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Explaining labor wedge trends: An equilibrium search approach[1]

Coralia A. Quintero Rojas[2], François Langot[3]

Abstract

In this paper, we present a search and matching model of the labor market and use this as a device to explain the long-run variation in the aggregate hours worked in several OECD countries over the period 1980-2013. The model distinguishes between hours worked per employee (intensive margin) and the employment rate (extensive margin) and includes a tax/benefit system. This allows us to assess the impact of the observed time-varying heterogeneity of taxes, unemployment benefits, and workers' bargaining power on the two margins. Our method is based on an accounting procedure. Once it has been calibrated, we find that, for the ten countries of the sample, our search economy is able to explain the patterns of the two margins of aggregate hours worked over the 1980-2013 period, when it includes the cross-country heterogeneity of the labor market institutions.

JEL: E23, J21, J22, J23, J64.

Keywords: Aggregate hours of work, intensive and extensive margins, labor market institutions, labor wedge, matching model.

1. Introduction

Over the last few decades, most OECD countries have shown large differences in aggregate hours of market work. The interesting issue of understanding these differences in work effort has resulted in a number of significant contributions. For instance, Prescott (2004) studies the taxes account for differences in labor supply over time and across countries from the early 1970's to the mid-1990's and finds that for acceptable values of labor supply elasticity, the effective marginal tax rate on labor income explains most of the differences at points of time and the large change in relative (to US) labor supply over time. On this line of research, Rogerson (2004) points to the role of taxes and technology as determining factors in the changes from 1956-2000, whereas Rogerson (2006) argues that changes in technology and government are promising candidates to explain the broad changes over the period 1956-2003. Finally, Ohanian, Raffo and Rogerson (2008) emphasize the intensive margin of aggregate hours of work and find that the neoclassical growth model, augmented with taxes, can account for most of the variations over the period 1956-2004.

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[2] Departamento de Economía y Finanzas, Universidad de Guanajuato, DCEA-Sede Marfil. Fraccionamiento I, El Establo, Guanajuato, GTO 36250, México. e-mail: coralia@ugto.org

[3] GAINS-TEPP, Université du Maine, Avenue O. Messiean, 72085 Le Mans, France. e-mail: flangot@univ-lemans.fr

However, since the late 1970's, the differences in aggregate hours across countries seem to be largely to quantitatively important differences along the extensive margin. Moreover, the relative change in the employment rate behaves differently than the relative change in hours worked per employee. To stress this point, Langot and Quintero Rojas (2009) construct counterfactuals to quantify the relative importance of the extensive and intensive margins of aggregate hours of market work in the observed differences between Europeans and Americans since the 1970's. They show that the extensive margin explains most of the total-hours-gap between regions, while the intensive margin plays the smallest role. Furthermore, Ljungqvist and Sargent (2007a, 2007b and 2008) suggest that the large decrease in the employment rate in European countries observed after 1980, was an important factor in the dynamics of total hours worked. In addition, there is a bulk of evidence from previous literature on the European unemployment problem regarding the effects of labor market indicators other than taxes on the extensive margin[4].

This suggests that the basic neo-classical growth model with endogenous labor supply is insufficient to account for the impact of the various labor market institutions on aggregate hours of work. However, when this model is extended to include a search and matching process in the labor market it is able to explain the employment dynamics. An example of this is the study by Quintero Rojas (2009), who examines the incidence of various labor market institutions on the extensive margin to explain the evolution of aggregate hours over the period 1980-2003. However, her model holds the intensive margin constant, thereby neglecting an interesting dimension of the problem.

Against this rich background, our main contribution is twofold. Firstly, we take into account the differentiated dynamics of the two main margins of aggregate hours of work, i.e., the average hours worked per employee (or *intensive margin*); and the employment rate (or *extensive margin*). This enables us to assess the relative effect of taxes on each margin, on the one hand; and that of unemployment benefits and workers' bargaining power on the other. Secondly, the analysis covers the updated period 1980-2013.

More precisely, we develop a dynamic general equilibrium model with search and matching frictions, wage bargaining, and efficient bargain on the number of hours worked per employee. The model is extended to include a tax/benefit system consisting of taxes on consumption, labor income, and payroll, unemployment benefits, and the workers' wage bargaining power. Since the model distinguishes between the two margins of the aggregate hours of work, we are able to look at the relative contribution of taxes and labor market institutions to each margin.

[4] Some previous papers on the European unemployment problem find a significant positive impact of unemployment benefits and wage-bargaining arrangements (union density, union coverage, and corporatism) on unemployment. ―See Daveri and Tabellini (2000) and Bassanini and Duval (2006) for more details on this topic.

Contrary to Ljungqvist and Sargent (2007a), our "representative family model" incorporates congestion effects through a matching function. This friction leads to a more realistic elasticity of the employment rate to the observed shifts in the unemployment replacement ratio (Ljungqvist and Sargent, 2007b).

The model builds on the Diamond-Mortensen-Pissarides workhorse (Diamond, 1982; Mortensen, 1970; Pissarides, 1985), though avoids the kind of criticism leveled by Shimer (2005), by taking a long-run approach and through our choice of labor market institutions and the changes that occurred in these[5].

With respect to methodology, we proceed as follows. First, the observed differences in aggregate hours of work are summarized by the labor wedge (Shimer, 2009), defined as the deviation of the marginal product of labor (MPL) from the marginal rate of substitution between consumption and leisure (MRS). Next, we conduct an accounting procedure inspired by Ohanian *et al.* (2008).[6] In broad terms, we compute the empirical counterparts of theoretical labor wedges, under various scenarios in order to evaluate the impact of distortions. The closer the empirical wedges are to zero, the better the model accounts for the observed labor behavior. Hence, the reduction of a wedge that results from the introduction of a distortion is interpreted as a measure of the quantitative importance of such distortion.

We show that; for the ten countries in our sample; the trends of the two margins of the aggregate hours are well explained by our search model; when it includes the observed heterogeneity of both taxes and labor market institutions. Since these empirical results come from a unified framework, they also provide a strong support for the matching models.

The remainder of the paper is organized as follows. Section 2 present some stylized facts on total hours worked and on the contrasted dynamics of the hours worked per employee (the intensive margin) and the employment rate (the extensive margin). In Section 3, we present a search and matching model in which both margins are endogenous. In Section 4 we quantitatively evaluate the model using an accounting procedure. Section 5 presents the concluding remarks. Finally, the Appendix A is devoted to data.

[5] Shimer (2005) shows that the Diamond-Mortensen-Pissarides model fails to match business cycle statistics with the usual calibrations. Nevertheless, both Ljungqvist and Sargent (2007b) and Costain and Reiter (2008) show that the usual calibration lead the model to fit the observed elasticity of the employment rate to a large permanent change in unemployment benefits. The distinction between the short- and long-run elasticities is discussed at length in Rogerson and Wallenius (2009).

[6] This methodology has proved very successful in business cycle accounting: for instance, Chari *et al.* (2007), and Galí, Gertler and López-Salido (2007) show that the labor market wedge explains a large part of the changes in hours worked in the U.S. during recessions. Ohanian et al. (2008) and Quintero Rojas (2009) apply this method to the long-run analysis also.

2. Empirical Regularities

In this section we establish a number of facts concerning the allocation of time in ten OECD countries. Our sample includes Austria, Belgium, Finland, France, Italy, the Netherlands, Spain, Sweden, the United Kingdom and the United States. The analysis covers the period 1980-2013. First, we define aggregate hours worked and its two main dimensions. Next, we describe our sample and the main variables and labor market institutions. The full definition of variables and data sources are included in the Appendix A. Finally, we perform a series of empirical exercises.

2.1 Aggregate hours of work in Western Europe and the U.S.

Let N, h and Lrespectively denote employment level, average hours worked per employee and working age population. Thus, the decomposition of the aggregate hours of market work, H, is given by

$$H = h \times \frac{N}{L} \tag{1}$$

The first component of this decomposition is the intensive margin, since it represents the average work effort that each employed person invests. Meanwhile, the second term is the extensive margin, since it refers to the proportion of people who have a job.

To provide an initial overview of the labor behavior, we compute the sample mean of each variable in equation (1) from 1980 to 2013. We observe notable differences in the total hours worked. Moreover, countries with similar performances (measured by the aggregate hours) show contrasting work efforts and employment rates. For instance, the average total hours worked in Italy and the United States is the same. However, the individual work effort in Italy is higher to compensate the lower employment rate. Similarly, the average aggregate hours worked in Belgium, Spain and France are very similar to one another. However, while employees in Belgium work virtually the same amount of hours as those in Sweden, in Spain the individual work effort is high enough to compensate for its lower employment rate with respect to Belgium and Sweden.

