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WORKING PAPER

Cross-country differences in unemployment: fiscal policy, unions and household preferences in general equilibrium

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First version: February 2015
This version: July 2015

2015/899

D/2015/7012/01

Cross-country differences in unemployment: fiscal policy, unions and household preferences in general equilibrium

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July, 2015

Abstract

We develop and parameterize an overlapping generations model that explains hours worked, education, and unemployment within one coherent framework. We extend previous work in this tradition by introducing individuals with heterogeneous ability to acquire human capital and a unionized labour market for lower ability workers. Unemployment is due to above market-clearing wages for these workers. Our calibrated model's predictions match the facts remarkably well in a sample of continental European, Nordic and Anglo-Saxon countries. We then use the model to explain the cross-country variation in unemployment. A Shapley decomposition reveals an almost equal role for differences in fiscal policy variables and in union preferences. Both account for about half of the explained variation in unemployment rates. While it is the above market-clearing wage chosen by the unions that directly leads to unemployment, the fiscal policy variables determine most of its magnitude. As to specific fiscal variables, differences in unemployment benefit generosity play a much more important role than tax differences. Controlling for fiscal variables and union preferences, any differences in the taste for leisure of the households have no role to play in determining cross-country variation in unemployment.

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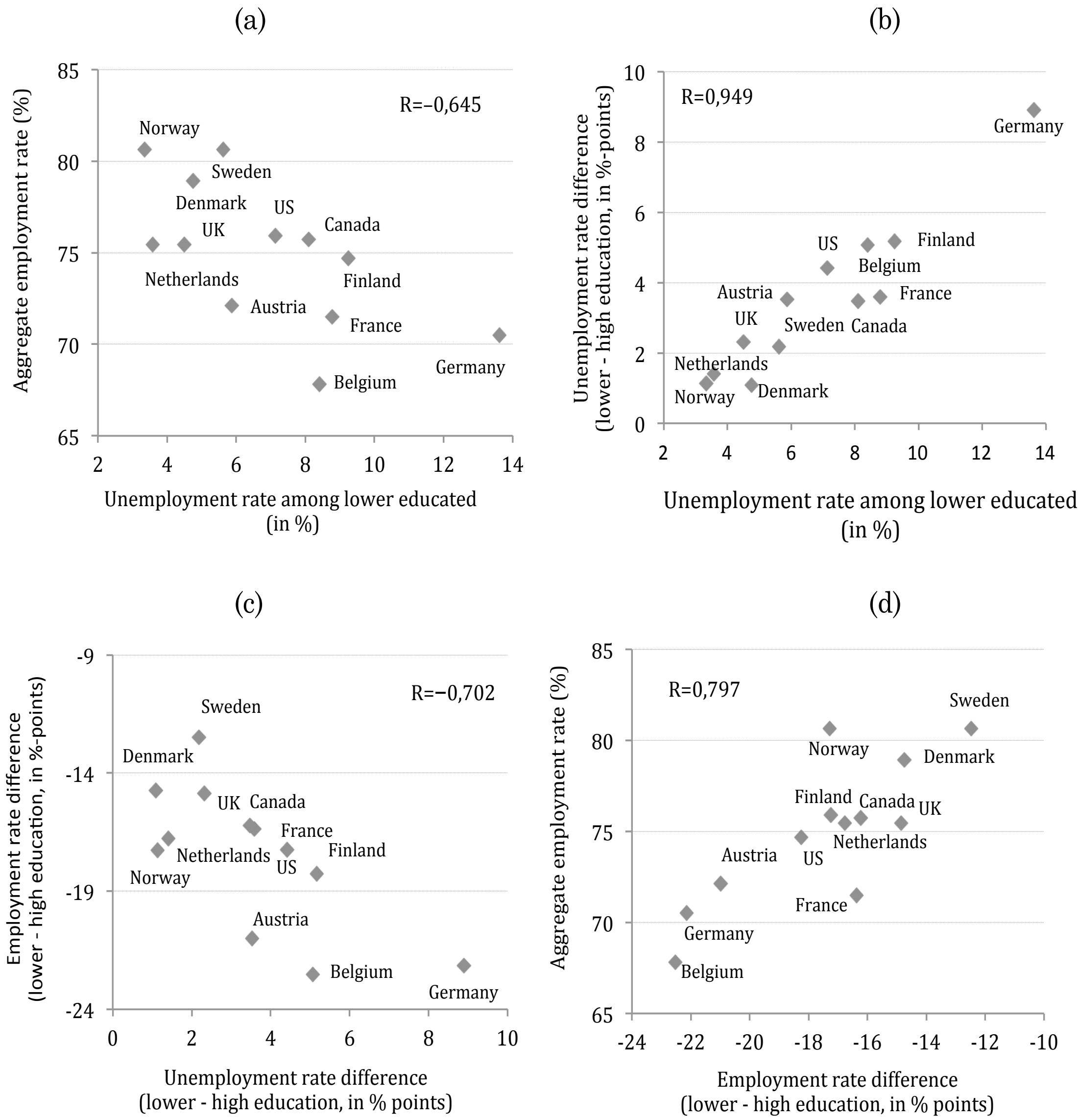
1 Introduction

Labour market performance differs widely across OECD countries. Since about a decade many researchers have built gradually richer general equilibrium models to account for these differences. Initial contributions by Prescott (2004), Rogerson (2007), Dhont & Heylen (2008), Ohanian *et al.* (2008) and Olovsson (2009) tried to explain differences in aggregate per capita hours worked. Later work introduced a life-cycle dimension in labour supply and employment in order to explain also the huge cross-country differences in employment among persons older than 50 (see Prescott *et al.* (2009), Rogerson & Wallenius (2009), Erosa *et al.* (2012), and Alonso-Ortiz (2014)). Another advantage of introducing a life-cycle dimension is that it became possible to model the time allocation of young people between labour and education, and to explain human capital formation as an endogenous variable (see e.g. Ludwig *et al.* (2012); Heylen & Van de Kerckhove (2013); Wallenius (2013)).

Despite the enormous progress that has been made in this literature, one clear weakness has not been dealt with. A striking observation in all the aforementioned models is their assumption of a perfectly competitive labour market. They cannot explain equilibrium unemployment, let alone the huge and persistent differences in unemployment between for example high and lower educated individuals. Yet, as demonstrated in Figure 1 for 12 OECD countries in 2001-2007, cross-country differences in unemployment - in particular unemployment among lower educated individuals - explain a significant fraction of cross-country differences in aggregate employment. Panel (a) reveals a strong negative correlation. We observe the highest aggregate employment rates in countries which are relatively successful in avoiding unemployment among lower educated individuals, like Denmark, Norway and Sweden. By contrast, countries that fail in fighting unemployment among the lower educated, like Belgium and Germany, also show relatively bad aggregate employment performance. The other panels in Figure 1 reveal a number of interesting other regularities, which will guide us later in this paper. Panel (b) establishes the fact that almost all cross-country variation in the gap between the unemployment rates of lower and high educated individuals is due to variation in the unemployment rate among the lower educated. Correlation in this panel is almost 0.95. Countries vary much less when it comes the labour market situation of the high educated. (Correlation between the unemployment rate among individuals with a tertiary degree and the unemployment gap between the lower and the high educated is only 0.14). Panel (c) shows a strong inverse relationship between the unemployment gap and the employment gap between lower and high educated individuals. Finally, panel

Figure 1: Employment and unemployment in OECD countries, 2001-07.



Notes: We compute the (un)employment rate among lower educated individuals as the average of the (un)employment rates among individuals with less than upper secondary education and among individuals with upper secondary, but no tertiary degree. The (un)employment rate among individuals with higher education relates to those with a tertiary degree. Unless defined differently, all reported employment and unemployment rates concern the age group 25-64. Data sources: Eurostat (LFS series: lfsa_ergaed, lfsa_urgaed) and OECD Labour Force Statistics (Total Employment).

(d) reveals this employment gap as a strong driver of the aggregate employment rate. We conclude that if it is the objective of countries to raise aggregate employment, an important challenge will be to fight unemployment among lower educated individuals. The existing (dynamic) general equilibrium models for labour market analysis in the tradition of Prescott (2004) and Rogerson (2007) have no clear answer to deal with this challenge.

Next to excluding a potential role for labour imperfections, the above mentioned general equilibrium literature also leaves little room for differences in individual preferences across countries to show up. Blanchard (2004) and Alesina *et al.* (2005) have argued that a key factor behind the lower employment in many European countries compared to the US is a higher taste for leisure. Yet, the general equilibrium literature generally imposes the same preferences upon individuals.

Our contribution in this paper is to take the dynamic general equilibrium literature studying aggregate employment and employment over the life-cycle one step further and quantitatively explore which variables drive cross-country differences in unemployment among the lower ability individuals. More precisely, first, we develop a five generations OLG model for a small open economy, which explains not only hours worked and human capital formation within one coherent framework, but also equilibrium unemployment among lower educated individuals. Two assumptions are key. The first one is the assumption that individuals are heterogeneous by ability. They enter the model with different human capital stocks and have different capacity to build more human capital. This approach may offer the best match to recent findings by Huggett *et al.* (2006), Huggett *et al.* (2011) and Keane & Wolpin (1997) that heterogeneity in human capital endowment at young age and in learning abilities, rather than shocks to human capital, account for most of the variation in lifetime utility. Our second assumption and key novelty compared to previous work in this tradition is the assumption of a unionized labour market for lower ability (lower educated) individuals[1]. Like Faia & Rossi (2013), we introduce a monopolist firm-specific trade union that determines the real pre-tax wage for these workers while taking aggregate variables and fiscal policy parameters (e.g. tax rates, unemployment benefits) as given. We specify a Stone-Geary utility function for the union with both wages and employment as arguments, albeit with a different

[1]For higher ability workers we assume that wages and employment are determined in a perfectly competitive way. Several authors have provided empirical evidence that the effects of the presence of unions are much stronger for low skilled individuals than for the high skilled, e.g. through a higher union-non union wage premium among the low skilled workers. See e.g. Card (2001), Card *et al.* (2004), and Checci & García-Peñalosa (2008).

weight. As to wages, the firm-specific union only derives utility from the difference between the after-tax wage and a reference wage. Just like in de la Croix *et al.* (1996), we use a weighted average of different variables to model the reference wage. These variables are the after-tax wage that would prevail if the lower ability labour market were competitive, the after-tax wage of higher ability workers and the unemployment benefit. The first variable is rather standard in the union literature. The unemployment benefit too is often used to model the reference wage which the union takes into account. We choose to include the wage of the higher ability individuals, as it might be a union target to reduce wage inequality. As such, we allow for a very flexible specification of the reference wage. The monopoly union chooses the wage in a first stage. In the next stage, the firm will choose employment (number of workers), while the households of lower ability individuals decide on the supply of hours per employed. Both the firm and the households take the wage set by the union as given.

The union wage-setting framework in our model is motivated by the observation that in Europe union wage bargaining is still the most common way of wage determination. While union membership rates have decreased over time, the coverage of collective bargaining is still at least 80% in most continental European countries and Nordic countries (Du Caju *et al.* (2008)). Also, despite the fact that unions are not that powerful in the US, there exists a form of minimum wage in the US. As such, a union pushing the wage above its perfectly competitive counterpart might be a valid assumption for all countries to introduce unemployment.

Firms in our model act competitively on the goods market. Furthermore, building on earlier work in Heylen & Van de Kerckhove (2013), we introduce a government with a rich set of fiscal policy instruments. Government spending on goods and unemployment benefits are financed by taxes on labour, capital and consumption. As to labour taxes, we distinguish between taxes paid by the employer and the employees[2]. Another novelty is the modelling of progressive income taxes paid by the households. We follow the approach used by Guo & Lansing (1998) and Koyuncu (2011). Lump sum transfers ensure a balanced budget.

