y}_{i1} = y_{i1}, \ldots, \widetilde{y}_{iq^*+1} = y_{iq^*+1}$, where $q^* = \max(q_1, \ldots, q_N)$. With respect to resampling $\hat{\mu}_{it}$ we need to take into account its structure implied by equation (5). As resampling the cross-sectional dimension would fail to preserve the cross-country dependencies and heteroscedasticity, we resample the time series dimension only, keeping the cross-section index fixed, i.e. a bootstrap sample of residuals $\widetilde{\mu}_i$ is obtained as

$$\widetilde{\mu}_i = \left(\hat{\mu}_{it_{q^*+2}}, \ldots, \hat{\mu}_{it_T}\right)', \qquad i = 1, \ldots, N, \tag{6}$$

where the $(T - q^* - 1) \times 1$ vector $(t_{q^*+2}, \ldots, t_T)'$ is obtained by drawing with replacement from the index $(q^* + 2, \ldots, T)'$. Next we perform an Augmented Dickey-Fuller (ADF) unit root test

[2] The cross-country correlation ranges from -0.42 to 0.97 for the unemployment rate and from -0.17 to 0.99 for labour taxes.

on the bootstrapped country-specific series $\widetilde{y}_{it}$. The appropriate lag length in each of these tests is determined using the sequential testing procedure described above. We include a constant but no trend in all ADF regressions. Upon drawing 10.000 samples, we obtain bootstrapped country-specific distributions for the ADF unit root test. These distributions are then used to calculate p-values for the country-specific ADF tests which are, using equation (3), combined into the panel P_{MW} test statistic for (i) the real data and (ii) each of the 10.000 bootstrap samples. The former provides the P_{MW} test statistic for the real data while the latter yields its distribution under the null hypothesis of a unit root taking into account the cross-sectional dependencies observed in the data.

Table (1) reports results for the country-specific ADF and MW-ADF panel unit root tests. The null hypothesis of a unit root in unemployment cannot be rejected for any of the observed countries nor for the three country groups. Labour taxes are non-stationary for all countries except for Ireland and the UK. As a result the unit root hypothesis is also rejected for the country group ANGLO.

3.2 Efficient estimation and cointegration tests

In this section, we check for cointegration between unemployment and labour taxes using an Engle-Granger (EG) procedure. First, the long-run relation between unemployment and labour taxes is estimated using an extension to the panel data context of the dynamic ordinary least squares (DOLS) estimator suggested by Saikkonen (1991) and Stock and Watson (1993). The DOLS estimator eliminates nuisance terms that stem from endogeneity and serial correlation in the error term by augmenting a single equation regression with leads and lags of the explanatory variables. The panel DOLS (PDOLS) estimator, suggested by Mark and Sul (2003), estimates a homogeneous cointegrating vector but allows for country-specific fixed effects and short-run dynamics (i.e. heterogeneous coefficients on the leads and the lags). Second, we check for cointegration using country-specific EG tests, i.e. ADF tests on the country-specific residuals, and combine these EG tests in a MW-EG panel cointegration test using equation (3). Distributions for these tests are simulated using a bootstrap procedure highly similar to the one presented in section 3.1. Under the null of no cointegration between u_{it} and τ_{it}, we simulate bootstrap samples for u_{it} from the data generating process in equations (4)-(5) and the bootstrap residual resampling

