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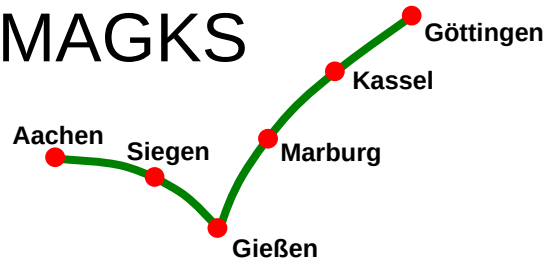

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Wage and (Un-)Employment Effects of an Ageing Workforce*

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April 24, 2009

Abstract

In almost all Western economies the median age of the workforce is increasing due to demographic factors. Given the empirical fact that workers of different ages are not perfect substitutes in production, this paper explores how change in the age pattern affects wages and (un)employment. We develop a general equilibrium model where wages for young and old workers are set by monopoly unions at the firm-level. Contrary to the common wisdom on this topic, we show that an increase in the relative number of older workers for a given labor force size has no effect on young and old unemployment. If, however, unions attach a higher weight to the wishes of the old, the unemployment rate of the old (young) will increase (decrease). In this case we observe a redistribution of wage income from the young to the old.

JEL-Classification: E2, J2, J5

Keywords: workforce ageing, unemployment, wage bargaining

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1 Introduction

It is a truism that demographic change leads to an increase in the median age of the population and the median age of the workforce. The baby-boom generation, those born in the late fifties and sixties, is moving into higher age groups and will retire in the near future. The decline in fertility rates substantiates the process of an ageing workforce via a lower number of entrants into the labor market.[1] Such a change in the age structure would not matter if workers of different age groups were perfect substitutes. But numerous studies show that they differ, for instance, with respect to participation rates, labor productivity, job turnover rates, labor adjustment costs and not least with respect to the degree of unionization (see eg. Skirbekk 2004, Ichino et al. 2007, Blanchflower 2007). The purpose of this paper is to develop a general equilibrium model of a unionized economy to analyze the equilibrium effects of workforce ageing on the labor market. The focus will be on age-dependent wage and unemployment differentials.

There is no standard approach on how to model the process of an ageing workforce. Thus we will distinguish between different scenarios: old workers carry more weight in union preference functions than young workers do, the ratio of old to young workers rises for a given labor force, and unemployment benefits for older individuals become more generous and/or less generous for younger workers.

The first scenario has a straightforward motivation: age matters for both union membership and the union objective function. As stated by Schnabel and Wagner (2008a), the international evidence is somewhat mixed, but in general the relationship between age and union membership tends to be positive. Union members are on average older than non-unionized employees (Schnabel and Wagner 2008b). We take up this empirical regularity by assuming that unions do not treat all members identically but attach more weight to the wishes of the old. If the union, in order to be re-elected, is assumed to maximize the expected utility of the median-aged member and this member is getting older, the union objective function will be

[1] In the United States the median age of the workforce is projected to rise from 35.4 years in 1986 to 42.1 years in 2016 (see Toossi 2007). In some countries the ageing will be even stronger. According to the World Population Prospects of the United Nations (2007), Western Europe will face an increase in the median age of the population from 34.5 in 1980 to 44.7 in 2020. In Germany the modal age of the labour force is projected to rise from thirty-six years in 2000 to fifty-four years in 2020 (Börsch-Supan 2003).

biased towards the interests of the old. This process will probably be magnified by the observation that the representatives of the union are typically older individuals. Furthermore, if old workers gain insider status through seniority and ageing on the job, almost all insider-outsider arguments can be put forward to justify a higher weight of the old in the union objective function (Pissarides 1989).

Our second scenario - model the demographic change by a rise in the ratio of old to young workers - suggest itself. The third approach reflects discussions on how the ageing of the median voter will influence the outcome of the political process. Even today in almost all Western economies the unemployment benefits for the old are more generous than for the young. We suppose that, due to the change in the ageing pattern, the gap in the unemployment benefits between old and young will widen in the future.

Only a small number of theoretical papers is concerned with the issue of workforce ageing in a unionized economy. Schmidt (1993) develops a model where wages are set by a large monopoly union that organizes the workforce of the whole economy. Assuming that the union maximizes the sum over age-specific wage bills, he shows how the chosen wages and the corresponding age-specific unemployment rates are influenced by the age structure. Hetze and Ochsen (2006) use a search-theoretic framework to analyze how an age-specific separation risk influences equilibrium wages and unemployment.

The most detailed analysis of the issue at hand is given by Pissarides (1989). He uses an equilibrium model of a decentralized but completely unionized economy. At the firm-level the union and the firm simultaneously determine wages and employment (efficient bargaining model). The union preference is a weighted average of the utility functions of young and old workers. To arrive at the general equilibrium, all union-firm pairs are assumed to be identical. Within this framework Pissarides (1989) derives some unorthodox results. Most noticeably, an increase in the ratio of old to young workers reduces the unemployment rate and the wage rate of both age groups in the population. These results are not very intuitive. It is by now well-known that the right-to-manage and the efficient bargaining models may deliver different outcomes with respect to wages and employment (Layard and Nickell 1990), so the modelling of the labor market imperfection is decisive. But since in the real world efficient bargains are more the exception than the rule, it

is doubtful whether the Pissarides framework allows for a meaningful description of the most likely effects of an ageing workforce.

We prefer the right-to-manage approach. The model we set up in the next section frames an economy with two types of workers, young and old, and two types of occupations, junior jobs and senior jobs. Senior jobs are open only to old workers. Junior jobs, however, can be filled by both young and old workers. The wages are set by a monopoly union at the firm level, the firm continues to choose the number of workers it wishes to employ. We get, at least from our point of view, more intuitive results which are very different from those of Pissarides (1989). In particular, an increase in the relative number of older workers for a given labor force size has no effect on young and old unemployment. Even in a unionized economy it is optimal to adjust the wages, so that employment moves one-to-one with the change in the labor force. This theoretical result is in line with the empirical study of Zimmermann (1991) who, using German data, finds an impact of the age composition of the population on short-term dynamics, but no clear relation between the age structure and age-specific unemployment rates in the long run. If, however, the process of an ageing workforce is modelled as an increase in unions' preference for old age, we can show that the unemployment rate of the old (young) will increase (decrease). The net effect on overall employment depends on the parameter constellation. There will always be a redistribution of wage income from the young to the old.

The rest of the paper is structured as follows. Section 2 briefly introduces the main features of the model. Section 3 solves for the general equilibrium. The analysis of the labor market effects of an ageing workforce is performed in Section 4. Section 5 concludes.

2 Setup of the model

As just mentioned, we consider an economy with two types of workers, young and old, and two types of occupations, junior jobs and senior jobs. Senior jobs can be filled only by old workers. Junior jobs are open to both young and old workers. Young and old workers are imperfect substitutes in filling a junior job. The wages are set by a monopoly union at the firm level, whereas the firm retains the right

to determine the number of jobs and to pick the required employees from a pool of unemployed workers. Each firm sells its output in monopolistic markets.

