Labor unions, unemployment, and inequality in an OLG-model with heterogeneous agents

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Labor Unions, Unemployment, and Inequality in an OLG-Model with Heterogeneous Agents

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Abstract

As a consequence of falling relative demand for low skilled labor in the OECD, people with no or minor qualification experience a deterioration of their economic situation. While flexible labor markets have led to higher wage differentials in the USA, the major problem of most European countries is the high rate of unemployment of the low skilled.

To integrate currently discussed determinants of wage distribution and unemployment into a common context, labor unions and qualification differences in labor supply are introduced to an OLG-model with heterogeneous agents. The model generates skill specific unemployment rates and a wage dispersion affected by production technology, wage setting procedure, and qualification structure of labor supply. As an application of the model, the relative importance of wage dispersion, unemployment, and lifelong learning for economic growth and income distribution can be evaluated.

JEL Classification: J31, J51, D91, O41, C86

1 Introduction

The reasons for the currently bad economic situation of people with no or minor qualification are of particular interest to all OECD countries. While this situation is mainly caused by low paid work in the USA, the major problem in most European countries is the high rate of unemployment of low skilled workers. Low pay and high unemployment are often considered as consequences of a common cause, namely the falling relative demand for low skilled labor because of new, skill intensive technologies and rising competition from low

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skill abundant countries. The differences are supposed to result from different degrees of wage flexibility: While the flexiblity of the US labor markets led to falling relative wages of the low skilled, labor market organization and institutions in Western Europe prevented sufficient wage adjustments and, thus, low skilled workers became unemployed. This reasoning leads to the opinion that lower unemployment in Europe will come at the cost of higher inequality of incomes.

There is common consensus that labor unions play a significant role for wage determination and, therefore, for the unemployment history of Western Europe during the last 25 years, see e. g. Nickell & Layard (1999). In particular, labor unions are held responsible for the rigidity of wages at the lower end of the wage distribution and for the failure of wage adjustments in the face of high unemployment rates of low skilled workers, see e. g. Blau & Kahn (1996). On the other hand, it is argued that low wage inequality in some European countries reflects the homogeneous distribution of skills in comparison to the US, see e. g. Freeman & Schettkat (1999) and Nickell & Layard (1999). According to this opinion, unemployment in Europe is a consequence of high wage costs in general and is no skill specific problem.

Hence, to examine the relationship between labor market institutions, unemployment, and wage distribution it seems natural to search for a theoretically founded and at the same time tractable way to consider labor unions in a model with qualification specific labor market segments. Because the individual decision for education is made in view of future earnings one would like to choose a dynamic context, additionally, for example like Heckman, Lochner & Taber (1998) in their approach to explain the rising wage inequality in the USA. This paper takes a first step in this direction by introducing labor unions and unemployment benefits to an OLG-model with heterogeneous agents. Labor unions and firms Nash bargain over wages of the low skilled, while the labor market segment for high skilled workers is competitive.

Under certain, plausible assumptions the unemployment rate of the unskilled corresponds to that of a standard static union model with Nash bargaining, i. e., it is determined by the low skilled's income share, the generosity of unemployment benefit, and the bargaining position of unions. The wage dispersion is determined by production technology, wage setting procedure, and qualification structure of labor supply. Therefore, the model allows to discuss the significance of labor market rigidity, skill biased technological progress, and skill structure of labor supply for unemployment, wage, and income inequality in a common context. Furthermore, it yields a microeconomic foundation of the treatment of unemployment in a model that is commonly used as a starting point for studying income inequality, see Quadrini & Ríos-Rull (1997).

The paper proceeds as follows: Sect. 2 describes the model and contains a discussion of the crucial assumptions. For a special case of the model, some simulation results concerning the relative importance of wage dispersion, unemployment, and lifelong learning for economic growth and income distribution are described in Sect. 3. It contains a short explanation of the method used to simulate the model, too. Sect. 4 concludes.

2 The Model

2.1 Government

The government raises a proportional social security tax on wages with rate $\tau \in [0, 1]$ to finance an unemployment benefit and a pay-as-you-go pension system. The unemployed receive a transfer of $b_u \in [0, 1]$ times the net wage they would earn in case of employment. This amounts to the assumption that employment benefits remains constant for one period and that almost all unemployed agents find a job in the next period. Retired workers receive $b_r \in [0, 1]$ times the mean net wage of their skill group for a pension. In particular, pensions are independent of unemployment spells. The government's budget is balanced, i. e., the revenue of the social security tax equals the spending for unemployment benefits and pensions.