Table 1: Unit root and cointegration tests

Panel analysis	MW-ADF tests		Cointegration analysis	
	unemployment	labour taxes	PDOLS	MW-EG tests
ANGLO	5.46 [0.70]	19.20 [0.01]	0.41 (0.15)	7.22 [0.59]
EUCON	22.06 [0.17]	19.10 [0.27]	0.45 (0.18)	21.12 [0.19]
NORDIC	9.23 [0.34]	10.30 [0.24]	0.50 (0.10)	12.00 [0.16]
Country analysis	ADF tests			EG tests
	unemployment	labour taxes		
ANGLO				
Ireland	-0.88 [0.76]	-2.83 [0.04]		-1.62 [0.49]
Japan	1.19 [0.79]	-2.10 [0.12]		-1.53 [0.27]
UK	-1.80 [0.39]	-3.90 [0.05]		-1.57 [0.50]
US	-1.94 [0.28]	-1.40 [0.24]		-1.37 [0.60]
EUCON				
Belgium	-2.69 [0.07]	-3.08 [0.20]		-2.40 [0.13]
France	-1.82 [0.27]	-2.17 [0.37]		-2.27 [0.17]
Germany	-2.26 [0.31]	-3.59 [0.18]		-1.60 [0.57]
Italy	-1.90 [0.20]	-2.50 [0.33]		-2.05 [0.21]
Netherlands	-1.40 [0.65]	-2.31 [0.38]		-3.25 [0.10]
Portugal	-3.61 [0.16]	0.34 [0.61]		-1.26 [0.74]
Spain	-2.10 [0.32]	-2.69 [0.13]		-2.38 [0.28]
Greece	-1.39 [0.42]	-0.06 [0.56]		-1.48 [0.48]
NORDIC				
Austria	-0.81 [0.52]	-1.65 [0.30]		-2.52 [0.16]
Denmark	-2.35 [0.14]	-1.36 [0.56]		-1.03 [0.79]
Finland	-1.48 [0.54]	-2.21 [0.18]		-2.95 [0.36]
Sweden	-2.08 [0.25]	-2.18 [0.19]		-3.02 [0.05]

The ADF statistics are from a test regression with constant and no trend. The EG statistics are calculated by performing an ADF unit root test, with no deterministic terms, on the residuals of the PDOLS regression using either the country grouping or the full panel. The number of leads and lags used by the PDOLS estimator is set to 3. The MW-ADF and the MW-EG test statistics combine, using equation (3), the country-specific ADF and EG statistics respectively. *P*-values are reported in square brackets. Standard errors, written in parentheses, are computed using the pre-whitening method suggested by Andrews and Monahan (1992).

scheme in equation (6). Next, we estimate the relation between the bootstrapped unemployment data and the original tax data using the PDOLS estimator and perform an EG cointegration test on the residuals of these regressions. After repeating this 10.000 times, we obtain bootstrapped country-specific distributions for the EG cointegration test based on the underlying PDOLS estimator. These distributions are used to calculate p-values for the country-specific EG tests on the real data, which are then combined into the panel P_{MW} test statistic using equation (3). A bootstrapped distribution for the P_{MW} statistic is obtained by using the bootstrapped country-specific EG distributions to compute country-specific EG p-values and a panel P_{MW} test statistic in each of the 10.000 bootstrap samples.

The results are reported in Table 1. The null hypothesis of no cointegration cannot be rejected at conventional significance levels for all countries individually (except Sweden) and for each of the three country groups. Note that the result of no cointegration is what one should expect from theory as finding cointegration would imply that labour taxes are the only driving force of unemployment in the long run, i.e. all other factors such as changes in the benefit system or employment protection legislation would only have transitory effects on the unemployment rate.

3.3 Consistency of the pooled least squares estimator

The conclusion of no cointegration does not necessarily invalidate the results from a homogeneous panel data regression. Phillips and Moon (1999) show that even in the absence of cointegration, different from a pure time series context, the pooled least squares estimator is $\sqrt{N}$-consistent for the long-run average relation over the cross-sections. The intuition behind this result is that the information in (independent) cross-section data carries a stronger signal compared to the pure time series case. This would imply that PDOLS is a consistent estimator for the long-run regression coefficients such that the estimates presented in Table 1 are reliable. However, as shown by Kao (1999), the t-statistic diverges so that inferences about the regression coefficients are wrong with a probability that goes to one asymptotically. Moreover, given the relative small number of cross-sections, large N asymptotics are probably a poor guide to the small sample properties.