2.1 Technology

Junior jobs and senior jobs are assumed to be imperfect substitutes in production. Many studies on the issue of age and productivity find that older workers are particularly strong when a good knowledge of production processes, organizational skills and verbal abilities is important, but they are relatively weak when learning and physical strength matter more. As a consequence, workers in different age brackets perform different tasks (see Barth et al. 1993, Börsch-Supan 2003, Aubert et al. 2006, and, for a survey, Skirbekk 2004). Given this evidence we write the firm's production function as

$$Y = (N_1)^{\gamma}(N_2)^{\beta}, \tag{1}$$

where N_1 and N_2 denote the number of junior jobs in efficiency units and the number of senior jobs, respectively. Due to a fixed factor and/or a decline in the output price, Eq. (1) shows diminishing returns to scale ($\gamma + \beta < 1$). Senior jobs require skills like education and (employment) experience, only old workers are endowed with these skills, and thus only old workers can fill these jobs. On the other hand, junior jobs can be filled by everyone. But since workers in different age brackets may differ in their productivity, we introduce some degree of imperfect substitutability between young and old workers filling a junior job. To preserve tractability the junior job-"technology" is assumed to be Cobb-Douglas:

$$N_1 = (N_1^y)^{\delta}(N_1^o)^{1-\delta}, \tag{2}$$

where N_1^y (N_1^o) is the number of young (old) workers with a junior job. Let w_1^y, w_1^o and w_2 be the wages of a young worker with a junior job, an old worker with a junior job and an old worker with a senior job, respectively. Given these wages the firm maximizes its profit function, $\pi = R\left(N_1^y, N_1^o, N_2\right) - w_1^y N_1^y - w_1^o N_1^o - w_2 N_2$,

with respect to N_1, N_1^o and N_2. The first-order conditions

$$\gamma\delta(N_1^y)^{\gamma\delta-1}(N_1^o)^{\gamma(1-\delta)}(N_2)^{\beta} = w_1^y \quad (3)$$

$$\gamma(1-\delta)(N_1^y)^{\gamma\delta}(N_1^o)^{\gamma(1-\delta)-1}(N_2)^{\beta} = w_1^o \quad (4)$$

$$\beta(N_1^y)^{\gamma\delta}(N_1^o)^{\gamma(1-\delta)}(N_2)^{\beta-1} = w_2 \quad (5)$$

are the standard textbook result, as the firm employs workers up to the point where the marginal product equals the wage. The labor demand schedules (3), (4) and (5) pin down the number of jobs for given wages.

2.2 Wage determination at the firm-level

The union maximizes a weighted sum of its members' utility. Only the rent of unionization, i.e. the surplus income over the fallback income, enters the utility function of an individual worker. Assuming risk-neutral workers, the union objective function is given by

$$U = (w_1^y - b_1)\, N_1^y + \theta(w_1^o - b_2)N_1^o + \alpha(w_2 - b_2)N_2, \quad (6)$$

where b_1 is the fallback income of a young worker defined as the income a young union member obtains when he is not employed by the firm in question. The fallback income of an old worker, b_2, differs from b_1 for two reasons: firstly, unemployment benefits for older individuals are generally more generous than for younger workers, and secondly, only old workers can apply for a senior job. If both weights, θ and α, are equal to one, all members are treated identically by the union. If, however, the union attaches more weight to the wishes of old workers, these weights exceed one. The objective function (6) also allows for a different treatment of old workers with junior jobs and old workers with senior jobs. If the reason older workers carry more weight in the union's preference function is primarily a pure age effect - young versus old -, it is natural to assume $\theta = \alpha > 1$. If, however, the main reason is long tenure, old workers with a junior job are newcomers and thus should be treated like young workers, $\theta = 1$ and $\alpha > 1$.

The monopoly union sets the wage levels w_1^y, w_1^o and w_2 unilaterally subject to the firms's labor demand schedules (3), (4) and (5). The first-order conditions read

$$N_1^y = -(w_1^y - b_1)\frac{\partial N_1^y}{\partial w_1^y} - \theta(w_1^o - b_2)\frac{\partial N_1^o}{\partial w_1^y} - \alpha(w_2 - b_2)\frac{\partial N_2}{\partial w_1^y} \quad (7)$$

$$\theta N_1^o = -\theta(w_1^o - b_2)\frac{\partial N_1^o}{\partial w_1^o} - (w_1^y - b_1)\frac{\partial N_1^y}{\partial w_1^o} - \alpha(w_2 - b_2)\frac{\partial N_2}{\partial w_1^o} \quad (8)$$

$$\alpha N_2 = -\alpha(w_2 - b_2)\frac{\partial N_2}{\partial w_2} - (w_1^y - b_1)\frac{\partial N_1^y}{\partial w_2} - (w_1^o - b_2)\frac{\partial N_1^o}{\partial w_2}. \quad (9)$$

The junior wage w_1^y will be set such that the utility gain of young members with a junior job is equal to the utility loss arising from a decline in employment. But the decline in employment is not restricted to a lower N_1^y. Because of positive cross-derivatives, the marginal revenue of all old workers declines too, causing layoffs of old workers (lower N_1^o and N_2). A similar line of argument holds for the optimal wages w_1^o and w_2.

Observing (3), (4) and (5), rearrangement of (7), (8) and (9) yields

$$w_1^y = \frac{1}{\gamma\delta + \alpha\beta + \gamma(1-\delta)\theta} \cdot b_1 \quad (10)$$

$$w_1^o = \frac{\theta}{\gamma\delta + \alpha\beta + \gamma(1-\delta)\theta} \cdot b_2 \quad (11)$$

$$w_2 = \frac{\alpha}{\gamma\delta + \alpha\beta + \gamma(1-\delta)\theta} \cdot b_2. \quad (12)$$

The optimal senior wage w_2 is a mark-up on the fallback income b_2, and the mark-up is increasing in the weight α. But attaching a higher weight to the wishes of old workers with a senior job is equivalent to attaching a relatively lower weight to the wishes of young union members and old union members with a junior job. Consequently, the mark-ups and thus the optimal wages w_1^y and w_1^o decrease in α. Similarly, a higher weight of old union members with a junior job (higher θ) leads to a higher wage w_1^o, but a decline in w_1^y and w_2. In the case where all old union members are treated identically ($\theta = \alpha$), the wages of all old workers are identical, $w_1^o = w_2$ holds.

2.3 Search environment and flow equilibria

The critical step in going from the partial to the general equilibrium is the specification of the fallback incomes b_1 and b_2. A young worker unable to get a job within the firm under consideration receives unemployment benefits B_1 and searches for a junior job elsewhere. He finds a job and leaves unemployment with per period probability h. While employed he gets the wage w_1^y. But he faces the risk of losing the job again; in each period a proportion z of all job matches is separated for exogenous reasons. Having defined the relevant transition rates and the compensation in each state we can write the value functions for young workers as

$$rV_u^y = B_1 + h(V^y - V_u^y) \tag{13}$$

$$rV^y = w_1^y + z(V_u^y - V^y), \tag{14}$$

where V_u^y is the present value of the (expected) income stream of an unemployed young worker, V^y is the present value of the income of an employed young worker, and r is the discount rate. Equations (13) and (14) embody the assumptions that time is continuous and individuals have infinite horizons.