2.2 Households

In every period a mass of $\bar{N}_h/D$ high skilled and $\bar{N}_l/D$ low skilled individuals enter the economy for D periods. The mass of households $\bar{N} = \bar{N}_h + \bar{N}_l$ is normalized to one. In the first d periods of living an individual inelastically supplies one unit of labor services; she retires for the last $D - l$ periods. As is common to the human capital literature, it is assumed that work efficiency depends on skill and experience; to approximate work experience age is used (see e. g. Card (1999)). Absolute efficiency grows from one cohort to the next with a rate $z \geq 1$ but relative efficiency is independent of cohorts. In the following, the work efficiency of a worker of skill $j \in \{h, l\}$ and age $q \in \{0, \ldots, d-1\}$ in period t is given by

$$z_{j,q}(t) = z_{j,q} z^t \ , \quad z_{j,q} > 0 \ .$$

Hence, work efficiency does not depend on unemployment spells.

Notation for gross wage of a skilled and an unskilled worker of age q in period t is $W_{h,q}(t)$ and $W_{l,q}(t)$, respectively. For net wages in efficient units small letters are used:

$$w_{j,q}(t) = (1 - \tau) W_{j,q}(t)/z^t \ .$$

The labor market for skilled workers is competitive, while a fraction $u_q(t)$ of unskilled workers of age q is unemployed in period t. An unemployed worker of age $q \in \{0, \ldots, d-1\}$ receives a transfer $z^t b_u w_{l,q}(t)$. Pensioners of skill group $j \in \{h, l\}$ are paid a fraction b_r of the average income of skill j workers. Hence, pensions $z^t b_r w_{j,q}(t)$, $w_{j,q}(t) := 1/d \sum_{p=0}^{d-1} w_{j,p}(t)$, are independent of age $q \in \{d, \ldots, D-1\}$ but dependent on skill $j \in \{l, h\}$. To simplify notation, we denote

$$s = \begin{cases} s^e, & \text{if an individual is employed,} \\ s^u, & \text{if an individual is unemployed,} \\ s^r, & \text{if an individual is retired,} \end{cases}$$

and set

$$b(s) = \begin{cases} 1, & \text{if } s = s^e, \\ b_u, & \text{if } s = s^u, \\ b_r, & \text{if } s = s^r. \end{cases}$$

Therefore, the net income from employment, unemployment benefit, and pensions is given by $z^t b(s) w_{j,q}(t)$.

In period t_0 a household of age q_0 chooses consumption $z^t c_{q_0}$ and assets $z^{t+1} a_{q_0+1}$ to maximize her discounted stream of future expected utility. Consumption utility $u(z^t c_q)$ is of CES-form:

$$u(c) = \ln(c) \ , \ \gamma = 1 \ , \ \text{ or } \ u(c) = \frac{c^{1-\gamma}}{1-\gamma} \ , \ \gamma > 1 \ .$$

The discount factor is $\tilde{\beta} > 0$. Therefore, the expected life time utility can be written as

$$\sum_{q=q_0}^{D-1} \beta^{q-q_0} E_{q_0, s_{q_0}}(u(c_q)) \ , \quad \beta = \tilde{\beta} z^{1-\gamma} \ .$$

The household observes her budget constraint, her current situation characterized by age q_0 and state $s_{q_0} \in \{s^e, s^u, s^r\}$, and the evolution of future wages depending on the distribution of unemployment spells. It is assumed that assets earn a return $r(t)$. Households enter the economy with zero assets, $a_0 = 0$, and they are not allowed to borrow: $a_q \geq 0$. Hence, the optimization problem of the individual in efficiency units reads (skipping time indices):

$$\begin{aligned} & \max_{a_{q_0+1}} \ E_{q_0, s_{q_0}} \left(\sum_{q=q_0}^{D-1} \beta^{q-q_0} u(c_q) \right) \\ & \text{s. t. } \ c_q = (1+r) a_q + b(s_q) w_{j,q} - a_{q+1} > 0 \quad \text{for } \ q = q_0, \ldots, D-1, \\ & \qquad a_{q_0} \ \text{ given, } \ a_{q+1} \geq 0 \ , \quad a_D = 0 \ . \end{aligned} \tag{1}$$

If households foresee their individual employment path $(s_0, \ldots, s_{d-1})$ or if they can insure against employment risk, aggregate asset holdings can be calculated from a representative agent version of (1) skipping the expectations operator. Otherwise, the household's problem can be solved by approximation of its value function v. For this, a recursive representation of (1), namely its Bellman equation is used:

$$v(a,q,s,j) = \max_{a' \text{ permitted}} u((1+r)a + b(s)w_{j,q} - za') + \beta E_{q,s}\left(v(a',q+1,s',j)\right) \ . \quad (2)$$

Here a' is permitted, if it is non-negative and allows for a positive amount of consumption $(1+r)a + b(s)w_{j,q} - za'$. A short description of the approximation algorithm can be found in Sect. 3.