We then use our model to investigate the main drivers of the differences in labour market performance across OECD countries, in particular unemployment. A large range of variables play a role in the model. To find out which of these matter most, our

[2]In a perfect labour market situation, whether labour taxes are levied on workers or firms does not matter for the cost of labour, nor for after-tax wages and employment. However, as Heijdra & Ligthart (2009) argue, it is not immediately clear whether the same result holds in imperfectly competitive labour markets. We therefore choose to distinguish explicitly between the two.

procedure is as follows. First, we calibrate our model and show its empirical relevance for twelve countries belonging to three groups (five continental European countries, four Nordic countries and three Anglo-Saxon countries). More precisely, we simulate our calibrated model for each country imposing common technology on all countries, but country-specific fiscal policy parameters and country group-specific household and union preferences. We find that the predictions of our model match the main facts in most countries. These facts concern hours worked per employed person in different age groups and the unemployment rate. Having established its empirical reliability, we then use the model to find out what policy or preference parameters account for the cross-country differences in the aggregate unemployment rate. Our objective is similar to the one of Dhont & Heylen (2008), Wallenius (2013) and Alonso-Ortiz (2014) in earlier work. We make progress by also explicitly testing the potential explanatory power of labour market imperfections, different union preferences in particular, and different tastes for leisure of the households. Performing a Shapley decomposition, we find an almost equal role for differences in fiscal policy variables and in union preferences. Both account for about half of the explained variation in unemployment rates across countries. By contrast, any differences in the households' taste for leisure play virtually no role. Our story will then be that the above market-clearing wage chosen by the unions is the source of unemployment, while the fiscal policy variables explain a significant part of the magnitude of unemployment. Going into greater detail on the fiscal side, we find that the key variable driving cross-country differences in unemployment of lower ability individuals is the unemployment benefit replacement rate. In the Nordic countries and (even more) the continental European countries, this has a significant impact on the reference wage of the union. This is not a surprising result. In the search and matching literature, higher replacement rates often lead to higher unemployment rates (see e.g. Ljungqvist & Sargent (2007)). On the empirical side, our results are in line with e.g. Nunziata (2005), Bassanini & Duval (2009), and Nymoen & Sparrman (2015). The second most important fiscal policy variable is government spending on goods. We find no contribution, however, from differences in labour taxes to account for cross-country unemployment variation on a interregional level.

Several earlier contributions have made an attempt to introduce unemployment in OLG models. Daveri & Tabellini (2000), Corneo & Marquardt (2000), and Ono (2010) among others developed OLG models with a unionized labour market, while Ravn & Sørensen (1999), Cahuc & Michel (1996) and Sommacal (2006) introduced minimum wages. Other authors embed a search and matching setup in a life-cycle model, e.g. Bean & Pissarides (1993) and de la Croix *et al.* (2013). We make progress compared to this literature along two dimensions. First, most of the models incorporating unions in a life-cycle model, leave the intensive margin of employment (i.e. hours worked) unexplored. Individuals supply one unit of labour inelastically. However, hours of work per employed person are substantially lower in most European countries than in the Anglo-Saxon countries. Therefore, in the search for a realistic setting, models resembling the European labour markets should be such that both the extensive and intensive margin of employment are endogenous. Second, to the best of our knowledge, all the existing OLG models where unions are present are populated by only two generations, which means that they lack a life-cycle dimension of labour supply.

The structure of this paper is as follows. In Section 2, we describe the basic setup of our model. Section 3 discusses optimal behaviour of unions, households and firms, and how this drives hours worked, unemployment and real output. Section 4 presents our calibration procedure and data on all exogenous parameters. In Section 5 we test and show the empirical validity of our model for 12 OECD countries as described above. Finally, in Section 6 we investigate the relative importance of institutional and (household and union) preference related variables versus several fiscal policy variables to explain differences across countries in the unemployment rate. Section 7 concludes.

2 The model: setup, preferences and constraints

Time is discrete and runs from 0 to infinity. We assume a small open economy populated by five overlapping generations of households, firms, unions and a fiscal government. Individual members of the household enter the model at the age of 18 and live for five periods j of 12 years. Individuals have either high or low innate ability. Those with higher ability enter the model with high human capital and also have the capacity to pursue tertiary education. Those with lower ability enter with low human capital. They will not spend time in further education. We assume that households have only higher or lower ability members, but not both. Both the goods market and the labour market for higher ability individuals are competitive, whereas the labour market for lower ability individuals is unionized. In every period t, wages for lower ability workers are set by a monopoly union at the firm level. The government in our model disposes of a rich set of fiscal policy instruments. Government spending on goods and unemployment benefits are financed by taxes on capital, labour and consumption. Taxes on labour income are non-linear. There is no uncertainty.

In the following sections, we discuss preferences and constraints of households (2.1), firms (2.2), unions (2.3) and the government (2.4).

2.1 Households

In the spirit of Merz (1995) and Andolfatto (1996), we assume a number of households each consisting of a continuum of members of the same age and the same ability. Each household has unitary mass. We normalise the number of households of a given age and ability type to one. Therefore, the economy consists of 10 households in total. All members pool their income, meaning that consumption across household members is the same. As such there is perfect insurance within the household against the risk of unemployment. A household that enters the model in period t (a household of generation t) is denoted with a superscript t. Subscripts are reserved for the age j $\in (1, 2, 3, 4, 5)$ and the ability type a $\in (H, L)$. Hence, n_{2H}^{t+1} denotes the fraction of time devoted to labour services by a member of a higher ability family who is in the second period of life and who started active life in period t+1. As a short introduction, we present here a short overview of the model structure with respect to the households:

Table 1: Life-cycle of a member of a higher ability household of generation t

Time	t	$t+1$	$t+2$	$t+3$	$t+4$
Hours worked	n_{1H}^t	n_{2H}^t	n_{3H}^t	n_{4H}^t	0
Education	e_{1H}^t	0	0	0	0
Participation rate	1	1	1	1	0
Unemployment rate	0	0	0	0	0
Employment rate	1	1	1	1	0
Leisure time	$1 - n_{1H}^t - e_{1H}^t$	$1 - n_{2H}^t$	$1 - n_{3H}^t$	$1 - n_{4H}^t$	1

Table 2: Life-cycle of a member of a lower ability household of generation t

Time	t	$t+1$	$t+2$	$t+3$	$t+4$
Hours worked when employed	n_{1L}^t	n_{2L}^t	n_{3L}^t	n_{4L}^t	0
Education	0	0	0	0	0
Participation rate	1	1	1	1	0
Unemployment rate	$u_{1,t}$	$u_{2,t+1}$	$u_{3,t+2}$	$u_{4,t+3}$	0
Employment rate	$1 - u_{1,t}$	$1 - u_{2,t+1}$	$1 - u_{3,t+2}$	$1 - u_{4,t+3}$	0
Leisure time when employed	$1 - n_{1L}^t$	$1 - n_{2L}^t$	$1 - n_{3L}^t$	$1 - n_{4L}^t$	1

1. Table 1 represents the detailed life-cycle of a member of the higher ability household of generation t. Members of this household enter the model with a human capital

stock h^t_{1H}. They have a time endowment of one in each period which they can devote to work, education when young, or leisure. During four active periods (age j = 1,2,3,4), all these individuals are employed on a perfectly competitive labour market. During the fifth period (j=5), they are retired. The household chooses an optimal consumption path, the optimal amount of non-human wealth, the time each indidivual devotes to education when young and the amount of hours each member supplies labour.

2. Table 2 represents the detailed life-cycle of a member of the lower ability household of generation t. Members of this household enter with a human capital stock $h^t_{1L} < h^t_{1H}$. Just like their higher ability counterparts, they have a time endowment of one. A fraction $1 - u_{j,t+j-1}$ of all lower ability individuals of generation t at age j will be employed in period $t + j - 1$, the others are (involuntarily) unemployed. Lower ability individuals do not pursue tertiary education. Employed members devote time to either work or leisure, unemployed members only have leisure. The household chooses an optimal consumption path, the optimal amount of non-human wealth and the amount of time the employed members supply labour.

2.1.1 Higher ability households

Lifetime utility of the higher ability household of generation t is given by

$$u^t_H = \sum_{j=1}^{5} \beta^{j-1} \left(\ln c^t_{jH} + \gamma_j \frac{(1 - e^t_{jH} - n^t_{jH})^{1-\theta}}{1-\theta} \right), \tag{1}$$

with $0 < \beta < 1$, $\gamma_j > 0$, $\theta > 0$ ($\theta \neq 1$) and where $e^t_{2H} = e^t_{3H} = e^t_{4H} = e^t_{5H} = n^t_{5H} = 0$. In this equation, β represents the discount factor, γ_j is an age-specific parameter determining the value of leisure relative to consumption and $\frac{1}{\theta}$ is the intertemporal elasticity of substitution in leisure. The household's budget constraints are given by (2),(3) and (4). Income is derived from labour, non-human wealth and lump sum transfers from the government. It is allocated to either consumption or savings.

$$(1 + \tau_c)c^t_{1H} + \Omega^t_{1H} = w_{H,t}\varepsilon_1 h^t_{1H}(n^t_{jH} - \bar{n}_H)(1 - \tau_{1H}) + z_t. \tag{2}$$

$$(1 + \tau_c)c^t_{jH} + \Omega^t_{jH} = w_{H,t+j-1}\varepsilon_j h^t_{jH}(n^t_{jH} - \bar{n}_H)(1 - \tau_{jH}) + (1 + r_{t+j-1})\Omega^t_{j-1,H} + z_{t+j-1}, \quad j \in (2, 3, 4) \tag{3}$$

$$(1 + \tau_c)c_{5H}^t = (1 + r_{t+4})\Omega_{4H}^t + z_{t+4} \tag{4}$$

Employed individuals earn an after-tax wage of $w_{H,t+j-1}\varepsilon_j h_{jH}^t(n_{jH}^t - \bar{n}_H)(1 - \tau_{jH})$, where $w_{H,t+j-1}$ is the pre-tax real wage per unit of effective labour, ε_j is an age-specifc productivity parameter, and τ_{jH} is the average tax rate on labour. Due to our modelling of a progressive labour income tax system, tax rates depend on individuals' ability and age. We specify the tax system in greater detail below. Individuals endogenously choose the fraction of time endowment n_{jH}^t they allocate to labour services. The effective labour time they supply is $n_{jH}^t - \bar{n}_H$. As in Prescott *et al.* (2009), Rogerson & Wallenius (2009) and Wallenius (2013), we assume that if an individual with human capital stock h_{jH}^t devotes a fraction n_{jH}^t of his/her time to the labour market, this will yield $(n_{jH}^t - \bar{n}_H)h_{jH}^t$ units of effective labour market services. A fraction $\bar{n}_H$ is not productive due to e.g. commuting and getting setup in a job. As such, we model the fact that the firm prefers employing few people who work more hours rather than many people who work few hours. As to other variables, we denote the lump sum transfer from the government at time t by z_t. The consumption tax rate is τ_c. The households' accumulated non-human wealth at the end of their jth period of life is Ω_{jH}^t. Households enter the model without wealth and leave no bequests.

2.1.2 Lower ability households

In the spirit of the previous subsection, we again consider a large household, consisting of a continuum of lower ability members. Again, the decision unit is the household. The key difference is that in this household only a fraction $1 - u_{j,t+j-1}$ of the individuals is employed. A fraction $u_{j,t+j-1}$ is unemployed. Hence, $u_{j,t+j-1}$ represents the aggregate unemployment rate among the lower ability individuals of generation t at age j and time t+j-1. The household derives utility from consumption, while it only enjoys utility from the leisure of each employed member[3]. Thus, lifetime utility of the household of lower ability individuals of generation t is given by

$$u_L^t = \sum_{j=1}^{5} \beta^{j-1} \left(\ln c_{jL}^t + \gamma_j (1 - u_{j,t+j-1}) \left[\frac{(1 - n_{jL}^t)^{1-\theta}}{1 - \theta} \right] \right) \tag{5}$$

where $n_{5L}^t = 0$. Highly similar to the previous subsection, the household's budget

[3] A similar utility function is now widely used in business cycle models with search and matching frictions, e.g. Tomas (2008). Note that we assume that the leisure of the unemployed members is neutral in terms of utility.

constraints are given by (6), (7) and (8). Again, we assume that all members of the household pool their income:

$$(1+\tau_c)c_{1L}^t + \Omega_{1L}^t = w_{L,t}\varepsilon_1 h_{1L}^t(1-u_{1,t})(n_{1L}^t - \bar{n}_L)(1-\tau_{1L}) + \tilde{B}_1 + z_t \tag{6}$$

$$(1+\tau_c)c_{jL}^t + \Omega_{jL}^t = w_{L,t+j-1}\varepsilon_j h_{jL}^t(1-u_{j,t+j-1})(n_{jL}^t - \bar{n}_L)(1-\tau_{jL}) + \tilde{B}_j + (1+r_{t+j-1})\Omega_{j-1,L}^t + z_{t+j-1}, \quad j \in (2,3,4) \tag{7}$$

$$(1+\tau_c)c_{5L}^t = (1+r_{t+4})\Omega_{4L}^t + z_{t+4} \tag{8}$$

For the fraction $u_{j,t+j-1}$ of its members who are unemployed, the household receives a non-employment benefit, equal to a fraction $\tilde{b}_j$ of the after-tax labour income that these individuals would receive if they were employed. Formally,

$$\tilde{B}_1 = \tilde{b}_1 w_{L,t}\varepsilon_1 h_{1L}^t(n_{1L}^t - \bar{n}_L)(1-\tau_{1L})u_{1,t} \tag{9}$$

and

$$\tilde{B}_j = \tilde{b}_j w_{L,t+j-1}\varepsilon_j h_{jL}^t(n_{jL}^t - \bar{n}_L)(1-\tau_{jL})u_{j,t+j-1}. \tag{10}$$

The household takes both the unemployment benefit and the unemployment rate as given, when choosing consumption, savings and the supply of working hours. Note that, due to the progressivity of labour income taxes, lower ability households will face a different tax rate than higher ability households ($\tau_{jL} < \tau_{jH}$).