Old workers unable to get a job within the firm in question receive unemployment benefits B_2, they search for both senior and junior jobs. The probability of finding a senior job elsewhere is a, and the rate of pay is the wage w_2. Analogously, they escape unemployment for a junior job with probability p, the rate of pay is w_1^o. Observing a job separation rate of z, the asset values for old workers are thus given by

$$rV_u^o = B_2 + a(V_2^o - V_u^o) + p(V_1^o - V_u^o) \tag{15}$$

$$rV_2^o = w_2 + z(V_u^o - V_2^o) \tag{16}$$

$$rV_1^o = w_1^o + z(V_u^o - V_1^o), \tag{17}$$

where V_u^o, V_2^o and V_1^o are the present values of the income of an old worker who is unemployed, fills a senior job and fills a junior job, respectively. Our approach ensures that old workers with a junior job may switch back to a senior job (via a

spell of unemployment).[2]

Next consider the flow equilibria. Since we distinguish between three kinds of labor - young workers, old workers with a junior job and old workers with a senior job -, we have three flow equilibrium constraints. In a steady state where entries into unemployment equal exits from unemployment to employment, the equilibria are given by

$$zN_1^y = h(L_1 - N_1^y) \tag{18}$$

$$zN_2 = a(L_2 - N_2 - N_1^o) \tag{19}$$

$$zN_1^o = p(L_2 - N_2 - N_1^o), \tag{20}$$

where L_1 and L_2 denote the number of young and old workers in the workforce, respectively. Defining the fallback incomes b_1 and b_2 as flow equivalent of V_u^y and V_u^o, respectively, rearrangement of (13) - (20) leads to $b_1 = u_1 B_1 + (1 - u_1) w_1^y$ and $b_2 = u_2 B_2 + l_2 w_2 + l_1^o w_1^o$ with $l_2 := \frac{N_2}{L_2}$ and $l_1^o := \frac{N_1^o}{L_2}$. The derivation made use of the definitions of the unemployment rates:

$$u_1 = \frac{L_1 - N_1^y}{L_1} \tag{21}$$

$$u_2 = \frac{L_2 - N_2 - N_1^o}{L_2}. \tag{22}$$

The fallback income of a young worker is a weighted average of unemployment benefits B_1 and the junior wage obtainable in other firms of the economy, the weights being the rates of unemployment and employment. Similarly, the fallback income b_2 of an old worker is a weighted average of unemployment benefits B_2, the senior wage and the wage w_1^o. The weights are now given by the unemployment rate u_2, the ratio of senior jobs to the number of old workers (as proxy for the probability of finding a senior job), and the ratio of junior jobs filled with old

[2] Concerning the transition from junior to senior jobs there seems to be a flaw in the Pissarides (1989) model. He assumes that in each period a fraction of old workers is separated from their senior job for exogenous reasons. Some of them, or even all, will get a junior job. In subsequent periods they stay with the junior job, and they do not have a chance to switch back to a senior job. As a consequence, the number of old workers with a senior job constantly declines and goes to zero, which cannot be an equilibrium.

workers to the number of old workers (as proxy for the probability of finding a junior job). We restrict the analysis to the case of constant replacement ratios, that is, $\rho_1 \equiv \frac{B_1}{w_1}$ and $\rho_2 \equiv \frac{B_2}{w_2}$ are assumed to be kept constant by the government. This implies:

$$b_1 = u_1 \rho_1 w_1^y + (1 - u_1) w_1^y \tag{23}$$

$$b_2 = u_2 \rho_2 w_2 + l_2 w_2 + l_1^o w_1^o, \tag{24}$$

The unemployment benefits for the old, $B_2 = \rho_2 w_2$, must not exceed the wage w_1^o, otherwise no unemployed old worker will have an incentive to seek a junior job.

3 Solving the model

Because of non-linearities, the model here does not yield a closed-form solution. In order to perform comparative statics we log-linearize the model denoting relative

changes by a tilde. The structural form of our model is as follows:

$$\widetilde{N}_1^y = -\frac{\gamma(1-\delta)}{1-\beta-\gamma}\cdot\widetilde{w}_1^o - \frac{1-\beta-\gamma+\gamma\delta}{1-\beta-\gamma}\cdot\widetilde{w}_1^y - \frac{\beta}{1-\beta-\gamma}\cdot\widetilde{w}_2 \tag{25}$$

$$\widetilde{N}_1^o = -\frac{1-\beta-\gamma\delta}{1-\beta-\gamma}\cdot\widetilde{w}_1^o - \frac{\gamma\delta}{1-\beta-\gamma}\cdot\widetilde{w}_1^y - \frac{\beta}{1-\beta-\gamma}\cdot\widetilde{w}_2 \tag{26}$$

$$\widetilde{N}_2 = -\frac{\gamma(1-\delta)}{1-\beta-\gamma}\cdot\widetilde{w}_1^o - \frac{\gamma\delta}{1-\beta-\gamma}\cdot\widetilde{w}_1^y - \frac{1-\gamma}{1-\beta-\gamma}\cdot\widetilde{w}_2 \tag{27}$$

$$\widetilde{w}_1^y = -\frac{\alpha\beta}{A}\cdot\widetilde{\alpha} - \frac{\gamma(1-\delta)\theta}{A}\cdot\widetilde{\theta} + \widetilde{b}_1 \tag{28}$$

$$\widetilde{w}_1^o = -\frac{\alpha\beta}{A}\cdot\widetilde{\alpha} + \frac{\gamma\delta+\alpha\beta}{A}\cdot\widetilde{\theta} + \widetilde{b}_2 \tag{29}$$

$$\widetilde{w}_2 = \frac{\gamma\delta+\gamma(1-\delta)\theta}{A}\cdot\widetilde{\alpha} - \frac{\gamma(1-\delta)\theta}{A}\cdot\widetilde{\theta} + \widetilde{b}_2 \tag{30}$$

$$\widetilde{b}_1 = \widetilde{w}_1^y - \frac{(1-\rho_1)u_1}{1-(1-\rho_1)u_1}\cdot\widetilde{u}_1 + \frac{\rho_1 u_1}{1-(1-\rho_1)u_1}\widetilde{\rho}_1 \tag{31}$$

$$\widetilde{b}_2 = \frac{u_2\rho_2 w_2}{b_2}\cdot(\widetilde{w}_2+\widetilde{\rho}_2+\widetilde{u}_2) + \frac{l_2 w_2}{b_2}\cdot(\widetilde{l}_2+\widetilde{w}_2) + \frac{l_1^o w_1^o}{b_2}\cdot(\widetilde{l}_1^o+\widetilde{w}_1^o) \tag{32}$$

$$\widetilde{u}_1 = \frac{1-u_1}{u_1}\cdot(\widetilde{L}_1 - \widetilde{N}_1^y) \tag{33}$$

$$\widetilde{u}_2 = -\frac{l_2}{u_2}\cdot\widetilde{l}_2 - \frac{l_1^o}{u_2}\cdot\widetilde{l}_1^o \tag{34}$$

where $A \equiv \gamma\delta+\alpha\beta+\gamma(1-\delta)\theta > 0$ and $\widetilde{l}_1^o = \widetilde{N}_1^o - \widetilde{L}_2$ and $\widetilde{l}_2 = \widetilde{N}_2 - \widetilde{L}_2$. Equations (25) - (34) constitute a system of ten equations with ten endogenous variables: $\widetilde{w}_1^y, \widetilde{w}_1^o, \widetilde{w}_2, \widetilde{N}_1^y, \widetilde{N}_1^o, \widetilde{N}_2, \widetilde{b}_1, \widetilde{b}_2, \widetilde{u}_1, \widetilde{u}_2$. Eqs. (25) - (27) indicate that all three kinds of labor are gross substitutes, the direct as well as the cross elasticities of labor demand are negative. As explained above, the target junior wage, i.e. the junior wage intended by the wage setters, is decreasing in θ and α (see Eq. (28)). The target wage for old workers with a junior job, as given by (29), is increasing in θ but decreasing in α. If unions treat all old workers identically ($\theta = \alpha$ and thus $\widetilde{\theta} = \widetilde{\alpha}$), the wage w_1^o is increasing in the weight representing the wishes of old workers. The target senior wage rises with α and declines with θ (see Eq. (30)).