2.3 Firms

In every period a mass one of firms produce a good Y with a Cobb-Douglas production technology

$$Y(t) = (Z(t)N(t))^{\alpha} K(t)^{1-\alpha} \ , \ \ \alpha \in (0,1) \ ,$$

using capital K and efficient labor ZN. Efficiency Z grows at a rate $z \geq 1$ as already indicated describing the household sector: $Z(t) = z^t$. Labor services $N(t)$ emerge as a combination of low skilled labor, $N_{l,q}(t)$, and high skilled labor, $N_{h,q}(t)$, respectively, supplied by workers of age q:

$$N(t) = (N_l(t))^{\alpha_l} (N_h(t))^{\alpha_h} \quad \text{with} \quad N_j(t) = \sum_{q=0}^{d-1} z_{j,q} N_{j,q}(t) \ , \quad j = l,h \ , \qquad \alpha_l, \alpha_h \geq 0 \ , \quad \alpha_l + \alpha_h = 1 \ . \quad (3)$$

Goods markets are monopolistically competitive, i. e., firms face a demand function for their good Y depending on its price P, a price index $\bar{P}$, and aggregate demand $\bar{Y}(t)$:

$$(P(t)/\bar{P}(t))^{-\varepsilon} \bar{Y}(t) \ , \quad \varepsilon > 1 \ .$$

In this setting, the elasticity of demand for goods, ε, determines the degree of competitiveness of goods markets. Specifically, the higher $\kappa = 1 - 1/\varepsilon$ the more willing are consumers to substitute for a good in face of a rising price of that good.

A firm issues equities to finance investments. Because equities of different firms are perfect substitutes each equity pays the same dividend rate $r(t)$. The firm's goal is to maximize the value of issued equities. Hence, if rational speculative bubbles are ruled out, the firm maximizes the discounted present value of future cash flows. The cash flow, denoted as Π, is given by revenues PY less wage bill, $\sum W_{j,q}(t)N_{j,q}(t)$, and investment costs, $I(t) = K(t+1) - (1-\delta)K(t)$, $\delta \in (0,1)$. Thus, the optimization problem of a firm in period t_0 reads

$$\max_{(N_{j,q}(t_0))_{j,q},\, K(t_0+1)} \quad E_t\left(\sum_{t=t_0}^{\infty} \frac{\Pi(t)}{\prod_{i=t_0}^{t}(1+r(i))}\right)$$

s. t.

$$\Pi(t) = P(t)Y(t) - \sum_{j=l,h}\sum_{q=0}^{d-1} W_{j,q}(t)N_{j,q}(t) - K(t+1) + (1-\delta)K(t)\ ,\ t \geq t_0\ ,$$

$$r(t_0)\ ,\ (W_{q,j}(t_0))_{q,j} \ \text{ and } \ K(t_0) \ \text{ given.}$$

There are two important assumptions concerning the optimization problem of the firm: Firstly, today's employment and investment decision do not influence future wages. Hence, future wages can be considered as constant, i. e., they do not play a role for the firm's decision. Secondly, firms can foresee the future development of wages and dividend rates. Thus, for the derivation of next period's capital stock, the expectations operator can be skipped. Under these assumptions the decision rule of the firm for employment is given by

$$W_{j,q}(t) = \frac{\partial P(t)Y(t)}{\partial N_{j,q}(j)} = z_{j,q}\alpha_j \alpha\kappa \frac{P(t)Y(t)}{N_j(t)}\ ,\quad \kappa = 1 - 1/\varepsilon\ , \tag{4}$$

and for investments by

$$r(t+1) + \delta = (1-\alpha)\kappa \frac{P(t+1)Y(t+1)}{K(t+1)}\ . \tag{5}$$

Observing (4) and the definition of $N_j(t)$ in (3), the profit of a firm can be written as

$$P(t)Y(t) - \sum_{j=l,h}\sum_{q=0}^{d-1} W_{j,q}(t)N_{j,q}(t) = (1-\alpha\kappa)P(t)Y(t)\ . \tag{6}$$

2.4 Wage Setting and Unemployment

There are different labor market segments for high and low skill workers, respectively: Wages of high skilled workers are determined at competitive labor markets and, thus, ensure full employment of this group. Wages of low skilled workers are the outcome of Nash bargaining at firm level between the management and a labor union representing all low skilled employees of the firm. Hence, a fraction u_q of low skilled workers of age q is unemployed. It is assumed that bargaining for period t_0 takes place at the end of period $t_0 - 1$ after firms have determined capital inputs and employment of high skilled workers in t_0. Firms and labor unions do not bargain over employment, i. e., the firm has a *right-to-manage*. Because there is no commitment regarding future periods $t > t_0$ both parties aim to maximize utility of period t_0.