4 An unobserved component approach

In this section, we estimate equation (2) taking into account other factors, in addition to labour taxes, that affect unemployment. Unlike other studies, we are not attempting to include all variables affecting equilibrium and temporary unemployment but treat u_{it}^{NR} and u_{it}^{C} as unobservable and model them using an UC model. The main reason for this is that there are many factors which potentially affect unemployment, most of them being hard to measure or even unobservable. As a robustness check, we will add data on six observed labour market institutions in section 4.3.4.

4.1 Model and state space representation

Equation (1) models equilibrium unemployment as being composed of a labour tax effect and an unobserved component u_{it}^{NR}. As unemployment and labour taxes are shown not to be cointegrated, u_{it}^{NR} should be non-stationary. Therefore, we model it as

$$u_{it+1}^{NR} = (1+\delta)\,u_{it}^{NR} - \delta u_{it-1}^{NR} + \eta_{it}^{NR}, \tag{7}$$

where η_{it}^{NR} is a Gaussian mean zero white noise error term. As a pure random walk process would result in a non-smooth series that is hard to reconcile with the expected smooth evolution of the structural characteristics driving equilibrium unemployment, the AR(2) specification in equation (7) allows for a smooth evolution of u_{it}^{NR} over time, i.e. the closer δ to one the smoother u_{it}^{NR}. If $\delta = 0$, u_{it}^{NR} is a pure random walk process. Note that in order to induce smoothness, the equilibrium rate of unemployment is nowadays often modelled as an I(2) series, i.e. δ is set to one (see e.g. Orlandi and Pichelmann, 2000). We do not restrict δ to be equal to one in equation (7) as in this case u_{it}^{NR} exhibits a (time-varying) drift, which would be hard to justify from an economic perspective. The short-run deviation of unemployment from its equilibrium rate, which could be labelled cyclical unemployment, is assumed to be an AR(2) process

$$u_{it+1}^{c} = \phi_1 u_{it}^{c} + \phi_2 u_{it-1}^{c} + \eta_{it}^{C}, \tag{8}$$

where η_{it}^{C} is a Gaussian mean zero white noise error term. The AR(2) specification allows cyclical unemployment to exhibit the standard hump-shaped pattern.

The model in equations (2), (7) and (8) can be written in a panel linear Gaussian state space representation of the the following form

$$u_t = \Gamma\tau_t + Z\alpha_t, \tag{9}$$

$$\alpha_{t+1} = S\alpha_t + R\eta_t, \qquad \eta_t \sim N(0, Q), \qquad t = 1, \ldots, T. \tag{10}$$

The observation equation (9) models the vector of observed unemployment rates $u_t = [u_{1t}, \ldots, u_{Nt}]'$ as a function of a vector of observed labour tax rates $\tau_t = [\tau_{1t}, \ldots, \tau_{Nt}]'$ and a vector of unobserved states α_t, which includes $u_t^{NR} = \left[u_{1t}^{NR}, \ldots, u_{Nt}^{NR}\right]'$ and $u_t^C = \left[u_{1t}^C, \ldots, u_{Nt}^C\right]'$. The latter are modelled in the state equation (10). Γ, Z, S and R are matrices including the parameters γ, δ, ϕ_1 and ϕ_2. These parameters are assumed to be homogeneous within each of the three considered country groups. $\eta_t = \left[\eta_{1t}^C, \ldots, \eta_{Nt}^C, \eta_{1t}^{NR}, \ldots, \eta_{Nt}^{NR}\right]'$ is a vector of independent Gaussian disturbances with covariance matrix Q. We assume that the innovations in η_t are mutually independent with variances that are heterogeneous over countries. The exact specification of the state vector α_t and the matrices Γ, Z, S, R and Q is given by

$$\alpha_t = \begin{bmatrix} u_t^{C'} & u_{t-1}^{C'} & u_t^{NR'} & u_{t-1}^{NR'} \end{bmatrix}', \quad Z = \begin{bmatrix} I_N & O_N & I_N & O_N \end{bmatrix}, \quad \Gamma = \gamma I_N,$$