2.1.3 Human capital

Individuals enter our model at the age of 18 with a predetermined level of human capital. This level is generation-invariant, but higher for individuals with high innate ability. The latter reflects for example higher intelligence and greater capacity to learn and accumulate knowledge at primary and secondary school. In Equation (11) we normalize the human capital of a young individual with high ability to h_0. A young individual with low ability enters the model with only a fraction $\epsilon_L h_0$. This fraction will be calibrated.

$$h_{1a}^t = \epsilon_a h_0, \quad a \in (H, L) \tag{11}$$

with

$$0 < \epsilon_L < \epsilon_H = 1. \tag{12}$$

During youth, individuals with high ability will invest a fraction of their time in tertiary education. They accumulate more human capital, making them more productive in later periods. We adopt in Equation (13) a human capital production function similar to Lucas (1990), Glomm & Ravikumar (1998) and Bouzahzah *et al.* (2002). The production of new human capital by these individuals rises in the amount of time they allocate to education (e^t_{1H}) and in their initial human capital (h^t_{1H}). The parameter σ indicates the elasticity of time input, ϕ is an efficiency parameter. Individuals with low innate ability do not study. In Equation (14) their human capital remains constant. Finally, we assume in Equation (15) that the human capital of all individuals remains unchanged after the second period. A rationale for this assumption is that learning-by-doing in work may counteract depreciation. The same assumption explains the lack of depreciation in Equations (13) and (14).

$$h^t_{2H} = h^t_{1H}(1 + \phi(e^t_{1H})^\sigma) \tag{13}$$

$$h^t_{2L} = h^t_{1L} \tag{14}$$

$$h^t_{4a} = h^t_{3a} = h^t_{2a}, \quad a \in (H, L) \tag{15}$$

with $0 < \sigma \leq 1, \phi > 0$.

2.2 Firms

Both the goods market and the labour market for higher ability individuals are perfectly competitive, whereas the labour market for lower ability individuals is unionized. All firms are identical. They maximize profits, pay taxes on capital income and social security contributions when hiring labour. Total domestic output is given by the production function (16). Production exhibits constant returns to scale in aggregate physical capital (K_t) and labor in efficiency units ($A_t H_t$). Given our assumption of perfect competition on the goods market, profits are zero in equilibrium.

$$Y_t = K^\alpha_t (A_t H_t)^{1-\alpha} \tag{16}$$

Technology A_t is growing at an exogenous and constant rate x: $A_{t+1} = (1 + x)A_t$. As to total effective labour H_t, we assume that higher and lower ability individuals are imperfectly substitutable in production. This framework was pioneered by Katz & Murphy (1992) and Borjas (2003). So,

$$H_t = \left[\eta H_{H,t}^{\frac{\iota-1}{\iota}} + (1-\eta) H_{L,t}^{\frac{\iota-1}{\iota}}\right]^{\frac{\iota}{\iota-1}} \tag{17}$$

with η being a share parameter and ι the elasticity of substitution between higher and lower ability labour. Furthermore, workers of the same ability type but different age are assumed to be perfect substitutes. Formally,

$$H_{H,t} = \sum_{j=1}^{4} (n_{jH}^{t-j+1} - \bar{n}_H)\varepsilon_j h_{jH}^{t-j+1} \tag{18}$$

$$H_{L,t} = \sum_{j=1}^{4} (1 - u_{j,t})(n_{jL}^{t-j+1} - \bar{n}_L)\varepsilon_j h_{jL}^{t-j+1} \tag{19}$$

2.3 Unions

The economy is populated by decentralized trade unions, operating at the firm level. Every single union represents all the lower ability workers in a firm. As such, unions are large compared to the workers. The union will determine the lower ability workers' wage while taking aggregate variables and fiscal policy parameters as given. Just like in e.g. Pencavel (1984) and de la Croix *et al.* (1996), the objective function of the unions follows the Stone-Geary specification,

$$V_t = \sum_{j=1}^{4} \left[\frac{1}{\chi_j} (w_{L,t}(1 - \tau_{jL}) - \bar{w}_{j,t})^{\chi_j} (1 - u_{j,t}) \right] \tag{20}$$

with $\chi_j > 0$. The union derives utility from both wages and employment, albeit to a different degree[4]. As to wages, what matters is the difference between the after-tax wage $w_{L,t}(1 - \tau_{jL})$ and a reference wage, $\bar{w}_{j,t}$. The age-specific parameter χ_j measures the concavity with respect to the excess wage gap. The higher χ_j, the higher the preference of the union for wages versus employment for the age group j, i.e. the more jobs it is

[4]As mentioned by Pemberton (1988), the Stone-Geary specification can represent a 'managerial' model of the trade union, treating the objectives of the union as the outcome of a conflict or bargain between the members of the union and the leaders of the union. The model of Pemberton can be situated in the Ross-Dunlop controversy about whether trade unions should be seen as 'economic' (Dunlop (1944)) or 'political' (Ross (1948)) institutions. The former author argued that unions 'maximise (or minimise) something' (1944, p. 4). The latter author saw unions as political organisations, meaning that the behaviour of the union reflects the internal conflicts between different fractions. In the managerial model of Pemberton (1988), these two views are merged. The members of the union care about higher wages represented by the former term, the leaders of the union are interested in the number of members, i.e. the employment rate at the firm. In the past, the functional form of the Stone-Geary was criticised for lacking strong microeconomic foundations. However, as already mentioned, in the model of Pemberton (1988), this specification reconciles the preference of the workers for higher wages with the preference of the union leaders for a higher membership.

willing to give up for a higher wage. Every union has the same reference wage. We define this as a weighted average or combination of the after-tax wage that would prevail if the lower ability labour market were competitive, the after-tax wage of higher ability workers and the unemployment benefit. The respective weights are ϱ_1, ϱ_2 and $\varrho_3\,(= 1-\varrho_1-\varrho_2)$. They sum up to 1. Formally,

$$\bar{w}_{j,t} = \varrho_1 w^c_{L,t}(1-\tau^c_{jL}) + \varrho_2 w_{H,t}(1-\tau_{jH}) + \varrho_3 \tilde{b}_j w_{L,t}(1-\tau_{jL})$$

At the beginning of each period t, in the first stage the monopoly union decides on the pre-tax wage, knowing that in the next stage the firm and the household decide on the extensive and intensive margin of employment. Both individuals and the firms take the wage set by the monopoly union as given. Moreover, as they move simultaneously, they take the action of the other player as given. Therefore, the union maximizes its utility subject to the optimality conditions of both the household and the firm. Once the wage has been determined, the firm decides on the extensive margin (number of employees of low ability) and the household on the intensive margin (hours worked per employed).

2.4 Government

Government expenditures on unemployment benefits and government spending on goods are financed by taxes on capital, labour (both on employers and employees) and consumption. Lump sum transfers ensure a balanced budget. Formally, the government budget constraint is given by

$$G_t + B_t + Z_t = T_{nt} + T_{kt} + T_{ct} \tag{21}$$

$$\text{with:} \begin{cases} G_t = gY_t \\ B_t = B_{L,t} \\ Z_t = 10z_t \\ T_{nt} = T_{nH,t} + T_{nL,t} \\ T_{kt} = \tau_k \alpha Y_t \\ T_{ct} = \tau_c \sum_{j=1}^{5}(c^{t+1-j}_{jH} + c^{t+1-j}_{jL}) \end{cases} \tag{22}$$

And

$$B_{L,t} = \sum_{j=1}^{4} \tilde{b}_j w_{jL,t} \varepsilon_j h_{jL}^{t+1-j} (n_{jL}^{t+1-j} - \bar{n}_L)(1 - \tau_{jL}) u_j^t \tag{23}$$

$$T_{nH,t} = \sum_{j=1}^{4} w_{jH,t} (n_{jH}^{t+1-j} - \bar{n}_H) \varepsilon_j h_{j,H}^{t+1-j} (\tau_{jH} + \tau^p) \tag{24}$$

$$T_{nL,t} = \sum_{j=1}^{4} w_{jL,t} (1 - u_{j,t})(n_{jL}^{t+1-j} - \bar{n}_L) \varepsilon_j h_{jL}^{t+1-j} (\tau_{jL} + \tau^p) \tag{25}$$

where τ_{ja} is the average tax rate that applies to the labour income of an individual of age j and ability a and τ_j^p is the tax rate paid by the employer. What remains is the specification of progressive income taxes. The tax rates appearing in the budget constraints of the households are average tax rates and are given by

$$\tau_{ja} = \Gamma \left(\frac{y_{ja,t}^{lab}}{\bar{y}_t^{lab}} \right)^{\xi} \text{ with } a = (H, L), \xi \geq 0, 0 < \Gamma \leq 1 \tag{26}$$

where $y_{ja,t}^{lab}$ is total pre-tax labour income of the household of age j and ability a at time t and $\bar{y}_t^{lab}$ is the average total labour income in the economy. Just like in Guo & Lansing (1998) and Koyuncu (2011), the parameters ξ and Γ govern the level and slope of the tax schedule. The average tax rate τ_{ja} increases with the total taxable labour income of the household when $\xi > 0$. In previous work, ξ was equal to 0, meaning that all households faced the same average tax rate. Households are aware of the progressive structure of the tax system when making decisions, but take this as given. As such, they do take into account that the tax rate determining their after-tax income increases in labour income. The marginal tax rate τ_{ja}^m is then simply the rate applied to the last euro earned:

$$\tau_{ja}^m = (1 + \xi) \Gamma \left(\frac{y_{ja,t}^{lab}}{\bar{y}_t^{lab}} \right)^{\xi} \tag{27}$$

Rewriting this yields

$$\frac{\tau_{ja}^m}{\tau_{ja}} = 1 + \xi \tag{28}$$

This means that the marginal tax rate is higher than the average tax rate when $\xi > 0$, i.e. the tax schedule is said to be progressive. When $\xi = 0$, the average and marginal tax rates coincide.