More specifically, firms maximize profits (6) obeying the decision rule for employment (4). Up to a positive constant, profits are given by $N^{\alpha\kappa}$. Unions maximize the average income of a member, i. e., the weighted sum of earnings in case of employment at the firm, $W_{l,q}$, and $V_q = (1-u_q)E(W_{l,q}) + u_q b_u E(W_{l,q})$, otherwise; here, $E(W_{l,q})$ is the expected wage of a union member who finds a job outside the firm. If union members of age $q \in \{0, \ldots, d-1\}$ have mass $\bar{N}_{l,q}$ the objective function of the union can, thus, be written as

$$\sum_{q=0}^{d-1} W_{l,q} \frac{N_{l,q}}{\bar{N}_{l,q}} - V_q \frac{\bar{N}_{l,q} - N_{l,q}}{\bar{N}_{l,q}} \ .$$

Therefore, the Nash maximand reads

$$\left(\sum_{q=0}^{d-1} N_{l,q}(W_{l,q} - V_q) \right)^{\nu} N^{\alpha\kappa(1-\nu)} \ , \quad \nu \in (0,1) \ . \tag{7}$$

If we assume an inner solution, wages are set as a markup on alternative incomes (see the appendix for details):

$$W_{l,q} = \left(\nu \frac{1}{\alpha_l \alpha \kappa} + 1 - \nu \right) V_q \ . \tag{8}$$

Unemployment of low skilled workers can be calculated for a symmetric equilibrium from (8) observing $V_q = (1 - u_q(1-b))W_{l,q}$:

$$u = u_q = \frac{1 - \alpha_l \alpha \kappa}{(1-b)\left(1 + \alpha_l \alpha \kappa \frac{1-\nu}{\nu}\right)} \ . \tag{9}$$

Hence, if unions do not favor a special group of workers and if bargaining parties do not take into account future consequences of their decisions, the unemployment rate among low skilled workers is independent of age and matches that of a static standard union model, see e. g. Layard, Nickell & Jackman (1991).

Following from the employment decision of firms (4) relative wages within groups are determined by relative work efficiency:[1]

$$\frac{w_{j,p}}{w_{j,q}} = \frac{W_{j,p}}{W_{j,q}} = \frac{z_{j,p}}{z_{j,q}} \ .$$

Relative wages between groups depend upon unemployment rates, relative labor supply, and income shares, additionally:

[1] All cohorts have the same mass $\bar{N}_j/D$ of members.

$$\frac{w_{l,p}}{w_{h,q}} = \frac{W_{l,p}}{W_{h,q}} = \frac{z_{l,p}}{z_{h,q}} \cdot \frac{\alpha_l}{\alpha_h} \cdot \frac{\bar{N}_h}{(1-u)\bar{N}_l} \; .$$

The latter equations show that unions can achieve higher relative wages for their members only at the cost of higher unemployment among low skilled workers. At the same time, the model disentangles the influence of market institutions and skill structure of labor supply on wage inequality: Given unemployment, a less heterogeneous labor force, i. e., a lower dispersion of the $z_{j,q}$, allows for a more homogeneous wage distribution. Hence, besides labor market rigidity, the model incorporates a second crucial determinant of wage dispersion, that is made responsible for differences of wage inequality across OECD countries.

Furthermore, wage structure is influenced by production technology through relative income shares α_l/α_h and relative work efficiency $z_{l,p}/z_{h,q}$. Thus, skill biased technological progress modeled as an increase in relative income share α_h/α_l or a higher productivity $z_{h,p}/z_{l,q}$ of highly skilled workers, respectively, yields higher wage inequality. On the other hand, this effect is mitigated, if relative endowment $\bar{N}_h/\bar{N}_l$ increases as a consequence of a higher wage premium of skilled workers.