$$S = \begin{bmatrix} \phi_1 I_N & \phi_2 I_N & O_N & O_N \\ I_N & O_N & O_N & O_N \\ O_N & O_N & (1+\delta)I_N & -\delta I_N \\ O_N & O_N & I_N & O_N \end{bmatrix}, \quad R = \begin{bmatrix} I_N & O_N \\ O_N & O_N \\ O_N & I_N \\ O_N & O_N \end{bmatrix}, \quad Q = \begin{bmatrix} \mathrm{diag}(\sigma^2_{\eta^C}) & O_N \\ O_N & \mathrm{diag}(\sigma^2_{\eta^{NR}}) \end{bmatrix},$$

where I_N is an identity matrix of size N, O_N is a $N \times N$ matrix of zeros and $\mathrm{diag}(\sigma^2_{\eta^C})$ and $\mathrm{diag}(\sigma^2_{\eta^{NR}})$ are defined as diagonal $N \times N$ matrices containing $\sigma^2_{\eta^C} = \left[\sigma^2_{\eta_1^C}, \ldots, \sigma^2_{\eta_N^C}\right]$ respectively $\sigma^2_{\eta^{NR}} = \left[\sigma^2_{\eta_1^{NR}}, \ldots, \sigma^2_{\eta_N^{NR}}\right]$ on the diagonal.

4.2 Estimation results[3]

The likelihood for the linear Gaussian state space model in (9)-(10) can be calculated by a routine application of the Kalman filter and maximised with respect to the unknown parameters using an iterative numerical procedure (see e.g. Harvey, 1989; Durbin and Koopman, 2001). The stationary state variables u_{it}^C are initialised by drawing from their stationary distributions while a diffuse initialisation is used for the non-stationary state variables u_{it}^{NR}. Standard errors for the estimates are calculated by inverting the Hessian matrix.

[3]The GAUSS code to obtain the results presented in this section is available from the authors on request.

Table 2: UC model estimates (1970-2001)

	ANGLO	EUCON	NORDIC
γ	-0.06 (0.05)	0.13 (0.04)	0.05 (0.04)
ϕ_1	0.97 (0.20)	1.37 (0.07)	1.52 (0.11)
ϕ_2	-0.44 (0.11)	-0.65 (0.06)	-0.75 (0.10)
δ	0.79 (0.20)	0.82 (0.12)	0.39 (0.12)
LM_{AR}	0.01 [0.92]	0.07 [0.79]	0.11 [0.74]
LM_{MA}	0.10 [0.54]	0.26 [0.60]	0.33 [0.63]

The dependent variable is the unemployment rate. Labour taxes are measured by the effective tax rate on employed labour. Standard errors are in parentheses. LM_{AR} and LM_{MA} are LM tests for an AR respectively MA structure in the residuals. P-values are in brackets.

Table (2) presents the results. The estimates for ϕ_1 and ϕ_2 imply that the properties of the cyclical component are in line with previous empirical studies, i.e. a hump-shaped response to shocks and a cycle periodicity of about 10 years. The estimates for δ imply that the trend component is smoother than a simple random walk, especially for the ANGLO and the EUCON group. With respect to the impact of labour taxes we find a significant effect only for the EUCON group and not for ANGLO and NORDIC. This result is consistent with existing empirical literature (e.g. Daveri and Tabellini, 2000) and with theory which argues that only in the EUCON countries unions have successfully resisted the downward pressure of higher taxes on net wages. For the EUCON countries the tax elasticity is estimated to be 0.13 with a standard error of 0.04. It is worth highlighting that this lies in the interval of Planas et al. (2007) but the point estimate is considerably lower and, more important, it is estimated with a fairly low degree of uncertainty.