3 Optimisation and Equilibrium

3.1 Households

3.1.1 Higher ability households

The maximization problem of the higher ability households boils down to:

$$\max_{\Upsilon_H} \quad u_H^t = \sum_{j=1}^{5} \beta^{j-1} \left[\ln c_{jH}^t + \gamma_j \frac{\left(1 - e_{jH}^t - n_{jH}^t\right)^{1-\theta}}{1-\theta} \right]$$

s.t. the household budget constraints and the human capital accumulation process, while taking fiscal policy variables, the wage and the interest rate as given. The vector Υ_H of decision variables is $[\Omega_{1H}^t, \Omega_{2H}^t, \Omega_{3H}^t, \Omega_{4H}^t, n_{1H}^t, n_{2H}^t, n_{3H}^t, n_{4H}^t, e_{1H}^t]$. Optimisation yields the following first order conditions guiding the optimal consumption path (29), the labour-leisure choice (30, 31) and the optimal time allocation to education (32):

$$\frac{c_{j+1,H}^t}{c_{jH}^t} = \beta(1 + r_{t+j}), \quad j \in (1,2,3,4) \tag{29}$$

$$\frac{\gamma_1}{(1 - n_{1H}^t - e_{1H}^t)^\theta} = \frac{w_{H,t}\varepsilon_1 h_{1H}^t (1 - \tau_{1H}^m)}{(1 + \tau_c) c_{1H}^t} \tag{30}$$

$$\frac{\gamma_j}{(1 - n_{jH}^t)^\theta} = \frac{w_{H,t+j-1}\varepsilon_j (1 + \phi(e_{1H}^t)^\sigma) h_{1H}^t (1 - \tau_{jH}^m)}{(1 + \tau_c) c_{jH}^t}, \quad j \in (2,3,4) \tag{31}$$

$$\frac{\gamma_1}{(1 - n_{1H}^t - e_{1H}^t)^\theta} = \beta \frac{1}{c_{2H}^t} \frac{\partial c_{2H}^t}{\partial e_{1H}^t} + \beta^2 \frac{1}{c_{3H}^t} \frac{\partial c_{3H}^t}{\partial e_{1H}^t} + \beta^3 \frac{1}{c_{4H}^t} \frac{\partial c_{4H}^t}{\partial e_{1H}^t} \tag{32}$$

$$\text{with:} \quad \frac{\partial c_{jH}^t}{\partial e_{1H}^t} = \sigma \phi (e_{1H}^t)^{\sigma-1} \frac{w_{H,t+j-1}\varepsilon_j h_{1H}^t (1 - \tau_{jH}^m) \left(n_{jH}^t - \bar{n}_H \right)}{(1 + \tau_c)}, \quad j \in (2,3,4) \tag{33}$$

3.1.2 Lower ability households

For the lower ability individuals, the objective is to

$$\max_{\Upsilon_L} \quad u_L^t = \sum_{j=1}^{5} \beta^{j-1} \left[\ln c_{jL}^t + (1 - u_{j,t+j-1}) \gamma_j \frac{\left(1 - n_{jH}^t\right)^{1-\theta}}{1-\theta} \right]$$

s.t. the household budget constraints and the human capital accumulation process, while taking the unemployment rate, wages, the interest rate, taxes and the unemployment benefit as given. The vector Υ_L of decision variables is $\left[\Omega^t_{1L}, \Omega^t_{2L}, \Omega^t_{3L}, \Omega^t_{4L}, n^t_{1L}, n^t_{2L}, n^t_{3L}, n^t_{4L}\right]$. Optimisation yields the following first order conditions:

$$\frac{c^t_{j+1,L}}{c^t_{jL}} = \beta(1+r_{t+j}), \quad j \in (1,2,3,4) \tag{34}$$

$$\frac{\gamma_1}{(1-n^t_{1L})^\theta} = \frac{w_{L,t}\varepsilon_1 h^t_{1L}(1-\tau^m_{1L})}{(1+\tau_c)c^t_{1L}} \tag{35}$$

$$\frac{\gamma_j}{(1-n^t_{jL})^\theta} = \frac{w_{L,t+j-1}\varepsilon_j h^t_{1L}(1-\tau^m_{jL})}{(1+\tau_c)c^t_{jL}}, \quad j \in (2,3,4) \tag{36}$$

3.2 Firms

The representative firm in our model operates in a small open economy with perfect mobility of physical capital. In Section 2, we extensively described the nature of the labour market for lower ability individuals. Therefore, the problem every firm faces is somewhat different from previous work. It chooses the optimal capital stock and the total amount of effective higher ability labour, since there is no unemployment present on the latter market. However, on the labour market for lower ability individuals, the firm can only choose the fraction of persons it wants to employ, as the wage is chosen by the union and hours of work are chosen by the households. In terms of production, the firm prefers a combination of few people working more hours over a combination of many people working few hours, as each individual causes a time cost for commuting and getting setup in a job. Firms maximize profits with respect to the vector $[K_t, H_{1H,t}, H_{2H,t}, H_{3H,t}, H_{4H,t}, (1-u_{1,t}), (1-u_{2,t}), (1-u_{3,t}), (1-u_{4,t})]$, leading to the following first order conditions,

$$\alpha\left[\frac{A_t H_t}{K_t}\right]^{(1-\alpha)}(1-\tau_k) = r_t \tag{37}$$

$$(1-\alpha)A_t^{1-\alpha}\left[\frac{K_t}{H_t}\right]^\alpha \eta\left[\frac{H_t}{H_{H,t}}\right]^{\frac{1}{\iota}} = w_{H,t}(1+\tau^p) \tag{38}$$

$$(1-\alpha)A_t^{1-\alpha}\left[\frac{K_t}{H_t}\right]^\alpha (1-\eta)\left[\frac{H_t}{H_{L,t}}\right]^{\frac{1}{\iota}} = w_{L,t}(1+\tau^p) \tag{39}$$

where $H_{H,t}$ and $H_{L,t}$ are defined in equations (18) and (19). Equation (37) relates the after-tax marginal product of capital to the exogenous world interest rate, r_t. Due to the perfect mobility of capital, the firm will hire capital until its after-tax marginal product equals the exogenous world interest rate. There is no depreciation of capital. Whenever the net return to investment exceeds the world interest rate, capital will flow into the country until optimality is restored. Equations (38) and (39) are standard equations relating the marginal product of high and lower ability individuals to their total wage cost for the employer. Equation (39) implies that following a change in the supply of hours or the wage rate, the firms will change the unemployment rate to restore the equality between the marginal product of lower ability labour and the total wage cost.

Our assumptions of constant population and of individuals entering the model with a predetermined and generation-invariant level of human capital imply that in steady state effective labor will be constant. Physical capital, output and real wages by contrast will all grow at the exogenous technology growth rate x.

3.3 Union

The maximization problem of the union boils down to

$$\max_{w_{L,t}} \quad V_t = \sum_{j=1}^{4} \left[\frac{1}{\chi_j} (w_{L,t}(1-\tau_{jL}) - \bar{w}_{j,t})^{\chi_j} (1-u_{j,t}) \right] \tag{40}$$

$$\text{s.t.} \begin{cases} F(n_{jL}^{t-j+1}, 1-u_{j,t}, w_{L,t}) = (1-\alpha) A_t^{1-\alpha} \left[\frac{K_t}{H_t}\right]^{\alpha} (1-\eta) \left[\frac{H_t}{H_{L,t}}\right]^{\frac{1}{\iota}} - w_{L,t}(1+\tau_j^p) = 0 \\ G(n_{jL}^{t-j+1}, 1-u_{j,t}, w_{L,t}) = \frac{\gamma_j}{(1-n_{jL}^{t-j+1})^{\theta}} - \frac{w_{L,t}\varepsilon_j h_{jL}^{t-j+1}(1-\tau_{jL}^m)}{(1+\tau_c) c_{jL}^{t-j+1}} = 0 \end{cases}$$

with $j \in (1,2,3,4)$. To derive the first order condition, one has to know how the optimal unemployment rate resulting from the second stage of the game changes when the chosen wage changes. From the second stage, we derive a system of two implicit equations in the supply of hours worked, the unemployment rate, and the wage rate.

Using matrix notation, evaluating at the equilibrium values of the supply of hours worked, the unemployment rate, and the wage rate, and taking the total differential yields:

$$\begin{bmatrix} \frac{\partial F}{\partial n_{jL}^{t-j+1}} & \frac{\partial F}{\partial (1-u_{j,t})} \\ \frac{\partial G}{\partial n_{jL}^{t-j+1}} & \frac{\partial G}{\partial (1-u_{j,t})} \end{bmatrix} \begin{bmatrix} dn_{jL}^{t-j+1} \\ d(1-u_{j,t}) \end{bmatrix} = \begin{bmatrix} -\frac{\partial F}{\partial w_{L,t}} dw_{L,t} \\ -\frac{\partial G}{\partial w_{L,t}} dw_{L,t} \end{bmatrix} \tag{41}$$

Under normal parameter values the (2x2)-matrix is non-singular. We can then take the inverse to calculate $\frac{d(1-u_{j,t})}{dw_{L,t}}$, the change in the equilibrium unemployment rate resulting from the second stage of the game, following an increase in the chosen wage rate by the union. The first order condition for the union is given by:

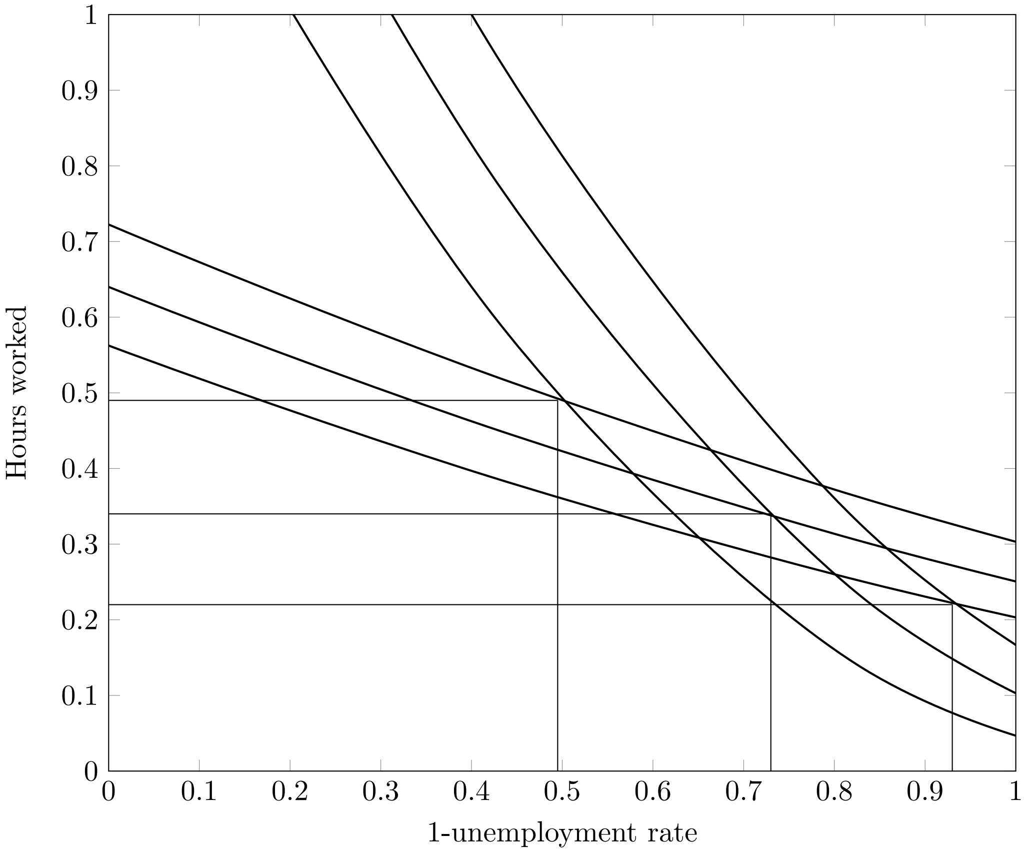
$$w_{L,t}(1-\tau_{jL})-\bar{w}_{j,t}=-\frac{\chi_j(1-u_{j,t})}{\frac{\partial(1-u_{j,t})}{\partial w_{L,t}}}(1-\tau_{jL}^{m}) \tag{42}$$

As the right-hand side of this equation is positive, the left-hand side has to be positive as well. This implies that the after-tax wage determined by the union will exceed the alternative wage. The higher χ_j, the higher the ex-ante union wage premium. Ex-post, a rise in χ_j will also be reflected in higher unemployment u_j, though. The reason is that if the union has a higher preference for wages for a particular age group, the firm will in the end replace the workers of this age group by low ability workers of other age. Unemployment among these other age groups might fall. Due to more expensive low ability labour, however, aggregate unemployment among low ability workers will rise.