2.5 Merits and Drawbacks

Several features of the model establish its usefulness to study the relationship between labor market institutions, unemployment, and wage distribution. Firstly, low skilled workers face a higher employment risk than high skilled workers, as can be observed in all OECD countries. Different unemployment rates are induced by differenct wage setting processes for the two skill groups: As is commonly assumed in empirical studies on the impact of labor market institutions, labor unions bargain over the wages of lower wage groups only, see e. g. Fitzenberger (1999). Secondly, the model encompasses several aspects discussed in the context of the different unemployment and wage distribution developments in Europe and the USA: Unions can maintain a given wage distribution in the face of skill biased technological progress ($z_{l,p}\alpha_l/(z_{h,q}\alpha_h)$ falls) only at the cost of higher unemployment of lower wage workers. This idea is expressed in the 'two-sides-of-the-same-coin' view of unemployment in Europe and high wage dispersion in the USA (Krugman (1994)). On the other hand, the degree of wage inequality is determined by the skill structure of the work force, too. For example, pointed out by Freeman & Schettkat (1999) or Nickell & Layard (1999), qualification is considerably more homogeneous in Germany than in the USA and, therefore, the distributions of wages in efficiency units in both countries are more similar than wage distributions by education group. Thus, low wage inequality in Germany may just like high wage gaps in the USA reflect an efficient market outcome.

Somewhat unsatisfactory is the static view of the wage bargaining process. It hinges on two crucial assumptions: Firstly, there are no adjustment costs in the model, as for example introduced in models of search unemployment, see e. g. Pissarides (2000). Secondly, bargaining parties do not consider the consequences of wage agreements for the future development of the firm. Therefore, the objective function of firms and labor unions, respectively, is influenced by current wage and employment only. While the first assumption is made to simplify things, the second is reasonable for a bargaining structure as in Germany. There, the bargaining takes place between an employer federation and a union representing the workers of a whole sector. Because employment and investment decisions are made at the firm level it is not possible for the employer federation to credibly make any agreements concerning future employment and investment.[2] Besides plausibility for certain bargaining settings, the static view of wage setting is in accordance with empirical evidence on the relationship between the determinants of economic growth and unemployment, see Nickell & Layard (1999).

3 Some Implications of the Model

In this section, the results of some simulation exercises are described. The simulations are confined to the steady state and the case of one skill group. Therefore, we set $\alpha_l = 1$ and $\bar{N} = \bar{N}_l = 1$, i. e., we consider the case of experience dependent work efficiency and a homogeneous unemployment rate for all experience groups. In the following, the index l for wages and employment is skipped. To simplify notation, the price index $\bar{P}$ is normalized to one.

3.1 Steady State

In steady state the dividend rate is constant: $r(t) = r^*$. Employment of workers of age q is $(1-u)/D$, where u is determined by model parameters (see (9)) and $1/D$ is the mass of age q workers. Therefore, the model behaves at aggregate level like a standard neoclassical growth model with labor input

$$N = (1-u)\bar{Z}/D \ , \quad \bar{Z} = \sum_{q=0}^{d-1} z_q \ ,$$

and exogenous growth rate of labor augmenting technological progress z. Accordingly, capital, labor, and transfer income, as well as capital input and production grow at rate z.

The dividend rate r^* determines the capital stock in efficient units of labor input, $k = K/(ZN)$, through (5):

$$k^* = \left(\frac{(1-\alpha)\kappa}{r^* + \delta} \right)^{\frac{1}{\alpha}} \ . \tag{10}$$

Observing (6) and $K(t+1) - (1-\delta)K(t) = (z - 1 + \delta)K(t)$, steady state cash flows $\pi = \Pi/(ZN)$ can be calculated as:

[2] Fitzenberger (1999) quotes that argument as justification for assuming a *right-to-manage* of the firm.

$$\pi^* = (1 - \alpha\kappa)(k^*)^{1-\alpha} - (z - 1 + \delta)k^* \ . \tag{11}$$

This in turn leads to an equation for the value of issued assets, i. e., for the discounted present value of future cash flows $a^s = A/(ZN)$, as a function of r^* and model parameters:

$$A(t) = \frac{\Pi(t) + A(t+1)}{1 + r^*} \quad \overset{A(t+1)=zA(t)}{\Longrightarrow} \quad a^s(r^*) = \frac{\pi^*}{1 + r^* - z} \ .$$

Furthermore, from (10) and (4) net wages in efficiency units, $w_q = (1-\tau)W_q/(ZN)$, follow as:

$$w_q^* = (1 - \tau)\alpha\kappa(k^*)^{1-\alpha}\frac{\bar{z}_q}{(1-u)/D} \ , \quad \bar{z}_q = \frac{z_q}{\bar{Z}} \ . \tag{12}$$

The size of the social security tax rate can be determined from the government's budget constraint:

$$\underbrace{\tau\frac{(1-u)}{D}\sum_{q=0}^{d-1} w_q^*}_{\text{revenue}} = \underbrace{(1-\tau)\left(b_u\frac{u}{D}\sum_{q=0}^{d-1} w_q^* + b_r\frac{D-d}{D}\frac{1}{d}\sum_{q=0}^{d-1} w_q^*\right)}_{\text{expenses}}$$

$$\Longrightarrow \ \tau = \frac{b_u u + b_r\frac{D-d}{d}}{1 - u + b_u u + b_r\frac{D-d}{d}} \ .$$