For $\theta = \alpha$ and thus $\widetilde{\theta} = \widetilde{\alpha}$, the wage w_2 is increasing in α. Eqs. (31) and (32) reflect the fallback incomes, and Eqs. (33) and (34) describe the unemployment rates.

Our focus will be on the change in the median age of the workforce. We thus restrict the analysis to the case where unions do not look at tenure but treat all old workers identically. For $\theta = \alpha$ and thus $\widetilde{\theta} = \widetilde{\alpha}$, the solution of the model reads:

$$\widetilde{u}_2 = \frac{(1-u_2)b_2}{u_2 D}\frac{\gamma\delta}{A}\cdot\widetilde{\alpha} + \frac{(1-u_2)\rho_2 w_2}{D}\cdot\widetilde{\rho}_2 \tag{35}$$

$$\widetilde{u}_1 = -\frac{1-(1-\rho_1)u_1}{(1-\rho_1)u_1}\frac{\alpha F}{A}\cdot\widetilde{\alpha} + \frac{\rho_1}{1-\rho_1}\cdot\widetilde{\rho}_1 \tag{36}$$

$$\widetilde{N}_2 = -\frac{b_2}{D}\frac{\gamma\delta}{A}\cdot\widetilde{\alpha} - \frac{u_2\rho_2 w_2}{D}\cdot\widetilde{\rho}_2 + \widetilde{L}_2 \tag{37}$$

$$\widetilde{N}_1^y = \frac{\alpha E F}{A}\cdot\widetilde{\alpha} - G\cdot\widetilde{\rho}_1 + \widetilde{L}_1 \tag{38}$$

$$\widetilde{N}_1^o = \widetilde{N}_2 \tag{39}$$

$$\widetilde{w}_1^o = \widetilde{w}_2 \tag{40}$$

$$\tag{41}$$

$$\widetilde{w}_2 = \frac{\gamma\delta}{A}\left(\frac{b_2}{D} + \alpha E F\right)\cdot\widetilde{\alpha} + \frac{(1-F)u_2\rho_2 w_2}{D}\cdot\widetilde{\rho}_2 - \gamma\delta G\cdot\widetilde{\rho}_1 - (1-F)\cdot\widetilde{L}_2 + \gamma\delta\cdot\widetilde{L}_1 \tag{42}$$

$$\widetilde{w}_1^y = -\frac{1}{A}\left[\frac{\gamma\delta b_2}{D} + \alpha E(1-\gamma\delta)F\right]\cdot\widetilde{\alpha} - \frac{F u_2\rho_2 w_2}{D}\cdot\widetilde{\rho}_2 + (1-\gamma\delta)G\cdot\widetilde{\rho}_1 + F\cdot\widetilde{L}_2 - (1-\gamma\delta)\cdot\widetilde{L}_1 \tag{43}$$

where $D \equiv b_2 - \rho_2 w_2 > 0$ and $E \equiv \frac{1-(1-\rho_1)u_1}{(1-\rho_1)(1-u_1)} > 0$ and $0 < F \equiv \beta + \gamma - \gamma\delta < 1$ and $G \equiv \frac{\rho_1 u_1}{(1-\rho_1)(1-u_1)} > 0$. For the change in the labor income of the old and the

young we get

$$\begin{aligned}\widetilde{w}_2 + \widetilde{N}_2 &= \frac{\alpha\gamma\delta}{A} EF \cdot \widetilde{\alpha} - \frac{Fu_2\rho_2 w_2}{D} \cdot \widetilde{\rho}_2 - \gamma\delta G \cdot \widetilde{\rho}_1 \\ &\quad + F \cdot \widetilde{L}_2 + \gamma\delta \cdot \widetilde{L}_1 \end{aligned} \tag{44}$$

$$\begin{aligned}\widetilde{w}_1^y + \widetilde{N}_1^y &= -\frac{\gamma\delta}{A}\left[\frac{b_2}{D} - \alpha EF\right] \cdot \widetilde{\alpha} - \frac{Fu_2\rho_2 w_2}{D} \cdot \widetilde{\rho}_2 - \gamma\delta G \cdot \widetilde{\rho}_1 \\ &\quad + F \cdot \widetilde{L}_2 + \gamma\delta \cdot \widetilde{L}_1 \end{aligned} \tag{45}$$

Note that we have $\widetilde{w}_2 + \widetilde{N}_2 = \widetilde{w}_1^o + \widetilde{N}_1^o$. Combining the log-linearized versions of the junior job-"technology" (2) and the production function (1) with (37) - (39) delivers the change in the number of junior jobs in efficiency units and the change in output:

$$\begin{aligned}\widetilde{N}_1 &= \frac{\delta}{A}\left[EF - \frac{\gamma(1-\delta)b_2}{D}\right] \cdot \widetilde{\alpha} - \frac{(1-\delta)u_2\rho_2 w_2}{D} \cdot \widetilde{\rho}_2 - \delta G \cdot \widetilde{\rho}_1 \\ &\quad + (1-\delta) \cdot \widetilde{L}_2 + \delta \cdot \widetilde{L}_1 \end{aligned} \tag{46}$$

$$\begin{aligned}\widetilde{Y} &= -\frac{\gamma\delta F}{A}\left[\frac{b_2}{D} - E\alpha\right] \cdot \widetilde{\alpha} - \frac{Fu_2\rho_2 w_2}{D} \cdot \widetilde{\rho}_2 - \gamma\delta G \cdot \widetilde{\rho}_1 \\ &\quad + F \cdot \widetilde{L}_2 + \gamma\delta \cdot \widetilde{L}_1 \end{aligned} \tag{47}$$

Note that we do not specify the initial equilibrium around which we log-linearize the model. The analysis is thus not restricted to, for instance, a symmetric initial steady state.

4 Effects of an ageing workforce

In this section we use our model to address the question of how an ageing workforce affects the labor market. Since there is no standard approach on how to model the process of an ageing workforce, we distinguish between the following scenarios:

- unions attach more weight to the wishes of old workers
- the number of old workers increases
- the number of young workers decreases

- the ratio of old to young workers rises for a given labor force

- unemployment benefits for older individuals become more generous and/or less generous for younger workers.

Of course, the overall effect of an ageing workforce is a mixture of all scenarios, but splitting up the overall effect allows for a better understanding of the transmission mechanisms at work.