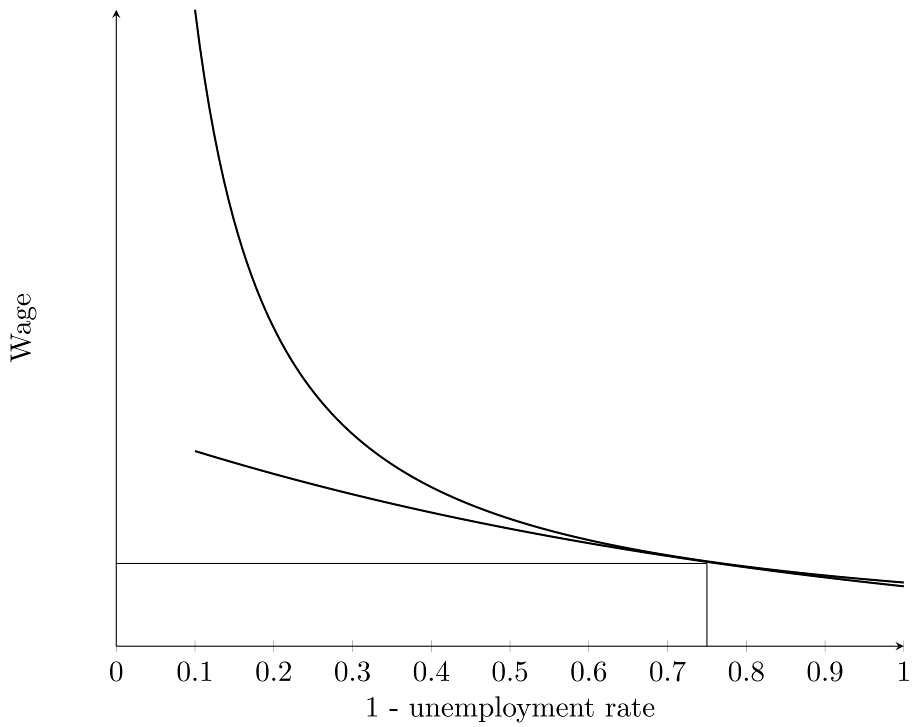
3.4 Solving for the Subgame Perfect Equilibrium

Within every period t, a dynamic two-stage game is played between a triplet of a firm, a union and a lower ability household. In the first stage, the unions choose the wage for the lower ability workers, whereas in the second stage firms choose the fraction of people they want to employ, and lower ability households choose their labour supply in hours. As such, the second stage is a static game, played between the firm and the lower ability household. We use backward induction to solve for the subgame perfect equilibrium of our game. In the second stage, the firm and the households play simultaneously, taking the union's wage and the action of the other player as given. In the previous sections, we already solved for the best responses of the household and the firm, taking the optimal behaviour of the other player into account, while also taking the wage and the fiscal policy variables as given. In Graph 1, we show the second stage of the game. The flatter curves are the 'best response'-fuctions of the households given the real wage rate, the unemployment rate chosen by the firm, tax rates and the unemployment benefit. If the unemployment rate increases, the income and consumption of the household will decrease, implying that the marginal benefit of working increases. Household members will then supply more hours. This argument explains the negative slope of the households' best-response curves. If the wage chosen by the union increases, the best-response curves shift upwards, leading to a higher supply of hours for a given unemployment rate. Intuitively, the substitution effect of a higher wage dominates the income effect. The best-response curves of the firm are calculated using the first-order conditions of the firm. If the households decide to supply more hours for a given wage rate, the firm will employ fewer people. If the wage chosen by the union increases and households maintain their supply of hours, the firm will also employ fewer people, implying that the best-response curves will shift to the left. Thus, if the wage increases, the best-response curves of the household shift upwards, while the best-response curves of the firm shift to the left. The intersection of the 'best response'-functions for different wage rates represent the Nash equilibria of the second stage of our game. In Graph 2, an indifference curve of the union has been drawn. The other curve is the collection of Nash equilibria for different wage rates resulting from the second stage of the game. This curve indicates the employment rates which are Nash Equilibria in the second stage given different levels of the real wage rate. The optimal combination of the wage and the employment rate is found where the indifference curve of the union is tangent to the Nash-function of the second stage. In Graph 2, one optimal point is drawn. From this value for the wage, we can calculate the exact Nash equilibrium in the second stage. In a symmetric equilibrium, the wage will be the same at every firm.

Graph 1: Second stage of the game



Graph 2: First stage of the game



3.5 Equilibrium

Definition 1 *Given an initial value for the technology stock level* A_0 *and a value for the predetermined human capital stock of young higher ability individuals* h_0*, a vector of exogenous fiscal policy variables* $\{\tau_c, \tau_k, \tau^p, g_y, g_c, \tilde{b}_j\}_{j=1}^4$ *and the exogenous world interest rate, an intertemporal equilibrium consists of sequences of household decision rules* $\{c_{1a}^t, c_{2a}^t, c_{3a}^t, c_{4a}^t, c_{5a}^t, \Omega_{1a}^t, \Omega_{2a}^t, \Omega_{3a}^t, \Omega_{4a}^t, e_{1H}^t, n_{1a}^t, n_{2a}^t, n_{3a}^t, n_{4a}^t\}_{t=0}^{\infty}$*, sequences of prices* $\{w_{a,t}\}_{t=0}^{\infty}$*, human capital stocks* $\{h_{1a}^t, h_{2a}^t, h_{3a}^t, h_{4a}^t\}_{t=1}^{\infty}$*, lump sum transfers* $\{Z_t\}_{t=0}^{\infty}$*, tax rates* $\{\{\tau_{ja}, \tau_{ja}^m\}_{j=0}^4\}_{t=0}^{\infty}$*, unemployment rates* $\{u_{1,t}, u_{2,t}, u_{3,t}, u_{4,t}\}_{t=0}^{\infty}$ *and aggregate variables* $\{Y_t, K_t, H_t, A_t\}_{t=0}^{\infty}$ *for* $a \in \{H, L\}$ *such that*

1. *Households' decision rules maximize the intertemporal utility function subject to the budget constraints and the human capital accumulation process.*

2. *Firms' choices* $\{K_t, H_{1H,t}, H_{2H,t}, H_{3H,t}, H_{4H,t}, (1-u_{1,t}), (1-u_{2,t}), (1-u_{3,t}), (1-u_{4,t})\}$ *maximize profits.*

3. *The wage* $\{w_{H,t}\}$ *is such that the labour market for higher ability individuals clears.*

4. *Given the wages chosen by the union, each couple* $\{n^t_{jL}, 1 - u_{j,t}\}$ *forms a Nash equilibrium in the second stage of the dynamic game played between the household, the firm and the union, the union chooses* $\{w_{L,t}\}$ *to maximize its utility subject to the optimal responses of the household and the firm. These actions form a subgame perfect equilibrium.*

5. *Human capital of the individuals evolves according to the human capital accumulation process.*

6. *Lump sum transfers ensure a balanced government budget.*

7. *Average and marginal tax rates are determined via equations (26) and (27)*

8. Y_t *follows from the production function and the values for* K_t *and* A_tH_t*.*

9. *National income equals the aggregate demand for goods.*

4 Data and Calibration

In this paper we construct an OLG model where unemployment and hours worked by individuals of different age and ability are the main endogenous variables. Our aim is that the model is able to explain cross-country differences in these variables. Similar to Pissarides (2007) and Rogerson (2007), we study three groups of countries: Anglo-Saxon countries (the United States, the United Kingdom and Canada), continental European countries (Belgium, France, Germany, the Netherlands, and Austria) and Nordic countries (Denmark, Finland, Norway and Sweden). In the first step we calibrate our model and compare its predictions regarding the main labour market variables to the true data for these twelve countries. Note, however, that we make a distinction between country-specific variables (fiscal policy variables), region-specific variables which are the same for respectively the Anglo-Saxon, the continental European and the Nordic countries (household and union preferences) and parameters which are common for all the countries in our sample (all the parameters in Table 8, cf. infra). If explanatory power is good, we want to know in the next stage what exogenous variables in the model exactly account for the largest parts of the explanation. What is the share of fiscal policy variables? What is the role of union preferences? And what is the contribution of household preferences? Section 4 is devoted to a description of the data and the calibration. For a detailed summary of the different data sources and for details on the construction of the data, we refer to Appendix A. In Section 5, we test the empirical relevance of our model. We will see that the model's predictions match the actual cross-country data well for hours worked. By far the best match emerges, however, for unemployment among the lower educated. In section 6, our focus will therefore be on explaining the cross-country variation in unemployment rates.

4.1 Unemployment

In our model we have assumed that all individuals (except the retired) of both higher and lower ability participate in the labour market. Those of higher ability will all work. Among those of lower ability, only a fraction $1 - u_j^t$ will work. The difference between both employment rates corresponds to the rate of unemployment u_j^t. The data that we report in Table 3 reflect this setup. They are the difference in percentage points between the actual employment rate (in persons) among those within a particular age group who enjoyed tertiary education and those who did not. We notice that in most countries older individuals (age 54-65) of lower education are suffering the highest unemployment rates, followed by the young (age 18-29). Exceptions are the UK and Belgium with relatively low unemployment in the oldest age group and Denmark, Norway and Sweden with relatively low unemployment in the youngest age group.

Our proxy for unemployment among the lower educated is consistent with the setup of our model. It differs, however, from official unemployment series, which are also affected by participation decisions. The fact that we assume everyone to participate will therefore induce some bias in our data. It will not affect our main conclusions though. The correlation coefficient between respectively the difference in employment rates and the difference in unemployment rates between higher and lower educated individuals in actual data is strongly negative. Depending on the age group considered, it varies between -0.60 and -0.85 (see also Figure 1(c)).

4.2 Hours worked per employed person

Data on hours worked are given in Table 4. We report the fraction of time individuals devote to work relative to their total time endowment on an annual basis. Like Wallenius (2013), we assume that the total time endowment of each individual consists of 14 hours a day, 7 days a week and 52 weeks per year. Except in Germany and Austria, the life-cycle profile of hours worked in every country in our sample is hump-shaped. People with a job tend to work the lowest number of hours at the age of 18-29. In the second and third period of life, there is a considerable increase in hours worked, whereafter it decreases somewhat in the fourth period of life. As is very well known, the number of hours worked is the highest in the Anglo-Saxon countries.

Table 3: Unemployment rates among four generations of lower educated individuals (2001-2007), in %

Unemployment rates	18-29	$30-41$	$42-53$	$54-65$
Belgium	23.7	17.1	18.9	17.6
France	5.9	12.5	10.2	17.4
Germany	20.0	18.5	18.5	23.5
Austria	9.8	14.1	16.4	25.0
Netherlands	10.5	12.4	13.5	17.7
Denmark	4.9	10.2	11.4	19.1
Finland	20.7	12.5	13.8	17.0
Norway	7.9	13.5	14.2	23.1
Sweden	1.2	11.1	10.9	15.7
United States	17.3	15.7	15.8	21.0
United Kingdom	17.7	14.5	13.9	8.5
Canada	15.7	14.3	14.5	12.9
Average	13.5	14.0	14.3	18.2

Source: Eurostat (see Appendix A). For a description of the data, see also the main text.

Table 4: Hours worked per person employed (fraction of time) - average for tertiary and non-tertiary educated individuals (2001-2007)

Hours worked	18-29	$30-41$	$42-53$	$54-65$
Belgium	0.309	0.311	0.311	0.311
France	0.292	0.301	0.301	0.291
Germany	0.285	0.283	0.283	0.277
Austria	0.339	0.349	0.349	0.351
Netherlands	0.252	0.319	0.319	0.299
Denmark	0.283	0.354	0.354	0.344
Finland	0.327	0.366	0.366	0.349
Norway	0.263	0.309	0.309	0.297
Sweden	0.300	0.341	0.341	0.332
United States	0.338	0.383	0.383	0.374
United Kingdom	0.325	0.359	0.359	0.332
Canada	0.331	0.371	0.371	0.358
Average	0.305	0.338	0.338	0.323

Source: OECD (see Appendix A). Data limitations explain why there is no difference in hours worked between the age groups 30-41 and 42-53.

Table 5: Fraction of time allocated to education by young high ability individuals (2001-2007)

	Education
Belgium	0.450
France	0.450
Germany	0.386
Austria	0.434
Netherlands	0.442
Denmark	0.522
Finland	0.564
Norway	0.512
Sweden	0.444
United States	0.574
United Kingdom	0.366
Canada	0.474
Average	0.468

Source and explanation: see Appendix A.