In the state space model presented in equations (9)-(10) the residuals are assumed to be white noise. Following Durbin and Koopman (2001) we check whether this property holds by testing for autocorrelation in the standardised one-step ahead prediction errors of the state space model. We use two LM tests suggested by Baltagi and Li (1995). The first test specifies the residuals as an $AR(1)$ process, i.e. $v_{it} = \rho v_{it-1} + \varepsilon_{it}$, and tests the null hypothesis that $\rho = 0$. The second test models the residuals as a $MA(1)$ process, i.e. $v_{it} = \varepsilon_{it} + \lambda\varepsilon_{it-1}$, and test the null hypothesis that $\lambda = 0$. Both tests show that we cannot reject the null of no autocorrelation in any of the three country groups (see bottom Table (2)).

As stated earlier we assume the shocks to the unobserved components to be mutually independent. This assumption seems questionable as one would expect these components to be correlated over countries. In fact, attempts to estimate the covariances of the shocks for smaller groups of countries show that the components are indeed correlated. Particularly our measure of cyclical unemployment is highly correlated over countries. The point estimate of the tax elasticity and its standard error were virtually unaffected, though. However, for a group of 8 countries, allowing all innovations to be correlated implies estimating 140 parameters in total. Given this large number of parameters and the fact that it only has a modest impact on the tax elasticity we do not estimate the covariances. Note that this does not imply that the estimated components are not correlated, we simply do not estimate their correlation.

4.3 Robustness checks

4.3.1 Alternative country grouping

The country grouping, outlined in section 2.3, pooled countries with similar wage setting institutions. An implicit assumption was that these institutions did not change over the considered period. This assumption seems questionable as we cover a period of 30 years. Infact, a recent study, OECD (2004), shows that particularly Sweden, Denmark and Ireland have experienced substantial changes to their wage setting institutions. In this section we shall test whether relaxing the assumption of time-invariant wage setting processes affects our results. We re-group countries taking into account the changes in the wage setting institutions. According to the OECD, Sweden and Denmark have become much less centralised/coordinated since the second half of the 1980s. Contrary, Ireland has moved to a more centralised and coordinated wage bargaining system since the 1990s. Therefore, Denmark and Sweden are classified in the EUCON group from 1985 onwards and Ireland in the NORDIC group from 1990 onwards The results of the UC model with this alternative country grouping are shown in Table (3). Two miner changes can be emphasised. First the point estimate of γ for the EUCON groups drops from 0.13 to 0.11 and the standard error for the NORDIC group has become smaller implying a small but significant impact of labour taxes on unemployment.

Domenech and Garcia (2007, p.7) mention the need to include Spain to get a significant positive tax impact in the country group EUCON. This result cannot be confirmed here. When Spain is omitted, the estimated tax elasticity for the EUCON countries is 0.136 (0.04). Generally, we find

Table 3: Robustness check: Alternative country grouping

	ANGLO	EUCON	NORDIC
γ	-0.06 (0.05)	0.11 (0.04)	0.07 (0.03)
ϕ_1	0.98 (0.21)	1.39 (0.06)	1.43 (0.12)
ϕ_2	-0.45 (0.11)	-0.65 (0.05)	-0.76 (0.10)
δ	0.79 (0.23)	0.83 (0.11)	0.47 (0.10)
LM_{AR}	0.03 [0.87]	0.06 [0.81]	0.16 [0.69]
LM_{MA}	0.17 [0.57]	0.24 [0.60]	0.40 [0.66]

The dependent variable is the unemployment rate. Labour taxes are measured by the effective tax rate on employed labour. Standard errors are in parentheses. LM_{AR} and LM_{MA} are LM tests for an AR respectively MA structure in the residuals. P-values are in brackets.

that the reported results are not very sensitive to the omission of individual countries.[4]

4.3.2 Alternative tax data

In order to check the robustness of our results we use an alternative measure for labour taxes. Instead of the effective tax rate we consider the tax wedge as calculated by the OECD based on micro-simulation of the national tax legislation. Data are available for two socio-economic groups, i.e. "single" and "one-earner married couple with two children". Unfortunately the data only range over the period 1979-2004, where for the first 10 years data had to be interpolated as only one observation every two years is available. Table 4 presents the results. Using data for the socioeconomic group "single", the results from Table 2 are confirmed, i.e. the estimated tax impact is only significant in the EUCON group with a point estimate of 0.14. For the "one-earner married couple" group none of the estimated tax effects is significant at the 95% level. For the country groups EUCON and NORDIC the tax elasticity is 0.06 and 0.08 respectively and significant at the 90% level.