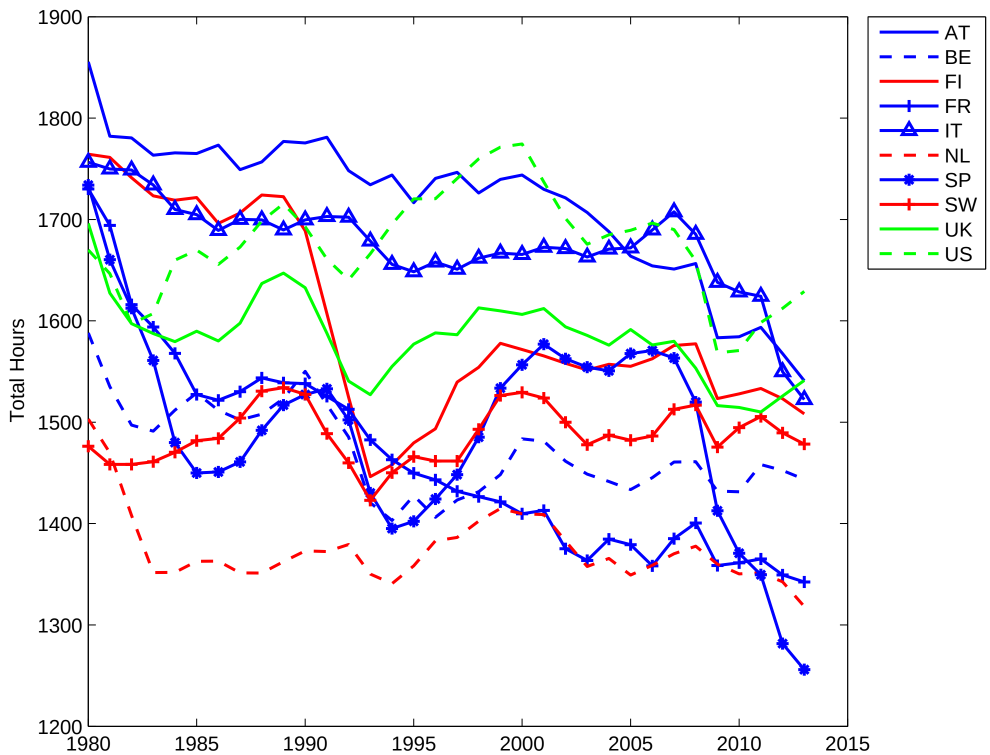
Table 1. 1980 – 2013 Averages

Country	H	$min.$	$max.$	h	$min.$	$max.$	$\frac{N}{L}$	$min.$	$max.$
Austria	1715	1541	1855	1787	1628	1890	0.96	0.94	0.98
Belgium	1472	1403	1588	1607	1554	1702	0.92	0.89	0.94
Finland	1598	1447	1764	1749	1643	1855	0.91	0.82	0.96
France	1465	1342	1730	1598	1484	1823	0.92	0.90	0.95
Italy	1675	1522	1756	1839	1733	1890	0.91	0.88	0.95
Netherlands	1375	1318	1503	1474	1421	1579	0.93	0.87	0.97
Spain	1494	1256	1734	1757	1699	1918	0.85	0.74	0.92
Sweden	1488	1423	1534	1592	1508	1665	0.94	0.88	0.98
United Kingdom	1583	1510	1696	1719	1641	1820	0.92	0.88	0.95
United States	1675	1568	1774	1790	1729	1849	0.94	0.90	0.96

Source: Values deduced from the OECD data described in the Appendix.

For a more detailed analysis, we turn to the evolution over time of aggregate hours and its components, shown in Figures 1 to 3.

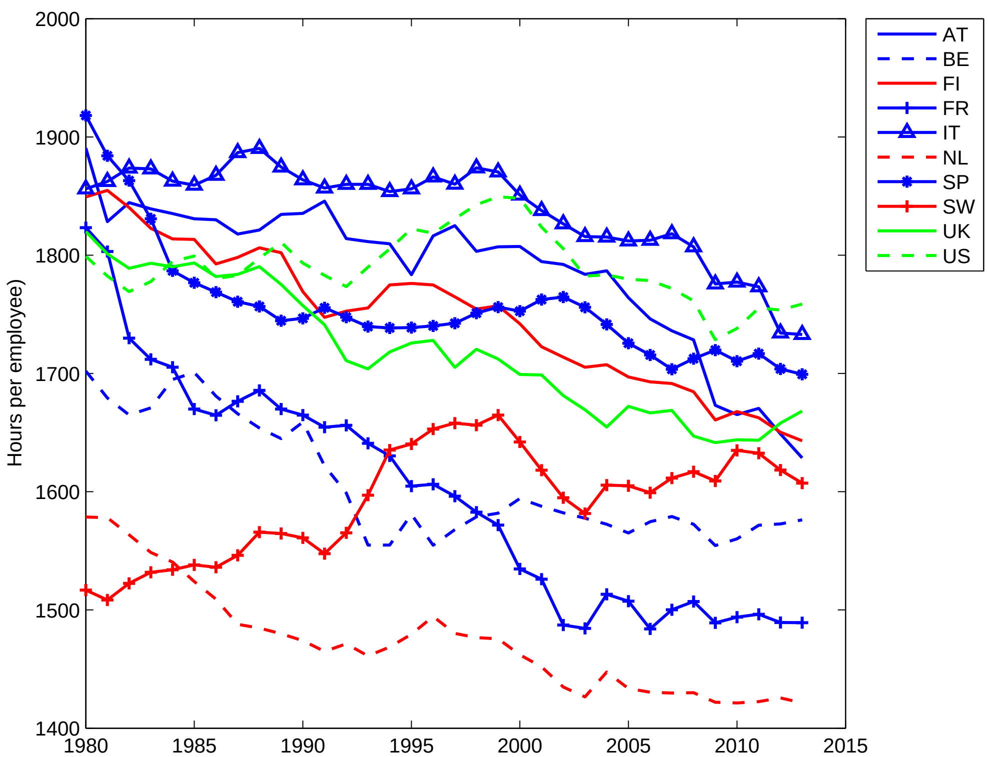
Figure 1. Aggregate Hours Worked, 1980 – 2013



Source: results of equation (1) using OECD data described in the Appendix. Central and southern European countries are plotted in blue: Austria (AT), Belgium (BE), France (FR), Italy (IT) and Spain (SP). Northern European countries are plotted in red: Finland (FI), the Netherlands (NL) and Sweden. Anglo-Saxon countries are plotted in green: the United Kingdom (UK) and the United States (US).

Aggregate hours worked. From Figure 1, we can see very varied trend-experiences: Austria (AT) and France (FR) show a steady decline over the whole period. Spain (SP), Belgium (BE), the United Kingdom (UK), the United States (US), Italy (IT), the Netherlands (NL) and Sweden (SW) exhibit similar fluctuations around their means, though these are less marked in the last three countries, and far more marked in Spain and the Anglo-Saxon countries. Moreover, all mainland European countries start and finish the period with a declining trend, whereas the trend in the Anglo-Saxon countries starts to increase by the end. In contrast, Finland (FI) displays a unique pattern with a sharp decline in the middle of the period.

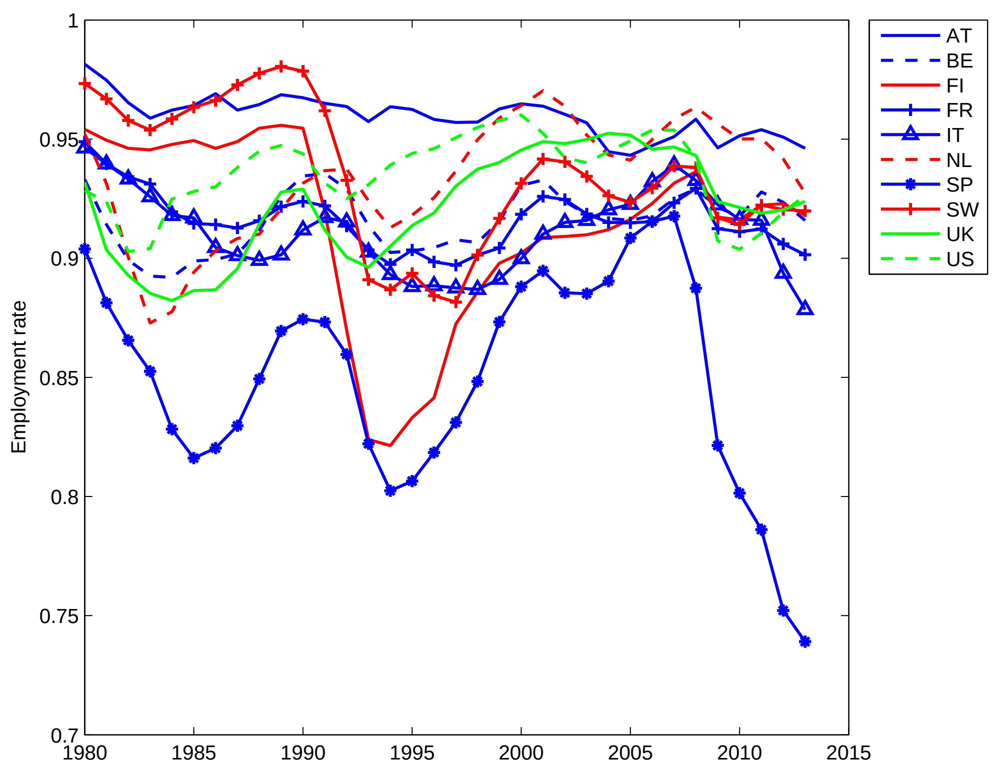
Figure 2. Average Hours per Employee, 1980 – 2013



Source: results of equation (1) using OECD data described in the Appendix.
Central and southern European countries are plotted in blue: Austria (AT), Belgium (BE), France (FR), Italy (IT) and Spain (SP). Northern European countries are plotted in red: Finland (FI), the Netherlands (NL) and Sweden. Anglo-Saxon countries are plotted in green: the United Kingdom (UK) and the United States (US).

Average hours per employee. The patterns for the average work effort seem more similar (Figure 2): most countries show a declining trend over the whole period, though that is less marked in Italy, Spain and the Netherlands. The two exceptions are Sweden and the United States. Sweden experienced an increasing trend until the end of the 1990's, followed by a few years of decline, then a slightly longer upward trend before finally decreasing again from 2010 on. In contrast, the United States shows a flat trend at the beginning and then oscillates in a way similar to its aggregate hours.

Figure 3. Employment Rate, 1980 – 2013



Source: results of equation (1) using OECD data described in the Appendix.
Central and southern European countries are plotted in blue: Austria (AT), Belgium (BE), France (FR), Italy (IT) and Spain (SP). Northern European countries are plotted in red: Finland (FI), the Netherlands (NL) and Sweden. Anglo-Saxon countries are plotted in green: the United Kingdom (UK) and the United States (US).

Employment rate. In most countries the employment rate (Figure 3) shows a similar but sharper fluctuating pattern than aggregate hours. Two notable exceptions are Austria and France. In the first case, the trend is quite flat, while in the second the employment rate fluctuates around a flat trend, in contrast to the downward sloping pattern of aggregate hours.

Summing up, the data show that aggregate hours shows a different evolution than at least one of its components. Moreover, in general the dynamics of the intensive margin differ from those of the extensive margin, suggesting that they may have different determinants. Therefore, any theory that seeks to explain the aggregate hours of work must include both margins and allow the impact of different variables on each to be evaluated. Such a theory is developed in the next section.

2.2 Aggregate hours and labor market institutions

Using the data and formulas from the Appendix A, we generate time series for the average tax rates. Taxes on labor income (τ_w) and consumption (τ_c) were obtained following the Mendoza, Razzin and Tessar (1994)' and McDaniel (2007)'s approaches based on National Accounts, whereas the payroll tax τ_f was obtained as the ratio of the compensation of employees to the wages and salaries.