4.3 Education

In Table 5, we report the education rate. In our model, the education rate is the fraction of time higher ability individuals devote to tertiary education. The US and the the Nordic countries show the highest participation in tertiary education.

4.4 Fiscal policy variables and education quality

The government in our model finances government spending on goods and benefits to the unemployed with taxes on consumption, labour and capital. Data on $\tilde{b}_j$, ξ, Γ and τ^p are new. For the variables τ_k, τ_c, and g, we use the same data as Heylen & Van de Kerckhove (2013).

As we have mentioned in section 2.4, the government administers a non-linear tax system applied to employees. In our sample, we see in Table 6 an average value for ξ of 0.337, which implies that the tax code is progressive. Continental European countries are less progressive than the average, Anglo-Saxon countries are more progressive. Finland and Sweden stand out. The cross-country average value of Γ is 26.3, indicating an average labour tax rate for an individual whose income coincides with the average income in the economy of 26.3%. Belgium and Germany have higher values, France a lower one.

Table 6: Labour tax rates on employees and employers and unemployment benefit, in %

	ξ	Γ	τ^p	$\tilde{b}_j$
Belgium	0.343	33.4	29.1	59.6
France	0.296	21.7	38.7	46.0
Germany	0.245	30.2	19.9	64.7
Austria	0.311	27.3	28.6	56.3
Netherlands	0.391	25.2	11.2	55.0
Denmark	0.233	35.3	0	61.9
Finland	0.424	28.9	24.1	61.3
Norway	0.392	25.1	12.7	56.9
Sweden	0.376	28.9	32.2	55.4
United States	0.330	17.1	7.7	30.5
United Kingdom	0.383	24.0	9.8	51.1
Canada	0.331	17.9	11.1	44.4
Average	0.337	26.3	18.8	53.4

Sources and data construction: see Appendix A.

Hence, the tax rates in continental European countries are high in level, but increase less following an increase in income. The opposite holds for the Anglo-Saxon countries: low in level, but they increase more when income increases. The Nordic countries administer tax codes which are high in level and with a high degree of progressivity.

In addition to the non-linear tax system applied to employees, the fiscal government also imposes a linear tax system on employers. The cross-country average value of τ^p is 18.8%. All continental European countries have higher values, while all Anglo-Saxon countries have lower ones. The Nordic countries are in between.

The fourth column in Table 6 lists the data for the net replacement rate in the unemployment benefit formula. We observe the highest replacement rates in Germany, Denmark, Finland and Belgium. Unemployed workers receive the lowest after-tax benefits in France, Canada and the US.

The data in Table 7 have been taken from Heylen & Van de Kerckhove (2013). The Nordic countries stand out with the highest consumption tax rates, the US with the lowest. While labour and consumption are heavily taxed in the Nordic countries, the opposite holds for capital, which is taxed relatively little. Next to among the highest labour tax rates, Germany and Belgium also have the highest capital tax rates. As to

Table 7: Tax rates on consumption and capital (in%), and government spending on goods (in % of GDP)

	τ_c	τ_k	g
Belgium	13.4	27.1	24.8
France	17.1	21.7	28.5
Germany	11.1	34.4	23.2
Austria	13.2	17.3	23.4
Netherlands	12.2	24.3	27.3
Denmark	18.9	22.5	29.8
Finland	15.2	17.2	26.8
Norway	16.4	22.1	26.3
Sweden	17.9	16.1	32.6
United States	7.2	23.6	19.5
United Kingdom	14.5	21.2	21.4
Canada	14.5	24.8	23.6
Average	14.3	22.1	25.7

Sources and data construction: see Appendix A.

government spending on goods, we observe the largest numbers in the Nordic countries. Anglo-Saxon governments spend the lowest fraction of GDP on goods. The continental European countries take an intermediate position.

4.5 Calibrated parameters

How well does our model match reality? When we impose each country's policy parameters described in the previous section, how close are the model's predictions to the true data? To find out, we first have to parameterize the model. We discuss our procedure in this section. Tables 8 and 9 contain an overview of all parameters. Many have been set in line with, or taken from, the existing literature. Others have been calibrated to match key data.

We set the rate of time preference at 2% per year and the (exogenous and constant) world real interest rate at 4.5% per year. Considering that periods in our model last 12 years, this choice implies a discount factor $\beta = 0.788$ and interest rate $r = 0.696$. In the production function for goods, we assume a capital share coefficient α equal to 1/3. Following Caselli & Coleman (2006), who state that the empirical labour literature consistently estimates values between 1 and 2, we set the elasticity of substitution ι between the two ability types in effective labour equal to 1.5. In line with Rogerson (2007), who considers a value for the inverse of the intertemporal elasticity of substitution in leisure θ between 1 and 3 as being reasonable, we set $\theta = 2$. Two other sets of parameters that we took directly from the literature are the age-specific productivity parameters ε_j and the time cost of commuting and being set-up in a job $\bar{n}$. For the former we follow the hump-shaped pattern imposed by Miles (1999) and Cournède & Gonand (2006). For the latter we impose a value of 0.05, in line with Wallenius (2013). We impose the same ϵ_j and $\bar{n}$ for both ability types.

Three parameters relate to the production and the level of human capital with which individuals enter the model. For the elasticity with respect to education time (σ) we choose a conservative value of 0.3. This value is within the range considered by Bouzahzah *et al.* (2002) and Docquier & Paddison (2003), but much lower than the value imposed by Lucas (1990). The literature provides much less guidance for the calibration of the relative initial human capital of lower ability individuals (relative to the initial human capital of high ability individuals, ϵ_L). To determine this parameter we follow Buyse *et al.* (2014) who rely on PISA science scores. We use the average of the test scores of students at the 17th and the 50th percentile as representative for lower ability individuals in our model, and the test score of students at the 83th percentile as representative for high ability individuals. The data are remarkably robust across countries.

Table 8: Basic parameterization of the model - imposed on all countries

Discount factor in utility	β	0.788
World real interest rate	r	0.696
Inverse of the intertemporal elasticity of substitution in leisure	θ	2
Age-specific productivity parameter 18-29	ε_1	2.325
Age-specific productivity parameter 30-41	ε_2	2.770
Age-specific productivity parameter 42-53	ε_3	2.776
Age-specific productivity parameter 54-65	ε_4	2.341
Capital share parameter in goods production	α	0.33
Share parameter of high ability individuals in effective labour	η	0.6074
Elasticity of substitution between different ability types of labour	ι	1.5
Exogenous technology growth	x	0.255
Efficiency parameter in human capital production	ϕ	3.44
Relative initial human capital of lower ability individuals (to h_0)	ϵ_L	0.755
Elasticity of human capital with respect to education time	σ	0.3
Time cost for e.g. commuting	$\bar{n}$	0.05

The science test score of students at the 17th percentile is always very close to 67% of the test score of students at the 83th percentile, while in all countries the test score of students at the 50th percentile is very close to 85% of the test score of students at the 83th percentile[5]. The differences across countries being so small, we take these relative scores as objective indicators of the relative cognitive capacity of lower and high ability individuals, and will correspondingly set ϵ_L equal to 0.755 (= the average of 0.67 and 0.85). Last but not least, the efficiency parameter ϕ in the human capital production function of the individuals with high ability has been determined by a calibration procedure that we discuss now.

We determined 36 parameters by calibration. Next to the efficiency parameter in human capital production (ϕ), these are the exogenous technology growth rate (x), the share parameter in aggregate effective labor (η), the four taste for leisure parameters ($\gamma_1, \gamma_2, \gamma_3, \gamma_4$) which we allow to differ by country group (Anglo-Saxon, continental European and Nordic countries), and the seven union preference parameters ($\chi_1, \chi_2, \chi_3, \chi_4, \varrho_1, \varrho_2, \varrho_3$), which may also differ across the three country groups. The efficiency parameter in human capital production (ϕ) is determined to correctly predict average participation in education (e) over all twelve countries in our sample. The

[5]The data that we report are averages of the PISA results for the years 2000, 2003 and 2006. The available data concern students aged 15.

parameter turns out to be 3.44. The exogenous growth rate of technology (x) is calibrated to match actual per capita growth over a period of 12 years. The underlying annual growth rate is 1.91%, being the average annual per capita growth in our sample of twelve countries in 2001-2007. Following Buyse *et al.* (2014), we calibrate the share parameter in aggregate effective labor (η) to match the relative wage of young workers without a tertiary degree versus young workers with tertiary degree in the US. This relative wage is 0.53[6]. As shown by Equations (38) and (39), the share parameter η is an important determinant of the relative productivity of labour and relative wages. Actual wages are informative if a close link can be assumed between wages and productivity. This condition is much more likely fulfilled in the US than in Europe, which explains the introduction here of US relative wages. The value for η that emerges is 0.61.

Finally, we calibrated the taste for leisure parameters of the households (γ_j), the union's preference for wage parameters (χ_j) and the weights in the reference wage of the union (ϱ_1, ϱ_2 and $\varrho_3 = 1 - \varrho_1 - \varrho_2$) for each of the three country groups, using a sensitivity analysis in line with Heylen & Van de Kerckhove (2013). In a first step – executed separately for each country group - we imposed values for ϱ_1, ϱ_2 and ϱ_3. With these imposed values we calibrated the parameters χ_j with $j = 1, 2, 3, 4$ to match the average of actual unemployment rates in four generations over all countries in the country group. Analogously, we calibrated the parameters γ_j with $j = 1, 2, 3, 4$ to match the average of actual hours worked n per generation (over both ability types) over all countries in the country group. The obtained set of household taste for leisure and union preference parameters for each of the three country groups - together with all other calibrated parameters - would then allow us to compute the predictions of our model for all unemployment rates and all hours worked in all generations in each of the twelve countries in our sample. We repeated this procedures many times, each time starting from different values for ϱ_1, ϱ_2 and ϱ_3. Our guideline to pin down our final values for these parameters and the corresponding values for γ_j and χ_j was to minimize the deviation of our model's predictions from the true data[7].

The results in Table 9 reveal much higher values for χ_j in the continental European countries than in the Anglo-Saxon countries and – even more so – the Nordic countries. Considering Graph 2 and Equation (42), this implies that in continental Europe the

[6]OECD data (Education at a Glance, 2009, table A7.1a) show a relative wage of 0.43 for workers of age 25-34 without upper secondary education versus workers of this age with a tertiary degree. The relative wage of workers of age 25-34 with upper secondary degree is 0.63. On average this is 0.53.

[7]From the predictions of our model and the true data for 12 countries we computed each time for each variable (u_j, n_j with $j = 1, 2, 3, 4$) the root mean squared error normalized to the mean. We minimized the average normalized RMSE over all variables.

unions' indifference curves are flatter, wages will more rigid, and the mark-up of union wages on the reference wage will be higher. Intuitively, this result matches quite well with Calmfors and Driffill's (1988) prediction of a hump-shaped relationship between the degree of centralization (coordination) in wage bargaining and the level and rigidity of wages. As documented by Du Caju *et al.* (2008), in all the continental European countries in our sample, the sectoral level is the dominant level of wage bargaining. In the Anglo-Saxon countries the company level is the dominant one. The Nordic countries show both highly centralized models of wage bargaining (e.g. Finland) and sectoral models (e.g. Sweden). Each Nordic country, however, shows a very high degree of coordination in wage bargaining.

As a second interesting result, we observe that in each country group χ_j rises in the age of the workers involved. Wages are therefore the most (least) rigid and the highest (lowest) for the oldest (youngest) workers. Seniority pay systems and the insider-outsider theory may provide an explanation for this result. According to the theory older workers are much more likely to have insider status since they will have accumulated firm-specific skills, while younger workers are often just entrants. Their insider status raises older workers' job security, which may be reflected in a higher preference for wages versus employment. Among the young, with much lower job security, one would rather expect to see the opposite.

As to the different weights in the unions' reference wage, we notice in each country group a major role for the competitive wage of lower ability individuals. In continental Europe this competitive wage has weight 0.8, in the other two groups even 0.9. In the Anglo-Saxon countries, which are considered as being the closest to perfectly competitive labour markets, the high weight for the competitive wage is no surprise. The only other variable that matters in the unions' reference wage in the Anglo-Saxon countries is the wage of the high skilled. In the Nordic countries it is the unemployment benefit. In continental Europe both these other variables have an impact on union wage setting, with unemployment benefits being more important.