4.1 Unions attach greater weight to the wishes of old workers

Since the median age of the labor force and thus the median age of the union members will increase, older workers will get a greater weight in the formation of the unions' preferences. The labor market effects of such a process are described in

Proposition 1 : *Suppose unions attach a greater weight to the wishes of old workers ($\widetilde{\alpha} > 0$). Then (i) the unemployment rate of the old increases whereas (ii) the unemployment rate of the young decreases. The net effect on (iii) overall employment and (iv) output cannot be signed unambiguously. (v) The wage differential between the wage rate for senior and junior jobs widens, there will always be (vi) a redistribution of labor income from the young to the old.*

Proof: All proofs of all propositions immediately follow from the inspection of (35) - (47). ■

Attaching a higher weight to the wishes of the old is equivalent to attaching a lower weight to the wishes of the young. Thus the impact on the unions' wage claims is twofold; monopoly unions will set a higher senior wage w_2 and a higher wage for old workers with a junior job w_1^o but a lower junior wage w_1^y. At the firm-level, the wage mark-ups on the exogenously given fallback incomes adjust. At the aggregate level, where the fallback incomes are endogenous, the change in the wage rates is even more pronounced, that is, the repercussions from the aggregate level enhance the impact effects on wages. By making use of the concept of wage-setting (WS) and price-setting (PS) schedules, cf. Lindbeck 1993 and Layard et al. (2005), we can visualise the labor market effects. In Figures 1 and 2 the WS-schedules

describe the target real wage. For a given level of unemployment benefits these schedules are negatively sloped in the wage-unemployment space. For a constant replacement ratio, however, the WS schedules degenerate to a vertical pinning down the aggregate unemployment rate. For the junior job market, the vertical WS schedule can be obtained by combining (28) with (31); for the senior job market, the vertical WS schedule can be derived by combining (30) with (32) (remember that we have assumed $\widetilde{\alpha} = \widetilde{\theta}$ and thus $\widetilde{w}_1^o = \widetilde{w}_2$). The PS schedules decribe the feasible real wage, that is, the wage firms are willing to pay for a worker filling a job. Due to a declining marginal product of labor the PS schedules are positively sloped in the wage-unemployment space.

Figure 1 and Figure 2 about here

Suppose the initial steady state is given by point A. The increase in α shifts the WS(B_2) schedule to the right (in Figure 1) and the WS(B_1) schedule to the left (in Figure 2). We observe a higher senior wage and a lower junior wage. Consequently, the unemployment rate of the old increases whereas the unemployment rate of the young decreases (point B in both Figure 1 and 2). Point B, however, is not an equilibrium. Compared to point A, the replacement ratio of the old (young) has gone down (up). In order to keep the replacement ratio constant, the government will raise the unemployment benefits for the old and cut the unemployment benefits for the young. This in turn triggers an even higher target senior wage and an even lower target junior wage. In Figure 1 and 2 we observe point C. Note, however, that the price-setting schedules shift too. Due to higher employment of the young and its positive cross-effect on the marginal product of senior jobs, the feasible real wage for senior jobs shifts up (from PS_0 to PS_1 in Figure 1). The same mechanism, but with a reversed sign, causes a downward shift of the PS-schedule for young workers in Figure 2. Point D represents the new equilibrium.

Concerning the number of junior jobs in efficiency units, N_1, we observe two counteracting forces, a higher N_1^y and a lower N_1^o. The net effect, however, cannot not be signed without further restrictions on the initial steady state. This holds true even for aggregate production (see Eq. (47)). If both N_1 and N_2 decline, the decline in output is obvious. But if N_1 goes up, it is possible that aggregate

production also goes up. Simulations indicate that this scenario is quite extreme, but there are some parameter constellations generating an increase in output as a result of a higher α.

A higher α leads to a redistribution of labor income from the young to the old. The size of the pie (in terms of production) probably declines, but labor income of the old unambiguously increases (see Eq. (44)). The increase in the senior wage always outweighs the decline in employment of old workers. The wage income of young workers decreases for most plausible parameter constellations. But if production increases there is some room even for an increase in the labor income of the young (the inspection of Eqs. (45) and (47) reveals that a higher Y is necessary but not sufficient for such a scenario). The ratio of the wage income of the old to the wage income of the young, given by $\widetilde{w}_2 + \widetilde{N}_2 - (\widetilde{w}_1^y + \widetilde{N}_1^y)$, always increases.

4.2 Increase in the number of old workers

As mentioned in the Introduction, the baby-boom generation ages and moves from the prime-age to the older labor force. The employment and wage effects of such an increase in the number of old workers are described in

Proposition 2 : *Suppose the number of old workers increases ($\widetilde{L}_2 > 0$). The monopoly unions will (i) reduce the wage rates for the old, so that (ii) employment of the old moves one-to-one with the increase in L_2, (iii) the unemployment rate of the old does not depend on the cohort size. (iv) The wage rate of the young increases, but (v) this is neutral for (un-)employment of the young. Furthermore, (vi) output increases, and (vii) all three kinds of labor profit from higher production by an increase in their labor income; (viii) the labor income shares remain constant.*

On impact, that is, for a given senior wage w_2 and thus for a given number of senior jobs N_2, an increase in L_2 leads to a higher rate of unemployment u_2. There is a larger number of old workers willing to take a senior job at the given level of w_2. In Figure 3 (see below), the PS schedule shifts to the right taking the economy from A to B. Because of a lower fallback income b_2, unions are now in a weaker position, so they set a lower senior wage w_2 and a lower wage for old workers

with a junior job, w_1^o. The downward pressure on w_2 and w_1^o creates new jobs, the economy moves from B to C. Point C is not an equilibrium, since the rise in the replacement ratio provokes a cut in unemployment benefits for the old, which enhances the fall in the wages rates of the old. The decline in these wages will be sufficient to absorb all additional old workers. Hence, there is some short-term dynamics, but the unemployment rate u_2 gradually returns to its initial level (point D in Figure 3). Because of positive cross-derivatives the increase in employment of the old causes an increase in the marginal product of young workers. The feasible real wage for young workers moves up. This works as employment stimulus. But, as a consequence of a constant replacement ratio, the government is assumed to answer the increase in w_1^y with an increase in unemployment benefits for the young. The employment stimulus for a higher N_1^y vanishes, employment of the young and thus the unemployment rate u_1 returns to its initial level.

Figure 3 about here

The higher number of employed old workers allows for a higher output and thus a higher labor income. Concerning old workers, the fall in the senior wage w_2 has to be balanced with the increase in employment. The former effect always falls short of the latter effect, so that the wage income of the old, $\widetilde{w}_2 + \widetilde{N}_2$, unambiguously increases. Because of the increase in the junior wage w_1^y and the unaltered level of young employment, the wage income of the young, $\widetilde{w}_1^y + \widetilde{N}_1^y$, also goes up. The ratio of the wage income of the old to the wage income of the young remains constant, which is a result of our assumption of Cobb-Douglas-technologies. A CES-specification of either (1) or (2) would allow for shifts in the incomes shares.

4.3 Decline in the number of young workers

The age structure of almost all Western economies has changed as a result of a drastic decline in fertility. The employment and wage effects of such a decline in the number of young workers are summarized in

Proposition 3 : *Suppose the number of young workers decreases ($\widetilde{L}_1 < 0$). This leads to (i) a higher junior wage and (ii) a decline in employment of young workers,*

(iii) the unemployment rate of the young remains unaltered. Moreover, (iv) the wages for the old fall, but there is (v) no employment effect for the old. Both (v) output and (vi) the wage income of all three kinds of labor decline.