As regards labor market institutions, workers' bargaining power, $1-\epsilon$, is set as the average of union coverage and union density, since it is closely linked to both these indicators: a high level of union coverage or high union density implies that the probability of the employee of being alone during the bargaining process is very low. Hence, bargaining power is higher in economies where firms do not have a monopsony power. Furthermore, the unemployment benefits are directly related to the average replacement rate (*arr*) and the wage rate net of taxes.

2.2.1 Statistical glance

To have a broad glance of the long-run dynamics of the different labor market institutions, we conduct a simple statistical exercise. For each country *i* of the sample, we regress the labor market variable $x_i = \{\tau_{w,i}, \tau_{c,i}, \tau_{f,i}, 1-\epsilon_i, arr_i\}$, over a constant and a time-trend given by the variable $year = [1,2,\ldots,34]$, representing the time period from 1980 to 2013.

The estimated coefficients $\hat{\beta}$ and the respective 95% confidence intervals are reported in Table 2. Remark that apart from the average replacement rate in Italy, all the estimates are significant at the 95% level of confidence. Moreover, the trend components are increasing in all cases. The ongoing nature of these labor market indicators suggest that they may play a key role in shaping aggregate hours of work. Two next sections explore this intuition.

Table 2. OLS Estimates

Country	$\widehat{\beta}_{\tau w}$	$\widehat{\beta}_{\tau c}$	$\widehat{\beta}_{\tau f}$	$1-\epsilon$	arr
Austria	0.2657 (0.2413,0.2901)	0.2199 (0.2134,0.2264)	0.1992 (0.1968,0.2016)	0.7582 (0.7553,0.7611)	0.2922 (0.2771,0.3073)
Belgium	0.3409 (0.3251,0.3567)	0.1899 (0.1733,0.2066)	0.2795 (0.2673,0.2918)	0.7272 (0.7225,0.7318)	0.4414 (0.4330,0.4497)
Finland	0.2966 (0.2781,0.3152)	0.2245 (0.2092,0.2399)	0.2347 (0.2206,0.2489)	0.7412 (0.7239,0.7586)	0.3080 (0.2836,0.3324)
France	0.3024 (0.2869,0.3180)	0.2708 (0.2466,0.2950)	0.3690 (0.3622,0.3759)	0.5062 (0.4990,0.5134)	0.3382 (0.3184,0.3581)
Italy	0.2633 (0.2490,0.2777)	0.1236 (0.0907,0.1565)	0.3544 (0.3347,0.3741)	0.6496 (0.6413,0.6579)	0.0172 (-0.0575,0.092)
Netherlands	0.3889 (0.3571,0.4206)	0.1391 (0.1217,0.1566)	0.3374 (0.2992,0.3756)	0.5577 (0.5489,0.5666)	0.5816 (0.5382,0.6249)
Spain	0.1357 (0.1157,0.1557)	0.1901 (0.1747,0.2055)	0.2269 (0.2204,0.2334)	0.4742 (0.4583,0.4900)	0.3132 (0.2951,0.3313)
Sweden	0.3990 (0.3733,0.4248)	0.3352 (0.2949,0.3756)	0.1713 (0.1602,0.1824)	0.8491 (0.8286,0.8696)	0.2402 (0.2172,0.2631)
United Kingdom	0.2486 (0.2393,0.2578)	0.1877 (0.1795,0.1958)	0.1302 (0.1171,0.1432)	0.5992 (0.5656,0.6329)	0.2307 (0.2215,0.2399)
United States	0.1984 (0.1902,0.2065)	0.0945 (0.0878,0.1012)	0.1967 (0.1897,0.2038)	0.2136 (0.2063,0.2208)	0.1000 (0.0702,0.1298)

Ordinary Least Squares regressions. The confidence intervals (in brackets) are at the 95% level.

3. The model economy

In this section, we provide a theoretical framework that allows us to simultaneously explain the long term evolution of aggregate hours of work and its two dimensions. We also attempt to explore the effect of taxes and other labor market institutions (such as bargaining power and unemployment benefits) on these variables. To this end, we develop a general equilibrium model with search frictions in which each margin is clearly distinguished. Moreover, the model is extended to include several variables related to labor market institutions.

3.1 Labor market flows

Employment is predetermined at each moment in time and changes only gradually as workers separate from jobs, at the exogenous rate s, or unemployed agents find jobs, at the hiring rate M_t. Let N_t and V_t, respectively be the number of workers and the total number of new jobs made available by firms; hence, employment evolves according to

$$N_{t+1} = (1 - s)N_t + M_t \tag{2}$$

$M_t = V_t^{\psi}(1 - N_t)^{1-\psi}, \quad 0 < \psi < 1$ represents the matching function.

3.2 Households

The economy is populated by a large number of identical households whose measure is normalized to one. Each household consists of a continuum of infinitely-lived agents. At any period, agents engage in only one of two concurring activities: working ($z = n$) or searching for a job ($z = u$). The contemporaneous utility function is assumed to be increasing and concave in both arguments and shows conventional separability between consumption C and leisure$L$, whereby:

$$U(C_t^z, L_t^z) = \ln C_t^z + \Gamma_t^z, \quad z = n, u. \tag{3}$$

In this last expression, the utility for leisure of employed workers is defined as $\Gamma_t^n = \sigma \log(1 - h_t)$, with $\sigma > 0$, and h the hours worked per employee. However, we assume that the search activity does not causes disutility, so that for unemployed workers, $\Gamma_t^u = \Gamma^u = 0$, $\forall\ t$.

The representative household uses employment lotteries to decide who works. Ex-post, there is a fraction N of employed agents working h hours while the complement $1 - N$ unemployed agents are searching for a job. The unemployed are randomly matched with job vacancies. The individual idiosyncratic risks faced by each agent in her job match are perfectly insured: agents have access to private insurance arrangements in the tradition of Hansen (1985) and Rogerson (1988). Hence, the representative household's preferences are:

$$\sum_{t=0}^{\infty} \beta^t \left[\log(C_t) + N_t \sigma \log(1 - h_t)\right] \tag{4}$$

where $0 < \beta < 1$ is the discount factor. Let us define the job finding rate as $\Psi \equiv M_t/(1 - N_t)$. Thus, the household's employment opportunities evolve as follows:

$$N_{t+1} = (1 - s)N_t + \Psi_t(1 - N_t) \quad (5)$$

Households own capital stock K_t and rent this to firms at net price $(r_t + \delta)$, where $0 < \delta < 1$ is the depreciation rate of capital and r_t the interest rate. Employed workers receive an hourly wage w_t which is taxed at rate $\tau_{w,t}$ while unemployed workers receive the unemployment benefits, b. Consumption is also taxed at rate $\tau_{c,t}$. The household's budget constraint is

$$K_{t+1} = (1 + r_t)K_t + (1 - \tau_{w,t})[N_t w_t h_t + (1 - N_t)b_t] + L_t + \pi_t - (1 + \tau_{c,t})C_t \quad (6)$$

L_t and π_t represent two types of lum-psum transfers: the first comes from the budgetary constraint of the government, while the second corresponds to the firm's profits. Hence, the representative household chooses $\{C_t, K_{t+1} | t \geq 0\}$ to maximize (4) subject to the labor supply constraint (5) and to the budget constraint (6).

3.3 Firms

There are many identical firms in the economy. Each firm chooses a number V_t of job vacancies, produces the same homogeneous good and pays wages and capital services, while supporting a payroll tax burden $\tau_{f,t}$ The unit cost of maintaining an open vacancy is ω. The production technology is Cobb-Douglas:

$$Y_t = A_t K_t^{\alpha}(N_t h_t)^{1-\alpha}, \quad 0 < \alpha < 1 \quad (7)$$

Job vacancies are matched at the constant rate $\Phi_t = M_t/V_t$. Hence, a firm's labor employment evolves as

$$N_{t+1} = (1 - s)N_t + \Phi_t V_t \quad (8)$$

Each firm chooses $\{N_{t+1}, K_t, V_t | t \geq 0\}$ to maximize the discounted value of the dividend flow, $\pi_t = Y_t - (r_t + \delta)K_t - \omega_t V_t - (1 + \tau_{f,t})w_t h N_t$, subject to constraints (7) and (8).

3.4 Government

The government levies taxes to finance its expenditure. We assume a balanced budget in each period, whereby any revenue that is not used to finance current purchases is transferred to households in a lump-sum payment given by:

$$L_t = \tau_{c,t}[N_t C_t^n + (1-N_t)C_t^u] + (\tau_{f,t} + \tau_{w,t})w_t h_t N_t - b_t(1-\tau_{w,t})(1-N_t) \quad (9)$$

3.5 Wages and hours bargaining

Wages and hours are determined *via* generalized Nash bargaining between individual workers and their firms:

$$\max_{w_t,h_t} (\lambda_t \mathcal{V}_t^F)^{\epsilon_t} (\mathcal{V}_t^H)^{1-\epsilon_t} \quad (10)$$

with $\mathcal{V}_t^F$ the marginal value of a match for a firm and $\mathcal{V}_t^H$ the marginal value of a match for a worker. Since this marginal value is given in utility units, we multiply it by the Lagrange multiplier of the budgetary constraints, λ_t. Thus, the two parts of the surplus are expressed in consumption units. Finally, ϵ_t denotes the firm's bargaining power at date t. In line with our empirical measure of the worker's bargaining power, this parameter varies over time and across countries.