For the household taste for leisure parameters γ_j, our main finding is that these hardly differ across country groups, confirming the approach adopted by e.g. Prescott (2004), Rogerson (2007), and Dhont & Heylen (2008). Somewhat surprising is to see a hump shaped pattern in these parameters by age. Observing a higher taste for leisure among workers of middle age than among the young is fully in line with earlier results of Heylen and Van de Kerckhove (2013). But finding a lower taste for leisure among older workers is not.

Table 9: Calibration of the taste for leisure of households and union preferences - Region-specific parameters

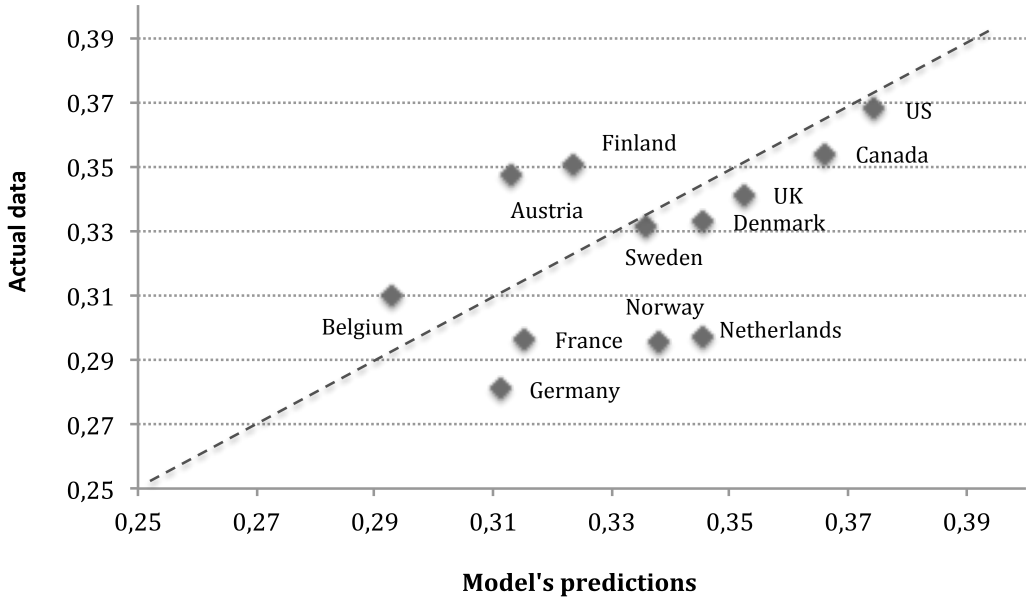
	Anglo-Saxon	Continental Europe	Nordic
χ_1	1.573	2.304	1.635
χ_2	3.041	4.273	2.430
χ_3	2.990	4.252	2.426
χ_4	3.088	4.440	2.653
ϱ_1	0.9	0.80	0.9
ϱ_2	0.1	0.05	0
ϱ_3	0	0.15	0.1
γ_1	0.480	0.642	0.717
γ_2	1.054	1.160	1.054
γ_3	0.779	0.856	0.780
γ_4	0.533	0.557	0.529

5 Empirical relevance of the model

In this section we demonstrate the empirical relevance of the model. In Figure 2, we relate our model's predictions to the facts for the time allocated to labour by the employed members of households aggregated over all generations and both ability types. Note that the model's predictions are presented on the horizontal axis, whereas the actual data are represented on the vertical axis. The coefficient of correlation between the two is 0.544, which implies that the model matches cross-country differences fairly well. In Figure 3 we have a closer look at per capita labour input of the age group 55-64. Formally, our measure is $\frac{n_{4H}+(1-u_4)n_{4L}}{2}$. It rises in hours worked per employed high ability individual of age 54-65 and in hours worked per employed lower ability individual of this age. It falls in the unemployment rate among lower ability individuals in this age group. Correlation in Figure 3 is 0.451.

Figure 4 is the key novelty in this paper. Plugging each country's policy parameters into our calibrated model, it matches the facts for the aggregate unemployment rate very well. Correlation between the predictions of the model and the facts is over 80 %.

Figure 2: Hours worked per employed person (average over all age groups of both ability types, 2001-07) - Correlation: 0.544



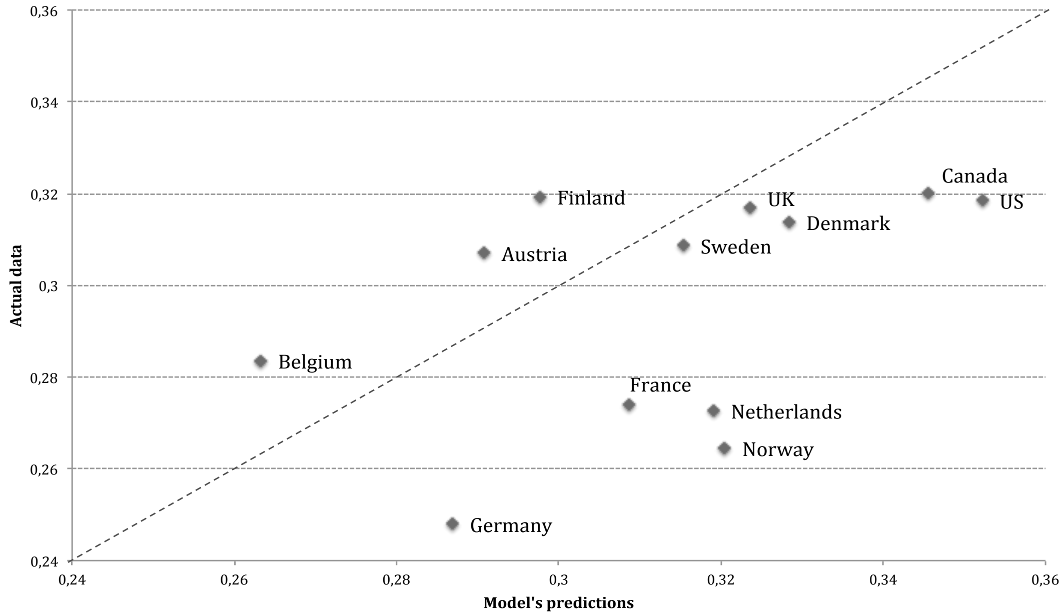
6 Quantitative experiment: accounting for cross-country variation in unemployment.

Figure 4 showed large differences across OECD countries in the unemployment rate. From Figure 1 we know that these differences explain an important fraction of cross-country differences in aggregate employment and labour market performance. The final step in this research is to account for these unemployment differences. What exactly causes higher unemployment in some countries compared to other countries within the context of our model? Are these variations due to differences in fiscal policy variables or to union preferences and wage setting? Or to differences in the taste for leisure of the households? And what is the contribution of (progressive) tax rates on labour, tax rates on consumption, unemployment benefits, etc.? For policy makers who are challenged to tackle unemployment, it is crucial to know.

6.1 Description of the experiment

We find a correlation of 0.804 between the predictions of our model for the aggregate unemployment rate and the actual unemployment data. From this, we derive an R-squared

Figure 3: Per capita hours worked in the age group 54-65 (average over both ability types, 2001-07) - Correlation: 0.451

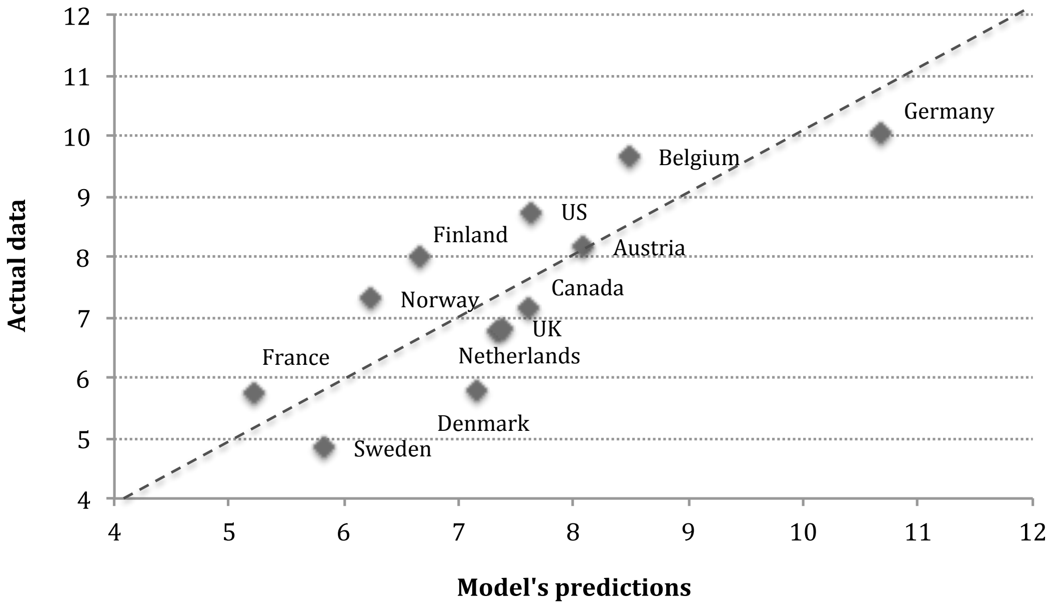


coefficient of 0.646. Following Israeli (2006), we perform a Shapley decomposition of the R-squared coefficient in order to evaluate the relative importance of the different fiscal policy variables, union wage setting and household preferences in generating cross-country unemployment differences. More specifically, according to a Shapley decomposition, the contribution of each of our variables equals its marginal effect measured by the change in the R-squared coefficient after eliminating the cross-country differences in this variable. This change in R-squared is computed for every subset S of other explanatory variables. For example, if we had four explanatory variables, x_1, x_2, x_3, and x_4, the marginal effect of x_1 on the R-squared would be

$$M_1 = R^2[x_1, S \subseteq \{x_2, x_3, x_4\}] - R^2[S \subseteq \{x_2, x_3, x_4\}]$$

for every subset S. Next, we take a weighted average over all these marginal effects where the weight is respectively $\frac{s!(n-s-1)!}{n!}$, with s the number of elements in the subset and n the total number of explanatory variables. Hence, for each of our variables in the Shapley decomposition, we successively replace their country-specific values by the average value over the twelve countries in our sample, implying that we shut down the influence of these specific variables in generating cross-country differences in the unemployment rate.

Figure 4: Aggregate unemployment rate (computed over all age groups of both ability types in %, 2001-07) - Correlation: 0.804



These variables are (i) the labour tax rate imposed on employers; (ii) the labour tax rate imposed on employees; (iii) the replacement rate in the unemployment benefit formula; (iv) the tax rate on capital; (v) the tax rate on consumption; (vi) government spending on goods; (vii) the union preference parameters, and (viii) the taste for leisure of the households.

6.2 Fiscal policy, union preferences and wage setting, or households' taste for leisure?

In this section, we investigate whether the cross-country variation in unemployment rates is due to differences in union behaviour, household preferences or in fiscal policy variables. Blanchard (2004) and Alesina *et al.* (2005) emphasize the role of union behaviour and differences in the taste for leisure of households. Other authors such as Prescott (2004), Ohanian *et al.* (2008) and Dhont & Heylen (2008) conclude that differences in fiscal policy are superior. Looking at Table 10, the conclusion is that both fiscal policy variables and union preferences and wage setting matter. They account each for about half of the unemployment variation across countries. A correct diagnosis of the unemployment problem and analysis of cross-country differences clearly seems to require

Table 10: Shapley Decomposition

	u_t	
χ_j	0.214	32.17%
ϱ_1, ϱ_2	0.124	18.68%
γ_j	-0.018	-2.77%
ξ	-0.027	-4.08%
Γ	-0.032	-4.77%
τ^p	-0.028	-4.12%
$\tilde{b}_j$	0.217	32.61%
τ_c	0.040	6.07%
τ_k	0.051	7.58%
g	0.124	18.55%
Total R^2	0.6667	100%

both components. On the other hand, any differences in households' taste for leisure can safely be ignored. Integrating these findings, our interpretation is that while the above market-clearing wage chosen by the unions is the source of unemployment, the fiscal policy variables explain a large part of the magnitude of the unemployment rate.