The impact effect of a decline in the number of young workers follows from the definition of the unemployment rate u_1. For a given junior wage and hence a given number of employed young workers the unemployment rate u_1 decreases. There are now less young workers looking for a junior job. In Figure 4 (see below), a lower L_1 will shift the PS-schedule to the left and take the economy to point B. At B the position of the unions has been improved (higher fallback income b_1) motivating a higher wage claim for junior jobs, w_1^y goes up. Firms answer with a lower labor demand, the economy moves from B to C. At C the government increases unemployment benefits for the young taking the economy to point D. In the new equilibrium the drop in employment of young workers is equiproportionate to the decline in the labor force L_1. The rate of unemployment of the young returns to its initial level, so u_1 does not depend on the cohort size. Despite the decline in N_1^y there will be no employment-destroying side-effect on old workers. Due to the lower N_1^y the marginal products of old workers with a senior job and old workers with a junior jobs decline too. But such a fall in the feasible real wage for the old leads to a decline in the unemployment benefits for the old. The assumed policy response protects employment of the old against the decline in N_1^y.

Figure 4 about here

The decline in employment of the young is associated with a lower level of output. The burden of adjustment will be carried by the wages w_2 and w_1^o, they fall. A decline in the wage combined with a constant number of employed old workers implies a reduction in labor income of the old. Concerning the labor income of the young, we observe a decline in employment but an increase in the junior wage. Eq. (45) immediately reveals that the former effect exceeds the latter effect, that is, labor income of the young decreases too.

4.4 Change in the age composition of a given labor force

In this section we will focus on the pure age structure effect and its impact on the labor market outcome. Varying the size of either the young or the old cohort is a mixture of a level and a structure effect. If, for instance, it is assumed that only the number of old workers increases, then both the overall labor force and the ratio of old to young individuals increase. In order to distinguish between these two effects, we now investigate the case where the increase in the number of old workers will be accompanied by a one-to-one decrease in the number of young workers. In terms of our model, this scenario is captured by assuming $\widetilde{L}_2 > 0$, $\widetilde{L}_1 < 0$, and $\widetilde{L}_2 + \widetilde{L}_1 = 0$. The wage and employment effects are described in

Proposition 4 : *Suppose that, for a given labor force, the ratio of old to young workers increases. Such a shift in the age structure has no effect on (i) the unemployment rate of the young and (ii) the unemployment rate of the old. However, (iii) employment of the old increases, whereas (iv) employment of young workers decreases. If the production elasticity of young workers, δ, exceeds 0.5, (v) the number of junior jobs in efficiency units declines. A necessary and sufficient condition for (vi) a drop in output is $\delta > \frac{\beta+\gamma}{2\gamma}$. Concerning wages the results are clearcut, that is, (vii) the senior wage decreases, and (viii) the junior wage increases.*

The increase in L_2 and decrease in L_1 triggers the mechanisms described so far. On impact we observe an increase in u_2 and a decrease in u_1. The repercussions from the fallback incomes combined with the assumption of constant replacement ratios leads to a rise in the junior wage and a decline in the senior wage. The adjustment of labor demand and thus employment neutralizes the impact effect, the change in the age composition does not matter for the equilibrium unemployment rates. The wage differential between old and young widens even more due to the cross-effects. In Figure 3 the new equilibrium shifts up to point D, in Figure 4 the new equilibrium shifts down to point D.

The change in the number of junior jobs, N_1, depends on the production elasticity of young workers. On the one hand, there are more old workers with a junior job (higher N_1^o), on the other hand, employment of young workers N_1^y goes down.

If the production elasticity of young workers, δ, is greater than the production elasticity of old workers with a junior job, $1-\delta$, then N_1 decreases. This condition simplifies to $\delta > 0.5$, which is probably fulfilled. For $\delta > 0.5$, we have a decline in N_1 but an increase in N_2. For most plausible production elasticities the latter effect dominates and output will increase, but if δ exceeds a critical threshold, that is, for $\delta > \frac{\beta+\gamma}{2\gamma}$, the net effect on output will be negative. The critical threshold is increasing in the production elasticity of senior jobs β and decreasing in the production elasticity of junior jobs γ. Thus the higher is β and the lower is γ, the lower is the probability of a negative output effect.

Our results indicate that the age structure is neutral with respect to the unemployment rates. This is in stark contrast to Pissarides (1989), who states that an increase in the ratio of old to young workers reduces the unemployment rate of both groups in the population. Note, however, that our results are in line with the empirical study of Zimmermann (1991) who, using German data, finds an impact of the age composition of the population on short-term dynamics, but no clear relation between the age structure and age-specific unemployment rates in the long run.

4.5 More generous unemployment benefits for the old

Many discussions on the impact of the demographic change are centered around the question how the ageing of the median voter will influence the outcome of the political process. Even today in almost all Western economies the unemployment benefits for the old are more generous than for the young. We suppose that, due to the change in the ageing pattern, the gap in the unemployment benefits between old and young will widen in the future. In terms of our model this is an increase in the replacement ratio ρ_2 and/or a cut in the replacement ratio ρ_1.

Proposition 5 : *Suppose that the government raises the replacement ratio ρ_2, the replacement ratio ρ_1 remaining constant. Then (i) the senior wage rises, (ii) employment of old workers falls, (iii) the unemployment rate of the old moves up. Moreover, (iv) the junior wage decreases, but (v) employment of the young and thus (vi) the unemployment rate of the young will not be affected. (vii) Output and thus (viii) the wage income of both young and old workers decline.*

Proposition 6 : *If the government raises the replacement ratio ρ_2 and simultaneously cuts the replacement ratio ρ_1 with $\widetilde{\rho}_1 = -\widetilde{\rho}_2$, then we will observe (i) a rise in the senior wage, (ii) a rise in the unemployment rate of old workers, (iii) a fall in the junior wage and (iv) a fall in the unemployment rate of the young. (v) The number of junior jobs in efficiency units as well as (vi) output may rise or fall.*

Due to the higher replacement ratio ρ_2 the fallback income b_2 and hence the wages w_2 and w_1^o set by the monopoly unions will rise. Employment of old workers decreases implying a negative side-effect on the marginal product of young workers. The feasible wage for young workers goes down. The assumed answer by the government is a decline in the unemployment benefits for the young which magnifies the decline in the junior wage but avoids any negative employment effect for this group. A lower wage combined with an unchanged employment level corresponds to a decline in the wage income of the young. Similarly, the higher wage of the old will be overcompensated by the decline in employment of the old, even their wage income declines.

Turn to Proposition 6. In order to finance the increase in the unemployment benefits for the old, the government is forced to cut one-to-one the unemployment benefits for the young.[3] The increase in ρ_2 combined with a cut in ρ_1 is very similar to the case where unions place a higher weight to the wishes of the old. The impact effects are identical, the senior wage goes up, the junior wage shifts down. And, as our analysis indicates, the equilibrium labor market effects are identical too. At least the signs of the multipliers coincide. We thus do not want to repeat the dynamics of the adjustment process here but refer to section 4.1. Note, however, that, similar to the case of a higher α, the change in the number of junior jobs is not clearcut. We observe more young but less old workers with a junior job. The net effect is difficult to sign, it depends in a complex way on the parameters of the initial steady state. Provided that N_1 goes up, it is possible that even output goes up. Simulations, however, indicate, that this scenario is

[3] We impose the condition of ex-ante neutrality where the policy is budget neutral at the initial steady state. The concept of ex-post neutrality, where the budget is assumed to be neutral after all adjustments in the economy have taken place, is explored in Michaelis and Pflüger (2000) and Lingens (2004).

quite extreme. For most plausible parameter values, the decline in N_2 dominates generating a negative output effect.