The solution to this problem lies in the hours and wage contracts that determine the equilibrium allocation of work.[7]

Wage contracts. We assume that unemployment benefits are indexed to real wage as: $b_t = \rho_t w_t h_t$, with ρ_t the average replacement rate. Hence, the equilibrium wage equation (the extensive labor supply), can be written as follows:

$$\underbrace{(1+\tau_{f,t})w_t h_t}_{\substack{\text{Marginal Cost} \\ \text{of an employee } (MCE)}} = (1-\epsilon_t) \underbrace{\left\{(1-\alpha)\frac{Y_t}{N_t} + S_t\right\}}_{\text{Bargained surplus } (BS)}$$

$$+\epsilon_t \left\{ \underbrace{(1+TW_t)\overbrace{(\Gamma^u - \Gamma_t^n)C_t}^{MRS(C/E)} + (1+\tau_{f,t})\overbrace{b_t}^{UB}}_{\text{Reservation wage } (RW)} \right\} \quad (11)$$

with the search costs S_t and the tax wedge TW_t given by:

[7] See Chéron and Langot (2004) for more details on the wage bargaining process in the neo-classical growth model with matching.

$$\begin{aligned} S_t &= \left\{ \left(1 - \frac{1+\tau_{f,t}}{1+\tau_{f,t+1}} \frac{1-\tau_{w,t+1}}{1-\tau_{w,t}} \frac{\epsilon_t}{\epsilon_{t+1}} \frac{1-\epsilon_{t+1}}{1-\epsilon_t}\right) \frac{1-s}{\Phi_t} \right. \\ & \left. + \left(\frac{1+\tau_{f,t}}{1+\tau_{f,t+1}} \frac{1-\tau_{w,t+1}}{1-\tau_{w,t}} \frac{\epsilon_t}{\epsilon_{t+1}} \frac{1-\epsilon_{t+1}}{1-\epsilon_t}\right) \frac{\Psi_t}{\Phi_t} \right\} \omega \\ 1+TW_t &= \frac{(1+\tau_{f,t})(1+\tau_{c,t})}{1-\tau_{w,t}} \end{aligned} \quad (12)$$

The marginal labor cost per employee (MCE) expresses the opportunity cost of working as the sum of the bargained surplus (BS) and the reservation wage (RW) . The BS is the sum of the employee's marginal productivity and the cost of the search activity[8] S. In turn, the value of the search cost is a function of the time-varying bargaining power and taxes. Furthermore, the RW is the sum of the marginal rate of substitution of consumption for employment $(MRS(C/E))$ and the unemployment benefits (UB).

Hours' contracts. Since we are assuming an efficient bargaining process, the equilibrium number of hours (the intensive labor supply) is determined jointly with employment. The equilibrium hours' contract equation is:

$$\underbrace{(1-\alpha)\frac{Y_t}{N_t h_t}}_{MPH} = \underbrace{\left\{\frac{(1+\tau_{f,t})(1+\tau_{c,t})}{1-\tau_{w,t}}\right\}}_{1+TW} \underbrace{\sigma(1-h_t)^{-1}C_t}_{MRS(C/H)} \quad (13)$$

In this expression, $MRS(C/H)$ denotes the marginal rate of substitution of consumption and leisure, and MPH the marginal product of one hour worked. Note that given the efficient bargain, these contracts are only affected by the different taxes.

Employment. Finally, after the wage bargaining process, the right to manage assumption leads the firms to hire a number of workers based on the bargained labor cost per employee. Thus, from the firm's optimal choice of vacancies (the extensive labor demand), the marginal return from an employee (MRE) can be written as the sum of the instantaneous and the intertemporal returns:

$$\underbrace{(1+\tau_{f,t})w_t h_t}_{MRE} = \underbrace{(1-\alpha)\frac{Y_t}{N_t}}_{\text{Instantaneous returns}} \underbrace{+ (1-s)\frac{\omega}{\Phi_t} - \left\{\frac{(1+\tau_{c,t})C_t}{\beta(1+\tau_{c,t-1})C_{t-1}}\right\}\frac{\omega}{\Phi_{t-1}}}_{\text{Intertemporal returns}} \quad (14)$$

[8] Note that in the simple case where bargaining power and taxes are constant over time, we simply have $S_t = \omega\theta$, with $\theta_t \equiv V_t/(1-N_t) = \Psi_t/\Phi_t$.

3.6 Equilibrium on the labor market

Equilibrium is characterized by the hours' contracts, equation (13), and for the equality between the marginal cost of employment, equation (11), and its marginal return, equation (14). These equations show that taxes, unemployment benefits and bargaining power affect the intensive and extensive margins in different ways, i.e.,

$$MPH_t = (1 + TW_t)MRS(H/C)_t, \tag{15}$$

$$MRE_t = MCE_t \tag{16}$$

3.7 Labor wedges

Let Δ^h and Δ^n denote the labor wedges that result from computing the empirical counterparts of equations (15) and (16). The intensive margin wedge, Δ^h , will measure the gap between MPH and $MRS(C/H)$ that is produced using actual data. Similarly, the extensive margin wedge, Δ^n, will measure the gap between MCE and MRE. That is,

$$\begin{aligned} (1-\Delta_t^h)MPH_t|_{data} &= (1+TW_t|_{data})MRS_t(H/C)|_{data} \\ \Leftrightarrow \quad \Delta_t^h &= 1-(1+TW_t|_{data})\frac{MRS_t(H/C)|_{data}}{MPH_t|_{data}} \\ MRL_t|_{data} &= (1-\Delta_t^n)\times MCL_t|_{data} \\ \Leftrightarrow \quad \Delta_t^n &= 1-\frac{MCN_t|_{data}}{MRN_t|_{data}} \end{aligned} \tag{17}$$

The closer the Δ series are to zero, the better the model accounts for the observed data. In other words, in order to evaluate its explanatory power we can think of this accounting exercise as if we were looking at the data through the lens of a theoretical model.

In the next section, we assess the performance of our search and matching model in explaining the observed dynamics of hours and employment. In order to measure the impact of each component of the tax/benefit system on the intensive and extensive margins, we compute the series for the labor wedges in different counterfactual exercises.

4. Accounting exercise: Looking at data through the lens of the search economy

In this section, we test the explanatory power of our search economy through an accounting procedure based on counterfactual experiences. In all cases, the wedge series are obtained using the actual data for the variables described in the Appendix A.

4.1 Parameterization

We take standard values for the structural parameters: $\alpha = 0.4$ and $\sigma = 2$ (Ohanian *et al.*, 2008). The discount parameter is such that $\beta = 0.985$. The elasticity of the matching function with respect to vacancies is equal to $\psi = 0.6$. The ratio of aggregate recruiting expenditures to output ($\omega_t V_t / Y_t$) is 1% (Chéron and Langot, 2004). We set ω equal to the mean over time and across countries.

The specificities of each country with respect to the separation process are summarized in a unique parameter: the job separation rate s. For each country i we calibrate these job destruction rates in order to reproduce average unemployment. This is done as follows: Using data for employment $N_{i,t}$ and unemployment $U_{i,t}$, we can compute the series of job destructions, $D_{i,t}$ and job creations, $M_{i,t}$, as:

$$\begin{aligned} D_{i,t} &= s_i N_{i,t-1} \\ M_{i,t} &= p_{i,t} U_{i,t-1} \end{aligned} \tag{18}$$

where p_i is the inverse of the average unemployment spell. Moreover, we have that:

$$M_{i,t} = N_{i,t} - N_{i,t-1} + D_{i,t} \tag{19}$$

Thus, we deduce that:

$$s_i = 1 + \frac{p_{i,t} U_{i,t-1} - N_{i,t}}{N i, t-1} \tag{20}$$

The average unemployment spells and corresponding destruction rates are summarized in Table 3.[9]

[9] Unfortunately, the OECD data on Average duration of unemployment only cover two of the countries of our sample (Finland and United States).

Furthermore, for average tax rates on consumption and labor income we use the time series constructed by McDaniel (2007), though we extend these until 2013 using the Mendoza et al. (1994) method[10], while the payroll tax rates are deduced from the OECD data on wages and salaries and compensation of employees. Finally, as was explained above, workers' bargaining power, $1-\epsilon$, is set as the average of union coverage and union density, while the unemployment benefits are directly related to the average replacement rate (see Appendix A).

Table 3: Unemployment duration and the job separation rate

Country	Belgium	Spain	France	Italy	Netherlands
$\frac{1}{p}^{*}$ (months)	23	41	20	30	20.5
s^{**} (%)	5.72	6.15	6.10	5.80	3.60

Country	Austria	Finland	Sweden	United Kingdom	United States
$\frac{1}{p}^{*}$ (months)	7	7	5	10	2.5
s^{**} (%)	5.49	16.09	13.39	10.40	30.48

**Source: Blanchard and Portugal (2001). The authors construct monthly flows into unemployment as the average number of workers unemployed for less than one month, during the period 1985-1994, divided by the average labor force during the same period. The source of these data is the OECD duration database. Unemployment duration is constructed as the ratio of the average unemployment rate for the period 1985-1994 to the flow into unemployment.*
***Source: Author calculations using equation (20).*

4.2 Hours accounting

Since our theory predicts that the intensive margin wedge is only affected by taxes, we conduct a counterfactual exercise in which taxes are equal to zero. By comparing the resulting wedge with the case including taxes, we can assess the role of taxes in shaping the intensive margin.

4.2.1 Counterfactual exercise 1 (benchmark): taxes=0

By setting taxes equal to zero, we deduce from (17) that:

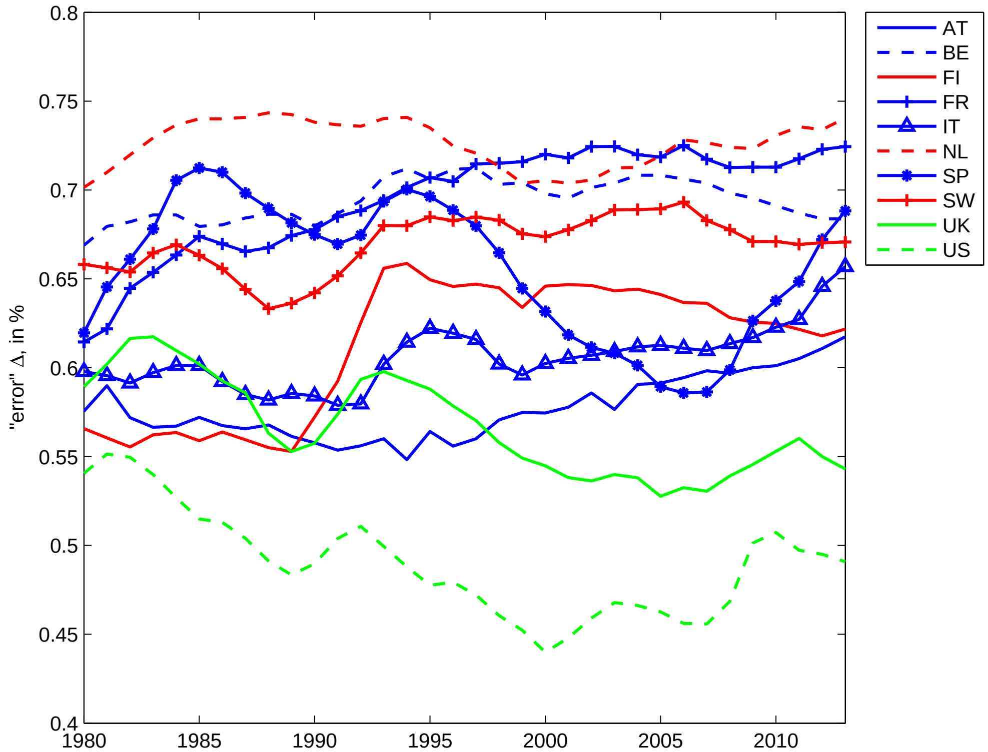
$$\Delta_t^{h,taxes=0} = 1 - \frac{MRS_t(H/C)|data}{MPH|data} \tag{21}$$

We expect that ignoring the effect of taxes leads to a larger wedge. The no-taxes-wedge series are reported in Figure 4. We can see that European countries,

[10] This is the same source as in Rogerson (2006) and Ohanian et al. (2008).

including the United Kingdom, show the largest gap between the theory and the data, since in all cases the intensive margin wedges are above 50%. In contrast, the labor wedge in the United States is lower and shows a decreasing trend until around 2000, when the tendency turns upwards, though the wedge is lower at the end of the period than at the beginning.