4.3.3 Employment rate as labour market indicator

So far we only considered the impact of labour taxes on the rate of unemployment. This assumes that unemployment is a good indicator of labour market performance. However, as pointed out by e.g. Blanchard (2006), there might be shocks which affect the state of the labour market but leave the rate of unemployment unaffected. An increase in labour taxes, for instance, lowers

[4]Note that this holds to a lesser extend for the ANGLO and NORDIC countries as these groups consist of fewer countries.

Table 4: Robustness check: OECD tax wedge data (1979-2004)

	Single			Married, two children		
	ANGLO	EUCON	NORDIC	ANGLO	EUCON	NORDIC
γ	0.02 (0.02)	0.14 (0.06)	0.05 (0.06)	0.02 (0.02)	0.06 (0.04)	0.08 (0.05)
ϕ_1	1.35 (0.12)	1.44 (0.07)	1.47 (0.09)	1.36 (0.12)	1.47 (0.07)	1.47 (0.09)
ϕ_2	-0.71 (0.12)	-0.81 (0.07)	-0.67 (0.08)	-0.71 (0.11)	-0.81 (0.07)	-0.67 (0.07)
δ	0.48 (0.13)	0.52 (0.11)	0.46 (0.16)	0.48 (0.13)	0.49 (0.13)	0.43 (0.16)
LM_{AR}	0.02 [0.87]	0.08 [0.78]	0.08 [0.78]	0.04 [0.84]	0.08 [0.77]	0.07 [0.79]
LM_{MA}	0.16 [0.56]	0.28 [0.61]	0.28 [0.61]	0.20 [0.58]	0.28 [0.61]	0.27 [0.61]

The dependent variable is the unemployment rate. Labour taxes are measured by the OECD tax wedge. Standard errors are in parentheses. LM_{AR} and LM_{MA} are LM tests for an AR respectively MA structure in the residuals. P-values are in brackets.

the incentive for people to join the labour force. This negative effect does not translate into higher unemployment rates but leads to lower participation and employment rates. Therefore, we consider the employment rate as an alternative measure for the state of the labour market. Table (5) shows the results from estimating the UC model with employment as the dependent variable and the effective tax rate as a measure for labour taxes.[5] The overall picture remains the same. Only for the EUCON group a statistically significant negative impact of labour taxes on the rate of employment is found.

Table 5: Robustness check: employment rate (1970-2001)

	ANGLO	EUCON	NORDIC
γ	0.06 (0.05)	-0.10 (0.04)	-0.04 (0.04)
ϕ_1	0.81 (0.21)	1.57 (0.08)	1.53 (0.10)
ϕ_2	-0.26 (0.15)	-0.82 (0.09)	-0.74 (0.12)
δ	0.69 (0.15)	0.53 (0.08)	0.38 (0.12)
LM_{AR}	0.06 [0.80]	0.05 [0.82]	0.08 [0.78]
LM_{MA}	0.25 [0.60]	0.22 [0.59]	0.28 [0.61]

The dependent variable is the employment rate. Labour taxes are measured by the effective tax rate on employed labour. Standard errors are in parentheses. LM_{AR} and LM_{MA} are LM tests for an AR respectively MA structure in the residuals. P-values are in brackets.