5 Conclusion

This paper investigates the labor market effects of an ageing workforce. It challenges the Pissarides (1989) conjecture that an increase in the ratio of old to young workers reduces the unemployment rate and the wage rate of both age groups in the population. Using a general equilibrium model of a unionized economy we show that such a change in the age pattern is neutral with respect to the unemployment rates. Even in a unionized economy it is optimal to adjust the wages, so that employment moves one-to-one with the change in the labor force. This neutrality result, however, crucially hinges on the assumption that the change in the age pattern does not affect the union objective function. If the demographic change implies that unions attach more weight to the wishes of the old, the unemployment rate of the old will increase whereas the unemployment rate of the young will decrease. The net effect on overall employment cannot be signed unambiguously, depending on the parameter constellation all three cases are possible.

Lastly, let us mention two limitations of our framework. We assume Cobb-Douglas technologies. In particular, if the elasticity of substitution between young and old workers filling a junior is different from unity, the sign of the wage and (un-)employment effects may be less clearcut. Further research is needed in order to identify the crucial assumptions and critical parameters. A related point is concerned with our focus on analytical results. The method of log-linearization restricts us to small changes in the (policy) parameters. In order to evaluate large (policy) shocks and/or to get a numerical assessment of the wage and (un-)employment effects, a calibration of the model would be necessary.

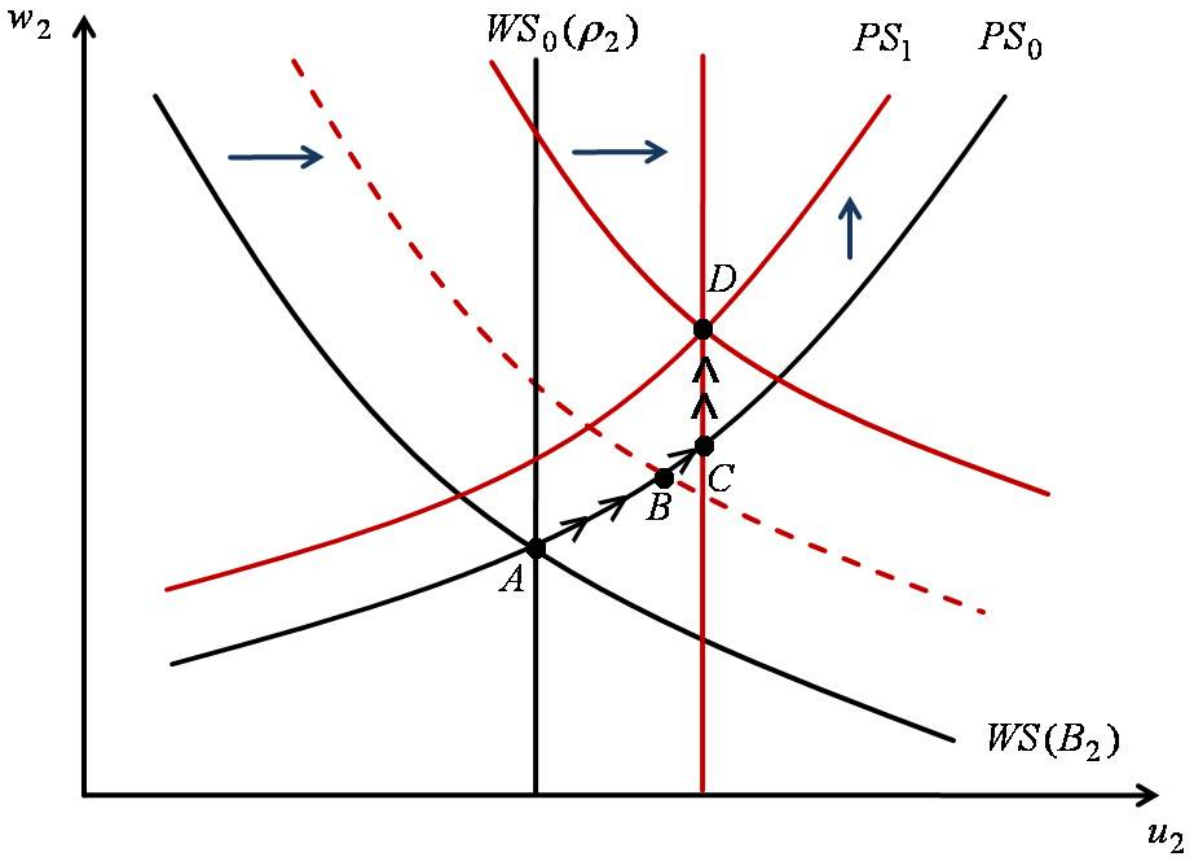

Figure 1: Increase in α (senior job market)

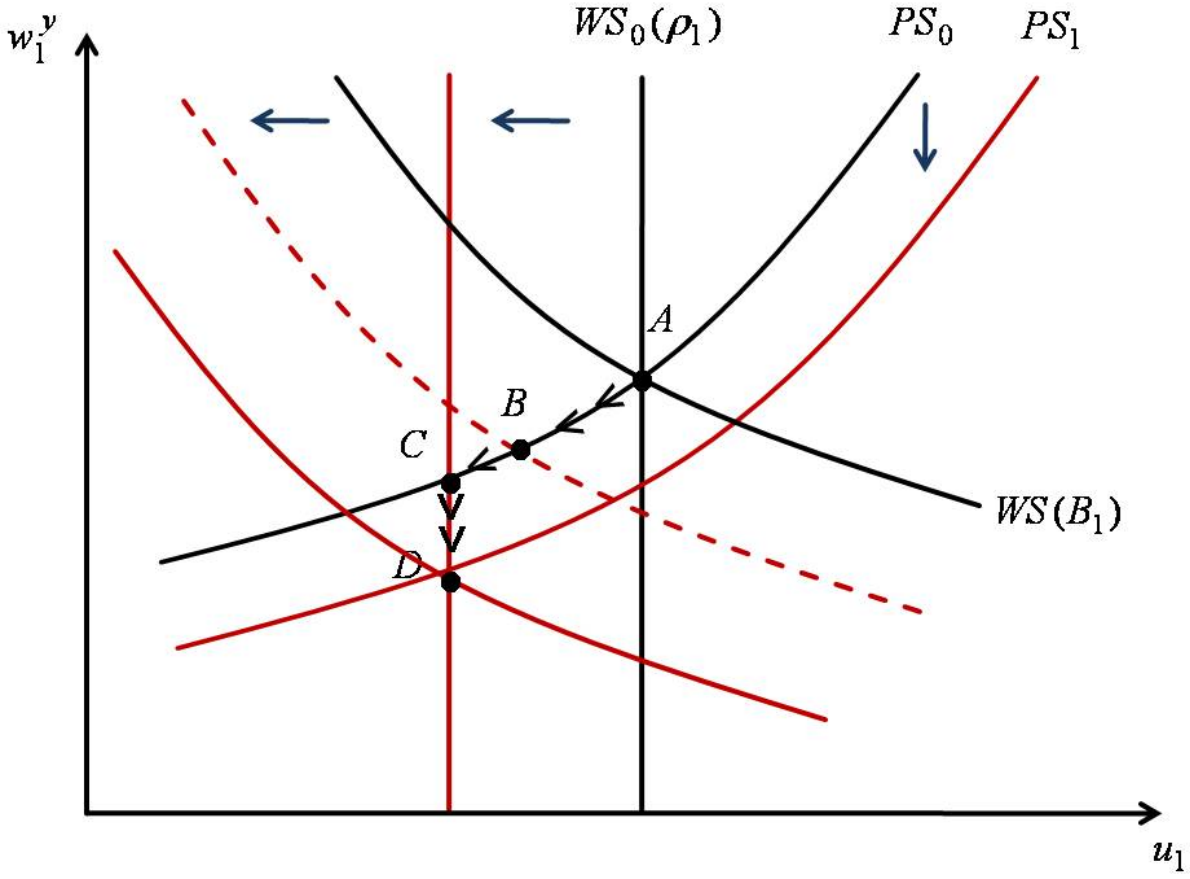

Figure 2: Increase in α (junior job market)