Figure 4, Hours Wedge (Taxes=0)



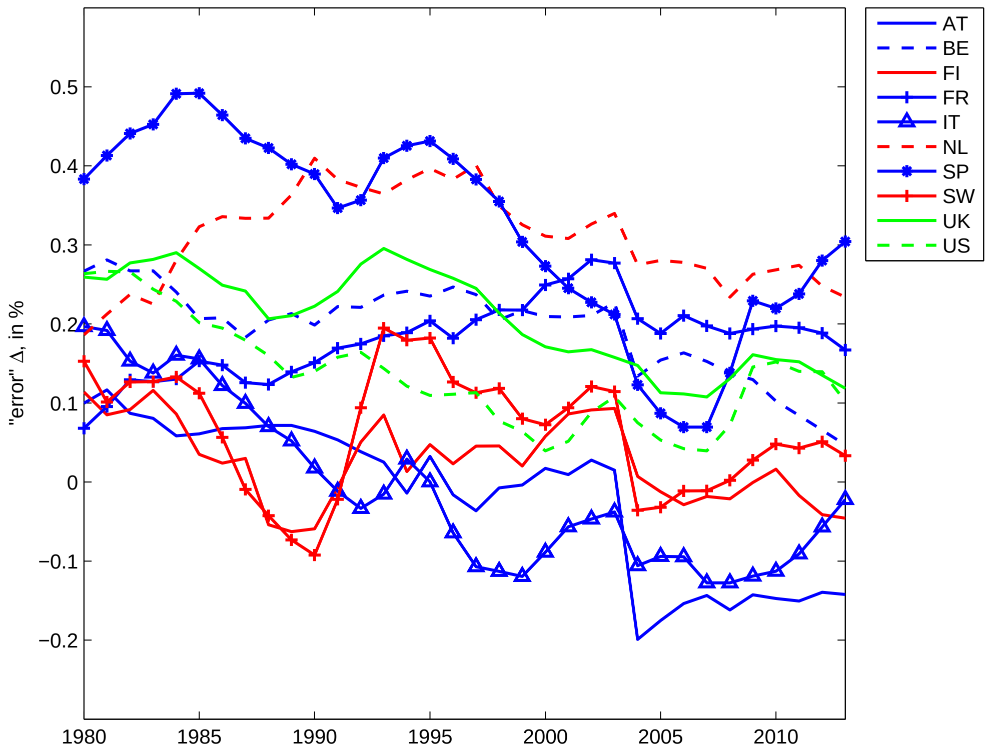
Source: First equation in expression (17) evaluated using actual data for the period 1980-2013 (see Appendix A for details) Taxes' refers to the average tax rates on consumption (τ_c), labor income (τ_w) and payroll (τ_f).

4.2.2 Counterfactual exercise 2: taxes>0

In this case, we obtain the wedge series, Δ_t^h, by evaluating the first equation in (17). Similar to previous results in literature (Prescott, 2004; Rogerson, 2006, Ohanian et al., 2008) we find that when the distortive effect of taxes is taken into account, the model better explain the observed data. That is, $\Delta_t^{h,taxes=0} > \Delta_t^h$.

In other words, the labor wedges are largely reduced in all countries, as is shown in Figure 5. The global picture seems support the view that taxes are a main factor explaining the dynamics of the intensive margin. However, in some cases, as in Italy and Austria after 2003, the wedge values fall below zero. This could be interpreted as an over estimation of the role of taxes in the model.

Figure 5, Hours Wedge (Taxes>0)



Source: First equation in expression (17) evaluated using actual data for the period 1980-2013 (see Appendix A for details). Taxes' refers to the average tax rates on consumption (τ_c), labor income (τ_w) and payroll (τ_f).

4.3 Employment accounting

In order to evaluate the impact of each distortion on the employment wedge, we conduct four counterfactual exercises. In the first, we introduce only search costs in the measure of the marginal return of employment. This setting is taken as the benchmark. According to our theory, this would produce the largest wedge. In the second counterfactual exercise, we consider only the effect of taxes, so that all other distortions (unemployment benefits and worker's bargaining power) are set as equal to zero. Conversely, in the third exercise, we consider only the effect of unemployment benefits and bargaining power, so that taxes are equalized to zero. Lastly, we look at the global impact of the tax/benefit system, in order to take into account the three sources of distortions in the model: taxes, unemployment benefits, and workers' bargaining power. This setting would produce the smallest wedge.

4.3.1 Counterfactual exercise 1 (benchmark)

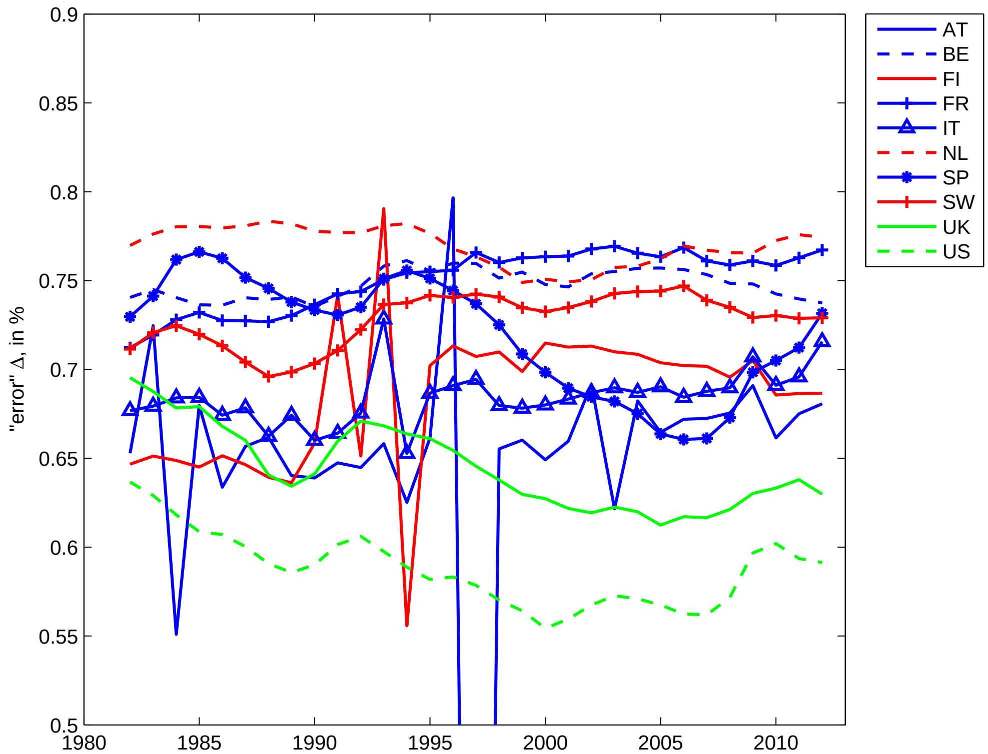
In our simple model, search costs are heterogeneous among countries given the country-specific patterns of labor market tightness (θ_t), and job-filling rate (Φ_t). If these are the only source of distortions (that is, if $\tau_{w,t} = \tau_{c,t} = \tau_{f,t} = 0$, $\rho = 0$,

$1-\epsilon=0$, $\omega>0$ and $s=E_i s_i>0$), we expect the model to produce the largest employment wedges, since we only take into account the fact that the search is a costly process, and ignore the heterogeneity among countries with respect to taxes and other LMI. Consequently, the wage contract is reduced to the reservation wage, and all countries have the same structural parameters. Formally, equations (11) and (14) become

$$\begin{aligned} MCE_t &= RW_t = MRS(C/N)_t \\ MRE_t &= (1-\alpha)\frac{Y_t}{N_t} + (1-s)\frac{\omega}{\Phi_t} - \frac{C_t}{\beta C_{t-1}}\frac{\omega}{\Phi_{t-1}} \end{aligned} \tag{22}$$

Using this and the second equation in (17) we compute the employment wedge and denote it by $\Delta^{n,0}$.

Figure 6, Employment Wedge (benchmark) when Taxes=0 and LMI=0



Source: Second equation in expression (17) evaluated using actual data for the period 1980-2013 (see Appendix A for details). Austria exhibits an outlier in 1995. In this year the value of the wedge is -0.2638. Taxes refers to the average tax rates on consumption (τ_c), labor income (τ_w), and payroll (τ_f). LMI denotes unemployment benefits, and workers' bargaining power.

Figure 6 confirms our intuition: the extensive margin wedges are very large for all countries. Nevertheless, we note that wedges are lower in the Anglo-Saxon countries than in the mainland European countries. A plausible interpretation of this is that, since the unemployment rate is significantly smaller in the Anglo-Saxon countries, the search costs for firms are higher. Equivalently, the value of a productive job in those countries is relatively higher than in the other. Conversely, in economies with high unemployment, the search costs afforded by firms are lower because it is easier for the firm to fill a job.