Given net wages and dividend rate, households steady state asset holdings can be calculated from the Bellman equation (2). It leads to a recursive definition of the value function v:

$$\begin{aligned} & v(a, D, s^r) \ \text{ constant and} \\ & v(a, q, s) = \max_{a' \text{ permitted}} u((1 + r^*)a + b(s)w_q^* - za') + \beta E_{q,s}\left(v(a', q+1, s')\right) \ , \\ & (q, s) \in \{0, \ldots, d-1\} \times \{s^e, s^u\} \cup \{d, \ldots, D-1\} \times \{s^r\} \ . \end{aligned} \tag{13}$$

A variety of algorithms is in use to approximate the value function and with that the decision rules in heterogenous agent economies, see e. g. Heer & Trede (2000) or Ríos-Rull (1995). The proceeding chosen here is to approximate the value function at a grid defined on the state space. A straightforward method would be to calculate the values of v at all grid points starting at period D and to search for the maximum by comparing the values of the function on the right hand side of (13) in every step $D-1, \ldots, 0$. This needs $\mathrm{O}(n^2)$ evaluations of the value function, where n is the number of grid points. But simplicity comes at the cost of long running time. Therefore, two simple, time saving refinements are made: Firstly, binary search for calculating the maximum needs only $\mathrm{O}(n \log_2(n))$ evaluations of the value function instead of $O(n^2)$. Secondly, a recursion starting at the time period of the agents decision is implemented. This approach is suggested by the Bellman equation and can be applied generally as a substitute of dynamic programming. Using a recursive procedure for implementation implies that the value function must be calculated only if the optimization algorithm calls for it. Therefore, the number of evaluations is determined flexibly at runtime and, in general, much less evaluations are required.

After the decision rules for a given dividend rate r are calculated, the asset holdings $a^d(r)$ per efficiency unit of labor, ZN, can be determined. To find the steady state dividend rate r^* a standard algorithm is used to solve the equation

$$0 = a^d(r^*) - a^s(r^*) \ . \tag{14}$$

3.2 Simulation Results

This section gives an impression of the impact of lifelong learning on economic performance. Furthermore, it describes the results of a model simulation for homogeneous work efficiency and a time profile of efficiency calibrated to match the age-earnings profile of West German males, respectively.

Tab. 1 shows the parameters values used to simulate the model. Most of them are chosen to match German time series data. Exemptions are β, γ, and b_r. The discount rate β was calibrated from the model using a steady state dividend rate of 4.5 percent[3] in case of homogeneous agents and $u = 0$. The intertemporal elasticity of substitution $\gamma = 2$ was chosen to fit into the range of microeconometric estimations of that parameter.[4] Finally, b_r is rather low for German data[5] but there would be an unrealistically strong impact for redistribution caused by the simplistic assumption concerning pension claims, otherwise.

firms					households					government	
α	α_l	κ	δ	z	d	D	β	γ	$\bar{N}_l$	b_u	b_r
0.78	1	0.83	0.04	1.012	40	58	0.98	2	1	0.6	0.3

Table 1: Parameter values for model simulation. Sources: Statistisches Jahrbuch 1999, Tab. 3.11, 3.31, and 6.4, Maußner (1999), Linnemann (1999).

There is a simple way to demonstrate the impact of lifelong learning within the model: As can be seen from (14) the dividend rate r^* is independent of Z. Therefore, production, capital, and wage levels are proportional to Z. More training on the job and better adoption of new working skills can be modeled through a steeper path of work efficiency z_q

[3]See Heer (2000).

[4]See Browning, Hansen & Heckman (1999).

[5]See the statistics of Verband deutscher Rentenversicherungsträger at http://www.vdr.de/statistik.

during working life $q = 0, \ldots, d-1$. For example, we can compare a path of no learning, $z_q = z^{-q} z_0$, to a path implying homogeneous labor, $z_q = z_0$. Relative efficiency and, with that, relative production, capital, and wage levels can be calculated as

$$\frac{d z_0}{\sum_{q=0}^{d-1} z^{-q} z_0} = 1.25 \ .$$

This points to the fact that there is a strong impact of lifelong learning on the performance of an economy.