If we explore the impact of the union parameters into more detail, we notice that the influence of χ_j is superior to that of ϱ_1 and ϱ_2.

Looking at the different components of fiscal policy, a surprising result is that - despite huge cross-country variation in these tax rates - ξ, Γ, and τ^p have no role to play when it comes to explaining unemployment differences across countries. Countries with higher average tax rates and a higher degree of progressivity in labour taxes are not necessarily the countries with the highest aggregate unemployment rate. Ambiguous effects from higher taxes may explain this. A rise in τ^p for example will imply higher unemployment because it raises the cost of low skilled labour for the firms. On the other hand, it also generates effects that may lead to lower unemployment. One is the negative effect of a rise in τ^p on competitive gross wages, which will imply more moderate wage claims from the unions. Another is that higher taxes may feed through into higher lump sum transfers in our model. The negative effect of higher transfers on the supply of hours per worker will induce firms to hire more people. Similar ambiguity follows after a rise in Γ. On the one hand, this negatively affects labour supply in the economy, pushing wages up and making low skilled workers more expensive for firms. They will then hire less workers, and unemployment rises. On the other hand, the fact that individuals supply less hours because of higher taxes (and an expected increase of lump sum transfers), will induce to hire more people.

The major role of the replacement rate $\tilde{b}_j$ is not a surprising result, however. From the results of the calibration in Table 9, it is clear that unions in both continental Europe and Nordic countries attach a weight to the level of these benefits. This weight is the largest in continental Europe. Benefit changes will therefore affect the cost of low educated labour most in these countries, and therefore firms' willingness to hire. Important differences in benefits as we observe them in Table 6 between France and Germany, for example, can then be expected to explain a significant fraction of unemployment differences. The contribution of $\tilde{b}$ might even be an underestimation, as it is the combined impact of the net replacement rate and the region-specific union preferences that drive the Shapley results for the union preferences.

The consumption and capital tax rates both have a positive contribution to the R-squared. The influence of the capital tax rate runs via the first order condition of the firm with respect to capital, and will as such also have an impact on the variation in wages over the different countries. The impact of the consumption tax rate works through the first-order conditions regarding labour. However, both the tax rates on both consumption and capital and government expenditures have also an indirect effect on the lump sum transfers, and therefore on consumption. For example, in the last step of the Shapley procedure for government expenditures, we look at the difference in R-squared between the situation where we only have cross-country variation in government expenditures and the situation where all possible cross-country variation is eliminated. While very small, the differences in lump sum transfers due to differences in government expenditures and their impact on the government budget, lead to differences in consumption. These differences lead to differences in the optimal labour supply from the households and therefore to differences in unemployment rates over the countries. And while these differences are very small in value, they lead to a high correlation between the predictions of our model and the data.

7 Conclusion

Huge differences in labour market performance across OECD countries have attracted the attention of many researchers during the last decade. One strand of the literature has emphasized the major role of the composition of fiscal policy, i.e. the level and structure of taxes and government expenditures (e.g. Prescott (2004), Rogerson (2007), Dhont & Heylen (2008), Olovsson (2009), Wallenius (2013), Alonso-Ortiz (2014)). The focus of these studies is mainly on explaining employment (hours worked). All assume perfect competition and as such disregard any role for labour market imperfections. Unemployment is not an issue in these studies. A second tradition in the literature also recognizes the role of labour taxes and unemployment benefits, but this tradition has put much more emphasis on the role of unions (e.g. union power and wage bargaining) and labour and product market institutions (e.g. Daveri & Tabellini (2000), Nickell *et al.* (2005), Alesina *et al.* (2005)). Last but not least, some other authors (e.g. Blanchard (2004)) have pointed to the key role of household preferences. In their view, a major element behind the weaker employment performance in many European countries compared to the US is a higher taste for leisure in Europe. Alesina *et al.* (2005) explain that stronger unions may have contributed to this higher taste for leisure in Europe.

This paper is situated within the first strand of the literature. We also develop a general equilibrium model (OLG model) that explains hours worked as one of the main variables. Our first contribution, though, is to take the dynamic general equilibrium literature one step further. We extend the model so that it can also explain equilibrium unemployment among lower educated individuals. Two assumptions are key. The first one is the assumption that individuals are heterogeneous by ability. They enter the model with different human capital stocks and have different capacity to build more human capital. A second assumption and key novelty compared to previous work in this tradition is the assumption of a unionized labour market and union wage setting for lower ability (lower educated) individuals. For higher ability individuals we assume that wages and employment are determined in a perfectly competitive way.

Calibrating and simulating this richer model for twelve OECD countries belonging to three regions (continental Europe, Nordic countries and Anglo-Saxon countries), we are able to assess the relative importance of a whole range of explanatory variables for cross-country differences in labour market performance. Our focus in this paper is on cross-country unemployment variation. What exactly causes higher unemployment in some countries than in others? What is the contribution of (progressive) tax rates on labour, tax rates on consumption, unemployment benefits, etc.? What is the contribution of union preferences and wage setting? What is the contribution of differences in households' taste for leisure? Performing a Shapley decomposition we find an almost equal role for differences in fiscal policy variables and in union preferences. Both account for about half of the cross-country variation in unemployment rates explained by our model. By contrast, any differences in the households' taste for leisure play no role. Integrating our findings, our interpretation will then be that the above market-clearing wage chosen by the unions is the source of unemployment, while the fiscal policy variables explain the major share of its magnitude. Going into greater detail on the fiscal side, we find that differences in unemployment benefit generosity play a much more important role than tax differences. In the Nordic countries and (even more) the continental European countries, the unemployment benefit replacement rate has a significant impact on union wage setting.

Our results highlight the relevance of integrating heterogeneity in individuals' ability and labour market imperfections into dynamic general equilibrium analyses of labour market performance. Imposing perfect competition seems to imply that an important fraction of reality is unfortunately ignored. By contrast, cross-country differences in households' taste for leisure seem insignificant, and can safely be disregarded.

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A Appendix: Details on data construction and sources

In this appendix we provide details on the construction and sources of our data.

A.1 Individuals of high and low ability

Individuals of high ability pursue tertiary education when they enter our model at the age of 18. Individuals of lower ability do not: they achieve at most an upper secondary degree, but no tertiary degree. These assumptions explain why we use existing data for individuals with a tertiary degree as proxy for variables (e.g. wages, employment) relating to higher ability individuals in our model, and the average of existing data for individuals with a lower secondary degree and individuals with an upper secondary degree (but no tertiary degree) as proxy for variables relating to lower ability individuals. According to ISCED classification, data for high ability individuals therefore relate to education levels 5-6. Data for lower ability individuals are constructed as the average for education levels 0-2 and 3-4.

A.2 Unemployment

In our model, all individuals participate in the labour market during four periods of working age (18-29, 30-41, 42-53, 54-65). A fraction of lower ability individuals becomes unemployed. High ability individuals are always employed. Since we do not model participation as an endogenous variable, our setup implies that the unemployment rate among lower ability individuals in a particular age group is the same as the gap in percentage points between the employment rate among higher ability individuals and the employment rate among lower ability individuals in that age group. In line with our explanation in A.1, as a proxy for the former we use data for individuals with a tertiary degree. As a proxy for the latter, we compute the average of data for individuals with a below upper secondary degree and individuals with an upper secondary degree, but no tertiary degree.

Data sources: Eurostat (Employment rates by sex, age and highest level of education attained (%) [lfsa_ergaed]) provides employment rates in persons by level of educational attainment and by age for all EU15 countries and Norway since 1995 at the latest. Data are available for the age groups 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59 and 60-64, among others. We compute the data for our four larger age groups as weighted averages of the Eurostat data. The data that we report and employ are for 2001-2007. For the United States and Canada we use data provided by OECD Education at a

Glance. Data by educational attainment are available for the age groups 25-34, 35-44, 45-54, 55-64.

A.3 Hours worked

For hours worked, we proceed as follows. First, we gather available OECD (Labour Force Statistics) data on the usual weekly number of hours that individuals work. These data are available for the age groups 15-24, 25-54 and 55-64. We compute the data for our four age groups as weighted averages of the OECD data. Second, we compute how many weeks individuals work per year. We divide OECD data on total annual hours worked per employee by the average number of hours worked per week. Data on total annual hours are only available at the level of the aggregate labour force. As such, we obtain a proxy for the number of weeks individuals work per year, also at the level of the aggregate labour force. Multiplying the first variable (usual hours per week) by the second (weeks per year), we obtain our proxy for total annual hours worked per employee in each generation. We express this number as a fraction of the total time endowment. Like Wallenius (2013), we assume that the total time endowment of each individual is 14 hours a day, 7 days a week and 52 weeks per year. This time can be allocated to work, leisure or (for young higher ability individuals) education.

A.4 Education rate of the young higher ability individuals

The education rate indicates the fraction of their total time endowment that high ability individuals allocate to schooling. Considering that in countries like Canada and Norway almost (or even more than) 50% of the 25-34 year-olds succeed in obtaining a tertiary degree, it will be our assumption that 50% of the population in each country has high ability, and therefore the potential to succeed at high level. The extent to which this potential is fully exploited may however differ across countries. Differences may show up in the fraction of individuals that effectively succeed in tertiary education and in the level of the tertiary degree that these individuals eventually achieve. We expect that the latter will be reflected in the number of years that is studied. Building on this assumption and these considerations, our empirical proxy for the education rate is the number of students in tertiary education in full-time equivalents divided by 50% of size of the population of age 18-29. Data on the number of students is obtained from Eurostat (Students by ISCED level, study intensity (full-time, part-time) and sex [educ_enrl1ad]). Population data are from the OECD database (Total Population by sex and age). The education rates that we report are averages for 2002-2007.

A.5 Growth rate of real per capita output

To compute the growth rate of real per capita output, which we need for the calibration of exogenous technological progress (x), we use data on real potential GDP and on population at working age (15-64). The former are available from OECD Economic Outlook (supply block), the latter from OECD Labour Force Statistics. In line with all other data we compute average growth rates over 2001-2007.

A.6 Fiscal policy variables

The government in our model finances spending on goods and unemployment benefits from taxes on labour (on both employers and employees), consumption, and capital. Lump sum transfers ensure a balanced budget. For the tax rates τ_k and τ_c, we use the same data as Heylen & Van de Kerckhove (2013). For government spending on goods in percent of GDP (g) we compute the sum of their data for government consumption and productive government spending. For details on the construction of these fiscal policy variables, we refer to Heylen & Van de Kerckhove (2013, their appendix 1).

For the unemployment benefit replacement rate ($\tilde{b}$) we make use of data provided by the OECD (Tax-Benefit Models). Since in our model unemployment is a structural or equilibrium phenomenon, the data that we use concern net transfers received by structurally or long-term unemployed people. They include social assistance, family benefits and housing benefits in the 60th month of benefit receipt. They also include unemployment insurance or unemployment assistance benefits if these benefits are still paid, i.e. if workers can be structurally unemployed for more than five years without losing benefit eligibility. The OECD provides net replacement rates for six family situations and three earnings levels. Our data in Table 6 are the averages of these 18 cases. Data are for 2001-2004.

Regarding labour tax rates, we distinguish between social security contributions paid by employers and taxes and social security contributions on labour income paid by employees. Our data source is OECD (Taxation, Tax Database, Tables I.4, I.5, I.6). More specifically, we use the OECD's average rate of employer social security contributions for τ^p (Table I.5). We calibrate the level parameter Γ in the workers' income tax rate using the OECD data for all-in average personal income tax rates at average wage. The all-in tax rate is calculated as the combined central and sub-central government income tax plus employee social security contribution, as a percentage of gross wage earnings. The OECD provides these tax rates for four family types (Table I.6). We computed the average over these types. A novelty compared to previous work is the inclusion of progressive income taxation. Just like Koyuncu (2011), we calibrate the country-specific degree of progressivity ξ according to Equation (28) as the ratio (minus 1) of the marginal tax rate on workers' gross wage to the average tax rate, both including social security contributions. The OECD provides these marginal and average tax rates for a single person without dependent at four different income levels (Tables I.4 and I.5). Our proxy for ξ reflects the average of the results over these four income levels. All computed and reported tax data in our Table 6 are averages over the period 2000-2007.