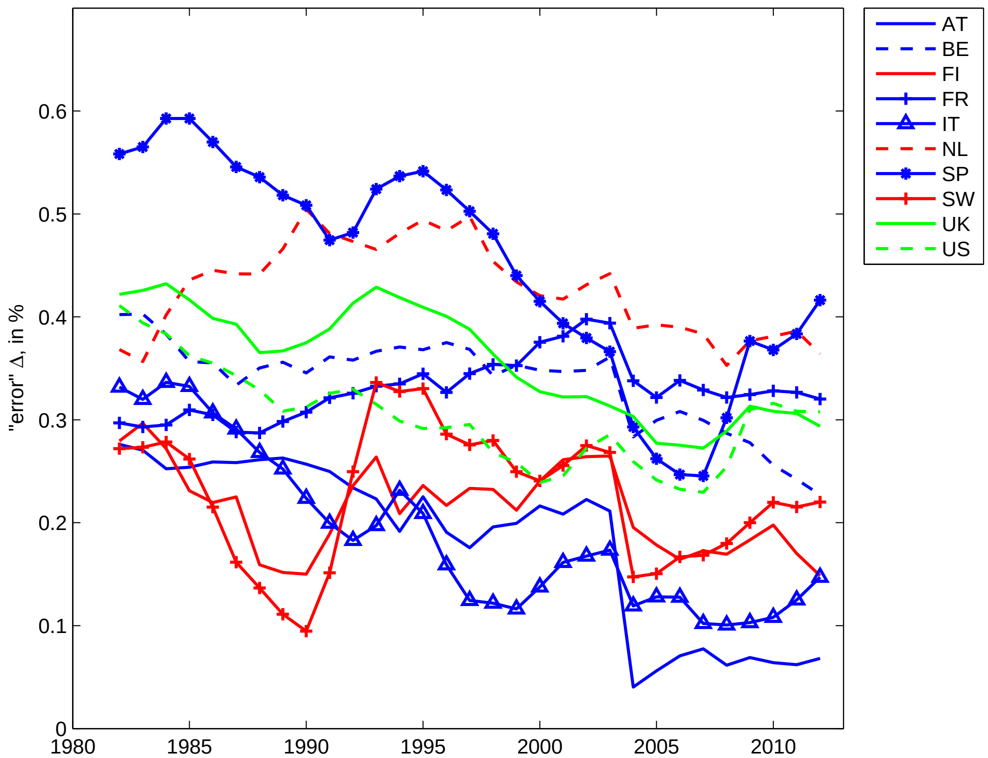
4.3.2 Counterfactual exercise 2

In this case, we consider the distortion coming from taxes in the model, i.e., we compute the employment wedge from (17) by setting $\tau_{c,t} > 0$, $\tau_{w,t} > 0$, $\tau_{f,t} > 0$, $b_t = 0$, $\omega = 0$ and $\epsilon_t = 1$. This experiment aims to shed light on the relative weight of taxes in the observed employment dynamics. In this case, workers have no bargaining power (since $1 - \epsilon_{i,t} = 0$) and, given that the unemployment benefits are equal to zero, the reservation wage is simply the marginal rate of substitution between employment and consumption, net of taxes. Finally, if the search is a costless process ($\omega = 0$), there are not intertemporal returns from labor. This configuration allows us to assess both the impact of the different tax systems across countries, and the relative weight of taxes with respect to the labor market institutions in shaping employment behavior. Under these assumptions, equations (11) and (14) become:

$$\begin{aligned} MCE_{i,t} &= (1 + TW_{i,t}) MRS(C/N)_{i,t} \\ MRE_{i,t} &= (1 - \alpha) \frac{Y_{i,t}}{N_{i,t}} \end{aligned}$$

Using this and (17) we compute the employment wedge and denote it by $\Delta^{n,taxes>0}$.

Figure 7, Employment Wedge (counterfactual 2) when Taxes>0 and LMI=0



Source: Second equation in expression (17) evaluated using actual data for the period 1980-2013 (see Appendix A for details). Taxes refers to the average tax rates on consumption (τ_c), labor income (τ_w), and payroll (τ_f). LMI denotes unemployment benefits, and workers' bargaining power.

Results are shown in Figure 7. Compared with the benchmark, we observe that in all cases, wedges are lower, since by taking into account the effect of taxes, we are reducing the gap between the theory and the real economy. However, the ordering in the size of wedges changes, which suggests that the mainland European countries are more sensitive to the effect of taxes than the Anglo-Saxon countries are.

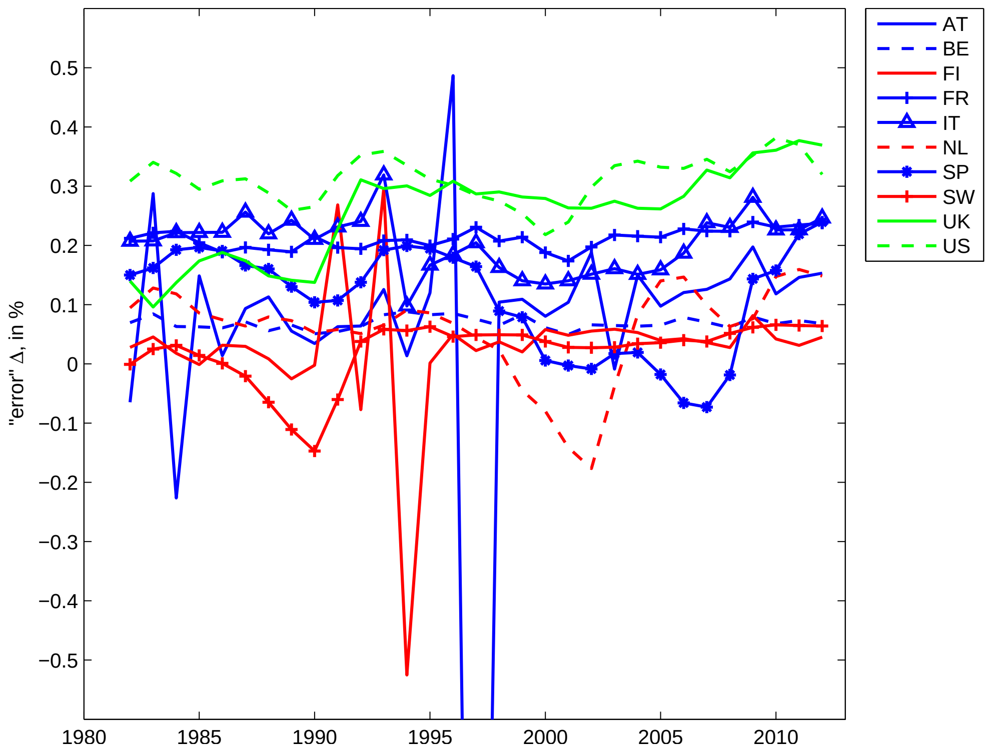
4.3.3 Counterfactual exercise 3

In contrast to the previous scenario, in this case we abstract from taxes and consider only the effect of the other labor market institutions on the extensive margin. That is, we set $\tau_{w,t} = \tau_{c,t} = \tau_{f,t} = 0$, $\rho_{i,t} > 0$, $\epsilon_{i,t} > 0$, $\omega > 0$ and $s_i > 0$. Hence equations (11) and (14) become

$$\begin{aligned} MCE &= (1-\epsilon_t)\left\{(1-\alpha)\frac{Y_t}{N_t} + S_t\right\} + \epsilon_t \left\{MRS(C/E)_t + UB_t\right\} \\ MRE &= (1-\alpha)\frac{Y_t}{N_t} + (1-s)\frac{\omega}{\Phi_t} - \left\{\frac{C_t}{\beta C_{t-1}}\right\}\frac{\omega}{\Phi_{t-1}} \end{aligned}$$

Then, we compute the employment wedge from (17) and denoted it by $\Delta^{n,LMI>0}$.

Figure 8, Employment Wedge (counterfactual 3) when Taxes=0 and LMI>0



Source: Second equation in expression (17) evaluated using actual data for the period 1980-2013 (see Appendix A for details). Austria exhibits an outlier in 1995. In this year the value of the wedge is -2.2386. Taxes refers to the average tax rates on consumption (τ_c), labor income (τ_w), and payroll (τ_f). LMI denotes unemployment benefits, and workers' bargaining power.

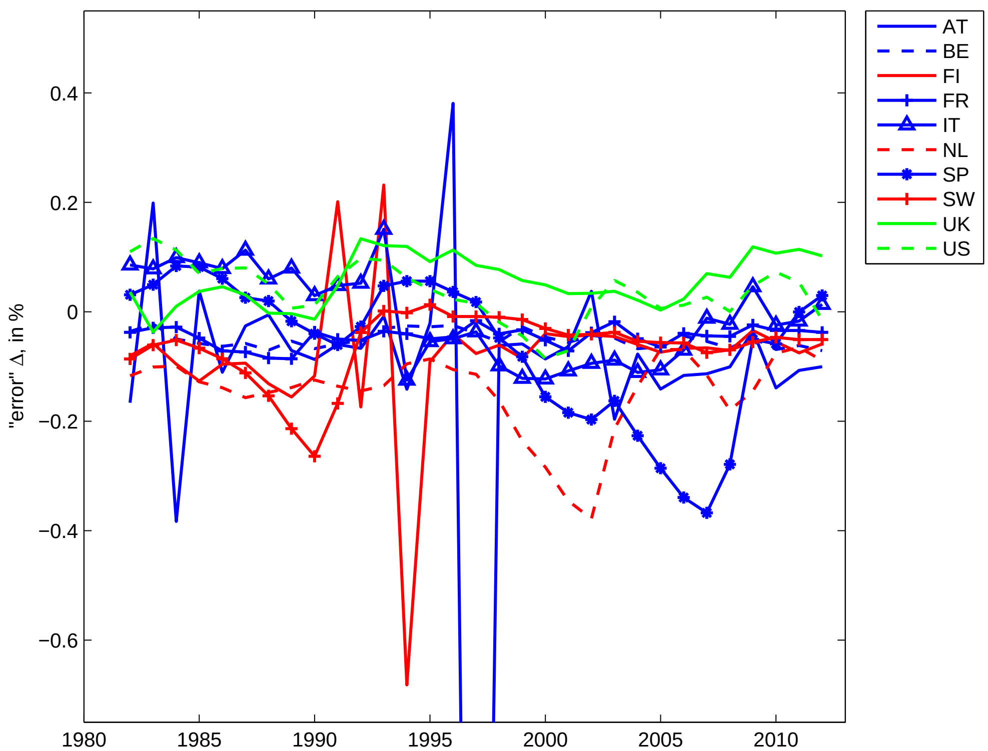
Results are reported in Figure 8. Based on the reductions in the employment wedges compared with the benchmark, the effect of the country-specific LMI seems larger than the effect of taxes: in most European countries the employment wedge approaches zero, particularly in the Northern European countries, Austria and Belgium, while the smallest impact of these indicators seems to be in the Anglo-Saxon countries. In other words, when the labor indicators point to the existence of high real rigidities, the introduction of such variables into the theoretical model largely improves its fit.