4.3.4 Labour market institutions

So far we ignored other variables that may explain structural unemployment. As discussed earlier, economic theory relates unemployment to factors which are difficult to measure or even unobserv-

[5]Employment data are taken from the OECD Economic Outlook.

able. The UC model takes this into account by filtering out the sum of all neglected variables affecting unemployment. However, there are certain labour market institutions for which data are available. In this section we test whether the estimates presented in Table 2 are robust to the inclusion of other explanatory variables. In particular we include six additional explanatory variables taken from Nickell et al. (2005): employment protection (EP), union density (UD), benefit replacement ratio (BRR), benefit duration (BD), wage bargaining coordination (BCO), and owner occupation rate (OOR). It must be stressed that these labour market institution measures are qualitative data and subjective indices. Thus they are likely to contain measurement errors (see Daveri, 2003). With the exception of Greece, for which these data are not reported, they are available until 1995. A natural question that arises when labour market institution indicators are taken into consideration is whether they are cointegrated with the rate of unemployment. From an economic perspective this might be plausible as these institutions are believed to be responsible for the increase in unemployment in many OECD countries since the 1970s. Thus we first test for cointegration using the approach described in section 3.2. The results show that the extended set of labour market institutions is not cointegrated with unemployment.[6] This implies that there are still other factors which explain structural unemployment and/or the institution variables are indeed measured with error.[7] Table 6 shows the results of the UC model with the institution data. The coefficients for all institution variables other than taxes are treated homogeneous over the three country groups. The main conclusion is that the coefficient on labour taxes is left unaffected. Most of the institutions are statistically insignificant and some even have the wrong sign. The imprecise estimate of the institution variables might be attributed to the short time span[8] but also to the subjective and qualitative nature of the data.

5 Conclusion

In this paper, we estimate the impact of labour taxes on unemployment for a panel of 16 OECD countries over the period 1970-2001. In order to take into account possible cross-sectional het-

[6] The coefficients for all additional institution variables in the cointegration test are homogeneous. Only the coefficient on labour taxes is allowed to be group-specific. The p-value for the null of no cointegration is 0.15.

[7] Berger and Everaert (2006) show that cointegration must also be rejected in the set-up of Nickell et al. (2005) where additionally time dummies and interactions between institutions and various macroeconomic shocks are allowed for.

[8] For most countries the dataset ranges from 1970 to 1995 but for some countries institution data are only available from the mid 1970s. This further reduces the time-series dimension.

Table 6: Robustness check: including institution variables (1970-1995)

	ANGLO	EUCON	NORDIC
γ	0.03 (0.05)	0.11 (0.05)	0.01 (0.04)
ϕ_1	0.73 (0.24)	1.30 (0.37)	1.29 (0.44)
ϕ_2	-0.24 (0.44)	-0.74 (0.36)	-0.65 (0.23)
δ	0.53 (0.14)	0.83 (0.08)	0.99 (0.08)
EP	1.07 (1.15)	RR	-1.32 (1.15)
UD	0.09 (0.03)	BCO	0.46 (1.30)
BD	0.11 (0.55)	OOR	-0.75 (4.56)
LM_{AR}	0.11 [0.74]	0.06 [0.80]	0.03 [0.87]
LM_{MA}	0.34 [0.63]	0.24 [0.60]	0.17 [0.57]

The dependent variable is the unemployment rate. Labour taxes are measured by the effective tax rate on employed labour. Standard errors are in parentheses. LM_{AR} and LM_{MA} are LM tests for an AR respectively MA structure in the residuals. P-values are in brackets.

erogeneity we group countries with similar labour market institutions: Anglo-Saxon countries, European countries and Nordic countries. Using panel unit root and cointegration tests we find that both unemployment and labour taxes are non-stationary but not cointegrated. This is not surprising as economic theory relates structural unemployment to various factors. Unfortunately some of these factors are unobserved, e.g. the reservation wage. Therefore, we estimate the model using an unobserved component approach in which the missing variable(s) are identified through the Kalman filter. The estimated impact of labour taxes on unemployment is statistically significant only for the European countries. The point estimate of 0.13 indicates a rather moderate economic importance, though. Consistent with standard bargaining models there is neither a significant impact for Anglo-Saxon nor for Nordic countries. This suggests that reducing labour taxes to fight high unemployment may be useful in countries with strong unions and a decentralised wage bargaining system, but the effect should not be overestimated.

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