The model is simulated for six settings: Besides the parameter values given in Tab. 1, regarding the distribution of wages we distinguished between the case of homogeneous labor ($z_0 = \ldots = z_{d-1}$), documented in column 'homogeneous labor', and an age-earnings profile calibrated to match that of West German males,[6] documented in column 'heterogeneous labor'. This leads to the wage dispersion shown in column 'heterogeneous labor' and row 'wages' of Tab. 2. Here, the row 'gini' gives the gini index; the notation P_x indicates the x percent quantile relative to the 50 percent quantile of a distribution. Furthermore, for unemployment rates a reference value of $u = 0$ and values $u \in \{0.05, 0.1\}$ are chosen. These are lower and upper bounds for unemployment rates in Germany between 1981-2000, with an average of 0.7 in this period.[7] For the simulation $\bar{Z}$ is set to 1. The table shows the simulated dividend rates r^* and the impact of unemployment on the relative level of production Y/Y_0. The simulated income distributions are given in row 'incomes'.

	empirical	homogeneous labor			heterogeneous labor		
u	0.7	0.0	0.05	0.1	0.0	0.05	0.1
r^*		0.0657	0.0660	0.0662	0.0772	0.0765	0.0765
Y/Y_0		1	0.949	0.899	0.971	0.924	0.876
wages gini	0.09	0.00			0.09		
wages P_{10}	0.64	1.00			0.67		
wages P_{90}	1.62	1.00			1.07		
incomes gini	0.27	0.18	0.18	0.19	0.21	0.22	0.22
incomes P_{10}	0.57	0.51	0.53	0.55	0.60	0.59	0.60
incomes P_{90}	1.72	1.39	1.40	1.41	1.67	1.68	1.70

Table 2: Simulation results.

In models of the kind presented here, the impact of uninsurable risks at macro level are modest. This is shown by the results presented in Tab. 2 where the dividend rate r^* is nearly

[6]The calibration makes use of the estimation of the age-earnings profile of Lauer & Steiner (2000). They estimate the equation $\ln(w) = \beta_0 + \beta_1 s + \beta_2 e + \beta_3 e^2$, were w are hourly wages, s years of schooling and e experience calculated as age minus 6.

[7]Including ex-GDR from 1991. Source: Eurostat.

independent of the size of unemployment. As a consequence, relative production, capital, and wage levels of two economies with different work efficiency and different unemployment rates can be approximated by relative levels of efficient labor input ZN.

Even though precautionary savings are insignificant at macro level, there is a value of using heterogeneous agent models with uninsurable risk, if one is interested in wage, income, or wealth distributions of economies with many different agents. This is due to the fact that the Bellman equation (13) is the same for every agent, given (q, s). Therefore, we have to distinguish only a maximum of $q \cdot s$ household types instead of one for every possible work history, i. e., 2^{d-1} types. Thus, if we want to consider the impact of unemployment as well as skill differences for income distributions there are much more household types than could be handled with a procedure based on a homogeneous agent model as proposed by Caselli & Ventura (2000), for example.

To give an impression of the suitability of the model to address questions of wage inequality, unemployment, and income inequality Tab. 2 shows the simulated income distribution for the two cases 'homogeneous labor' and'heterogeneous labor', respectively. Unemployment has only a minor impact. This result is probably due to the fact that unemployment spells are rather equally distributed and it allows for a good approximation of the heterogeneous agent model by a representative agent economy. But it do not conform to empirical research, see e. g. Hauser & Becker (2000). While unemployment does not explain much of the inequality in incomes, the empirical distribution of incomes is reproduced considerably better if one allows for age-dependent labor earnings. This is a common property of models of the kind presented here that is documented in Quadrini & Ríos-Rull (1997), for example.

4 Conclusion

A model integrating skill biased technological progress, labor market rigidity, and skill specific labor market segments has been developed. Skill specific unemployment rates depend on the wage setting process of the relevant labor market segment. Wage dispersion is determined by production technology, wage setting procedure, and skill structure of labor supply. Besides the additional structure arising from the microeconomic foundation of wage setting, a similar version of the model is already in use, see e. g. İmrohoroğlu, İmrohoroğlu & Joines (1995). It has shown to be a highly flexible tool to analyze the determinants of income distribution and welfare effects of policy reforms.

But, tractability comes at the price of strong assumptions concerning the wage setting process: It is assumed that bargaining parties do not take into account the impact of their agreement for future developments of wages, employment and investments. Hence, unemployment rates are determined by bargaining power, unemployment benefits, and the income share of union members–analogously to a standard static union model. This simplification is justified if bargaining takes place at sector level. In this case, bargaining parties cannot reach an agreement concerning employment and investment decisions, because these are made at the firm level.

While the myopic bargaining perspective can be justified, there are other simplifications which call for an extension of the model. Especially, to take into consideration the unequal distribution of unemployment spells within groups should lead to a higher impact of unemployment on income inequality. Furthermore, for a discussion of policy options to reduce unemployment in Europe without raising income inequality to US levels, the implications for the individual education decision become important. Thus, the model should be augmented in the way proposed by Heckman et al. (1998), for example.