4.3.4 Counterfactual exercise 4: All distortions at work

Once we have assessed the role of each labor market rigidity, we conclude this accounting exercise by considering all of the sources of heterogeneity in the model simultaneously. In doing this, we evaluate the explanatory power of our search model to account for the observed differences among countries, when the country-specific tax/benefit systems are accounted for. Therefore, we set $\tau_{c,t} > 0$, $\tau_{f,t} > 0$, $\tau_{w,t} > 0$; $1 - \epsilon_t > 0$, $UB_t > 0$, $s > 0$ and $\omega > 0$.

The resulting labor wedge series, $\Delta^{n,all}$, are reported in Figure 9. In general, since all of the effects are at work, this setting leads to the best fit of the model, given that the wedges are more concentrated around zero in all countries. In other words, it would appear that $\Delta^{n,0} > \Delta^{n,taxes>0}, \Delta^{n,LMI>0}, \Delta^{n,all}$.

Figure 9, Employment Wedge (counterfactual 4) when Taxes>0 and LMI>0



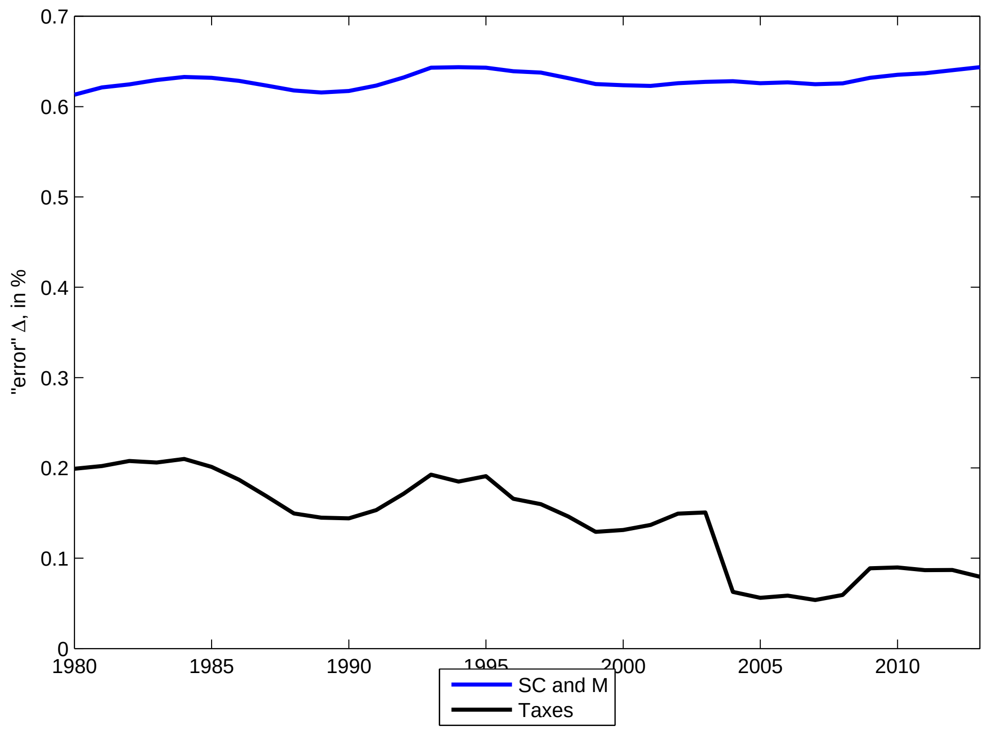
Source: Second equation in expression (17) evaluated using actual data for the period 1980-2013 (see Appendix A for details). Austria exhibits an outlier in 1995. In this year the value of the wedge is -2.9470. Taxes refers to the average tax rates on consumption (τ_c), labor income (τ_w), and payroll (τ_f). LMI denotes unemployment benefits, and workers' bargaining power.

4.3.5 Summing up: Average wedges

To close our accounting exercise, we look at the abridged view provided by the average wedges across all counties in each scenario. We first analyze the intensive margin. From Figure 10 we deduce that the introduction of the tax dynamics (the black line) results in a reduction in the average intensive margin wedge to less than 30% its value without taxes (the blue line). This reduction is even greater at the end of the period.

Since the empirical wedges provide us with a measure of the gap between the theory and the observed data, we can conclude that, on average, the search economy is able to explain between 80% (beginning of the period) and 90% (end of the period) of the observed dynamics of the intensive margin.

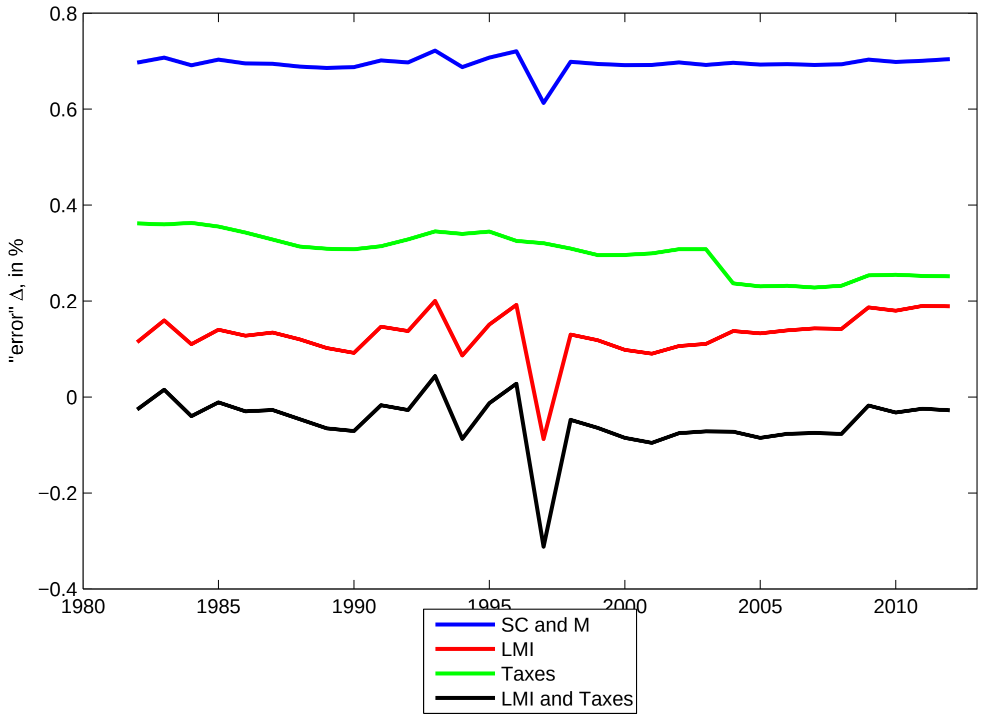
Figure 10, Mean Wedges – Hours Worked per Employee



Source: Average from the various scenarios.

We now turn to the extensive margin. From Figure 11 we can confirm that the lowest average wedges are obtained when the model incorporates both taxes and labor market institutions (the black line). In contrast, the largest average wedges correspond to the model evaluated without the tax/benefit variables (the blue line). In the middle, we observe that average wedges are reduced by a half when the model incorporates only the various taxes considered (the green line), and by even more when the model controls for the other labor market institutions only (the red line).

Figure 11, Mean Wedges - Employment Rate



Source: Average from the various scenarios.

5. Summary and conclusion

The aggregate hours of market work in the ten OECD countries of our sample exhibit large trend differences over the period 1980-2013. We also document the differences observed in the two components of this aggregate measure: the average hours worked per employee (intensive margin) and the employment rate (extensive margin) over the period. Previous literature has highlighted the role of distortive taxation in explaining the observed differences in the aggregate work effort, through their effects on the intensive margin. However, an important feature of the data since the 1980s is that the differences across countries in aggregate work effort also seem to be due to quantitatively important differences along the extensive margin, and to the labor market institutions that affect it.

Therefore, the aim of this paper is to assess the extent to which the observed differences in aggregate work efforts are due to the varied impact of country-specific labor market institutions on each margin. To this end, we develop a search and matching model in which the intensive margin is distinguished from the extensive margin. Moreover, the model incorporates a tax/benefit system consisting of taxes on consumption, labor income, and payroll, unemployment benefits and the bargaining power of workers. Then, the model is quantitatively evaluated over the period 1980-2013 using an accounting procedure inspired by Ohanian et al. (2008).

The results of our counterfactual exercises show that taxes explain to a large extent the dynamics of the intensive margin. In turn, the dynamics of the extensive margin are well accounted by the model when it includes all of the distortions from the tax/benefit system. However, it would seem that labor market institutions other than taxes play the greatest role in shaping the employment rate. In other words, we show that, for the ten countries of the sample, our search economy is able to explain the patterns of the two margins of aggregate hours worked over the period 1980-2013, when it includes the cross-country heterogeneity of the labor market institutions. Since these empirical results come from a unified framework, they also provide strong support for the search and matching models.

Our results also raise two important issues for further research. On the one hand, it would be interesting to test the performance of the model in rationalizing the labor wedge at the business cycle frequencies, according to the methodology proposed by Chari et al. (2007). On the other, throughout this paper we abstract from the participation decision, yet this margin could also be highly sensitive to tax and transfer programs. For instance, a large tax on continued activity is likely to discourage participation in the labor market through early retirement (Hairault, Langot and Sopraseuth 2008).