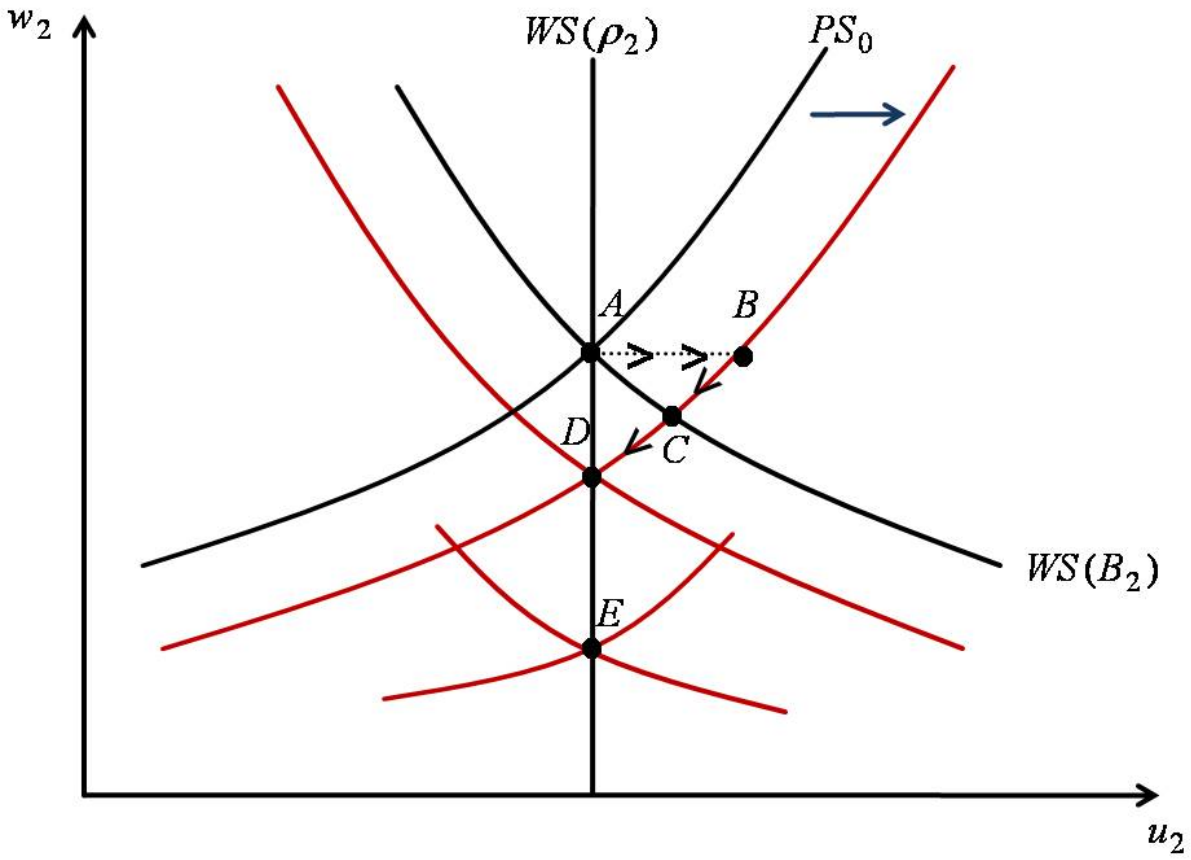

Figure 3: Increase in the number of old workers

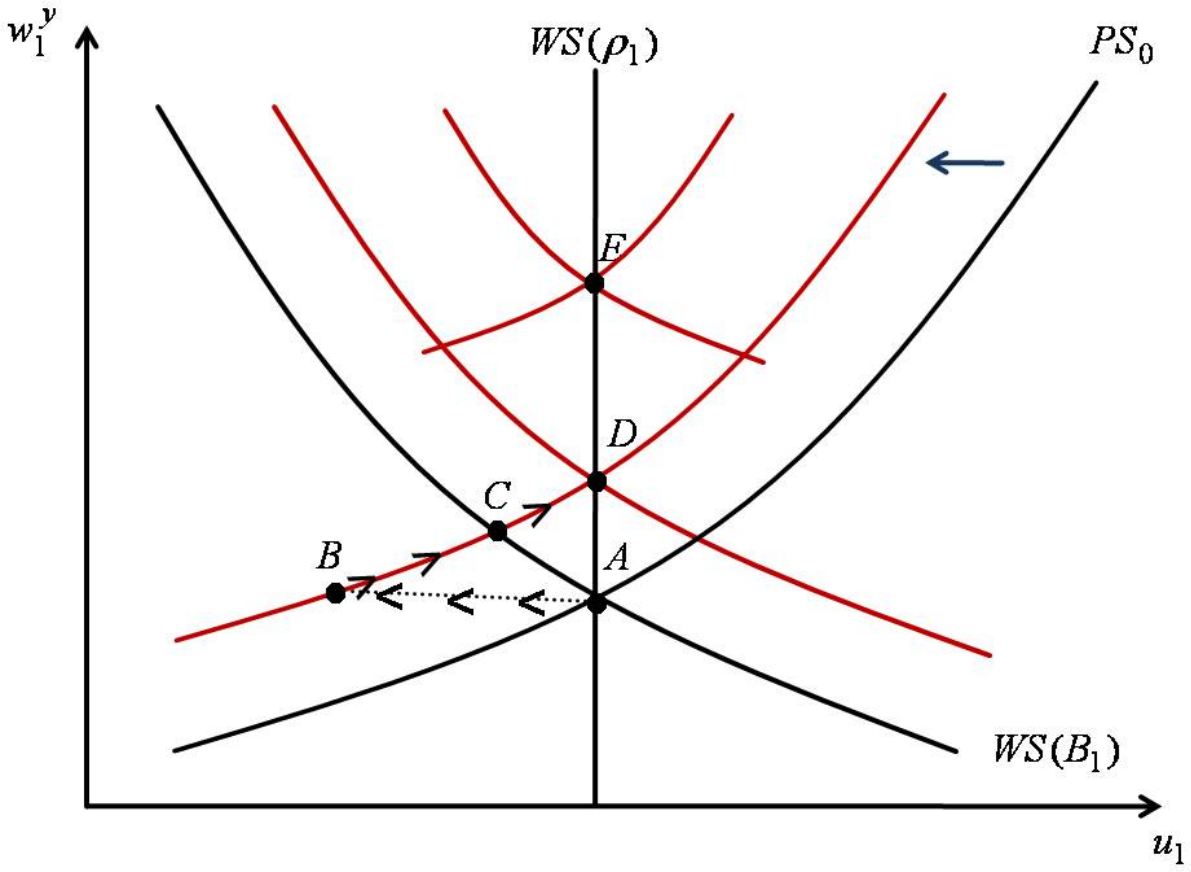

Figure 4: Decline in the number of young workers

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