To conclude, the model accounts for different reasons discussed in the context of widening wage gaps and high unemployment rates of unskilled workers in the OECD. It shows a theoretically founded and at the same time tractable way to study different proposals to improve the currently bad economic situation of the unskilled. For a meaningful analysis of the impact of economic and education policy the model should be augmented in the proposed directions.

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A Wage Setting

In this appendix it is shown how to derive (8) and (9). The Nash maximand of the bargain between firm and labor union is given by (see (7))

$$\left(\sum_{q=0}^{d-1} N_{l,q}(W_{l,q} - V_q) \right)^{\nu} N^{\alpha\kappa(1-\nu)} \ , \quad \nu \in (0,1) \ .$$

It is positiv for its maximum value. Hence, using the employment decision of the firm (4), additionally, it can be written, equivalently, as

$$\Omega = \tilde{\nu} \log (\alpha_u \alpha\kappa PY - \Phi) + \log N \ , \qquad \tilde{\nu} = \frac{\nu}{\alpha\kappa(1-\nu)} \ , \quad \Phi := \sum_{q=0}^{d-1} N_{l,q} V_q \quad .$$

Therefore, the optimization problem reads

$$\max_{(N_{l,0},\dots,N_{l,d-1})} \Omega \qquad \text{s.t. } N_{l,q} \le \frac{\bar{N}_{l,q}}{D} \text{ for } q = 0,\dots,d-1\,.$$

It is straightforward to show that the Kuhn-Tucker theorem can be applied for maximization. Therefore, an inner solution of the problem solves

$$\frac{\partial \Omega}{\partial N_{l,q}} = 0 \text{ for } q = 0,\dots,d-1\,. \tag{15}$$

To simplify the calculation we make use of the following equalities (see (4)):

$$\frac{\partial PY}{\partial N_{l,q}} = W_{l,q} \text{ and } \frac{\partial N}{\partial N_{l,q}} = z_{l,q}\alpha_u \frac{N}{N_{l,q}} = \frac{W_{l,q}N}{\alpha\kappa PY}\,. \tag{16}$$

Observing (16) we get from (15):

$$\begin{aligned}
0 &= \tilde{\nu}\frac{\alpha_u\alpha\kappa\frac{\partial PY}{\partial N_{l,q}} - V_q}{\alpha_u\alpha\kappa PY - \Phi} + \frac{\frac{\partial N}{\partial N_q}}{N} = \tilde{\nu}\frac{\alpha_u\alpha\kappa W_{l,q} - V_q}{\alpha_u\alpha\kappa PY - \Phi} + \frac{W_{l,q}}{\alpha\kappa PY} \\
\Longrightarrow \tilde{\nu}V_q &= \left(\tilde{\nu}\alpha_u\alpha\kappa + \alpha_u - \frac{\Phi}{\alpha\kappa PY}\right)W_{l,q} = \left(\frac{\alpha_u}{1-\nu} - \frac{\Phi}{\alpha\kappa PY}\right)W_{l,q} \\
\Longrightarrow W_{l,q} &= \underbrace{\frac{\nu}{\alpha\kappa(1-\nu)}\frac{1}{\frac{\alpha_u}{1-\nu} - \frac{\Phi}{\alpha\kappa PY}}}_{=:\mu}V_q
\end{aligned}$$

In particular, $\mu = W_{l,q}/V_q$ is independent of q. Therefore, Φ reduces to

$$\Phi = \sum_{q=0}^{d-1} N_{l,q}V_q = \frac{1}{\mu}\sum_{q=0}^{d-1} N_{l,q}W_{l,q} = \frac{\alpha_u\alpha\kappa PY}{\mu}\,.$$

This leads to

$$\mu = \frac{\nu}{\alpha\kappa(1-\nu)}\frac{1}{\frac{\alpha_u}{1-\nu} - \frac{\alpha_u}{\mu}} \quad \Longrightarrow \quad \mu = \frac{\nu}{\alpha_u\alpha\kappa} + 1 - \nu$$

as stated in (8).

In a symmetric equilibrium we have $V_q = (1-(1-b)u_q)W_{l,q} = (1-(1-b)u_q)\mu V_q$. Therefore, (9) follows:

$$1 = (1-(1-b)u_q)\mu \quad \Longrightarrow \quad u_q = \frac{1-\alpha_l\alpha\kappa}{(1-b)\left(1+\alpha_l\alpha\kappa\frac{1-\nu}{\nu}\right)}\,.$$

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