A last word concerns our collection of labor market indicators: Average tax rate estimates were computed using a national accounts approach, in order to make these comparable with previous studies. It would be interesting to test the robustness of the model to alternative measures of tax rates based other methods (if any). Furthermore, we used average union density and union coverage as a proxy for the bargaining power of workers. Further research is needed in order to improve this indicator. Similarly, since the employment wedges would be sensible to changes on the average unemployment spell, it would be advisable to build actualized data on the average unemployment spell for all countries in our sample. Finally, the model assumes that taxes and other labor market institutions have orthogonal effects. This is another interesting issue to be explored.

References

Bassanini A., Duval R. (2006), 'Employment Patterns in OECD Countries: Reassesing the Role of Policies and Institutions', *OECD Social, Employment and Migration Working Papers*, **4(35)**.

Blanchard O., Portugal P. (2001), 'What Hides behind an Unemployment Rate: Comparing Portuguese and U.S. Labor Markets', *American Economic Review,* **91(1)**, 187–207.

Chari V., Kehoe P., McGrattan E. (2007), 'Business Cycle Accounting', *Econometrica*, **75(3)**, 781–836.

Costain J., Reiter M. (2008), 'Business cycles, unemployment insurance, and the calibration of matching models', *Journal of Economic Dynamics and Control*, **32(4)**, 1120-1155.

Chéron A., Langot F. (2004), 'Labor market search and real business cycles: reconciling Nash bargaining with the real wage dynamics', *Review of Economic Dynamics*, **7**, 476–493.

Daveri F., Tabellini G. (2000), 'Unemployment, growth and taxation in industrial countries', *Economic Policy*, **15(30)**, 47–104.

Diamond P. (1982), 'Aggregate Demand Management in Search Equilibrium', *Journal of Political Economy*, **90(5)**, 881-894.

Galí J., Gertler M., Lopez-Salido D. (2007), 'Markups, Gaps, and the Welfare Costs of Business Fluctuations', *Review of Economics and Statistics*, **89(826)**, 44–59.

Hansen G. (1985), 'Indivisible labor and the business cycle', *Journal of Monetary Economics*, **16**, 309-328.

Hairault J.O., Langot F., Sopraseuth T. (2008), 'Quantifying The Laffer Curve On The Continued Activity Tax In A Dynastic Framework', *International Economic Review*, **49(3)**, 755-797.

Langot F., Quintero Rojas C. (2009), 'European vs American Hours Worked: assessing the role of the extensive and intensive margins', *Economics Bulletin*, **29(2)**, 530-542.

Ljungqvist L., Sargent T. (2007a), 'Understanding European unemployment with a representative family model', *Journal of Monetary Economics*, **54(8)**, 2180–2204.

Ljungqvist L., Sargent T. (2007b), 'Understanding European unemployment with matching and search-island models', *Journal of Monetary Economics*, **54(8)**, 2139–2179.

Ljungqvist L., Sargent T. (2008), 'Two Questions about European Unemployment', *Econometrica*, **76(1)**, 1–29.

McDaniel C. (2007), *Average tax rates on consumption, investment, labor and capital in the OECD 1950-2003*, mimeo.

Mendoza E., Razzin A., Tessar L. (1994), 'Effective tax rates in macroeconomics: Cross-country estimates of tax rates on factor incomes and consumption', *Journal of Monetary Economics*, **34**, 297–323.

Mortensen D. (1970), 'A Theory of Wage and Employment Dynamics', in Phelps E. (ed.), *Microeconomic Foundations of Employment and Inflation Theory*, Macmillan.

Ohanian L., Raffo A., Rogerson R. (2008), 'Long-term changes in labor supply and taxes: Evidence from OECD countries, 1956-2004', *Journal of Monetary Economics*, **55**, 1353-1362.

Pissarides C. (1985), 'Short-Run Equilibrium Dynamics of Unemployment, Vacancies, and Real Wages', *American Economic Review*, **75(4)**, 676-690.

Prescott E. (2004), 'Why do Americans work so much more than Europeans?', *Federal Reserve Bank of Minneapolis Quarterly Review*, **28(1)**, 2–13.

Quintero Rojas C. (2009), 'Hours Worked: Explaining Cross-Country Differences through the Effects of Tax/Benefit Systems on the Employment Rate', *Annals of Economics and Statistics*, **93/94**, 79-102.

Rogerson R. (1988), 'Indivisible Labor, Lotteries and Equilibrium', *Journal of Monetary Economics*, **21**, 3-16.

Rogerson R. (2004), 'Two views on the deterioration of European labor market outcomes', *Journal of the European Economic Association (Papers and Proceedings)*, **2**, 447-455.

Rogerson R. (2006), 'Understanding differences in hours worked', *Review of Economic Dynamics*, **9**, 365–409.

Rogerson R., Wallenius J. (2009), 'Micro and macro elasticities in a life cycle model with taxes', *Journal of Economic Theory*, **144**, 2277–2292.

Shimer R. (2005), 'The Cyclical Behavior of Equilibrium Unemployment and Vacancies', *American Economic Review*, **95(1)**, 25-49.

Shimer R. (2009), 'Convergence in Macroeconomics: The Labor Wedge', *American Economic Journal: Macroeconomics*, **1(1)**, 280–297.

Appendix A. Data sources and methodology

A.1 Data from AMECO, European Commission

AMECO is the annual macro-economic database of the European Commission's Directorate General for Economic and Financial Affairs (DG ECFIN). Variables from this source are (the theoretical counterpart is indicated in parentheses):

Employment, persons; total economy (N)

Annotation: Persons in employment are those who during the reference week did any work for pay, or were not working but had jobs from which they were temporarily absent. Family workers are included. Data refer to the national concept; annual average.

AMECO-code: NETN

Primary source: National Accounts; National, OECD or Eurostat.

Average annual hours worked per person employed (h)

AMECO-code: NLHA

Primary source: National, OECD or Eurostat.

Population: 15 to 64 years (L)

Annotation: working age population.

AMECO-code: NPAN

Primary source: Population statistics; National, OECD or Eurostat.

Private final consumption expenditure at current prices (C)

Annotation: Private final consumption expenditure refers to the expenditure on consumption of goods and services of households and non-profit institutions serving households. Goods and services financed by the government and supplied to households as social transfers in kind are not included.

Sector affected: Households (S.14) + Non-profit institutions serving households (S.15)

AMECO-code: UCPH

Primary source: National Accounts; Eurostat or National

Final consumption expenditure of general government at current prices (G)

Annotation: Final consumption expenditure of general government

= Individual consumption of general government

+ Collective consumption of general government.

Sector affected: General government (S.13)

AMECO-code: UCTG

Primary source: National Accounts; Eurostat or National

Gross domestic product at current market prices (Y)

Annotation: Sector affected: Total economy (S.1)

AMECO-code: UVGD

Primary source: National accounts; Eurostat or National

Compensation of employees

Annotation: Domestic concept, included are residents as well as non-residents working for resident producer units. Compensation of employees includes wages and salaries (D.11) and employers' social contributions (D.12). Sector affected: Total economy (S.1)

AMECO-code: UWCD

Primary source: National Accounts; Eurostat or National

Compensation of employees; general government

Annotation: Compensation of employees includes wages and salaries (D.11), and employers' social contributions (D.12). Sector affected: General government (S.13)

AMECO-code: UWCG

Primary source: National accounts; Eurostat or National

Gross wages and salaries; households and NPISH

Annotation: Gross wages and salaries *received* by resident households. Sector affected: Households (S.14)

AMECO-code: UWSH

Primary source: National Accounts; Eurostat or National

Non-labour income; households and NPISH

Annotation: Non-labour income of households (S.14) and non-profit institutions serving households (S.15) is the sum of: Gross operating surplus (B.2g) and mixed income (B.3g) + Net property income (D.4). Net property income is property income receivable, *minus* property income payable.

AMECO-code: UYOH

Primary source: National Accounts; Eurostat or National

A.2 Data from the OECD

The tax revenue data are from the OECD Revenue Statistics:

1100 taxes on income, profits and capital gains of individuals or households.

2000 Total social security contributions.

2200 Social security contributions paid by employers.

3000 Taxes on payroll and workforce.

5110 General taxes on goods and services.

5121 Taxes on specific goods and services: excise taxes.

Benefit entitlements are from the OECD Benefits and Wages Statistics:

Average gross unemployment benefit replacement rate (arr)

Gross replacement rates express gross unemployment benefit levels as a percentage of previous gross earnings. The OECD summary measure used is defined as the average of the gross unemployment benefit replacement rates for two earning levels (100% and 67% of APW or AW earnings), three family situations (single, with dependent spouse, with spouse in work) and three durations of unemployment (1st year, 2nd and 3rd years, and 4th and 5th years of unemployment).

Original data are available only for uneven years. Data for even years are obtained by linear interpolation.

Finally, data for the union density and union coverage are from the OECD and the ICTWSS database by J. Visser[11]:

Union density

This measure refers to the share of workers affiliated to a trade union, in %. Data for missing years are obtained by linear interpolation.

Union coverage

This measure refers to the share of workers covered by a collective agreement, in %. Data for missing years are obtained by linear interpolation.

[11] ICTWSS: Database on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts in 34 countries between 1960 and 2012. Author: Jelle Visser - Amsterdam Institute for Advanced Labour Studies (AIAS) University of Amsterdam.

A.3 Tax rates estimates

We used the same sources for taxes on labor income and consumption as Ohanian et al. (2008), for the period 1980-2003.[12] These series were extended to 2013 using the Mendoza's et al. (1994) method. That is:

Tax ratio on labor income (τw)

The labor income tax rate is computed as:

$$\tau_w = \frac{\tau_h . UWSH + 2000 + 3000}{UWSH + 2200}$$

where τ_h represents the tax ratio for total household income, computed as:

$$\tau_h = \frac{1100}{UYOH + UWSH}$$

Tax ratio on consumption (τc)

The tax rate on consumption is computed as:

$$\tau_c = \frac{5110 + 5121}{UCPH + UCTG - UWCG - 5110 - 5121}$$

Payroll tax (τf)

Finally, we approximated the payroll tax from the average between the compensation of employees and the wages and salaries, as follows:

$$\tau_f = \frac{UWCD}{UWSH} - 1$$

[12] Source: McDaniel (2007).